Research Institute Leiden Observatory

(Onderzoekinstituut Sterrewacht Leiden)

Annual Report 2010

Sterrewacht Leiden
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Cover:
In the Sackler Laboratory for Astrophysics, the circumstances in the inter- and circumstellar medium are simulated. In 2010, water was successfully made on icy dust grains by H-atom bombardment, understanding was gained how complex molecules form under the extreme conditions that are typical for space, and experiments are now ongoing that investigate under which conditions the building blocks of life form. The picture shows the lab's newest setup - MATRI2CES - that has been constructed with the aim to 'unlock the chemistry of the heavens'.

An electronic version of this annual report is available on the web at
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Production Annual Report 2010:
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Sterrewacht Leiden

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Chapter 1

Review of major events

Review of major events

Chapter 1

1.1 Foreword

2010 was another busy, successful year at the Sterrewacht. This Annual Report describes many individual events and achievements, in a slightly updated format.

I will not repeat the many science highlights described in this booklet. But it is fitting to remark that most of this work is done by our steadily growing body of graduate students and postdocs – together now some 100 young astronomers! - and maintaining an environment in which fundamental research with the latest facilities can take place, and attract brilliant minds from all over the world, remains the top priority for the institute.

As part of the six-yearly cycle of research assessments, Sterrewacht Leiden, our sister university astronomy departments, and the NOVA federation we all participate in, were visited in the spring by an international expert committee chaired by Prof. Frank Shu. The conclusions were clear and very gratifying: our institute is among the top astronomy research institutes world-wide.

Importantly, also the NOVA programme scored very well, and a high-level blue-ribbon committee overseeing all sciences ranked it among the very top of the current 'top-research schools' in the Netherlands, giving it the mark 'exemplary'. Such evaluations are important in these times of government austerity, and provide key ammunition with which to ensure our future. Fortunately, they could hardly have been better.

To underscore the success further, a number of significant prizes and grants were awarded to staff members. Marijn Franx was given a Spinoza award, the highest honour in Dutch sciences, to continue his studies of the earliest galaxies with the James Webb Telescope (JWST). Harold Linnartz won a VICI grant for his Laboratory Astrophysics work, and Huub Röttgering a TOP subsidy to exploit the scientific potential of LOFAR. At the Netherlands Astronomy Conference in May, Joop Schaye and Vincent Icke were awarded the three-yearly Pastoor Schmeits Prize and Willem de Graaff Prize respectively.

In 2010 we welcomed two new staff members: Matt Kenworthy, who works on direct imaging of exoplanets and active optics; and Rychard Bouwens, a specialist in studying galaxies in the high-redshift universe. Elena Rossi, a theoretical astrophysicist who specializes in dynamics around black holes was due to join us at the start of 2011, filling the vacancy left by Yuri Levin who left in the summer.

Last year saw, for the second year running, an unusually large number of new undergraduates in our BSc programme. Our Astronomy Masters programme continues to attract new students from abroad as well as our own BSc graduates.

Also for the second year running, we coordinated the selection of new PhD students by pooling all project grants and announcing the open positions in one common call. Competition for these positions is very strong, with over 300 applications for some 15 positions! The final selection was done after a 2-day visit by the 30 or so top candidates in February, during which potential supervisors and students can see each other in action. The days of the visits are very busy, but also very stimulating. It is by now clear that we have managed to increase the pool of applicants greatly with this coordinated approach, and we have decided to continue this scheme.

Outreach is the third part of the mission of the institute. While we were somewhat hampered in organising local activities during 2010 by the continuing restauration of the 'Old Observatory'- it will reopen in 2011, 150 years after its foundation - our programme of public lectures in schools and for the general public, press releases and media appearances continued unabated. As astronomers we are privileged to be able to spend our time following our passion of doing research, but this requires us to give something back to society as well. Astronomers are well-known for being able to solve problems based on incomplete and poorly-controlled data, and this skill can certainly come in handy outside the walls of astronomy institutes and observatories. A beautiful example of our outreach efforts is the Universe Awareness programme, started in Leiden by George Miley, which is now supported by the European Union. It aims to educate young children with an underprivileged background about the wonders of the universe and our place in it, and is now active in more than 40 countries.

We welcomed many distinguished guests in 2010: let me highlight the 2010 Oort professor, Richard Ellis (Caltech), our Sackler lecturer Linda Tacconi (Max Planck Inst for Extraterrestrial Physics), and Reinhard Genzel (also from MPE), in whose honour we held a small symposium on the morning of the Leiden dies natalis, hours before he was awarded a Leiden University honorary doctorate - the first astronomer in living memory to have this title bestowed on him.

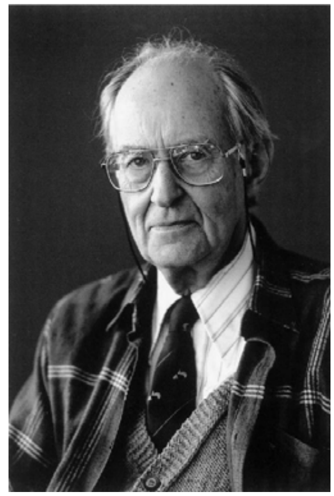
A number of social events were ably organized by the Soccom: the Christmas lunch and a visit by Sinterklaas in December, a summer barbecue for the whole institute and their families, and a visit to the Omniversum theater in The Hague to watch the impressive movie about the Hubble Space Telescope.

During 2010 we lost five dear 'Sterrewachters'. Adriaan Blaauw, professor emeritus and nestor of Dutch astronomy, died in December. Jaap Tinbergen, UHD, who moved in 1982 together with the technical staff to Roden (KSW) en later at ASTRON was the technical conscience op the Optical/IRT group, died in June. Two oud-sterrewachters who moved to ASTRON after graduating as Leiden PhDs, passed away as well: Titus Spoelstra (April) and Ernst Raimond (September). In that same month Annemieke Gloudemans-Boonman, who graduated in 2003 under Ewine van Dishoeck, left us all far too early. Obituaries of Adriaan and Jaap are included in this Annual Report.

2011 promises again to be an important year for the institute, with new scientific opportunities (including first science with LOFAR, ALMA and VLT Survey Telescope), a newly reopened Old Observatory building with its historic telescopes restored by the Leiden Instrumentmakers School (LIS), and the continuing challenge to keep us where we want to be: doing research at the forefront of modern astronomy.

Koen Kuijken
Scientific Director
Leiden Observatory

1.2 Obituary Adriaan Blaauw



Adriaan Blaauw, 1914-2010

Adriaan Blaauw was the Nestor of Dutch astronomy, a role he fulfilled with visible relish. Never short of a story (or the time to tell it), he loved to talk about astronomy, to anyone. Famous for his ground- breaking research on OB associations and runaway OB stars, and for co-editing Volume 5 (on galactic structure) of the 'Stars and Stellar Systems' series in 1965, he also contributed greatly to astronomy as the chair of the group that defined the input catalogue for the HIPPARCOS mission. His mind was sharp until the end, and many of us will remember conversations over the years in which a recent research result was met with a gracious and genuine compliment, accompanied by a probing question delivered with a twinkle in the eyes. These were always moments to treasure, and many students of astronomy, young and old, have enjoyed them. But the fondest memory will be for the warmth of his personality - it is hard to imagine a kinder man.

Adriaan Blaauw was born in Amsterdam 1914, and after meeting Willem de Sitter studied in Leiden from 1932 onwards. While still a student he moved to Groningen as an assistant to van Rhijn, where he obtained his PhD (cum laude) in 1946 on a study of the Scorpio Centaurus Cluster. In 1945 he joined the staff in Leiden, before becoming associate professor at Chicago's Yerkes Observatory in 1953.

He returned to the Netherlands in 1957 as director of the Kapteyn Institute in Groningen, where he started to build up the present institute. In the meantime he was deeply involved in the foundation of ESO, the European Southern Observatory, initially as its (part-time) scientific director. In 1970 he left Groningen to become the second Director-General. During his tenure he oversaw the move of the organization from Hamburg to Geneva, and the completion of the 'flagship' 3.6m telescope on La Silla. After his term at ESO he became full professor in Leiden, a position he held until his retirement in 1981. He served as president of the International Astronomical Union from 1976 to 1979. His talents as a diplomat served him well, as he succeeded into bringing China back into the IAU.

During his career Adriaan Blaauw saw astronomy change almost out of all recognition. The expansion of the universe, galaxy evolution, the distance scale, stellar evolution, stellar populations, quasars, and many other phenomena were all discovered or eludicated during his lifetime. Space observatories, radio telescopes and computers appeared over the same period, and continue to grow more and more powerful, as do optical telescopes including those of ESO. Earlier this year Adriaan visited Paranal Observatory again, where he could see the progress for himself - by all accounts the twinkle in his eyes, as he asked the astronomers about their observations, was as bright as ever.

Adriaan continued to enjoy good health well into his 90's, and he remained a regular visitor to Leiden. After his retirement he moved back to his historic farmhouse near Groningen and took an emeritus professor appointment at the Kapteyn Institute, where he continued to interact with students and staff alike. In this period he saw the HIPPARCOS satellite deliver spectacular results (thanks in no small part to his own contributions and encouragement). History and historical perspective were among his great passions, so not only did he produce an ´Early History of ESO´ around 1990, but he also became involved in researches into the history of the Blaauw family from 17th century sources from the township of Graft in the province of North Holland, where his roots lie. He also invested much energy in setting up the archives of the IAU, making frequent trips to Paris in his trusted small Volvo and producing a ´History of the IAU´ in 1994.

In 2004 Adriaan wrote up some of his reminiscences in the Annual Reviews of Astronomy and Astrophysics, and they make great reading. The warmth and humour, the respect and wit, as well as a true historical view, are very inspiring.

We have lost a dear friend, who will be remembered fondly and with admiration for many years.

May he rest in peace.
Koen Kuijken
Jan Lub

1.3 Obituary Jaap Tinbergen

Jaap Tinbergen 1934-2010

On June 20 our dear friend and colleague Dr. Jaap Tinbergen passed away at the age of 75.

Jaap was a well-known optical instrumentalist and polarization expert. He was an active member of IAU Commission 25 for many years. Many will know his book "Astronomical Polarimetry", published in 1996 by Cambridge University Press, that witnesses his phenomenal knowledge of the subject.

The main-belt asteroid 10434 Tinbergen (4722 P-L) was named after Jaap in recognition of his contributions to the role of electromagnetic polarization in instrumentation of radio and optical astronomy.

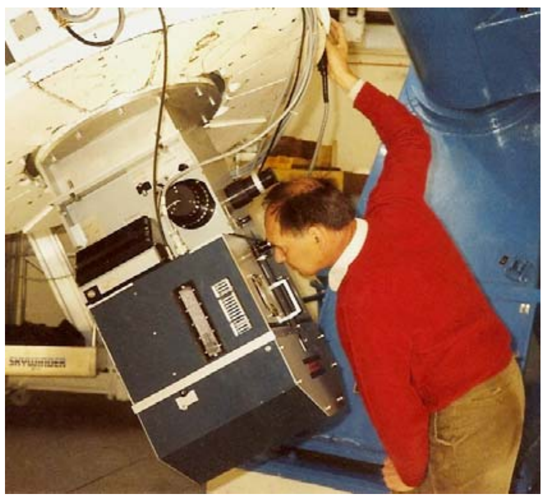
As the son of the biologist Niko Tinbergen, who was professor at Oxford University, Jaap started his academic education in the UK. After a B.A. in experimental physics at Cambridge University, two and a half years of ionospheric research on Antarctica and an M.Sc. degree in information engineering at the University of Birmingham, he moved to the Netherlands in 1960 and took up astronomy at Leiden University, where Oort, Van de Hulst, Westerhout and Walraven were his inspiring teachers. From the beginning polarization was a key subject. This started with his work, together with Westerhout, Brouw, Berkhuijsen and Muller, on the polarization of the Galactic radio background.

Graduated in 1965, he became staff member of Leiden Observatory. Under the influence of Theodore Walraven he then moved from radioastronomy to optical photometry and polarimetry. In 1972 he completed his dissertation "Precision spectropolarimetry of Starlight" with Walraven as Ph.D. supervisor.

When in 1982 the small optical group of Leiden joined their colleagues at the Kapteyn Observatory of Groningen University Jaap became an important member of the new Working Group for Astronomical Instrumentation, the group that eventually developed into the present NOVA-ASTRON optical group at Dwingeloo.

During his long career as senior instrumentation scientist Jaap was involved in the development of many instruments for telescopes in South-Africa, Chile and on La Palma, but his real domain was precision polarimetry. His papers (1988-2003) together with G. Können on polarization effects in planet atmospheres are beautiful applications of the power of polarimetry. Jaap always considered the polarimetric properties of the complete observing system, i.e. telescope plus instrument, and thus became the "polarimetry conscience" in the field of optical astronomical instrumentation. He remained active until the end and made decisive contributions to the polarimetric design of SPHERE-ZIMPOL, the "exoplanet-finder" instrument that is presently being built for the VLT. We will miss Jaap's wise advice, invincible optimism and friendship.

Jan-Willem Pel



Jaap Tinbergen at work with his Multipurpose Photometer, here on the Kapteyn telescope on La Palma (Photo courtesy G.P. Können)

Chapter 2

Research

Research

Chapter 2

2.1 Heritage

History of Dutch Science

The Sterrewacht is host to the History of Science group of the Leiden University Faculty of Science. Members of the group focus on a variety of topics in national and international history.

Weiss was able to illustrate the profound changes the term 'museum' underwent over the course of the nineteenth century and in particular how much these changes affected the role each individual collection that was housed in 'Teylers Museum' played within the overarching entity of that museum itself. He also addressed the more general question in what way 'art' and 'science' were perceived as being related towards the end of the 18th century by studying all known collections that were assembled in Haarlem during this period. He discovered previously unknown source material relating to 'Teylers Museum' such as travel reports and the archives of a mineral trader in Bonn. Furthermore he organised a symposium on the public usage of different types of collection in the nineteenth century and was guest editor of a special edition of the journal "De Negentiende Eeuw" on the same topic.

Elbers explored how radio astronomy established itself within the Netherlands and more specifically, why ZWO (now NWO) decided to fund a novel and uncertain field. A crucial factor was the success of Jan Hendrik Oort (Leiden) and Marcel Minnaert (Utrecht) in mobilising vital allies. She also examined how the specific background of Dutch radio astronomers in optical astronomy - elsewhere the field was dominated by engineers and physicists with a background in radar research - influenced the field, e.g. how Dutch radio astronomers dealt with their lack of technical know-how, and how this different origin affected research questions. Finally, she focused on the relations between Dutch and Soviet radio astronomers. It is remarkable that during the heydays of the Cold War, Oort made considerable efforts to stimulate contacts between Western and Soviet radio astronomers.

New names for minor planets

In 2010, 59 minor planets discovered by van Houten and van Houten-Groeneveld received a definitive number. The last four of the Trojans (minor planets in the resonant L4 and L5 points of Jupiter's orbit) discovered by them were named. Altogether 26 minor planets received a name communicated by van Houten-Groeneveld. These include:

Number	Name	MPC named	Date discovered
12152	Aratus	70407	1971 Mar.25
12153	Conon	70407	1971 Mar.26
12154	Callimachus	70407	1971 Mar.26
12155	Hyginus	70407	1971 Mar.26
12159	Bettybiegel	70408	1973 Sep.29
12160	Karelwakker	69492	1973 Sep.29
12161	Avienius	70408	1973 Sep.29
12162	Bilderdijk	70408	1973 Sep.29
12172	Niekdekort	70408	1977 Oct.16
10975	Schelderode	71347	1973 Sep.29
12163	Manilius	71348	1973 Sep.30
12174	vanhetReve	71348	1977 Oct.16
12175	Wimhermans	71348	1977 Oct.16
200069	Alastor	71352	1960 Oct.24
215089	Hermanfrid	71352	1960 Sep.24
216462	Polyphontes	71352	1973 Sep.30
225276	Leïtos	71353	1973 Sep.29
12144	Einhard	72989	1960 Sep.24
12145	Behaim	72989	1960 Sep.24
12147	Bramante	72989	1960 Sep.24
12148	Caravaggio	72989	1960 Sep.24
12149	Begas	72989	1960 Oct.17

Number	Name	MPC Named	Date discovered
12176	Hidayat	72989	1977 Oct.16
12177	Raharto	72989	1977 Oct.16
12178	Dhani	72989	1977 Oct.16
12179	Taufiq	72989	1977 Oct.16

MPC named gives the number of the Minor Planets Circular containing the announcement of the name, and a brief description of its meaning.

2.2 Extrasolar planets

A world first: molecular gas in an exoplanet atmosphere

Snellen, de Mooij and collaborators worked on the characterisation of extrasolar planet atmospheres. First in the world, they detected a molecular gas in the atmosphere of a hot Jupiter at very high spectral resolution, resulting in a paper in Nature. During the transit of exoplanet HD209458b, they registered absorption by carbon monoxide gas, showing a Doppler shift due to the change in the radial component of the orbital velocity of the planet. With this result, they could determine the planetary orbit as well as the masses of both the star and the planet using only Newton's law of gravitation. They attributed evidence for an additional blue-shift of the carbon monoxide absorption feature to a global wind blowing from the hot day-side to the cooler night-side of the planet.

Direct imaging of exoplanets

Kenworthy and Hinz (Tucson, Arizona, USA) carried out imaging of the multiple extrasolar planet system HR 8799 at thermal infrared wavelengths. The lack of a detection of any of the known planets at 5 microns represents a significant challenge to current planet atmospheric models. In collaboration with Mamajek, Kenworthy also imaged a low mass M dwarf around the bright star Alcor using the adaptive optics and thermal camera system of the Multiple Mirror Telescope Observatory (MMTO). More in general, his research is based on the development of techniques for the direct imaging and characterisation of extrasolar planet systems. A corona-graphic optic (called an apodising phase plate or APP) is now installed at ESO's Very Large Telescope the VLT and at the recently commissioned Large Binocular Telescope (LBT) in Southern Arizona. The VLT APP has been successfully commissioned during 2010 and is now on offer to the general community. Kenworthy and collaborators successfully obtained direct imaging of the planet around Beta Pictoris using the APP. The results were picked up by many popular news sites and several newspapers.

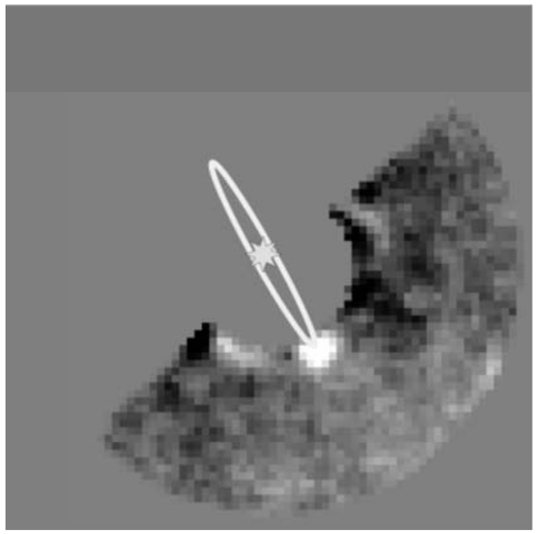


Figure 1. An image of the extrasolar planet beta Pictoris b, imaged at 4.05 microns on the VLT in April 2010. The location of the central star is indicated, along with a hypothetical orbit for the exoplanet (see Quanz et al. 2010 for details).

2.3 Cicumstellar gas and dust

Disks around young stellar objects

The scientific harvest of the Herschel Space Observatory characterised much of Hogerheijde's activities in 2010. As part of three large teams that successfully obtained significant amounts of observing time on Herschel, Hogerheijde was involved in the analysis and reduction of observations of star forming regions, young stars and their disks and outflows, and debris disks around nearby stars. He was especially closely involved in the observations of the protoplanetary disk around the young star DM Tau, searching for emission from cold water vapor using the Heterodyne Instrument for the Far Infrared (HIFI). These data were in fact some of the deepest integrations obtained with Herschel. In spite of this fact, no clear emission was detected; at best a tentative signal from one of the water vapor ground state lines. This, at first glance, disappointing result, actually places very strong limits on the amount of water vapor in disks. Although most water is expected to be frozen out onto small dust grains, ultraviolet radiation from the star releases an appreciable amount back into the gas phase. The strict upper limit from Herschel/HIFI implies that as much as 95 percent of the ice-carrying grains must have settled to the disk's mid-plane, out of the reach of the stellar radiation. The corresponding increase in the amount of icy grains near the mid-plane may aid the growth of planetesimals and ultimately planets.

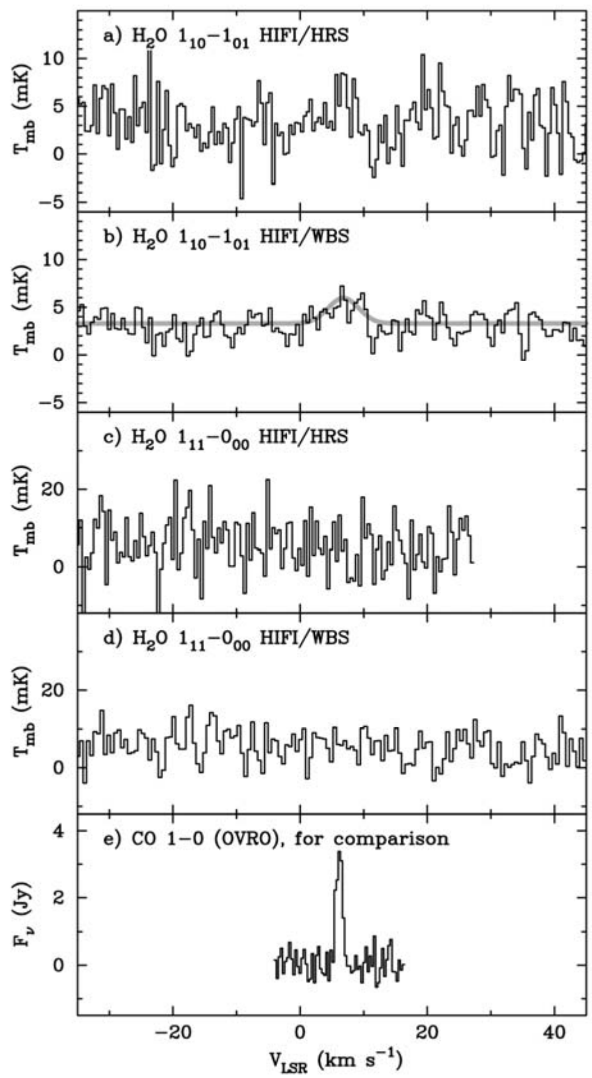


Figure 2. Herschel/HIFI observations of the ortho- and para-water ground state transition toward the disk around the young star DM Tau, as compared to the CO 1-0 emission detected earlier (bottom). At best a very tentative detection of water vapor emission was found, placing strong limits on the amount of water vapor in the disk and suggesting that 95% of the ice-covered grains have settled to the disk's mid-plane.

Led by student Salter, Hogerheijde and other collaborators carried out a multi-observatory campaign to monitor the millimeter-wave emission from the close eccentric binary DQ Tau. This pre-main-sequence binary is surrounded by a circumbinary disk, from which it is still actively accreting material. However, its millimeter emission, usually dominated by thermal radiation from the dust in the disk, every two weeks increases by large amounts. Discovered by Salter in 2009, this was explained by the fact that on closest approach in their two week orbit, the magnetospheres of the binary members overlap. The resulting reconnection accelerates electrons to relativistic speeds, giving off intense millimeter-wave radiation. The multi-observatory campaign confirmed that, as expected, the events repeat once every orbit on closest passage. The observations followed the flare of millimeter wave emission as seen from the French Alps, from the Eastern Sierras in California, and finally from the heights of Mauna Kea on Hawaii, and even recorded a simultaneous flare of X-ray emission from space with the Chandra X-ray Observatory.

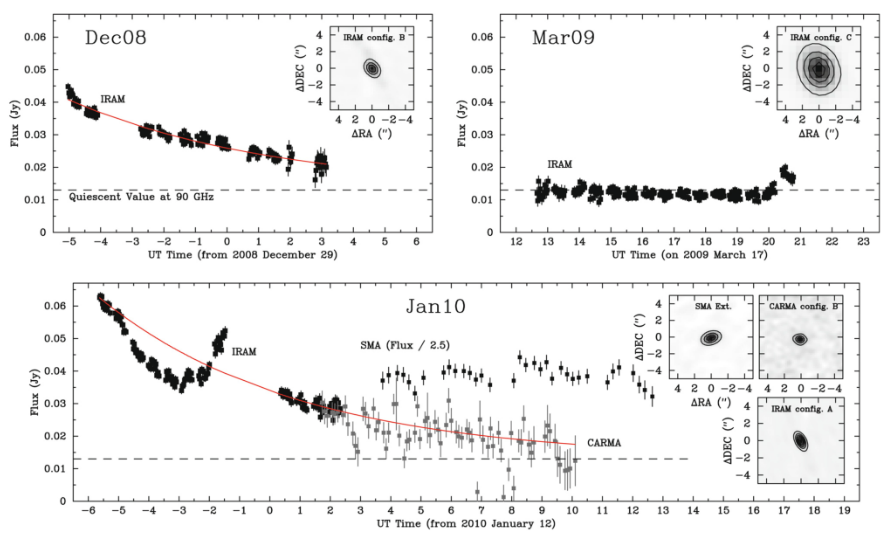


Figure 3. Repeating millimeter-wave light curves of the DQ Tau binary, followed by interferometers spanning the globe from the French Alps to Hawaii.

Warm molecular gas in the disk around HD 100546

The HD 100546 disk was observed with Herschel-PACS as part of the DIGIT program led by Evans. The first results, presented by Sturm, Bouwman, Henning (Heidelberg, Germany) and Mulders, Dominik, Waters (Amsterdam, NL) also involved van Dishoeck and Hogerheijde. The 69 micron feature of crystalline forsterite was detected and analysed in terms of position and shape to derive the dust temperature and composition. Most likely, it arises from dust at a temperature of 200 K, at about 13 AU from the star close to the mid-plane, a suggestion supported by radiative transfer models. The forsterite crystals have few defects and contain at most a few percent iron by mass. Furthermore, thirty-two gaseous emission lines from CO, OH, [C II] and [O I} were observed. The high-J rotational transition lines of CO indicate rotational temperatures of ~300 K for the transitions up to J=22-21 and T ~ 800 K for higher transitions, consistent with warm surface layers of disks.

Spitzer-IRS survey of protoplanetary disk dust evolution in Serpens

Oliveira, van Dishoeck, Pontoppidan (Pasadena, California, USA), Merin (Madrid, Spain), Olofsson and Augereau (both Grenoble, France) and collaborators finished their Spitzer-IRS survey of a complete flux-limited sample of 147 YSO-candidates selected on the basis of their infrared colors in the Serpens molecular cloud. Background stars, galaxies, and a planetary nebula amount to twenty-two per cent of contamination, leaving 115 true YSOs. Sources with rising spectra and ice absorption features, classified as embedded Stage I protostars, amount to eighteen per cent of the sample, very similar to the situation found in Taurus. The remaining eighty-two per cent (94) of the disk sources are analysed in terms of spectral energy distribution shapes, PAHs, and silicate features. About eight per cent of the disks have 30/13 micron flux ratios consistent with cold disks with inner holes or gaps, and three per cent of the disks show PAH emission. Comparison with models indicates that dust grains in the surface of these disks have sizes of at least a few microns. No significant difference is found in the distribution of silicate feature shapes between sources in clusters and in the field, nor with the c2d IRS sample distributed over five clouds and with a large sample of disks in Taurus. This remarkably similar distribution in samples with different environment and median ages imply that the dust population in the disk surface results from an equilibrium between dust growth and destructive collision processes that are maintained over a few million years for any YSO population irrespective of environment.

Spitzer c2d legacy survey of disks with inner dust holes

Understanding how disks dissipate is essential to studies of planet formation. However, determination how exactly dust and gas dissipate is complicated due to the difficulty of finding objects that are clearly in the transition phase of losing their surrounding material. Merin (Madrid, Spain), Brown, Herczeg (both München, Germany), Oliveira, Bottinelli, van Dishoeck and collaborators used Spitzer-IRS to examine 35 photometrically selected candidate 'cold' disks, supplemented with optical spectra to determine stellar and accretion properties and mm photometry to measure disk masses. Based on detailed SED modelling, fifteen new cold disks are identified. Based on these results, reliable criteria are determined to identify disks with inner holes from Spitzer photometry, and examine criteria already in the literature. Applying these criteria to the c2d surveyed regions gives a frequency of such objects of at least four, and most likely about twelve per cent of the YSO population. Hole sizes in this sample are generally smaller than in previously discovered disks and reflect a distribution in better agreement with exoplanet orbit radii. A correlation between hole size and both disk and stellar masses is found. Silicate features, including crystalline features, are present in the overwhelming majority of the sample, although the 10 micron feature strength above the continuum declines for holes with radii larger than about seven AU. In contrast, PAHs are only detected in 2 out of 15 sources. Only a quarter shows no signs of accretion, making it unlikely that photo-evaporation is the dominant hole-forming process.

How does matter accrete onto disks?

The ratio of disk mass over stellar mass is for a large part determined by the angular momentum of the original cloud core from which the system was formed. Visser and Dullemond (Heidelberg, Germany) used a semi-analytic model to investigate how the 2D nature of accretion affects the formation and evolution of the disk in the embedded phase of star formation. A proper treatment of this problem requires a correction for the sub-Keplerian velocity at which accretion takes place. The disks produced with this new method are smaller than those obtained previously, but their mass is mostly unchanged. The 2D treatment results in material accreting at larger radii, so a smaller fraction comes close enough to the star for amorphous silicates to be thermally annealed into crystalline form. The lower crystalline abundances thus predicted correspond more closely to observed abundances than did earlier model results.

The impact of X-rays on protoplanetary disks

Aresu, Kamp (Kapteyn Astronomical Institute) and Meijerink implemented the X-ray chemistry from the Meijerink & Spaans XDR code in the chemo-physical disk code ProDiMo. It was found that neutral molecular species are not much affected in their abundance and spatial distribution, but charged species such as N^+, OH^+, H_2O^+, and H_3O^+ abundances are enhanced in the disk surface. Furthermore, the vertical density structure of the disk is changed due to heating of the surface to temperatures T~8000 K out to distances of 50 AU.

Simulations of water ice photo-desorption

Arasa, van Dishoeck and Cuppen, in collaboration with Kroes (LIC) and Andersson (SINTEF Norway), simulated the UV photo-dissociation of amorphous water ice at different ice temperatures up to 90 K using molecular dynamics (MD) simulations and analytical potentials. The main conclusions are in agreement with the earlier 10 K results by our group: desorption dominates in the top layers, while trapping occurs deeper in the ice. The hydrogen atom photo-desorption probability does not depend on ice temperature, but OH and H_2O photo-desorption probabilities tend to increase slightly (~30%) with ice temperature. The total photo-desorption probability (OH+H_2O) follows the same trend as the experimental total photo-desorption yield by Öberg et al: in both cases the probabilities rise smoothly with ice temperature. The experimental yield is on average 3.8 times larger than our theoretical results, which can be explained by the different time scales studied and the approximations in our model.

2.4 Chemistry and physics of the interstellar medium

Grain surface molecule formation

Many simple, but important, interstellar molecules are believed to be formed on grain surfaces. In 2010, Cuppen's research efforts focused mainly on two of these molecules, H_2 and H_2O. She obtained valuable information about the formation routes of H_2O from laboratory experiments. This was achieved through simultaneous H-atom and O_2 deposition under ultra-high vacuum conditions for astronomically relevant temperatures. Different H/O_2 ratios were used to trace different stages in the hydrogenation network. The chemical changes in the forming ice were followed by means of reflection absorption infrared spectroscopy (RAIRS). New reaction paths were revealed as compared to previous experiments. Several reaction steps proved to be much more efficient (H + O_2) or less efficient (H + OH and H_2 + OH) than originally thought. This new extended network will have profound implications for models that describe the formation of water in space.

She also studied H_2 formation in post-shock regions using a recently developed model for H_2 formation on a graphite surface in warm conditions. The H_2 formation rate is substantially higher at high gas temperatures as compared to the original implementation of this rate in shock models, because of the introduction of H atoms which are chemically bonded to the grain (chemisorption). H_2 plays a key role in the cooling and the increased rate was found to have a substantial effect on the predicted line fluxes of an important coolant in dissociative shocks [OI] at 63.2 and 145.5 microns. With the new model, a better agreement between the model and observations was obtained. Since one of the goals of Herschel/PACS will be to observe these lines with higher spatial resolution and sensitivity than the former observations by Infrared Space Observatory-LWS, this more accurate model is very timely to help with the interpretation of these future results.

Water in star-forming regions with Herschel (WISH)

WISH is a Herschel-HIFI program designed to probe the physical and chemical structures of young stellar objects using water and related molecules and to follow the water abundance from collapsing clouds to planet-forming disks led by van Dishoeck. About 80 sources are targeted, covering a wide range of luminosities - from low to high-mass - and a wide range of evolutionary stages - from cold prestellar cores to warm protostellar envelopes and outflows to disks around young stars. The Leiden team members focus on low-mass protostars and protoplanetary disks.

Kristensen, Visser, Yildiz, van Dishoeck and the WISH team used the high spectral resolution provided by HIFI to observe three deeply embedded protostars in the low-mass star-forming region NGC 1333 in several lines of H_2O and CO and their isotopologues. The line profiles are surprisingly complex, consisting of broad (more than twenty km/s), medium-broad (five to ten km/s), and narrow (less than five5 km/s) components. In one source, an inverse P Cygni profile is observed. This is an unmistakable sign of in-fall in the envelope. From the line profiles alone, it is clear that the bulk of emission arises from shocks, both on small (a thousand AU) and large scales along outflow cavity walls (ten thousand AU). The H_2O/CO abundance ratios are in the range of one tenth to unity, corresponding to H_2O abundances of ~10^{-5}-10^{-4} with respect to

H_2. Approximately five to ten per cent of the gas is hot enough for all oxygen to be driven into water in warm post-shock gas, mostly at high velocities.

Yildiz and the WISH team also detected high-J lines (up to J=10) of ^{12}CO, ^{13}CO and $C^{18}O$ with HIFI toward the same sources. These were combined with low-J line measurements from the JCMT and radiative transfer models were applied to constrain the temperature of the broad-line shocked gas to 100-200 K. The narrow $C^{18}O$ J=9-8 lines probe the warmer part of the quiescent envelope. Their intensities require a jump in the CO abundance at an evaporation temperature around 25 K, thus providing new direct evidence for a CO ice evaporation zone around low-mass protostars.

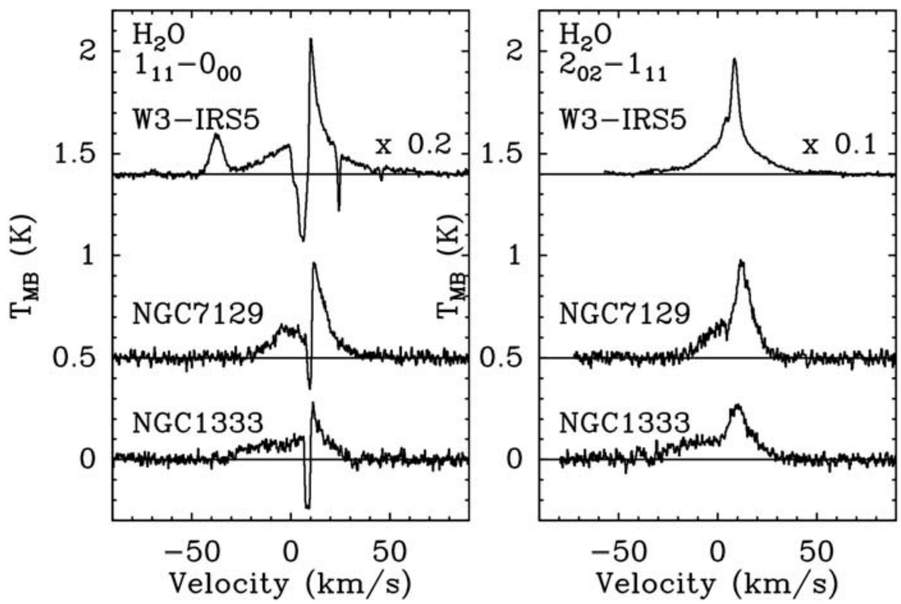


Figure 4. Herschel-HIFI spectra of the p-H_2O 1113 GHz (left) and 988 GHz (right) lines from the WISH key program. From top to bottom: the high-mass YSO W3 IRS5, the intermediate-mass YSO NGC 7129 FIRS2 and the low-mass YSO NGC 1333 IRAS2A. All spectra have been shifted to a central velocity of 0 km/s.

Origin of the hot gas in low-mass protostars

The WISH key program also uses the PACS 5x5 pixel array receiver to observe far-infrared lines of H_2O, CO, OH, [O I], and [C II] between 55 and 210 micron. Van Kempen, Kristensen, Herczeg (MPE, Germany), Visser, van Dishoeck and the WISH team observed the low-mass protostar HH 46 in the Herschel science demonstration phase. CO emission from levels of 2500 K above ground and higher is detected at the central position and along the outflow, as is warm H_2O emission, whereas OH emission is concentrated at the source position. Interestingly, strong [O I] emission is detected from the envelope as well as up to 170 km/s in both the red- and blue-shifted jets. Detailed modelling by Visser and Kristensen shows that passive heating of a spherical envelope by the protostellar luminosity cannot explain the high-excitation molecular gas detected with the PACS instrument. Instead, the warm CO and H_2O emission is probably produced in the walls of an outflow-carved cavity in the envelope, heated by UV photons and non-dissociative C-type shocks. The bright OH and [O I] emission is attributed to J-type shocks in dense gas close to the protostar.

A similar study has been performed by van Kempen, Kristensen, Herczeg, van Dishoeck, Evans (Texas, USA) in collaboration with the 'Dust, Gas and Ice in Time' key program (DIGIT) led by Evans for the protostar DK Chamaeleontis, an intermediate-mass star in transition from an embedded configuration to a star plus disk stage. A full Herschel-PACS scan has been obtained, showing about fifty molecular and atomic lines. Nearly the entire ladder of CO from J=14-13 to J=38-37 (4080 K above ground), water from excitation levels as high as 800 K and OH lines up to 290 K are detected. A similar scenario as found for HH 46 is invoked, with most of the emission arising from the walls of the cavities carved by the outflows.

Water vapor in a young disk around a low-mass protostar

Jørgensen (Copenhagen, Denmark) and van Dishoeck published the first spatially resolved observation of thermal emission of water obtained with the IRAM PdBI toward the deeply embedded Class 0 protostar NGC 1333-IRAS4B. The observations of the $H_2{}^{18}O$ transition at 203.4 GHz resolve the emission of water and show an extent of about 25 AU (radius). The water emission has a velocity gradient perpendicular to the protostellar outflow/jet, consistent with a disk. The line is narrow, only one km/s, significantly less than would be expected for emission from an infalling envelope or accretion shock, ruling out previous models. The water column density suggests that the emitting gas is in a thin warm layer containing about twenty-five M_Earth of material, or a thirtieth of the total disk mass traced by continuum observations. The result featured in an IRAM and NOVA press release.

Jørgensen and van Dishoeck also obtained deep searches for HDO at 225.6 GHz toward the same source, IRAS4B, using the SMA. The non-detection provides a direct, model-independent, upper limit to the HDO/H_2O abundance ratio of 6 x 10^{-4} in the warm gas associated with the central protostar. This upper limit suggests that the HDO/H_2O abundance ratio is not significantly enhanced in the inner 50 AU relative to what is seen in comets and Earth's oceans and does not support previous suggestions of a generally enhanced HDO/H_2O ratio in low-mass protostars. In contrast, the nearby protostar NGC 1333 IRAS2A appears to have HDO/H_2O ratios a factor of a hundred larger on scales of several thousand AU, as inferred from single-dish Herschel and ground-based data by Liu, Parise (both Bonn, Germany), Kristensen, Visser and van Dishoeck.

A cold complex chemistry toward the low-mass protostar B1-b

Gas-phase complex organic molecules have been detected toward a range of high- and low-mass star-forming regions at abundances which cannot be explained by any known gas-phase chemistry. Recent Leiden laboratory experiments by Öberg, Linnartz and van Dishoeck show that UV irradiation of CH_3OH-rich ices may be an important mechanism for producing complex molecules and releasing them into the gas phase. To test this scenario, Öberg (Harvard), Bottinelli, Jørgensen and van Dishoeck mapped the B1-b dust core and nearby protostar in CH_3OH gas using the IRAM 30m telescope to identify locations of efficient non-thermal ice desorption. The quiescent CH_3OH abundance peak and one outflow position were subsequently searched for complex molecules. Narrow $HCOOCH_3$ and CH_3CHO lines originating in cold gas are clearly detected, CH_3OCH_3 is tentatively detected, and C_2H_5OH and $HOCH_2CHO$ are undetected, while no complex molecular lines were found toward the outflow. The core abundances with respect to CH_3OH are similar to the few other low-mass sources surveyed to date. The observed complex molecule characteristics and the pre-dominance of HCO-bearing species suggests a cold ice (below the sublimation temperature of CO) formation pathway followed by non-thermal desorption through, e.g., UV photons traveling through outflow cavities. Together, the data point to clear evidence of efficient complex molecule formation in cold interstellar ices.

IRS spectra of embedded low-mass young stars: gas-phase lines

Lahuis, van Dishoeck and collaborators published their survey of Spitzer-IRS mid-IR gas-phase emission lines of H_2, H_2O and various atoms toward a sample of 43 embedded low-mass young stars in nearby star-forming regions taken as part of the 'Cores to Disks' (c2d) legacy program. The mid-IR spectral range hosts a suite of diagnostic lines which can distinguish PDRs, shocks, jets and circumstellar disks when combined with an optimal extraction method to separate both spatially unresolved (compact, up to a few hundred AU) and spatially resolved (extended, thousand AU or more) emission. The results are compared with the c2d sample of protoplanetary disks and with literature PDR and shock models to address the physical nature of the sources. Warm (T_ex ~ few hundred K) H_2 and [S I] 25 micron emission is observed primarily in the extended component and likely originates in a PDR along the cavity walls. On the other hand, hot (T_ex ~ 700 K) H_2 and [Ne II] emission is seen mostly in the spatially unresolved component, together with hot H_2O. [Fe II] and [Si II] lines are observed in both components. The compact emission is likely of mixed origin, comprised of circumstellar disk and/or jet emission.

2.5 Stars

Hunting for millimeter flares in very young spectroscopic binaries

Recent observations of the eccentric spectroscopic binaries DQ Tau and V773 Tau A have revealed that their radio emission at millimeter wavelengths is occasionally dominated by non-thermal flares. These are low-mass pre-main sequence (PMS) binary systems. The transient activity appears to be synchrotron emission resulting from powerful magnetic reconnection events. Such events occur typically near periastron when the separate magnetic structures of the binary components are briefly capable of interacting and forced to reorganise.

Are such flares always associated with sources experiencing similar inter-binary reconnection events? In order to find out, Kóspàl, Salter, Hogerheijde, Moer (Konkoly Observatory, Hungary), and Blake (Caltech, USA) conducted the first systematic study of the millimeter variability in a sample of 12 PMS spectroscopic binaries. This sample consisted entirely of short-period, close-separation binaries with either a circular or a very eccentric orbit. They used the MAMBO2 array on the IRAM 30 m telescope to obtain continuous monitoring at 1.25 mm (240 GHz) over a 4-night period, during which all of the high-eccentricity binaries passed periastron. They obtained simultaneous optical measurements in the V, R, and I bands, X-ray bursts suggest a strong link between stellar reconnection events and optical brightenings. As it turned out, UZ Tau E was the only source detected at millimeter wavelengths. It exhibited significant variation and it was also the only source to show strong and simultaneous optical variability. It had the largest orbital eccentricity in the sample, an important factor in interbinary reconnection events. With orbital parameters and variable accretion activity similar to those of DQ Tau, the millimeter behavior of UZ Tau E fits well into the DQ Tau model for colliding magneto-spheres, although the observations where insufficient to determine the periodicity and precise cause of the variability. With UZ Tau E, there are now 3 out of a total of 14 PMS binaries with known millimeter variability. This is not a conclusive result because important factors in the non-detection of the other targets are coarse time-sampling and limited millimeter sensitivity. Future studies should concentrate on nearby objects and should monitor them at millimeter and optical wavelengths with better temporal resolution.

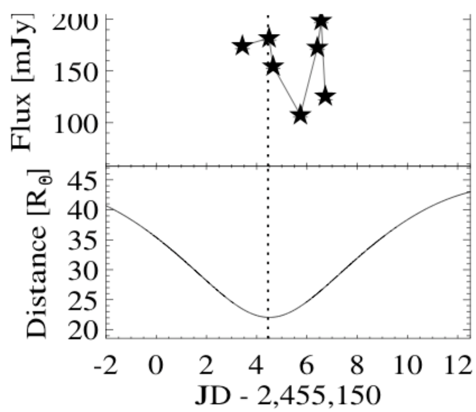


Figure 5. Optical (top panel) and millimeter (middle panel) light curves of UZ Tau E, as well as separation distance as a function of time (bottom panel).

Two young eruptive stars in the North America/Pelican Nebula Complex

The sudden optical brightening of two young stellar objects, HBC 722 and VSX J205126.1+440523, in the North America/Pelican Nebula Complex, was announced in August 2010. Early photometric and spectroscopic observations of these objects indicated that they might belong to the FUor or EXor class of young eruptive stars. The eruptions of FUors and EXors are often explained by enhanced accretion of material from the circumstellar disk onto the protostar. In order to determine the true nature of these two objects, Kóspàl and collaborators started an optical and near-infrared monitoring program complemented by the extraction of data from archives and literature. These data were used to construct pre-outburst and outburst spectral energy distributions (SEDs), multi-filter light curves, and color-color diagrams.

The quiescent SED of HBC 722 was consistent with that of a slightly reddened normal T Tauri-type star. This source brightened monotonically over two months and at maximum brightness the SED was that of a hot, single-temperature black-body. The current fading rate suggests that the star will return to quiescence in about a year, which questions its classification as a bone fide FUor. The quiescent SED of VSX J205126.1+440523 appears to be that of a highly embedded Class I source. The outburst of this source happened more gradually, but with a much higher amplitude. Its light curves showed a deep minimum two and a half months after peak intensity, when the object was close to its pre-outburst optical brightness. Further monitoring indicated that it is still far from being quiescent.

The shape of the light-curves as well as the bolometric luminosities and accretion rates suggest that these objects do not fit into the classic FUor group. Although HBC 722 exhibits all spectral characteristics of a bona-fide FUor, its luminosity and accretion rate are too low and its timescale is too short compared with classical FUors. VSX J205126.1+440523 seems to represent a case in which fast extinction changes modulate the light curve.

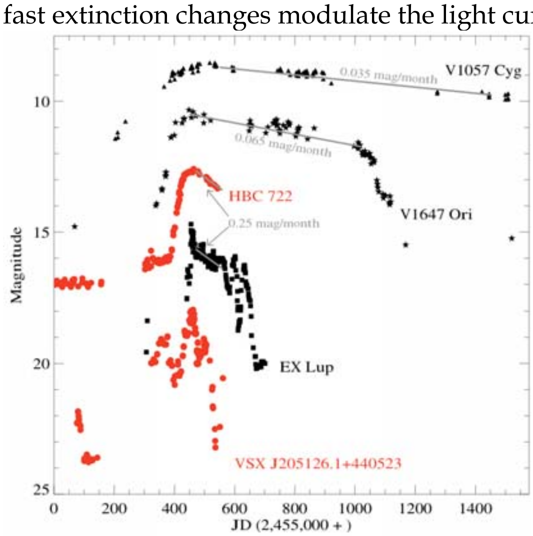


Figure 6. Light curves of the newly discovered objects and those of different young eruptive stars.

Maser emission from newly formed stars

With the same methods previously applied to Cep A data, Torstensson and van Langevelde continued their work on measuring the large-scale thermal methanol distribution in high mass star-forming regions with methanol masers. They used JCMT-HARP at 338 GHz to determine temperatures and column densities in a small sample of sources. Some of these appeared to be very complex, but many of the sources could be characterised by very well-confined (young) outflows, that seem to originate from the same location as the maser emission. A collaboration with van der Tak (SRON), Vlemmings (Bonn, Germany) and Kristensen had already determined that in the relatively nearby source Cep A, this argues for a single location of methanol production in this object. The detailed geometry of this source, determined with VLBI measurements, suggests that this could be in the shocked region where the accretion flow hits the circumstellar material.

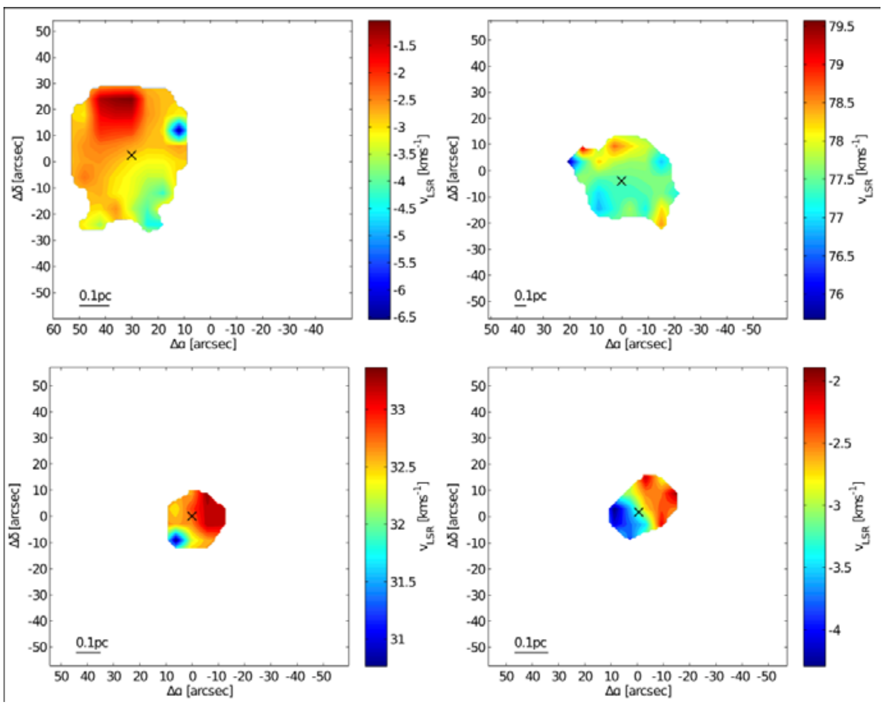


Figure 7. Velocity fields of the methanol $7_{-1} \rightarrow 6_{-1}$ E type transition in four methanol maser sources. The crosses define the position of the maser, which is argued to be associated with the origin of methanol in these high-mass star-forming regions.

Amiri, van Langevelde, and Vlemmings (Bonn, Germany) started a study to use the SiO masers in evolved stars to measure the effect of magnetic shaping. While previous SiO maser imaging has focused on Mira variables, the new work resulted in a beautiful ring image of the classic OH/IR star OH44.8-2.3. Unlike the predominant tangential linear polarisation morphology previously detected in Mira variables, the observations appear to show a dipole magnetic field morphology for the SiO maser region of this star.

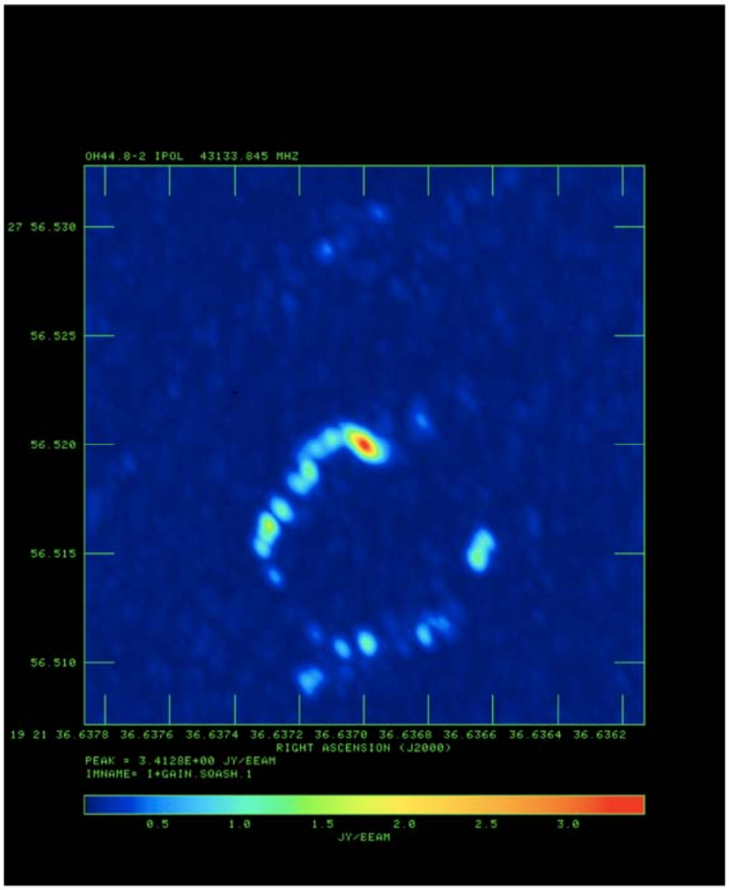


Figure 8. The SiO masers around OH44.8 are observed to lie in a 4.75 mas ring, corresponding to 5.6 AU for a distance of 1.13 kpc.

2.6 Galaxies of the Local Group

Magnetic fields of the Milky Way

Lambrechts and Haverkorn modeled the Faraday rotation imprint of three radio loops, major polarised features in the radio sky, extending tens of degrees in both Galactic longitude and latitude and thought to be nearby, old supernova remnants. Lambrechts showed that some of these loops have a clear signature in Faraday rotation, rendering straightforward interpretation of large-scale rotation measure features as regular Galactic magnetic field features difficult.

Haverkorn participated in a study of the vertical component of the Galactic magnetic field and small-scale structure towards the Galactic poles led by Mao (Boston, USA). The researchers determined the rotation measures of hundreds of extragalactic sources towards the Galactic North and South Poles, observed with the WSRT and ATCA. No consistent vertical magnetic field component through the Galactic disk at the solar radius was found towards the Galactic North Pole. However, a weak constant vertical magnetic field component was found towards the South Pole. This indicates the presence either of a variable local magneto-ionised medium or a difference in magnetic field structures in both hemispheres.

Searching for streamers in the Milky Way Halo

Together with Mateu, Bruzual, Hernandez (Merida), Aguilar, Velazquez (Ensenada, Mexico), Valenzuela, and Carigi (Mexico City, Mexico), Brown implemented an extension of an existing streamer-finding method that can be applied to the future Gaia data. The original method looks for streamers along great circles in the sky, the extension adds the kinematical restriction that velocity vectors should also be constrained to lie along these great circles, as seen by a Galactocentric observer. They tested the method by using a mock Gaia catalogue, which included a realistic Galactic background and observational errors. Detailed star formation histories were added for the simulated satellites. The inclusion of the kinematical restriction vastly enhanced the contrast between a streamer and the background, even in the presence of observational errors, provided only data with good astrometric quality are used (relative errors of 30 per cent or better). The global nature of the method diminishes the erasing effect of phase mixing and permits the recovery of merger events of reasonable dynamical age. Satellites with a star formation history different to that of the Galactic background are also better isolated. Satellites in the range of one hundred million to one billion solar luminosities can be recovered even for events as old as 10 gigayear. Even satellites with 40 to 50 million solar luminosities can be recovered for certain combinations of dynamical ages and orbits.

Anomalous dust and enhanced C^+ emission from the Magellanic Clouds

The Large and Small Magellanic Clouds are satellites of our own galaxy, characterized by heavy-element abundances that are lower (LMC) and much lower (SMC), respectively than those in the Solar Neighborhood. In each of these galaxies, local radiation field intensities vary by one or two orders of magnitude. The proximity of the Magellanic Clouds thus presents unique opportunities for studying star formation and the interstellar medium in environments very different from our own, with reasonably high spatial resolution.

To this end, Israel, Raban, Oonk and collaborators used the COBE-DIRBE and WMAP databases in an innovative way. From these cosmological surveys, they extracted maps of the Large Magellanic Cloud (LMC) and the Small Magellanic Cloud (SMC) in the far-infrared spectral range of 1.25 micron to 240 micron, and in the millimeter range of 3 - 15 millimeter (23 GHz - 93 GHz) and also determined spatially integrated (total) flux densities. They complemented the COBE-DIRBE and WMAP with flux densities at other wavelengths found in an exhaustive literature search, selected to reliably represent the global emission from the Clouds. They then used these data to construct the flux density and energy distributions over the full spectral range from low-frequency radio to ultraviolet.

This is the first time that the critical three spectral decades in the sub-millimeter to centimeter wavelength window (10 GHz - 1 THz) were fully covered. There are fewer than a dozen galaxies that have SEDs so reliably and completely known.

Israel and collaborators established that the SMC and the LMC exhibit significant emission above the expected free-free radio continuum starting at wavelengths of about 1 cm and extending over millimeter and sub-millimeter wavelengths into the far-infrared. They ruled out that the excess could be caused by cold, big dust grains, which would represent an enormous mass of dust. Instead, the excess is almost certainly caused by a combination of non-thermally emitting dust particles (notably spinning dust) and contamination by the cosmic background emission. The presence of millimeter excess emission in

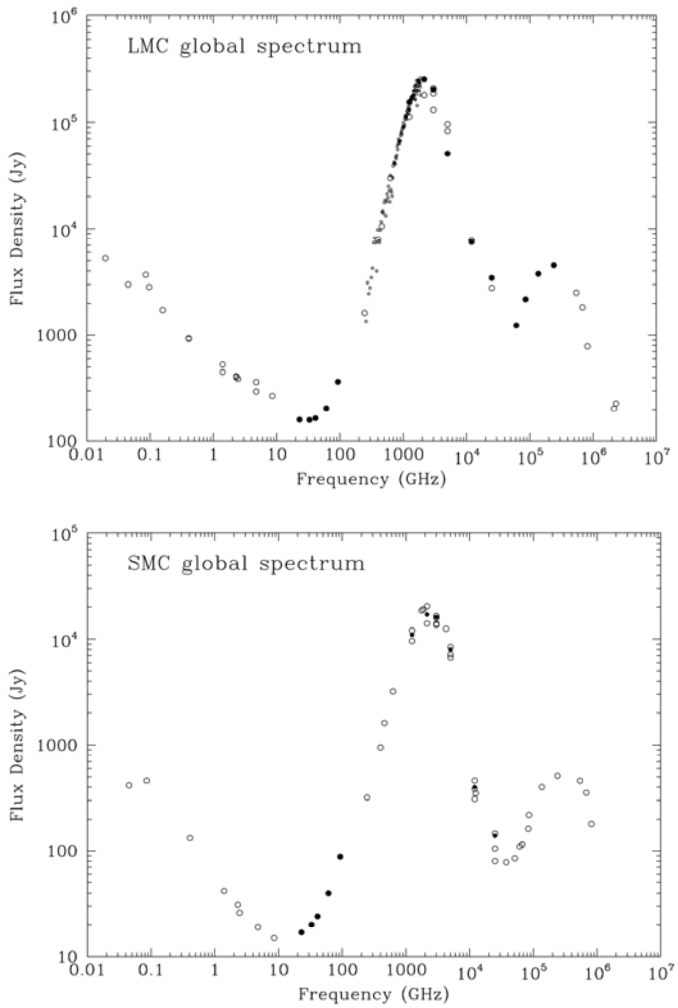


Figure 9. The spectral energy distributions of the electromagnetic emission from the Large Magellanic Cloud (top) and the Small Magellanic Cloud (bottom), ranging from very low freqency radio wavelengths to the ultraviolet. Open circles mark data from the published literature, filled circles represent newly derived flux densities. The new data for the first time completely fill the gap at millimeter and submillimeter wavelengths, and reveal the newly discovered millimeter-centimeter anomalous dust emission.

the Magellanic Clouds is expected to provide new insights into the nature of interstellar dust. In the meantime it masks any weaker signal by cold dust so that reliable determination of total dust mass as well as gas-to-dust ratio has become a virtual impossibility. Combined with the degeneracy of dust model SEDs in the far-infrared/sub-millimeter range, and the variation in sub-millimeter dust emissivities (beta) it is now becoming clear that the amount or even presence of dust colder than about 15 K in any external galaxy is effectively undetermined.

As a by-product of this research, Israel and colleagues also accurately determined for the first time the free-free thermal radio continuum emission from the Magellanic Clouds and the mean visual extinctions.

In a different effort, Israel and Maloney studied the emission in the far-infrared (157.7 micron) fine-structure line of ionised carbon (C^+). They used maps of the [CII] emission from several bright star-forming complexes including N11 in the LMC and N66 in the SMC, made with the now defunct Kuiper Airborne Observatory

They confirmed an earlier result, that in the LMC the ratio of [CII] to CO line and [CII] to far-infrared continuum emission is much higher than seen almost anywhere else, including Milky Way star-forming regions. The high [CII]/CO ratios reflect the relative constancy of the total C+ column in a UV-photon-dominated region (PDR) if both the gas-phase carbon abundance and the dust-to-gas ratio are varied in the same way, in contrast to decreasing CO column densities when self-shielding fails. In effect, in a low-metallicity molecular cloud the size of the CO-emitting core will shrink, so that the PDR will occupy a larger fraction of the total cloud volume. High [CII]/FIR ratios, implying very large grain photoelectric heating efficiencies of the order of a few per cent, result from normal PDR gas densities combined with unusually low ambient UV photon fluxes. The latter are again caused by the low metallicity and dust content of the Clouds, which provides UV photons with a relatively long mean free path length. In such environments, the sphere of influence of a UV photon source is much larger than in environments with solar metallicities, and the geometric dilution of the radiation field is correspondingly larger.

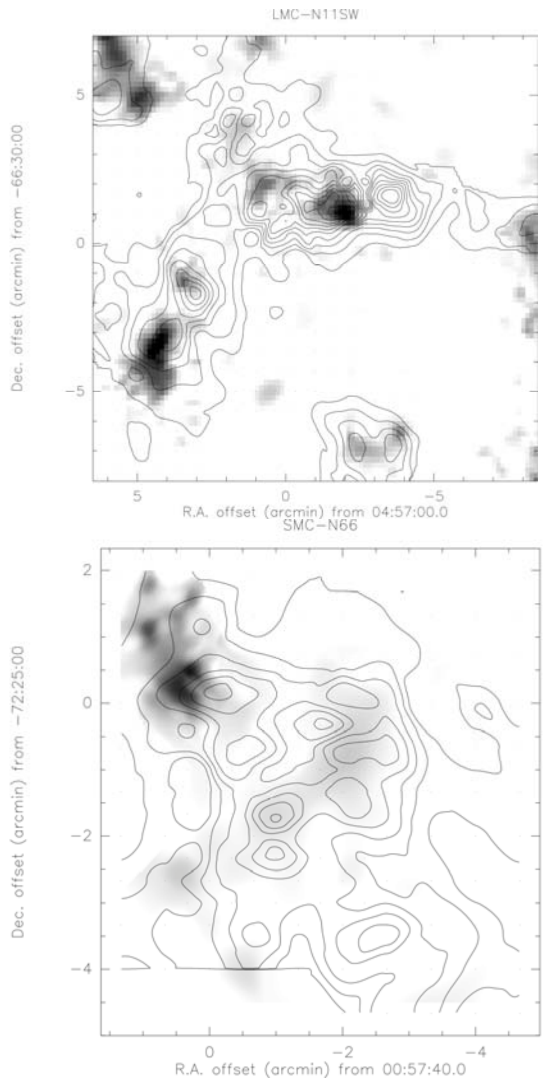


Figure 10.Contours of C^+ emission from the very bright star-forming complexes N11 in the Large Magellanic Cloud (previous page) and N66 in the Small Magellanic Cloud (this page) superposed on a grayscale representation of the CO emission from the complexex. Ionized carbon is much more widely distributed than CO in both complexes, but especially in the older and more evolved N66 complex. The morphologies and intrensity ratios point at an advanced erosion of the molecular cloud gas by the process of phot-dissociation.

These effects also operate in the SMC but contrary to expectations relative [CII] intensities in the SMC are no different from those in the LMC, notwithstanding the SMC's substantially lower metallicity. To explain this, Israel and Maloney noted that in addition to the low dust abundances, the SMC interstellar medium is also characterised by very low abundances of polycyclic aromatic hydrocarbons (PAHs) that have an opposite effect by diminishing photoelectric heating rates. Consequently, in low-metallicity environments relative [CII] strengths are high but exhibit little further dependence on actual metallicity. Indeed, [CII] data available for the irregular galaxy IC10, with a metallicity in-between those of the LMC and the SMC show the same relative intensities.

Dust, molecular gas, and star-bursts in M 33

Van der Werf and Israel were part of a team led by Kramer (IRAM, Spain) and Braine (Bordeaux, France) studying the molecular gas and dust in the Local Group galaxy M33. The molecular gas was studied using the HEterodyne Receiver Array (HERA) at the 30 m IRAM telescope in the CO J=2-1 line, at sufficiently high resolution to resolve individual giant molecular clouds (GMCs). The azimuthally averaged CO surface brightness decreases exponentially with a scale length of almost two kilo-parsec whereas the atomic gas surface density is constant. The star formation rate per unit molecular gas (a measure for the star formation efficiency, or the rate of transformation of molecular gas into stars) was traced by the ratio of CO to H\alpha line and far-infrared continuum emission, and was found to be constant with radius. A morphological comparison of molecular and atomic gas with tracers of star formation showed good general agreement between these distributions in terms of both peaks and holes. A few exceptions are noted.

The continuum emission from dust in M33 was studied using the SPIRE camera on board of the Herschel Space Observatory. With roughly half-solar abundances, M33 provides a valuable, first step towards the study of young low-metallicity galaxies where submillimeter emission may be used as an alternative to CO to measure the H_2 content. The dust emission cross-section was determined using SPIRE on Herschel and recent CO and HI observations; a variation in cross-section was found from a near-solar neighborhood cross-section to about half-solar with the maximum being south of the nucleus. Calculation of the total H column density from the measured dust temperature and cross-section, followed by subtraction of the measured HI column provided an estimate of the molecular hydrogen as a function of location in M33. This procedure yielded a morphology similar to that observed in CO. The H_2/HI mass ratio decreases from about unity to well below a tenth and is about a sixth averaged over the optical disk. The single most important observation to reduce the potentially large systematic errors is to complete the CO mapping of M 33, which is presently ongoing.

With a fitting routine that uses Bayesian statistics to calculate model parameter uncertainties, Martinez-Galarza, Groves and Brandl, together with collaborators in the US and Australia, have 'calibrated' the star-burst spectral-energy distribution (SED) models of Groves, Dopita and co=workers by applying them to the integrated spectrum of the 30 Doradus region in the Large Magellanic Cloud. 30 Doradus is a nearby, well studied star-burst region in miniature and therefore an ideal calibrator. The results show that mid-infrared SED fitting can provide reliable estimations of the physical properties of unresolved star-forming systems, such as total stellar mass, mass contribution from an embedded population (indicative of on-going star formation), and effective ages of the ionising stellar population. As part of a collaboration with Hunter (Flagstaff, Arizona, USA), the same routine was applied to the Spitzer-IRS spectral map of NGC 604, a giant HII region in Messier 33. The results are consistent with NGC 604 being a more evolved HII region as compared to 30 Doradus.

2.7 Nearby galaxies: observations and theory

The molecular ISM in active galaxies

Meijerink, Spaans (Groningen, NL), Loenen & van der Werf initiated a theoretical study to investigate the diagnostic power of the newly discovered ions OH^+ and H_2O^+ related to water in the ultra-luminous galaxy (ULIRG) Markarian 231. They found that fine-structure lines of [CII], [CI], and [OI] are remarkably similar for different mechanical and cosmic-ray heating rates when they are already exposed to large amounts of UV. The abundances of HCN and H_2O are boosted for very high mechanical heating rates, but ionised species are relatively unaffected. OH^+ and $H2O^+$ are enhanced for very high cosmic ray fluxes. They concluded that a combination of OH^+, OH, H_2O^+, H_2O, and H_3O^+ traces the cosmic-ray heating rates rather well, and that such a combinations allows to distinguish between enhanced cosmic rays and X-rays.

Aalto, Costagliola (Gothenburg, Sweden), van der Tak (Groningen, NL) and Meijerink analysed the H3O+ line emission from from a set of active galaxies in order to investigate the impact of star-burst and AGN activity on the chemistry of the molecular interstellar medium. Using the JCMT, they observed the 364 GHz line of p-H_3O^+ towards the centers of seven active galaxies, and detected it towards IC 342, NGC 253, NGC 1068, NGC 4418, and NGC 6240. They obtained only upper limits for IRAS 15250 or Arp 299. Comparison with the PDR and XDR models of Meijerink showed that in IC 342, a star-burst PDR chemistry is sifficient to explain the observed H3O+ abundance. In the other galaxies, the large H3O+ columns are generally consistent with XDR models.

As part of the first results of HEXGAL, Loenen (among others with Leiden team members Israel, Meijerink and van der Werf) published a paper on HIFI observations of the starburst galaxy M 82. By combining the HIFI observations with other available data, several components of the molecular ISM in M 82 could be identified, each with their own physical properties (see Fig. 11). Using the high spectral resolution provided by HIFI several velocity components were identified in the spectrum. One of these velocity components could succesfully be linked to a physical ISM component and to a particular location in the system.

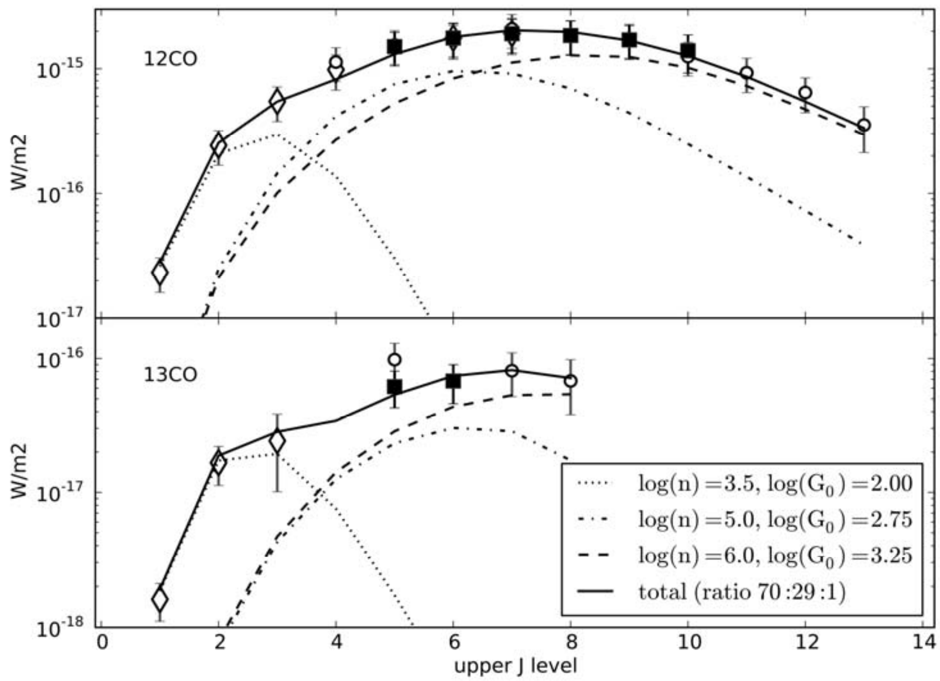


Figure 11. Excitation of ^{12}CO and ^{13}CO in M82. Squares and circles represent Herschel data, diamonds are ground based observations. Lines represent modelling results. Three different ISM components could identified (see legend; n is the gas density in cm $^{-3}$, G_0 is the UV flux in Habing units), ranging from diffuse, cold (dotted) to very dense, highly excited gas (dashed).

Water vapour in the star-burst galaxy M 82

In an effort led by Weiss (Bonn, Germany), van der Werf and Israel used HIFI on te Herschel Space Observatory to obtain the first extragalactic detections of the rotational ortho-water ground transition, the two lowest para-water transitions, and the ground transition of ionised ortho-water in the archetypal and very nearby star-burst galaxy M82. All three water lines show different spectral line profiles, underlining the need for high spectral resolution in interpreting line formation processes. Using the line shape of the para-$H_2O(1_{11}$-$0_{00})$ and ortho-H_2O^+ 1_{11}-0_{00}) absorption profile in conjunction with high spatial resolution CO observations, Weiss and collaborators showed that the (ionised) water absorption arises from a compact region within the HIFI observing beam located just off the dynamical centre of the galaxy. This region does not coincide with any of the known line emission peaks that have been identified in other molecular tracers, with the exception of HCO. The data suggest that water and ionised water have high area-covering factors of the underlying continuum. This indicates that water is not associated with small, dense cores within the ISM of M 82 but arises from a more widespread diffuse gas component.

ISM heating in the ultra-luminous galaxy Markarian 231

Within the context of the Herschel Comprehensive (U)LIRG Emission Survey (HerCULES), a team led by van der Werf and also involving Meijerink, Loenen and Israel, obtained a high-frequency (SPIRE FTS) spectrum of the relatively nearby ultra-luminous infrared galaxy Markarian 231 (Fig. 12). At least 25 lines were detected, including the CO J=5-4 through J=13-12 transitions, 7 rotational lines of H_2O, 3 of OH^+ and one line each of H_2O^+, CH^+, and HF. The excitation of the lower CO rotational levels can be accounted for by the UV radiation from newly formed luminous stars, but the approximately flat intensity distribution of the higher CO transitions requires the presence of a separate source of excitation. The team explored X-ray rather than UV-photon heating by the accreting super-massive black hole in Markarian 231 as a source of excitation for these lines, and found that this mechanism can reproduce the observed intensities. In principle, dense gas immersed in a strong UV radiation field may also reproduce the observed CO line intensity distribution, but this model predicts unrealistically high masses of hot dust in the galaxy. In the end, the team strongly favoured a model that consists of a star-forming disk of radius 560 pc, containing clumps of dense gas exposed to strong UV radiation, dominating the CO line intensities up to J=8. The X-rays from the accreting super-massive black hole at the nucleus then dominate the excitation and chemistry of the CO lines above J=8 in the inner disk out to a radius of 160 pc. This widely cited result demonstrated the usefulness of the CO ladder to separate star formation and black hole accretion as power sources for galaxy nuclei, providing a crucial local benchmark for high redshift observations with ALMA.

The spectrum in Fig. 12 also reveals up to seven rotational lines of water in emission, including a very high-lying (E_{upper} = 640 K) line detected in the SPIRE wavelength range, whereas PACS observations show a single H_2O line in absorption. This result was analysed by a team led by Gonzalez-Alfonso (Henares, Spain) and including van der Werf, Meijerink, Loenen and Israel. The absorption/emission dichotomy appeared to be caused by the pumping of the rotational levels by far-infrared radiation emitted by dust, and subsequent relaxation through lines at longer wavelengths. This allowed an estimate of the column density of H_2O and the general characteristics of the underlying far-infrared continuum source. Radiative transfer models including both collisional and radiative excitation were used to calculate the equilibrium level populations of H_2O and the corresponding line fluxes. The highest-lying H_2O lines detected in emission indicate that the source of far-infrared radiation responsible for the pumping is compact (radius = 110-180 pc) and warm (Tdust ~ 90 K) and accounts for almost half of the bolometric luminosity. This high column density nuclear component most probably reflects a violent environment characterised by shocks, intense cosmic rays, an XDR chemistry, and an undepleted chemistry where grain mantles are evaporated. A more extended region, presumably the inner region of the one-kpc disk observed in other molecular species, could contribute to the flux observed in low-lying H_2O lines through dense hot cores, and/or shocks.

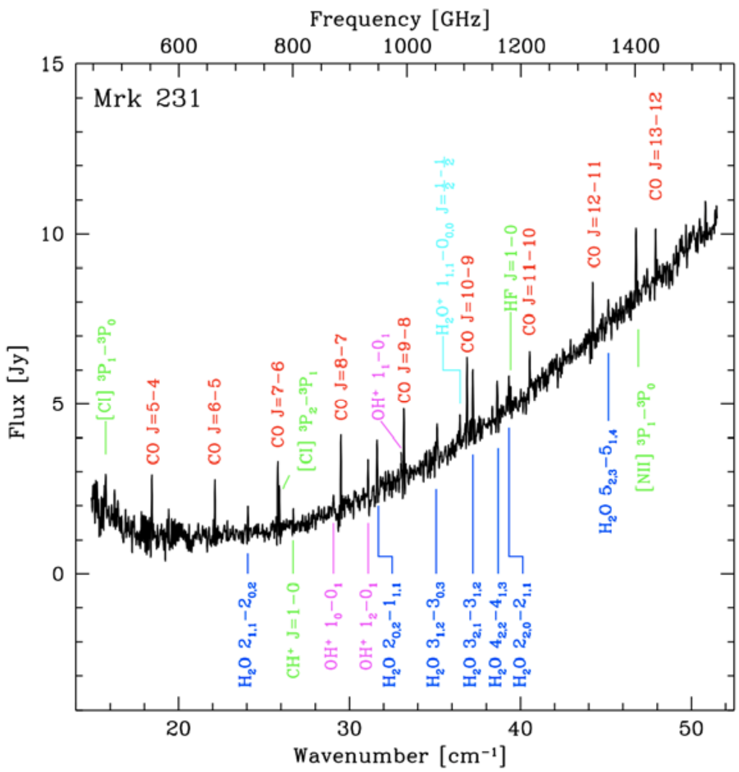


Figure 12. SPIRE FTS spectrum of Markarian 231. Line identifications are given in red for CO lines, in blue for H_2O, in magenta for OH^+, in cyan for H_2O^+, and in green for the remaining lines.

Ground-based CO rotational ladders of luminous infrared galaxies

With Papadopoulos (Bonn, Germany) and Isaak (ESTEC), van der Werf used CO J=6-5 line observations of several luminous infrared galaxies, obtained with the James Clerk Maxwell Telescope, to construct the first local CO spectral line energy distributions (SLEDs) for the global molecular gas reservoirs in such galaxies. These CO ladders are neither biased by strong lensing (which affects many of those constructed for high-redshift galaxies) nor suffer from under-sampling of CO-bright regions. The team discovered that low CO line excitation may globally occur even in vigorously star-forming systems. They identified the first case of a shock-powered high-excitation CO SLED in the radio galaxy 3C 293, where a powerful jet-ISM interaction occurs, and they found unusually highly excited gas in the optically powerful QSO PG 1119+120. The faintness of CO J=6-5 lines in Arp 220 and possibly in other (U)LIRGs as well can be attributed to significant dust optical depths at short submillimeter wavelengths which also causes the C^+ line luminosity deficit often observed in such extreme star-bursts. Re-analysis of the CO line ratios measured in submillimeter galaxies suggests that similar dust opacities also may be present in these high-redshift star-bursts, with genuinely low excitation of large amounts of non-star-forming gas being the only other possibility for their often low CO (high-J)/(low-J) line ratios. The team also presented a statistical method of separating these two almost degenerate possibilities, and showed that high dust optical depths at submillimeter wavelengths can impede the diagnostic potential of submillimeter and far-infrared lines (e.g., star-bursts versus AGNs as gas excitation agents).

The nuclear region of the luminous infrared galaxy NGC 6240

With Engel, Davies, Genzel and Tacconi (Muenchen, Germany), van der Werf published spatially resolved integral-field spectroscopic (SINFONI) K-band data at a resolution of only 0.13 arcsec (which corresponds to 60 parsec) and interferometric CO J=2-1 line observations of the prototype merging system NGC 6240. Despite a clear rotational signature, the stellar kinematics in the two nuclei of this system are dominated by dispersion. Jeans modelling was used to derive the masses and the mass-to-light ratios of the nuclei. Combination of the luminosities with the spatially resolved Brackett gamma equivalent widths showed that only a third of the K-band continuum from the nuclei may be associated with the most recent star forming episode. Less than a third of the system's bolometric luminosity and only a tenth of its stellar mass is due to this star-burst. The star formation properties, calculated from typical merger star formation scenarios, demonstrate the impact of differences in assumptions about the star formation history. The properties of the nuclei and the existence of a prominent old stellar population indicate that the nuclei are remnants of the progenitor galaxies' bulges.

Radio relics in the merging cluster CIZA J2242.8+5301

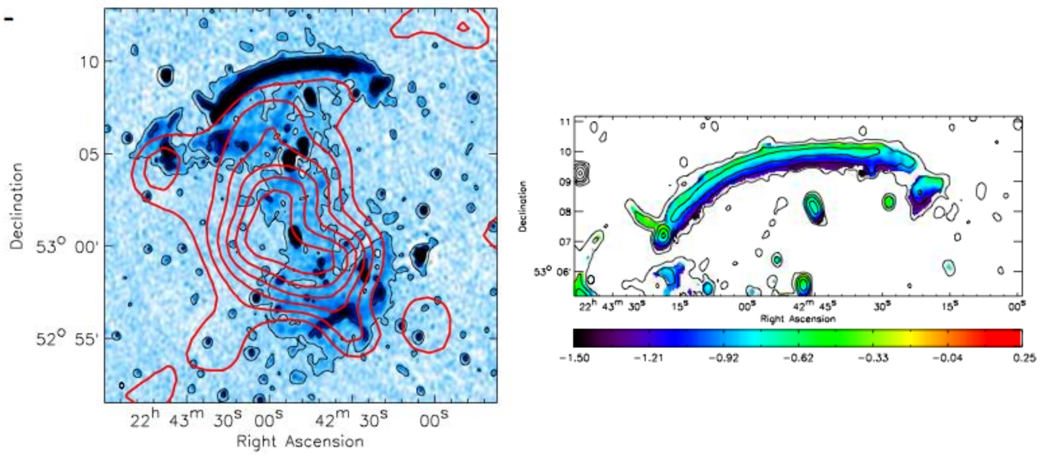


Figure 13. MHz WSRT image with ROSAT X-ray contours overlaidof the merging cluster CIZA J2242.8+5301 (z=0.19). (right) spectral index map using observations at 1400, 610 and 325 MHz (Van Weeren, Röttgering et al. 2010, Science 330,347).

Galaxy clusters grow by mergers with galaxy groups or other clusters, as well as through the accretion of gas from the intergalactic medium (IGM). Both these processes produce shocks in the intercluster medium. It is possible that particles can be accelerated within these shocks to highly relativistic energies by the diffusive shock acceleration (DSA) mechanism. At the periphery of clusters, large elongated and diffuse structures occur known as cluster relics. Van Weeren, Röttgering, Brüggen (Bremen), Hoeft (Tautenburg) discovered a spectacularly long and narrow relic with a size of 2.0 Mpc by 50 kpc (Fig. 13), a megaparsec away from the center of the merging cluster CIZA J2242.8+5301 (z=0.19). The relic displays highly aligned magnetic fields and a steep gradient in spectral index due to cooling of the synchrotron-emitting particles in the post-shock region. Van Weeren en co-workers consider these observations as conclusive evidence that shocks in merging clusters produce extremely energetic cosmic rays. Detailed modelling of the morphology, polarization properties and variations of the radio spectrum, allowed them to determine the strength of the magnetic field (5 G) and the Mach number (4.6) of the shock. Their numerical simulations indicated that the impact parameter of the cluster collision was about zero and that the mass ratio of the colliding clusters should be 2:1.

The velocity dispersion of extra-galactic young stellar clusters

Many young extra-galactic clusters have a measured velocity dispersion that is too high for the mass derived from their age and total luminosity, which has led to the suggestion that they are not in virial equilibrium. Most of these clusters are confined to a narrow age range centred around 10 million years because of observational constraints. At this age, the cluster light is dominated by luminous evolved stars, such as red super-giants, with initial masses of 13-22 solar masses for which (primordial) binarity is high. Gieles, Sana, and Portegies Zwart investigated to what extent the observed excess velocity dispersion is the result of the orbital motions of binaries. They demonstrated that estimates for the dynamical mass of young star clusters, derived from the observed velocity dispersion, exceed the photometric mass by up to an order of magnitude and are consistent with a constant offset in the square of the velocity dispersion. This can be reproduced by models of virialised star clusters hosting a massive star population of which about a quarter is in binaries, with typical mass ratios of about 0.6 and periods of about 1000 days. They concluded that binaries play a pivotal role in deriving the dynamical masses of young (about 10 million years), moderately massive (less than than a hundred thousand solar masses) and compact (typically 1 parsec) star clusters.

Formation of super-massive black holes

Three major mechanisms for the formation of super-massive black hole (SMBH) seeds in the high-redshift Universe have been proposed in the literature. These are: 1) collapsing remnants of the first metal-free stars; 2) direct collapse of a metal-free gas cloud; 3) runaway collisions in a low-metallicity dense stellar cluster. Each of these possibilities requires specific conditions in order to be valid. Devecchi focused on understanding in what dark matter halos the requirements for SMBH formation are fulfilled, depending on the dark matter halo mass, formation redshift and merger history. She developed a semi-analytical code that follows the evolution of baryons within their dark matter component. It traces gas cooling, star formation and metal enrichment, thus allowing to verify when and where the conditions for SMBH formation set in. SMBH seeds from channel 1) are formed with masses of a few hundred solar masses. These black holes mainly appear at high (z = 15-30) redshift. After z~15 chemical and radiative feed-backs prevent further production of metal-free stars, and of their remnant black holes. SMBHs from channel 3) start to form only after metal enrichment allows star formation in the low mass mode. Stellar clusters dense enough for runaway collision to set in can form at redshift ~6-15 in the centre of massive halos, leading to typical black masses in the range 300-1000 solar masses.

Forming and maintaining spiral arms

Spiral arms in pure stellar disks, especially the ones spontaneously formed, decay in several galactic rotations due to the increase of stellar velocity dispersions. Therefore, some cooling mechanism, for example dissipational effects of the interstellar medium, was assumed to be necessary to maintain the spiral arms. Fujii conducted a series of high-resolution three-dimensional N-body simulations of pure stellar disks. She showed that stellar disks can maintain spiral features for more than 10 gigayear without the help of cooling, if the number of particles is sufficiently large, e.g., three million. There is a self-regulating mechanism that maintains the amplitude of the spiral arms. Spiral arms increase Toomre's Q of the disk, and the heating rate correlates with the squared amplitude of the spirals. Since the amplitude itself is limited by Q, this makes the dynamical heating less effective in the later phase of the evolution. Using a simple analytical argument, Fujii suggested that the heating is caused by gravitational scattering of stars by spiral arms, and that the self-regulating mechanism in pure-stellar disks can effectively maintain spiral arms on a cosmological timescale.

Evolution of galaxies

Brinchmann participated in an effort to measure the gas content of massive galaxies in the $z<0.2$ Universe. The research was carried out within the GASS consortium and resulted in a quantification of the HI gas fraction in massive galaxies as a function of mass (led by Catinella, MPA, Germany) and one study, led by Schiminovich (New York, USA), that found the gas consumption time-scale to be a constant as a function of stellar mass. Shirazi and Brinchmann assembled a sample of 190 rare extremely star forming galaxies with He II 4686 nebular emission over a wide range of metallicity at low redshift universe using the Sloan Digital Sky Survey (SDSS) data release 7. The presence of the He II line is a stringent test of models for massive star evolution and normally require Wolf-Rayet stars. However in the spectra of 30% of the galaxies no Wolf-Rayet stars were seen. Brinchmann also participated in an effort to quantify outflows in star-forming galaxies in the low-redshift Universe using absorption lines in galaxy spectra. The effort, led by Y.-M. Chen (MPA/Wisconsin) was able to identify outflows in a wide range of galaxies and traced its dependence on various galaxy parameters such as star formation rate, orientation and stellar mass.

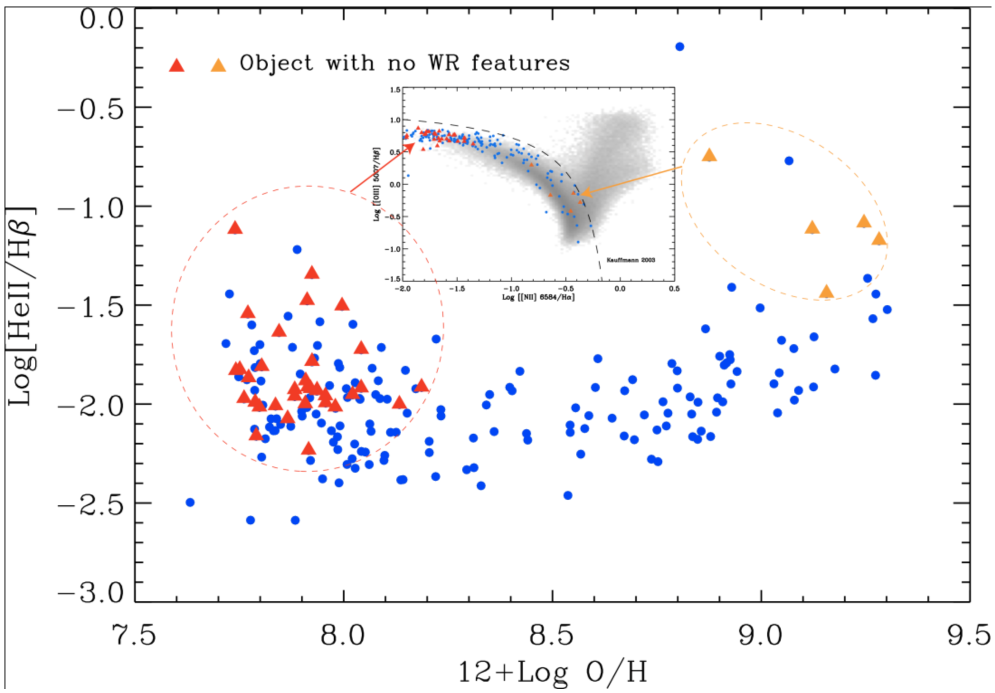


Figure 14. The ratio of HeII/Hβ versus oxygen abundance is shown for star forming galaxies showing He II nebular emission. Galaxies without Wolf-Rayet features are plotted as triangles. The distribution of these objects in the BPT diagnostic diagram is shown inset with the full SDSS shown as a gray-scale histogram. At low metallicities a significant fraction of these galaxies (30%) do not show Wolf-Rayet features in their spectra while the high metallicity objects without Wolf-Rayet features all appear to have sign of AGN activity.

2.8 Distant galaxies and large-scale structure

Massive galaxies

Taylor, Franx, Brinchmann and collaborators used the Sloan Digital Sky Survey to show that the dynamical masses of galaxies are nearly linearly related to the stellar masses, if the differences in galaxy structure are taken into account. The ratio of stellar mass to dynamical mass is nearly constant as a function of mass over a wide range in masses. There is no residual correlation with Hα equivalent width, mean stellar age, or the presence of emission lines.

Szomoru, Franx, and collaborators used the Wide Field Camera 3 on the Hubble Space Telescope to study a very massive, very compact galaxy at a redshift of 1.91. This galaxy is remarkable as it has a mass of 6 10^{11} solar masses and a size of only 0.42 kpc, many times smaller than galaxies in the nearby universe of the same mass. Szomoru developed a new technique for ultra-deep photometry. He used the very sensitive images taken on the Hubble Ultra Deep Field to show that this galaxy does not have a faint envelope. For the first time, the photometry is of comparable depth as photometry on nearby galaxies.

Williams, Quadri, Franx, and collaborators studied the evolution of quiescent galaxies. The presence of massive, compact, quiescent galaxies at redshifts greater than two presents a major challenge for theoretical models of galaxy formation and evolution. Using one of the deepest large public near-IR surveys to date, Williams investigated in detail the correlations between star formation and galaxy structural parameters (size, stellar mass, and surface density) from $z = 2$ to the present. At all redshifts, massive quiescent galaxies (i.e., those with little or no star formation) occupy the extreme high end of the surface density distribution and follow a tight mass-size correlation, while star-forming galaxies show a broad range of both densities and sizes. Conversely, galaxies with the highest surface densities comprise a nearly homogeneous population with little or no ongoing star formation, while less dense galaxies exhibit high star formation rates and varying levels of dust obscuration. Both the sizes and surface densities of quiescent galaxies evolve strongly from $z = 2$-0; Williams parameterized this evolution for both populations with simple power-law functions and present best-fit parameters for comparison to future theoretical models. Higher-mass quiescent galaxies undergo faster structural evolution, consistent with previous results. Interestingly, star-forming galaxies' sizes and densities evolve at rates similar to those of quiescent galaxies. It is therefore possible that the same physical processes drive the structural evolution of both populations, suggesting that "dry mergers" may not be the sole culprit in this size evolution.

Proto-cluster studies

Galaxy clusters are unique, high-density regions in the universe and are therefore important test beds for theories of galaxy formation and evolution. Miley and Röttgering pioneered the search for the progenitors of nearby clusters - proto-clusters - associated with high redshift radio galaxies (HzRGs), which are among the most luminous, most massive galaxies known at high redshifts at almost any wavelength. Over the last five years they have established that radio galaxies are often located in proto-clusters, the ancestors of local galaxy clusters. These proto-clusters have sizes of in excess pof three megaparsec, velocity dispersions of three hundred to a thousand km/s and total masses of more than 10^{14} M(sun). In 2010, Kuiper, Hatch, Miley and Röttgering and collaborators completed a population study of several types of galaxies within the massive protocluster surrounding the radio galaxy MRC 0316-257 at z~3.1. They used color-selection techniques to identify protocluster candidates that are Lyman break galaxies (LBG) and Balmer break galaxies (BBGs), in addition to the known population of Lya emitters and [O III] emitters. TRhey determined masses and star formation rates of the candidate protocluster galaxies were determined using spectral energy distribution fitting, and found that these did not differ significantly from those of field galaxies. The galaxies with the highest masses and star formation rates are located near the radio galaxy, indicating that the protocluster environment influences galaxy evolution at z ~ 3. They concluded that the protocluster around MRC 0316-257 is still in the early stages of formation.

Properties of galaxy clusters

Scaling relations between observed properties of clusters of galaxies and the total mass are an important ingredient for cosmological studies but also provide important observational constraints on feedback mechanisms. Weak gravitational lensing provides the most direct way to determine cluster masses, but low mass systems are difficult to study using ground based data due to the low density of sources. Using HST imaging, Hoekstra, in collaboration with Donahue, Voit (Michigan, USA), Concelice (Nottingham, UK) and McNamara (Waterloo, Canada) extended the range for which such scaling relations have been determined to lower masses in a regime where feedback might become relevant. The results are consistent with a single power law describing the full mass range that was studied.

The precision with which weak lensing cluster masses can be determined is limited by distant large-scale structure (or cosmic noise). Together with Hartlap, Hilbert (Bonn, Germany) and Van Uitert, Hoekstra examined whether the identification of other structures in the observations can be used to correct for this source of uncertainty. Indeed cosmic noise can be mitigated, albeit only by a limited amount due to intrinsic variations in the density profiles of intervening structures.

The hierarchical formation of structures in the universe leads to expulsion of stars during major mergers. In the case of massive clusters of galaxies this can be observed as intra-cluster light (ICL). Observations, however, are prone to systematic biases. Another way to examine this is by searching for type Ia supernovae that are unhosted. With Sand (Santa Barbara, USA) and collaborators, Hoekstra completed the first analysis of the search for type Ia supernovae in the Multi-Epoch Nearby Cluster Survey (MENeaCS). This unique survey has discovered 23 type Ia supernovae, 4 of which are likely intracluster events. The places a lower limit on the amount of ICL, whereas the ongoing determination of the SNe rate will establish the role of type Ia SNe on the enrichment of intra-cluster medium.

Star formation in the early universe

Bouwens, Franx, and collaborators have been making use of the new WFC3/IR instrument installed on the Hubble Space Telescope to identify substantial samples of galaxies in the first billion years of the universe and to explore their properties. By the end of 2010, Bouwens and collaborators had already identified 130 galaxies with redshifts greater or equal to 6.5 -- a tenfold increase over what was available just one year earlier. One probable galaxy was even found in the first 500 million years of the universe -- making it almost certainly the earliest and most distant galaxy ever seen. The discovery paper of this galaxy appeared in Nature and made world-wide news.

With these very large samples, Bouwens, Franx, and collaborators have been quantifying the star-formation rate density of the universe to even earlier times than had been possible before. The new results supported a hierarchical picture of galaxy formation, where the star formation rate increased rapidly in the first two billion years. The Leiden group had also been using these samples to estimate the ionising flux density coming from galaxies at these early times, and in particular the contribution from the faintest galaxies. These latter estimates come by way of the new faint-end slope determinations for galaxies in the first 850 megayears. While still uncertain, current results suggest even steeper faint-end slopes than measured at later times -- indicating that very low luminosity galaxies may be quite capable of reionising the universe.

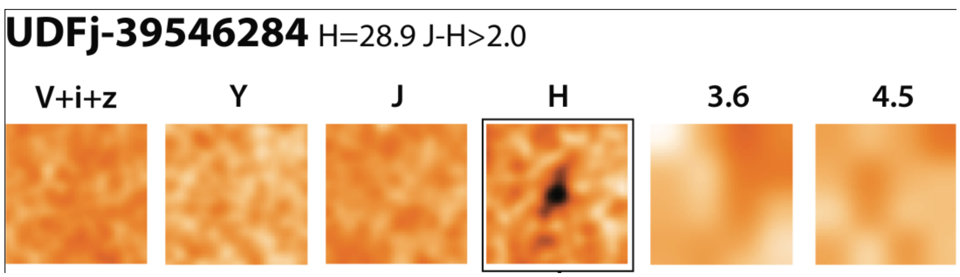


Figure 15. Optical and near-infrared images of the candidate z =98 10 galaxy, UDFj-3 9546284, Bouwens, Franx, and collaborators identified in the new ultra-deep WFC3/IR data obtained over the HUDF. The leftmost panel shows the HUDF ACS/optical data; the next three panels show the similarly deep HUDF09 near-infrared WFC3/IR data; the=20 last two panels show the longer wavelength Spitzer IRAC 3.6 and 4.5 micron observations. Each cutout is 2.4'' =D7 2.4'' on a side, and is orientated with north at the top. The candidate is detected at 5.4 sigma in the WFC3/IR band, but is entirely undetected at all bluer wavelengths as expected for a z~10 galaxy. This candidate is not seen in the redder IRAC data, which is not surprising given the limited depths of the Spitzer data. This candidate is plausibly the most distant galaxy ever seen.

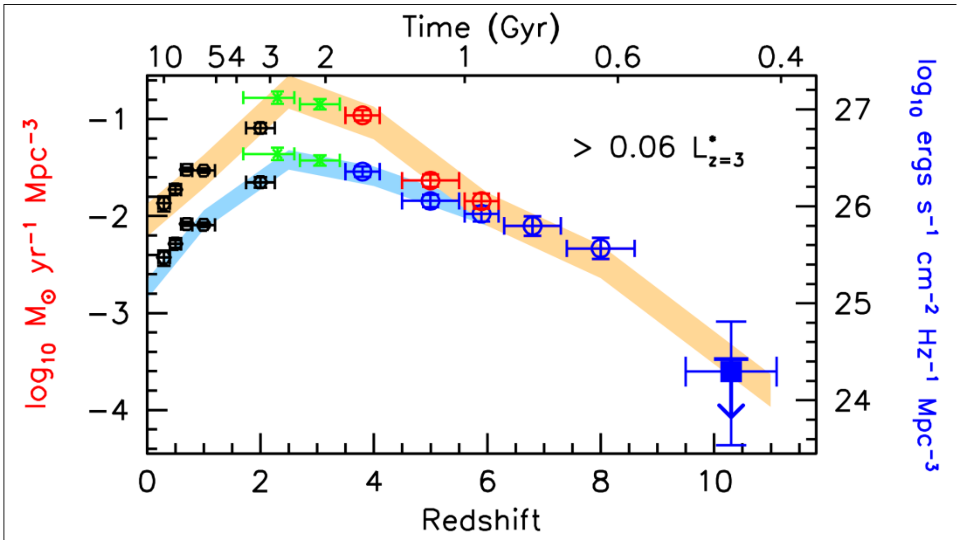


Figure 16. The luminosity density and star formation rate density in the Universe over the past 13.2 gigayear. The rest-frame continuum ultraviolet luminosity density (right axis, blue points), and the star formation rate density (left axis, red points) derived from the extinction-corrected luminosity density are integrated down to the approximate magnitude limit of our ultra-deep WFC3/IR data. The upper horizontal axis gives the time after the Big Bang and the lower axis the redshift. The star formation rate density estimates at z~7, z~8, and z~10 are from the recent work by Rychard Bouwens, Marijn Franx, and collaborators. At z~10, an upper limit is also shown given the uncertain nature of the z~10 candidate. Also included here are the star formation rate determinations at z~7 and z~8 from recent HUDF09 searches, and from the literature otherwise. These results show us how quickly the star formation rate density of the universe increased at early times.

The physics driving the cosmic star formation history

Schaye and collaborators investigated the physics driving the cosmic star formation (SF) history using the more than 50 large, cosmological, hydrodynamical simulations that together comprise the OverWhelmingly Large Simulations (OWLS) project. They found that SF is limited by the build-up of dark matter halos at high redshift, reaches a broad maximum at intermediate redshift and then decreases as it is quenched by lower cooling rates in hotter and lower density gas, gas exhaustion and self-regulated feedback from stars and black holes. The location and height of the peak in the SF history, and the steepness of the decline towards the present, depend on the physics and implementation of stellar and black hole feedback. Mass loss from intermediate-mass stars and metal-line cooling both boost the SF rate at late times. Galaxies form stars in a self-regulated fashion at a rate controlled by the balance between, on the one hand, feedback from massive stars and black holes and, on the other hand, gas cooling and accretion. Paradoxically, the SF rate is highly insensitive to the assumed SF law. This can be understood in terms of self-regulation: if the SF efficiency is changed, then galaxies adjust their gas fractions so as to achieve the same rate of production of massive stars. Self-regulated feedback from accreting black holes is required to match the steep decline in the observed SF rate below redshift 2, although more extreme feedback from SF, for example in the form of a top-heavy initial stellar mass function at high gas pressures, can help.

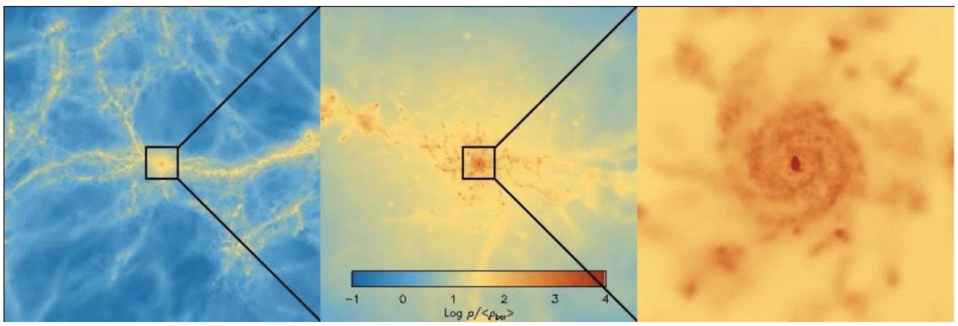


Figure 17. Zoom into a 1012 solar mass halo at redshift z=2 in the reference OWLS run. From left to right, the images are 10, 1 and 0.1 co-moving Mpc/h on a side. All slices are 1 co-moving Mpc/h thick. Note that the first image shows only a fraction of the total simulation volume, which is cubic and 25 co-moving Mpc/h on a side. The colour coding shows the projected gas density, log10(rho/<rho>), and the colour scale ranges from -1 to 4. The coordinate axes were rotated to show the galaxy face-on. This halo is the tenth most massive in the simulation. About half of the halos in this mass range host extended disk galaxies, while the other half have highly disturbed morphologies due to ongoing mergers.

Dark matter halos determine the masses of super-massive black holes

The energy and momentum deposited by the radiation from accretion flows on to the super-massive black holes (BHs) that reside at the centers of virtually all galaxies can halt or even reverse gas inflow, providing a natural mechanism for super-massive BHs to regulate their growth and to couple their properties to those of their host galaxies. However, it remains unclear whether this self-regulation occurs on the scale at which the BH is gravitationally dominant, on that of the stellar bulge, the galaxy or that of the entire dark matter halo. To answer this question, Booth & Schaye used self-consistent simulations of the co-evolution of the BH and galaxy populations that reproduce the observed correlations between the masses of the BHs and the properties of their host galaxies. They confirmed unambiguously that the BHs regulate their growth: the amount of energy that the BHs inject into their surroundings remains unchanged when the fraction of the accreted rest mass energy that is injected is varied by four orders of magnitude. The BHs simply adjust their masses so as to inject the same amount of energy. They then used simulations with artificially reduced star formation rates to demonstrate explicitly that BH mass is not set by the stellar mass. Instead, they found that it is determined by the mass of the dark matter halo with a secondary dependence on the halo concentration, of the form that would be expected if the halo binding energy were the fundamental property that controls the mass of the BH.

Impact of baryon physics on dark matter structures

The back-reaction of baryons on the dark matter halo density profile is of great interest, not least because it is an important systematic uncertainty when attempting to detect the dark matter. Duffy, Schaye, Kay (Manchester, UK) and collaborators used a large suite of simulations to systematically investigate this process and its dependence on the baryonic physics associated with galaxy formation. They found that the inclusion of baryons results in significantly more concentrated density profiles if radiative cooling is efficient and feedback is weak. The most significant effects occur in galaxies at high redshift, where there is a strong anti-correlation between the baryon fraction in the halo centre and the inner slope of both the total and the dark matter density profiles. If feedback is weak, isothermal inner profiles form, in agreement with observations of massive, early-type galaxies. However, they found that AGN feedback, or extremely efficient feedback from massive stars, is necessary to match observed stellar fractions in groups and clusters, as well as to keep the maximum circular velocity similar to the virial velocity as observed for disk galaxies. These strong feedback models reduce the baryon fraction in galaxies by a factor of 3 relative to the case with no feedback. This in turn results in inner density profiles which are typically shallower than isothermal and the halo concentrations tend to be lower than in the absence of baryons. --- The case for AGN feedback in galaxy groups

The relatively recent insight that energy input from super-massive black holes (BHs) can have a substantial effect on the star formation rates (SFRs) of galaxies motivates McCarthy (Cambridge, UK), Schaye, and collaborators to examine the effects of BH feedback on the scale of galaxy groups. At present, groups contain most of the galaxies and a significant fraction of the overall baryon content of the Universe and, along with massive clusters, they represent the only systems for which it is possible to measure both the stellar and gaseous baryonic components directly. To explore the effects of BH feedback on groups, they analysed two simulations from OWLS project. While both included galactic winds driven by supernovae, only one of the models included feedback from accreting BHs. They compared the properties of the simulated galaxy groups to a wide range of observational data, including the entropy and temperature profiles of the intragroup medium, hot gas mass fractions, the luminosity-temperature and mass-temperature scaling relations, the K-band luminosity of the group and its central brightest galaxy (CBG), SFRs and ages of the CBG, and gas- and stellar-phase metallicities. The run without AGN feedback suffered from the well-known over-cooling problem - the resulting stellar mass fractions are several times larger than observed and present-day cooling flows operate uninhibitedly. By contrast, the predictions from the run that includes BH feedback were in agreement with current observations, thus resolving the long-standing `cooling crisis' of simulations on the scale of groups. Based on the above, galaxy groups provide a compelling case that feedback fr om super-massive BHs is a crucial ingredient in the formation of massive galaxies.

Metal-line emission from the warm-hot intergalactic medium

Emission lines from metals offer one of the most promising ways to detect the elusive warm-hot intergalactic medium, which is thought to contain a substantial fraction of the baryons in the low-redshift Universe. Bertone (Santa Cruz, USA), Schaye, and collaborators presented predictions for the soft X-ray and Ultraviolet line emission from the WHIM using simulations from the OWLS project. They tested the dependence of the predicted emission on a range of physical prescriptions, such as cosmology, gas cooling and feedback from star formation and accreting black holes. Provided that metal-line cooling is taken into account, the models give surprisingly similar results, indicating that the predictions are robust. The emission traces neither the baryonic nor the metal mass. In particular, the emission that is potentially detectable with proposed missions traces over-dense and metal-rich gas in and around galaxies and groups. While observations of soft X-ray and UV line emission are therefore not a promising route to close the baryon budget, they do offer the exciting possibility to image the gas accreting on to and flowing out of galaxies.

X-ray coronae in simulations of disk galaxy formation

The existence of X-ray luminous gaseous coronae around massive disk galaxies is a long-standing prediction of galaxy formation theory in the cold dark matter cosmogony. This prediction has garnered little observational support, with non-detections commonplace and detections for only a relatively small number of galaxies which are much less luminous than expected. Crain (Swinburne, Autralia), McCarthy (Cambridge, UK), Frenk, Theuns (both Durham, UK), and Schaye investigated the coronal properties of a large sample of bright, disk-dominated galaxies extracted from the GIMIC suite of simulations.

Remarkably, the simulations reproduce the observed scalings of X-ray luminosity with K-band luminosity and star formation rate (SFR) and, when account is taken of the density structure of the halo, with disk rotation velocity as well. Most of the star formation in the simulated galaxies (which have realistic stellar mass fractions) is fuelled by gas cooling from a quasi-hydrostatic hot corona. Only a small fraction of the mass of the hot gas is outflowing as a wind but, because of its high density and metallicity, it contributes disproportionally to the X-ray emission. The bulk of the X-ray emission, however, comes from the diffuse quasi-hydrostatic corona which supplies the fuel for ongoing star formation in disks today.

The enrichment history of cosmic metals

Wiersma, Schaye, and collaborators used a suite of simulations to investigate the chemical enrichment history of the Universe. Specifically, they traced the origin of the metals back in time to investigate when various gas phases were enriched and by what halo masses. They found that the age of the metals decreases strongly with the density of the gas in which they end up. At least half of the metals that reside in the diffuse intergalactic medium (IGM) at $z = 0$ ($z = 2$) were ejected from galaxies above $z = 2$ ($z = 3$). The mass of the halos that last contained the metals increases rapidly with the gas density. More than half of the mass in intergalactic metals was ejected by halos with total masses less than 100 billion solar masses and stellar masses less than a billion solar masses. The range of halo masses that contribute to the enrichment is wider for the hotter part of the IGM. By combining the `when' and `by what' aspects of the enrichment history, they showed that metals residing in the lower density gas were typically ejected earlier and by lower mass halos.

Feedback and the structure of simulated galaxies at redshift two

Sales (Groningen, NL), Navarro (Victoria, Canada), Schaye, and collaborators studied the properties of high-redshift galaxies using runs from the OWLS project. The runs contrast several feedback implementations of varying effectiveness: from no feedback, to supernova-driven winds to powerful active galactic nucleus (AGN)-driven outflows. These different feedback models result in large variations in the abundance and structural properties of bright galaxies at z = 2. In agreement with earlier work, models with inefficient or no feedback lead to the formation of massive compact galaxies collecting a large fraction (upwards of 50 per cent) of all available baryons in each halo. Increasing the efficiency of feedback reduces the baryonic mass and increases the size of simulated galaxies. Despite the large differences in galaxy formation efficiency, the net specific angular momentum of a galaxy is, on average, roughly half that of its surrounding halo, independent of halo mass (in the range probed) and of the feedback scheme. Feedback thus affects the baryonic mass of a galaxy much more severely than its spin. Feedback induces strong correlations between angular momentum content and galaxy mass that leave their imprint on galaxy scaling relations and morphologies. Encouragingly, they found that galaxy disks are common in moderate-feedback runs, making up typically about half of all galaxies at the centres of halos with virial mass exceeding 100 billion solar masses.

2.9 Simulations and theory

A new radiative transfer tool

Brinch and Hogerheijde completed and published a new molecular line radiation transfer tool called LIME (Line Modeling Engine). This is a full 3-D code for predicting molecular line profiles and the continuum of a given input source model. This code is particularly suited for modeling interferometry observations with a high spatial resolution. LIME was developed for the purpose of predicting the emission signature of low-mass young stellar objects, including molecular envelopes and protoplanetary disks, but the method works for similar environments such as (giant) molecular clouds, atmospheres around evolved stars, high mass stars, molecular outflows, etc. as well. LIME was used to model carbon monoxide and water line observations in several Herschel Space Observatory Early Results papers during 2010. By the end of 2010, the LIME code had more than 40 registered users from more than 20 different institutions.

Almost-instant radiative transfer using a sparse-matrix Markov chain

Icke and Kruip, assisted by Vooys, determined the mathematical properties of SimpleX-type radiative transfer by formulating the transport problem as a Markov chain in which the connectivity between the nodes of the transport graph was prescribed by various ways, such as Voronoi-Delaunay-neighbours or nearest-neighbours. In this formulation, the transport of radiation is described by a sparse matrix that links the nodes of a graph by a fixed set of probabilities. Using the fact that the number of neighbours is easily three, and sometimes five orders of magnitude smaller than the number of nodes, Icke and Vooys found a method for computing the equilibrium Markov state that is so quick that the computing time is irrelevant when compared with the time it takes to construct the graph. In a way, this means that solving the radiative transfer takes effectively no time. Such an approach can be very efficient in obtaining the equilibrium solution to scattering problems in highly inhomogeneous media.

Ionising radiation escaping from high-redshift dwarf galaxies

Paardekooper, Pelupessy, Altay and Kruip computed the escape fraction of ionising radiation from high-redshift dwarf galaxies. They used the latest version of the SimpleX radiative transfer code, based on Voronoi-Delaunay triangulation, developed by Ritzerveld, Icke, Paardekooper and Kruip. They found that supernova feedback is the main driver of escaping ionising photons, by inducing spatial porosity in the galactic gas. Galaxies in which this feedback has a strong effect on the gas distribution may contribute significantly to reionisation in the early Universe, even when gas has stopped accreting onto the halo.

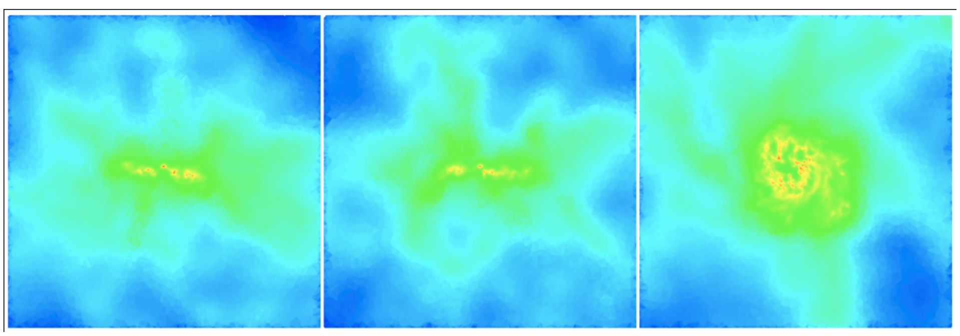


Figure 18. A typical accreting dwarf galaxy as seen along the X- Y- and Z-axis, respectively.

Cosmic reionisation: inside-out or outside-in?

Kruip has determined the influence of resolution and different radiation transport methods on the morphology of cosmic reionisation. Although resolution effects influence the results quantitatively, they do not change the overall morphology of reionisation. Using the SimpleX radiative transfer code, based on Voronoi-Delaunay triangulation, developed by Ritzerveld, Icke, Paardekooper and Kruip, a consistently `inside-out' reionisation scenario is found. These results are compared with those obtained using a different prescription for radiative transfer based on describing the transfer equation by its first two moments with respect to solid angle. The latter method finds a qualitatively different reionisation morphology (called inside-out-middle) where the intermediate `filaments' of the cosmic web are the last to ionise.

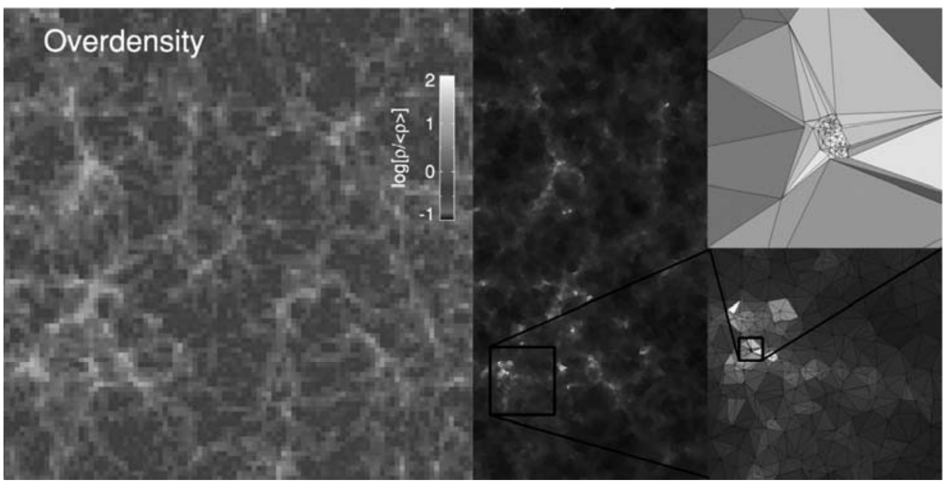


Figure 19. Comparing the radiative transfer grids at redshift z=6.49 side-by-side. Left panel: 96^3 regular grid from Finlator et al. 2009. Right panel: SimpleX grid based on a random sampling of the original 512^3 SPH particles with 10^6 particles. The insets demonstrate the adaptive resolution of the Delaunay grid which typically captures a dynamic range of five orders of magnitude in length scale.

AMUSE software development

Version 2 of the Astrophysical MUltiphysics Software Environment (AMUSE) was released in March by the AMUSE development team (van Elteren, Pelupessy, Marosvolgyi and de Vries). AMUSE aims to provide a flexible environment for astrophysical simulations by providing physically motivated and standardised interfaces to simulation codes, freely available under an open source license. The second release consisted of the Gravity and Stellar Evolution modules, unit handling and the AMUSE infrastructure. Version 3 was released in October and included the hydrodynamic modules.

Pelupessy used hydrodynamical simulations of galaxies to explore the evolution of gas-rich and metal-poor systems, which are expected to be numerous in the early universe. He found significant and systematic deviations of the star formation rate from that expected from the classical Schmidt-Kennicutt relation, showing that the simple-minded application of this relation in the high redshift universe may not be appropriate. Simulations of the gas dispersal in young clusters were run by Pelupessy using the prototype AMUSE software environment. These simulations showed that low mass stars are preferentially ejected due to mass segregation.

2.10 Advanced instrumentation programs

Data processing for the GAIA space mission

The Leiden Gaia group, led by Brown, is involved in the preparations for the data processing for ESA's Gaia mission. Scheduled for launch in 2013, Gaia aims at providing a stereoscopic census of the Milky Way by measuring highly accurate astrometry (positions, parallaxes and proper motions), photometry and radial velocities for a billion stars and other objects to 20th magnitude. Major activities in 2010 included the following.

Brown and Busso continued their work on the development of the data processing software for the photometric instrument of Gaia in collaboration with groups in Rome, Teramo, Cambridge, and Barcelona. The photometric data for Gaia will be collected through low dispersion spectrophotometry with prisms and the group in Leiden is responsible for developing the algorithms that extract the spectra from the raw data. During 2010 the infrastructure of the photometric pipeline was overhauled. This led to a redesign of the algorithms developed earlier. Busso ported the photometric code already developed for the initial data treatment pipeline (which first receives the raw telemetry from Gaia and carries out important pre-processing steps) to the new photometric pipeline. Brown proposed a new method for the deblending of overlapping prism spectra in crowded regions of the sky. It is based on the description of these images in terms of basis functions derived from a principle components analysis. The first tests of this method carried out by the group in Rome were promising.

Busso contributed to development of in-flight measurement strategies for characterising the background in the Gaia images, both the astrophysical background and that due to the artificial charge injections which are used to counter the effects of radiation damage to the CCDs. She also contributed to the development of the charge injection strategy.

A major concern for the Gaia mission is the effect of radiation damage to the CCDs (due to the solar wind and to cosmic ray protons). The consequence will be an increased level of charge transfer inefficiency which will cause a loss of signal as well as a distortion of the image. The latter will cause systematic errors in the astrometry if not carefully controlled. In this context Prod'homme is doing his PhD research on the theoretical and empirical modelling of radiation damage effects. Prod'homme, A. Brown, Lindegren (Lund, Sweden), Short (ESA), and S. Brown (Cambridge, UK) completed a detailed Monte Carlo model to simulate the operation of an irradiated CCD at the pixel electrode level. This model implements a new approach to both the charge density distribution within a pixel and the probabilities of charge capture and release by radiation induced traps. The model allows the reproduction of radiation damage effects on a variety of measurements for a large signal level range in particular for signals of the order of a few electrons.

An approximate but fast analytical model of CTI effects is under development within the Gaia project. In the Gaia data processing consortium, a forward modelling approach to CTI mitigation will allow the estimation of the true image parameters from observations affected by CTI. The analytical CTI model is a key element in this process, and its performance regarding the reproduction of the future damaged observations is critical to achieving the Gaia requirements. Prod'homme, Weiler (Paris, France), S. Brown, Short, and A. Brown completed the validation of this analytical model through a comparison against experimental data obtained with irradiated CCDs.

To counter the effect of radiation damage at low signal levels, each Gaia CCD pixel contains an extra doping implant, a so-called supplementary buried channel (SBC). Experimental tests carried out by Kohley et al. (ESA) and simulations by Seabroke et al. (Open University, UK) showed that the SBC might be missing in the first half of some of the Gaia CCDs. Prod'homme used his Monte Carlo CTI model to investigate this hypothesis by simulating the effects of a missing SBC on so-called first pixel response measurements. The results confirm the experimental tests.

In order for Gaia to reach its astrometric accuracy goals the highest quality for the attitude knowledge of the spacecraft is needed. It is thus important to incorporate a complete physical understanding of the dynamics of a continuously rotating space platform into the attitude modelling for Gaia. In this context Risquez is developing detailed simulations of Gaia's attitude, incorporating all of the relevant physical effects. This model is developed in collaboration with van Leeuwen (Cambridge, UK) and Keil (Bremen, Germany). During 2010 Risquez debugged and optimised the modules that simulate specific physical effects in the spacecraft attitude. These include: micro-meteoroid impacts, thermal infra-red emission from the satellite surface, and noise due to the micro-propulsion system. In addition Risquez implemented a simplified simulation of Gaia's Attitude and Orbit Control System.

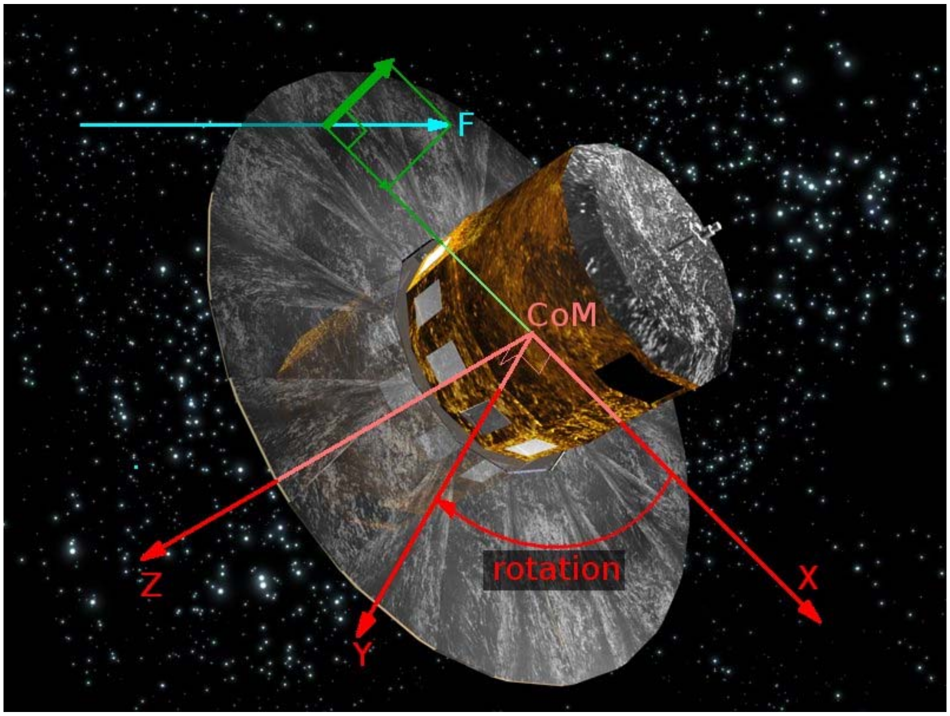


Figure 20. This is an artistic image of Gaia. It presents what the Dynamical Attitude Model (DAM) simulates: the spacecraft is spinning around the Z axis (that goes through its centre of mass, CoM), and some perturbations (the impact of a micro-meteoroid in this example) produce a force (blue "F") that modify the attitude.

MIRI for the James Webb Space Telescope

Martinez-Galarza, Kendrew and Brandl worked on the wavelength characterisation of the medium-resolution integral field spectrograph of the Mid-Infrared Instrument (MIRI), to be launched into space on-board the James Webb Space Telescope. Their work provides a method to calibrate the wavelength range and spectral resolving power for all four channels of the spectrometer and discusses preliminary results obtained with the instrument test model. Comparisons with optical models confirm that MIRI will be able to reach its specifications in terms of resolving power and line width.

ELT instrumentation: METIS

After completion of the conceptual design phase, the Mid-infrared E-ELT Imager and Spectrograph (METIS) team, led by Brandl (PI) and Molster (PM), continued the development of technologies and key components that will be important later on for the METIS instrument. These activities include the cold chopper demonstrator, an opto-mechanical device to switch quickly (5 milliseconds) and very accurately (1.7 microrad) between two beam positions in any direction under cryo-vacuum conditions. The project is done jointly with partners in industry and other academic institutions. Further development projects include an ultra-precise optical field (de)rotator, more powerful sorption-coolers, and novel aluminium mirror polishing techniques.

VLT instrumentation: MUSE and ASSIST

MUSE, the Multi Unit Spectroscopic Explorer is a second-generation instrument for ESO's Very Large Telescope (VLT), featuring wide-field, adaptive-optics-assisted integral-field spectroscopy. MUSE is currently being manufactured by a number of European companies and integration on sub-system level is currently taking place at various institutes around Europe. Integration will to start in mid-2011. The MUSE consortium consists of 7 institutes and is led by the Observatory of Lyon. NOVA, by way of Stuik at Leiden Observatory, is mainly involved in the interface between MUSE and its Adaptive Optics system (GALACSI), the preparations for scientific operation of MUSE--like the Exposure Time Calculator (ETC) and Operation, Calibration of MUSE, the MUSE observation templates efforts and the building of the database to handle the enormous amounts of data that will be delivered by MUSE--and the MUSE science team.

ASSIST--the Adaptive Secondary Setup and Instrument STimulator is the test system for the VLT Adaptive Optics Facility (AOF) and will allow verification of the operation of the various hardware and software systems for the AOF without the need for--sometimes long--on-sky testing. ASSIST, as currently developed by Stuik and Molster is now being manufactured. The main optical components as well as the main mechanical components are either delivered or nearly finished and integration is taking place at Leiden Observatory, with support from NOVA-ASTRON. ASSIST will be delivered to ESO in the summer of 2011.

Figure available at http://www.strw.leidenuniv.nl/~stuik/ASSISTMain.eps, caption: The ASSIST Main Structure during preliminary acceptance at Boess enkool Almelo. The ASSIST Main Structure will house ASSIST, including optics, mechanics and electronics. It will provide a stable environment for testing the components of the VLT Adaptive Optics Facility. The image also shows ASSIST before its final coating, which will increase the light-tightness and reduce reflection in the system.

Commissioning LOFAR

LOFAR, the Low Frequency Radio Array, is a pan-European radio telescope currently being commissioned. At the end of 2010, the array included 23 stations out to ~ 30 km within the Netherlands, three international stations in Germany and one each in France and the United Kingdom. Operating at frequencies from 30 to 200 MHz, LOFAR will open up the last unexplored window of the electromagnetic spectrum for astrophysical studies. One of the key science projects is to survey the entire low-frequency sky at a number of frequencies (PI Rottgering).The areas, depths and frequencies of these surveys have been chosen so that they would contain: (i) ~100 powerful radio galaxies close to or at the epoch of reionisation, (ii) ~100 radio halos at the epoch when the first massive bound galaxy clusters appeared, and (iii) ~100 proto-clusters. In 2010, a number of observational commissioning projects were carried out to commission LOFARs increasing capabilities. This resulted in low frequency images of a number of well-known objects such as the galaxy M 51, the radio source 3C61.1, and the cluster A2256. Van der Tol produced software that can produce flux-corrected images of the low frequency sky taking into account the variable observing beams. Rafferty and Birzan continued testing of the system, with particular emphasis on removal of radio frequency interference and cross-checking of the results from the new LOFAR reduction software with existing radio reduction packages.

2.11 Raymond and Beverly Sackler Laboratory for Astrophysics[1]

The conditions in space are extreme and do not favour an efficient chemistry: temperatures are low, radiation fields are intense, and particle densities are exceedingly low. Nevertheless, more than 150 different molecular species have already been identified in star-forming regions. These comprise both small and complex species as well as stable and transient molecules and are the result of an exotic chemical evolution. Today, astrochemists explain the chemical complexity in space as the cumulative outcome of gas, grain and gas-grain interactions. Gas phase models explain the observed abundances of the smaller and many of the larger radical species, but fail to explain the presence in space of stable and complex, partially organic species. It is now generally accepted that such species form on icy dust grains, small solid particles that are an important ingredient of the material found between the stars. They play an essential role as they provide opacity (blocking regions of the galaxy from UV radiation), the basic material from which icy planetesimals and ultimately planets are formed, and catalytic sites for molecule formation. Thermal and ultraviolet processing as well as atom bombardment of icy dust grains trigger a fascinating solid state astrochemistry. Understanding the cycle of matter in galaxies, the origin of stars and planetary systems and the complex (organic) chemistry that is found in molecular clouds and proto-planetary disks is intimately linked to the study of the role icy solids have in space. A quantitative characterisation of this role is only possible through detailed laboratory studies and this is the research topic of the work performed at the Sackler Laboratory for Astrophysics.

Particle processing of inter- and circumstellar ice analogues

The team around the setup SURFRESIDE (Ioppolo - PhD thesis 2010, Cuppen, Fedoseev) has been focussing on water formation upon hydrogenation reactions of oxygen/ozone ice. They derived temperature and flux-dependent reaction rates that elucidate the role of solid state reaction schemes in the formation of

[1] The Sackler laboratory participates in a large EU consortium (LASSIE - Laboratory Astrochemical Surface Science in Europe - www.u-cergy.fr/LERMA-LAMAP/LASSIE/) and the Dutch Astrochemistry network - www.nwo.nl/astrochemistry.

water in space and make it possible to extend the results to astrochemical models. For a first time, they performed detailed studies of binary ice mixtures ($CO:O_2$) that showed the efficient formation of CO_2.

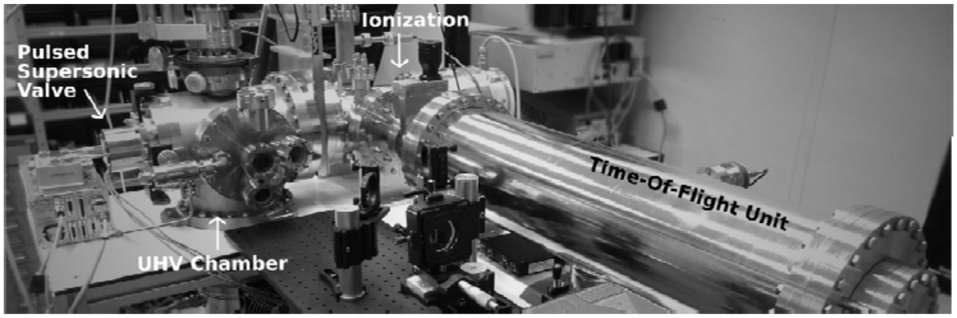


Figure 21.

In 2010, the construction of MATRI2CES was completed by Isokoski and Bossa. This setup combines laser desorption and time-of-flight detection and aims at visualising chemical pathways towards molecular complexity in much more detail than is possible with regular UHV RAIRS and TPD techniques.

UV photo-processing of inter- and circumstellar ice analogues

The successful photo-desorption, photo-processing and photo-dissociation studies by Öberg were continued by Fayolle and Zhen who focussed on frequency-dependent irradiation effects. In this context, a measuring campaign at SOLEIL (Paris) was successfully conducted, which showed that molecular processes in the solid state depend on the frequency of the incoming light. The team around the setup OASIS (Bouwman - Ph.D. thesis 2010, Allamandola, Tenenbaum and Cuylle) has been able to study the photo-physical and photo-chemical behaviour following UV irradiation of polycyclic aromatic hydrocarbons (PAHs) d in an astronomical water and ammonia ice analogue. In-situ and real time optical data provide insight in the role PAHs play in the solid state and in addition provide an alternative route to search for PAHs in space.

Gas-phase studies

For the first time, a promising overlap between a laboratory spectrum and a broad diffuse interstellar band (DIB) has been found by Wehres and collaborators. The resulting paper was chosen as an A&A highlight. More recently this work has also triggered a discussion whether the C_3H_2 molecule may be the carrier of several DIBs. She performed much of that work in close collaboration with Zhao and Ubachs (Amsterdam, NL) using a supersonic planar plasma setup to simulate interstellar clouds. On the setup SPIRAS Guss completed the construction of a new infrared laser detection scheme for molecular transients in space. A cavity enhanced detection scheme in combination with a planar plasma expansion is used to search for molecular fingerprints of transient species likely present in the spectra recorded by the HIFI instrument on board of the ESA Herschel Space Observatory

Chapter 3

Education, popularization and social events

Education, popularization and social events

Chapter 3

3.1. Education

Education and training of students is a major priority of Leiden Observatory. In 2010, 47 freshmen started their studies in astronomy. Of this number, 6 (13%) were women, and 25 (53%) pursued a combined astronomy/physics or astronomy/mathematics degree.

The Observatory registered a total number of 91 BSc students at the end of the year, of which 46 (48%) aimed at a combined astronomy/physics degree or astronomy/mathematics degree; 15% of all BSc students is female. There were 35 MSc students, including 16 (45%) women and 10 (28%) foreign nationalities. Several students from the applied physics department of Delft Technical University took courses of the Leiden astronomy curriculum as part of the requirements for a minor in astronomy.

Twelve students passed their propedeutical exam, of which eight completed the requirements in the nominal one year. There were 17 BSc exams, and 9 MSc exams.

At the beginning of the year, Pen started as the new education coordinator taking care of the daily running of tasks. In September, Linnartz stepped down as BSc study adviser and his tasks were taken over by Hoekstra. Portegies Zwart continued as the MSc study adviser

In addition to counseling by the student adviser, incoming students were assigned to small groups meeting at regular intervals with a staff mentor (Hoekstra, Icke, and Snellen) and a senior student mentor. In the tutor programme, physics and astronomy freshman students were provided on a voluntary but regular basis with coaching by senior students.

As part of the introductory astronomy course, students were taken to the Artis Planetarium in Amsterdam for a lesson in coordinate systems, time and constellations in the sky (Hoekstra). As part of the second-year training in practical astronomy, 12 honors students were offered the opportunity to take part in a specially arranged observing trip to the Isaac-Newton-Telescope on La Palma, Canary Islands (van der Werf, de Mooij, Szomoru).

The astronomy curriculum is monitored by the 'Opleidingscommissie' (education committee), which advises the Director of Education on all relevant matters, and which was chaired by Röttgering. Other members are van Dishoeck, Franx, Schaye, and van Uitert, as well as Bremer, Pijloo, Segers, Vreeker for the student body. In the fall, the composition changed: student representatives became de Pous, Pijloo, Segers, Vreeker and Buijsman. Under the authority of the Opleidingscommissie, the lecture course monitoring system (SRS) was continued. In this system, students provide feedback to lecturers during and after the course.

The quality of curriculum and exams is guarded by the Exam Committee (Examencommissie) chaired by Lub, with Israel, Aarts (physics), Snellen en van der Werf as members.

Admission to the master-curriculum for students without a BSc in astronomy from a Netherlands university requires a recommendation by the 'Toelatingscommissie' (admissions committee) chaired by Schaye and having Israel and Linnartz as members. In September Hoekstra and Portegies Zwart took over the membership.

3.2. Degrees awarded in 2010

3.2.1. Ph.D. degrees

A total of 10 graduate students successfully defended their Ph.D. theses in 2010 and were duly awarded their Ph. D. degree: They are:

Name:	Pedro Lopes Beirao
Titel thesis:	ISM Conditions in Starburst Galaxies
Promotor:	F.P. Israel
Co-promotor	B.R. Brandl

Name: Mario Soto Vicencio
Titel thesis: 3-Dimensional Dynamics of the Galactic Bulge
Promotor: K. Kuijken
Co-promotor: J. Lub

Name: A.J.P. Raat
Titel thesis: The Life of Governor Joan Gideon Loten (1710-1789)
Promotor: Visser

Name: Maaike Damen
Titel thesis: The build up at Massive Galaxies
Promotor: M. Franx, P.G. van Dokkum
Co-promotor: I. Labbé

Name: Robert Wiersma
Titel thesis: Simulating the Chemical Enrichment of the Intergalactic Medium
Promotor: P.T. de Zeeuw
Co-promotor: J. Schaye

Name: Jordy Bouwman
Titel thesis: Spectroscopy and Chemistry of Interstellar Ice Analogues
Promotor: H.V.J. Linnartz
Co-promotor: L.J. Allamandola

Name: Demerese Salter
Titel thesis: Millimeter Emission from Protoplanetary Disks
Promotor: E.F. van Dishoeck, M.R. Hogerheijde

Name: Marcel Haas
Titel thesis: Nature and Nurture in Galaxy Formation Simulations
Promotor: M. Franx, J. Schaye

Name: Sergio Ioppolo
Titel thesis: Surface formation routes of interstellar molecules
Promotor: H.V.J. Linnartz, E.F. van Dishoeck

Name: J-P. Paardekoper
Titel thesis: And there was light: Voronoi-Delauney radiative transfer and cosmic reionisation
Promotor: V. Icke

3.2.2. Master's degrees (Doctoraal diploma's)

The following 9 students were awarded Master's/Doctoral degrees in 2010:

Name	Date	Present position
Annelies Mortier	Aug 31	Ph.D Portugal
Daniel Harsono	Aug 31	Ph.D Leiden Observatory
Marcel van Daalen	Aug 31	Ph.D Leiden Observatory, Leiden and Berlin
Sweta Shah	Aug 31	Ph.D Radboud University Nijmegen
Wouter Schrier	Aug 31	Student Administration Science Leiden University
Aleksander Shulevski	Sep 28	Ph.D Groningen
David Delgado Diaz	Oct 26	Colombia
Renske Smit	Oct 26	Ph.D Leiden Observatory
Michiel Lambrechts	Nov 30	Ph.D Lund, Sweden

3.2.3. Bachelor's degrees

A total of 10 students obtained their Bachelor's degree:

Name	Date	Present Position
Babs Beemster	Feb 19	MSc Programme, Leiden Observatory
Sascha Zeegers	Feb 19	MSc Programme, Leiden Observatory
Bas Crezee	Feb 19	Msc Programme, Leiden Observatory
Casper Schonau	June 4	Msc Programme, Leiden Observatory
Yorick van Boheemen	June 4	MSc Programme, LION
Ingrid Icke	June 4	MSc Programme, Leiden Observatory
Merlijn van Deen	Aug 31	MSc Programme, LION
Michiel Meijer	Aug 31	MSc Programme, LION
Ruben van Drongelen	Aug 31	MSc Programme, LION
Anna Freudenreich	Aug 31	MSc Programme, LION, BSc Mathematics
Tjibaria Pijloo	Aug 31	MSc Programme, Leiden Observatory
Rogier van Loo	Aug 31	MSc Programme, LION
Jeroen Franse	Aug 31	MSc Programme, Leiden Observatory
Paul Langelaan	Aug 31	MSc Programme, Leiden Observatory
Siebe Weersma	Aug 31	MSc Programme, Leiden Observatory
Luc Harms	Aug 31	MSc Programme, Leiden Observatory
Maria Drozdovskaya	Aug 31	MSc Programme, Leiden Observatory

3.3. Academic courses and pre-university programmes

3.3.1. Courses taught by Observatory staff

Elementary courses:

Semester	Course title	Teacher
1	Introduction astrophysics	H.V.J. Linnartz
2	Astronomy lab 1	H. Hoekstra
3	Stars	A.G.A. Brown
3	Modern astronomical research	M. Franx
4	Astronomy lab 2	P. P. van der Werf
5	Observational techniques 1	B. Brandl
5	Radiative processes	V. Icke
5-6	Bachelor research project	I. Snellen
6	Introduction observatory	E.R. Deul

Advanced courses (keuzevakken; semesters 7, 8, 9, 10):

Astronomy from space	M. Fridlund
Computational astrophysics	S. Portegies Zwart
Galaxies, structure, dynamics & evolution	M. Franx
IAC 2009: virtual observatories	J. Brinchmann
Stellar structure and evolution	J. Lub
Interstellar medium	M. Hogerheijde
Interferometry	W. Jaffe
Origin and evolution of the universe	K. Kuijken
Radio astronomy	M. Garrett
Stellar dynamics	S. Portegies Zwart

3.3.2. Pre-university programmes

LAPP-Top, the Leiden Advanced Pre-University Programme for Top Students, is aimed at enthusiastic and ambitious high-school students from the 5th and the 6th grade. Candidates are selected on the basis of their high-school grades and their enthusiasm to participate. Students that are selected will then take part in 6 to 8 meetings from January till May, following the programme of their own choice.

The Sterrewacht has been participating in the LAPP-TOP programme since its start in 2001. In that pilot year 5 students participated, growing to 6 (2002/3), 11 (2003/4), 33 (2004/5), 17 (2005/6), 27 (2006/7), 16 (2007/8), 20 (2008/9), and 10 (2009/10).

The astronomy LAPP-TOP programme was developed by Van der Werf from 2002 onward. From 2005-2008 the project was coordinated by Snellen. Since 2008 it is coordinated by Franx. In eight sessions the following subjects were treated:

The Milky Way and other galaxies – J. Schaye
Extrasolar planets – I. Snellen
Practicum I
Gas and Radiation - V. Icke
Black Holes – P. P. van der Werf
Practicum II
Cosmology – H. Hoekstra
Excursion to the radio telescopes in Westerbork and Dwingeloo

After successfully completing the programme participants have been awarded with a certificate from the University of Leiden. High-school students are allowed to use this project as part of their final exams.

3.3.3. Contact.VWO

Contact.VWO has been in existence since May 2007. Buisman and van der Hoorn (physics teachers in secondary schools) both work one day a week for the Physics and Astronomy Departments in order to intensify the contacts between secondary schools and the university.

Van der Hoorn organizes twice yearly a production and mailing of posters and organizes three times an informative meeting for physics teachers, starting at 5 p.m. and featuring a lecture on modern developments in physics or astrophysics, an informal dinner with extensive networking between teachers and university workers, and after-dinner subjects dealing with the change from secondary school to university study.

Buisman is concerned with school classes (programmes for whole-day visits as well as individual help (assisting pupils with practical work, answering questions by mail etc.). He also has organized a training session for the module Measuring in Star Systems (Meten aan Melkwegstelsels) which is part of the school curriculum track Nature, Life and Technology (Natuur, Leven en Technologie).

Contact.Vwo answers ad hoc requests for assistance by school pupils or teachers. Buisman also has an appointment for half a day a week as local coordinator of the HiSPARC project, but although related, this is not a part of the activities of Contact.VWO.

Activities at Leiden University in 2010
For teachers:
January 21: Theme: Cosmic Radiation and HiSPARC.
May 18: Theme: Visiting Museum Boerhaave, Leiden
October 12: Measuring in star systems (NLT: Natuur, Leven en Technology)
November 2: Theme: LION: Research and Education

For teachers accompanied by their best pupils:
March 10: Einsteins Birthday party

For pupils:
February 5: Instituutsdag for pupils visiting CERN afterwards (preparation)

For School classes:
January 15, 2010; school: Hofstad Lyceum, Den Haag; Lab: Measuring in Star Systems (lab plus Lecture)
January 16, 2010, school: Monteigne Lyceum, Den Haag; Lecture Cosmology
March 26, 2010: De Populier (Den Haag) Measuring in Star Systems (lab plus Lecture)
April 9, 2010 VCL Measuring in Star Systems (labplus Lecture)

Seven teams of pupils have been supported by Contact.Vwo working on a practical assignment (profielwerkstuk) about astronomy.
Further information http://www.physics.leidenuniv.nl/edu/contactpuntvwo/index.asp

3.4. Popularization and media contacts

3.4.1. Public lectures and media interviews

Berné
'Fleurance' (Children astronomy festival, France; Aug 7-13)

Brinch
'Star formation and ALMA, (Lecture, Copenhagen, Denmark; Sep 6)
Idem, (Lecture, Århus, Denmark; Sep 13)

Brown
'Gaia - Een stereoscopische kaart van de Melkweg' (KNVWS, Nijmegen; Jan 26)
Idem (Venlo; Feb 26)
Idem (Rotterdam; Oct 13)
'Unravelling the formation history of the Milky with Gaia' (EADS-Astrium Toulouse, France; Sep 21)
Idem (EADS-Astrium Toulouse, France; Dec 2)

Van Delft
'Echo's van licht' (openingstoespraak tentoonstelling Marlies van Boekel en Marijke Gerritsen, Ars Aemula, Leiden; Jan 20)
'Koud, kouder koudst' (MuseumJeugdUniversiteit, Leiden; Feb 14)
'Newton in Nederland' (Teleac radio; Feb 17)
'Johannes Diderik van der Waals en de Tweede Gouden Eeuw' (Studium Generale Universiteit Twente, Enschede; Feb 18)
'Over oude en nieuwe zwaartekracht' (Museum Boerhaave, Leiden; Apr 8)
'Materieel erfgoed: van blingbling naar sleutelstukken met verhalen' (Docentennetwerk natuurkunde, Leiden; May 18)
'Tube your future' (Nemo, Amsterdam; May 26)
'Heike Kamerlingh Onnes en de Tweede Gouden Eeuw' (collegereeks Keerpunten in de geschiedenis van de natuurwetenschappen, Leiden; June 7)
'Getemde, dode en museale natuur' (Vroege Vogels, Radio 1; June 13)
'Sleutelstukken en storytelling in Museum Boerhaave' (master Wetenschapscommunicatie, Leiden; Sep 7)
'Dat mag in de krant! Over wetenschap en de pers' (collegereeks Fysica & Samenleving, Leiden; Sep 21)
'De laatste jaren van Paul Ehrenfest' (lustrumserie Ratio & Emotie,

Universiteit Leiden, Leiden; Nov 9)
'Materieel erfgoed: van blingbling naar sleutelstukken met verhalen' (collegereeks Fysica & Samenleving, Leiden; Nov 9)
'De Leidse jaren van Nobelprijswinnaar Pieter Zeeman (1865-1943)' (Cleveringalezing, Middelburg; Nov 25)
'De afscheidsbrieven van Paul Ehrenfest' (Leiden; Nov 28)
'Heike Kamerlingh Onnes: de man van het absolute nulpunt' (Koninklijk Genootschap Physica, Alkmaar; Dec 6)
'Jan zonder genade schreef gevoelige poëzie'(Nieuwsbrief Universiteit Leiden; Dec 7)
'De laatste jaren van Paul Ehrenfest' (VPRO-radio; Dec 12)
'De poëzie van J.D. van der Waals'(Labyrint, Radio 1; Dec 19)

Van Dishoeck
'Astrochemistry comes of age: 1970-1990' (Chemische historische vereniging, Utrecht; Mar 4)
'Leven in het heelal, Spinoza te Paard'(Den Haag; Mar 16)
'From molecules to planets, OECD forum' (Amsterda; Oct 11)
'Waar komt het water in de oceanen vandaan?' (Jeugdacademie Boerhaave museum, Leiden; Oct 17)
'Hot spots in de ruimte' (ESERO conferentie, Breukelen; Nov 3)
'Hoe ontstaan planeten?' (Science cafe, Enschede; Nov 24)
'First localisation of water in a protoplanetary disk'(IRAM, MPG, NOVA press releases; Feb 8)
'Leven in het heelal' (Spinoza te paard lecture, Teleac, DVD; Apr and Sep)
'Herschel's HIFI follows the trail of cosmic water'(ESA press release; May 6)
'HIFI op het spoor van nieuw water in de kosmos' (NOVA persbericht; May 7)
'Met het oog op morgen' (Radio 1; Sep 5)
'Puzzelen aan de kosmische achtertuin'(Reggae en Ratelslangen p. 47-57, UL; Sep)
'De ruimte is een uniek laboratorium' (Jaarboek NWO-CW; Sep)
'Viereneenhalf miljard jaar water'(Leidsch Dagblad; Oct 20)

Gürkan
'Derin Uzay Nesneleri (Deep Sky Objects)'(13th National Skygazing Festival, Saklikent, Antalya, Turkey; July 18)

Haverkorn
'Galactic Magnetism in the LOFAR Era' (NAC Annual Meeting, Utrecht; Feb 5)
'De gepolariseerde hemel door de ogen van een radioschotel' (CAMRAS Kwartaalvergadering, Dwingeloo; Sep 18)

Interview (TubeYourFuture; Feb 25)
Winner (National Science Quiz; Dec 26)

Hoekstra
'Donkere materie, Cosmic Senstations' (Nijmegen; Mar 12)
'Wat doet een sterrenkundige?' (Weekendschool, Den Haag; Mar 14)

Icke
Lezing (Teylers Museum, Haarlem; Jan 10)
Matt Dings "Jonge Jaren" (Jan 12)
(Bibliotheek Amstelveen; Jan 16)
'Gas en Straling' (college LappTop, Leiden; Feb 3)
Wiskundedagen (Feb 5)
BIGBROTHER Awardgala (De Balie, Amsterdam; Feb 5)
'Inspiratie tot leren' (Sprekersplatform; Feb 9)
'Toekomst in het Groot' (Universiteit van Amsterdam; Feb 10)
Dies Natalis alumni 2010 (Leids Universiteitsfonds, Leiden; Feb 13)
Lunchlezing (Toomre; Feb 16)
'Kunst en Wetenschap '(Volksuniversiteit Haarlem; Feb 16)
Lezing Van Stockum (Feb 20)
Studiekring (Golfclub Wassenaar; Mar 2)
Boekwinkellezing (Mar 3)
Ben van Tilborg (Museon, Den Haag; Mar 18)
Comenius leergang (Mar 19)
Opening tentoonstelling (Kunstuitleen, Amstelveen; Mar 28)
Nacht van de filosofie (Felix Meritis, Amsterdam; Apr 9)
Nieuw Archief Wiskunde (Apr 19)
Klukhuhn Lezing (Utrecht; Apr 20)
Minicollege nuldejaars (Leiden. Apr 23)
Meet & Greet (Kunstuitleen, Amstelveen; Apr 24)
Gastcollege TUE Brussaard (Apr 26)
Lezing (Openbare Bibliotheek Amsterdam; May 16)
'Tsnuk!' (Amersfoort; Jun 13)
Kosmologie Olympiade discussie (Jun 14)
PrOUT PhD-dag (Jun 16)
Lezing (Rabobank, Leiden; Jun 16)
Voordracht Vaderschapsdag (Jun 18)
Invited talk (APNs; Jun 23)
Communicating Science (June 24)
Symposium Privaatrecht (Universiteit van Amsterdam; Jun 30)

ObaLive interview (Desmetstudio, Jul 5)
'Zout' (Interview Theo Kroese; Aug 18)
Lezing MIC (Hotel Arena, Amsterdam; Aug 23)
Opening jaar Studium Generale (Universiteit Eindhoven; Sep 1)
Opening Haags schooljaar (Den Haag; Sep 2)
Petit Prince Festival (Ede; Sep 3)
Opening nieuw Reviuslyceum (Doorn; Sep 7)
Opening Kunstroute (Scheltema, Leiden; Sep 17)
Lezing St. Joost (Sep 22)
Lustrum Aesculapius (Sep 24)
Opening Centrum Beeldende Kunst Gelderland (Oct 2)
NOVA Herfstschool Science Communications (Oct 6)
Opening Universitair Sportcentrum UvA (Oct 8)
'Hoe zou hij het nu bouwen?' (Lezing Eise Eisinga; Oct 9)
Huygenslezing (Oct 13)
Interview KRO Radio 4 (Oct 26)
Interview Het Parool (Oct 26)
'Scherpdenkers' (Lezing, Concertgebouw Amsterdam; Oct 26)
Voordracht Muziekcentrum Frits Philips (Eindhoven; Oct 27)
Opening Ontdekhoek (Amsterdam; Nov 5)
Lezing CODA (Apeldoorn; Nov 7)
Kinderuniversiteit (Tilburg; Nov 8)
Interview Trouw (Nov 11)
Lezing Kunst en Wetenschap (Gynaecongres; Nov 12)
Kaleidoscoop Sterrenkunde (Nov 16)
Opening Olympus College (Arnhem; Nov 23)
Interview NWO (Nov 25)
Interview Ad Valvas (Nov 25)
Cleveringalezing (Amersfoort; Nov 26)
Opening tentoonstelling Vincent Cattani (Leiden; Nov 28)
Uitzending OBA Live (Amsterdam; Nov 29)
Interview KPMG (Nov 30)
De Wereld Draait Door (Amsterdam; Nov 30)
Socrateslezing (Den Haag; Dec 1)
Comenius leergang (Arnhem; Dec 3)

Israel
'Verleden en Toekomst van de Ruimtevaart' (VPRO Noorderlicht; Apr 7)
'Zicht op de Sterren' (Noordwijk Schilderfestival; June 21)

van Langevelde
Radio interview on SN2007gr and eVLBI (Noorderlicht radio, Hilversum; Feb 2)
'*eVLBI connecting remote telescopes in real-time*' (Kick-off GigaPort3, Den Haag; Feb 18)
'Een telescoop groter dan Europa' (ASTRON/JIVE open dag, Westerbork; Oct 24)

Linnartz
'VPRO Noorderlicht' (Radio 1; Feb 22nd)
'Van hier naar het einde van heelal en weer terug' (Christelijke School Vreeland, Vreeland, Feb 17)
'Leven in het heelal' (Spinoza te Paard, Den Haag; Mar 16 (zie ook http://www.wetenschap24.nl/video/bekijk/wmv/1/spinoza-te-paard--leven-in-het-heelal--harold-linnartz.htm)
'Oplossing van geheim in sterrenwolken is een stuk dichterbij' (Mare; Mar 11)
'Unlocking the chemistry of the heavens' (Discovery talk, May 27)
'Moderne sterrenkunde, op avontuur in het heelal' (Vrouwen van Nu, Abcoude/Braambrugge; Nov)
'De hemel boven Vreeland' (maandelijkse rubriek Vreelandbode)

Van Lunteren
'Commentary on the Scientifc Revolution in the Netherlands' (Leiden; Feb 17, Mar 17, Apr 15, May 12, June 9, July 7)
'Galileo Galilei en de grondslagen van de fysica' (Studium Generale Series Geschiedenis van de natuurkunde, Delft; Apr 20)
'Sonnenborgh als bastion van wetenschap: sterrenwacht en KNMI in de 19de eeuw' (Open Monumentendag, Museum Sterrenwacht Sonnenborgh, Utrecht; Sep 11 (2x))
'De gedachte-experimenten van Galileo Galilei' (Studium Generale Series Experimenteren in je hoofd, Leiden; Nov 8)
'De tragi-komische geschiedenis van de meter', (Woensdagavond Gezelschap, Utrecht; Dec 15)

Portegies Zwart
Astrophysics lectures for group 3 and 5, (Sint Bavoschool, Haarlem)
'*Het tumulteuze leven van een sterrenstelsel*', (Diligentia)
NEMO lecture, (Dag van de Sterren)
Radio interview voor Teleac Hoe?Zo!, (Radio 5, 747AM, Jan 14)
Interview Noorderlicht, (Radio 1, Jan 19)

Röttgering
'Nacht van de Onderzoeker'(presentatie onderdeel 'Sterren kijken in Rotterdam', Pathe, Rotterdam; Sep 27)
'Actieve sterrenstelsels' (Noordhollandse Sterrenkundige Organisatie, Hoorn; Sep 10)

Snellen
'Exoplanet atmospheres'(KNVWS symposium, Oct 9)
'ESO Press release, VLT detects first superstorm on exoplanet' (June 23)

Stuik
'Adaptieve Optiek: Op jacht naar de scherpste astronomische beelden met telescopen vanaf de grond' (Public Lecture Sterrenwacht Almere, Almere; Feb 16)
Idem (Public Lecture Stichting J.C. van der Meulen, Hoorn; June 4)

Visser
*'Chemische Processen in de Ruimte: van Interstellaire Stofwolken tot Leven'(*public lecture, Delft; Feb 16)
Idem (Venlo; Mar 26)
'Chemie Tussen de Sterren'(public lecture, Rotterdam; Mar 8)
'Vorming van Sterren en Planeten' (public lecture, Den Haag; Oct 22)
'Science with Herschel' (public lecture, Delft; Oct 28)
'Chemische Processen in het Heelal' (public lecture, Amsterdam; Nov 19)

van de Voort
'*Het heelal in de computer'* (public lecture, Amsterdam, Netherlands Oct 19)
Idem, (public lecture, Delft; Dec 14)
Idem, (public lecture, Den Haag; Dec 17)

Weiss
'Tiberius Cornelis Winkler: Een popularisator van de Wetenschap als Curator' (Teylers Museum, Haarlem; Jan 7)

3.5. Universe Awareness programme

Universe Awareness www.unawe.org is an international activity initiated by Miley designed to use the perspective and excitement of astronomy to inspire children aged 4 to 10 from underprivileged backgrounds. The goals are to broaden children's minds and introduce them to the scientific method. An additional long-term goal is to produce more tolerant and internationally minded adults. Started 5 years ago, UNAWE is now active in 40 countries with a multi-disciplinary network of more than 500 professional and amateur astronomers and educators. Miley is Chair of the International UNAWE Steering Committee and International Coordinator of the European EUNAWE FP7 project.

International UNAWE Project. In July 2010 Dr. Carolina Ödman left her position as International UNAWE Project Manager to begin a new life in South Africa. Although she will continue participate in the Board of EUNAWE, her departure left a large gap in the organisation of the international project.
A successor Mr. Pedro Russo, previously coordinator of the International Year of Astronomy, was appointed in January 2011.

European EUNAWE Project. During 2009 and 2010 Miley and Ödman conducted a vigorous lobbying campaign at the European Parliament to win European support for Universe Awareness. A proposal to support the implementation of Universe Awareness in 6 countries was submitted to the Directorate of Industry and Enterprise (responsible for the space programme). The EUNAWE proposal entered the negotiation stage in June and the negotiations were formally concluded in February 2011 with the award of 1.9 million Euro to a 3-year FP7 project to support EUNAWE in Germany, Italy, the Netherlands, South Africa, Spain and the UK (Northern Ireland).

Netherlands UNAWE-NL Project. The Netherlands UNAWE programme started officially in November 2009 with the appointment of Frederiek Westra van Holthe as UNAWE-NL project manager. This is being carried out as a joint venture with NOVA and with support from the VTB-Pro/ Plan Beta Techniek programme of the Ministry of Education, Culture and Science.
An important activity of UNAWE-NL during 2010 was to set up and coordinate "duo-stages", in which an astronomy student together with a PABO student develop and implement a series of astronomy "lessons" in Dutch primary schools located in disadvantaged districts. Pairing an astronomy student with a

PABO student ensures that the lessons are scientifically sound and pedagogically suitable for the children that are targeted.

Ten such UNAWE-NL duo-stages were carried out in 2010 throughout the Netherlands. Leiden students participated in duo-stages at three schools in the Hague - De Pous at the "Zuidwal" school, Pijloo at the "Onze Wereld" school and Crezee at the "Prinsehageschool". The duo-stages received excellent evaluations by the schools and the participating astronomy and teaching students were enthusiastic about the results.

One of the UNAWE highlights of 2010 was the participation in the inauguration by Queen Beatrix of the LOFAR radio telescope in the presence of an international audience that included Ministers from Australia, New Zealand and South Africa.

Prior to the inauguration, UNAWE-NL organised a SKYPE live-exchange between children from Class 7 of the "Burgemeester W.A. Storkschool" in Dwingeloo in Dwingeloo and children from schools close to radio telescopes in Australia and South Africa. This exchange was filmed and shown to the audience at the LOFAR inauguration. Five girls from the class assisted Queen Beatrix with the inauguration and this received considerable press coverage.

3.6. IAU Strategic Plan: Astronomy for the Developing World

Miley continued his work as Vice President of the International Astronomical Union with the portfolio "Development and Education". Considerable progress was made in working towards the implementation of the IAU Strategic Plan 2010 – 2020 "Astronomy for the Developing World". This Plan, written by Miley, foresees a substantial expansion of programmes, and funding, together with a large increase in the number of volunteers. Building on the IYA model, the focus will be on a demand-driven coherent mix of sustainable activities. As is stated in the large expansion and strategic approach will require a more suitable organisational structure.

At the heart of the Plan is a Global Office of Astronomy for Development (GOAD). A call for proposals was issued to host to host the Office and the response exceeded expectations. Forty letters of intent were received followed by 20 full proposals, many of which were excellent. In May 2010, the IAU Executive Committee selected the South African Astronomical Observatory as host organisation for GOAD. An agreement was signed in July between the IAU and the South African National Research Foundation, who will co-fund GOAD. Miley was appointed Chair of the GOAD Steering Committee.

3.7. The Leidsch Astronomisch Dispuut 'F. Kaiser'

L.A.D. 'F. Kaiser' has not organised any activity in 2010, but in September the board of Kaiser changed. The new members of the board are: Bart Bijvoets, Joris Hanse, Chris Lemmens. Later in the year Tiffany Meshkat joined as well. With the Old Observatory still closed, the main activities of Kaiser were postponed until the next academic year. Kaiser hopes to organise activities for the bachelor and master students in 2011, such as movie nights and the annual soccer tournament and barbecue on the end of the academic year.

3.8. Vereniging van Oud-Sterrewachters

The 'Vereniging van Oud-Sterrewachters' (VO-S; http://www.vo-s.nl/) is the official association of Sterrewacht/Observatory (ex-)affiliates. It has been in existence for over 15 years now and has seen another active year. As usual, the 150 members were offered a variety of activities. The activities included a social drink prior to the Oort Lecture and an annual meeting. This year, the annual meeting was held in Leiden and involved, among others, a visit of the old Sterrewacht buildings in the centre of Leiden. These buildings are currently under restauration and the attending members received a guided tour of the site by the architect. The meeting was attended by 20 members. VO-S members also received newsletters with Sterrewacht news and were offered an electronic member dictionary.

Appendix I

Observatory staff

Observatory staff

Appendix I

(As of December 31, 2010)

Names, e-mail addresses, room numbers, and telephone numbers of all current personnel can be found on the Sterrewacht website:

http://www.strw.leidenuniv.nl/people

Telephone extensions should always be preceded by (071) 527 … (from inside The Netherlands) or by +31-71-527 … (from abroad)

Full Professors:

E.F. van Dishoeck	G.K. Miley (0.0)
M. Franx	S. Portegies Zwart
V. Icke	H.J.A. Röttgering
F.P. Israel	A.G.G.M. Tielens
K. Kuijken (Director)	P.T. de Zeeuw (0.0)

Full Professors by Special Appointments:

D. van Delft*	(Museum Boerhaave, Stichting tot beheer Museum Boerhaave)
W.J. Jaffe	(Universiteit van Amsterdam)
M. Garrett**	(ASTRON, Sterrewacht, Faculty W&N)
H.V.J. Linnartz	(Stichting Fysica, Vrije Universiteit Amsterdam)
F. van Lunteren	(UL (0.5)/VU (0.3), Teijler's Hoogleraar
H.A. Quirrenbach	(Landessternwarte Heidelberg, Faculty W&N)

* Director Boerhaave Museum

** Director ASTRON

Associate Professors and Assistant Professors / Tenured Staff:

R.J. Bouwens
B.R. Brandl
J. Brinchmann
A. Brown
M. Haverkorn (0.0) *
H. Hoekstra
M.R. Hogerheijde
W.J. Jaffe
P. Katgert (0.0)
M.A. Kenworthy
H.J. van Langevelde (0.0)**
Y. Levin (0.0)***
H.V.J. Linnartz
J. Lub
R.S. Le Poole (0.0)
R. Quadri (0.0)
E.Rossi
J. Schaye
I.A.G. Snellen
R. Stuik (NOVA, Muse)
P.P. van der Werf

Visiting Scientists:

J.K. Katgert-Merkelijn
R. Mathar
M. Spaans (RUG)
R. Stark (NWO)
J.A. Stüwe

Emeriti:

A. Blaauw (†)
W.B. Burton
A.M. van Genderen
H.J. Habing
I. van Houten-Groeneveld
K. Kwee
A. Ollongren
C. Van Schooneveld
J. Tinbergen (†)

* Staff, ASTRON Dwingeloo
** Director, JIVE, Dwingeloo
***Monash University, Melbourne, Australia

Postdocs and Project Personnel:

Name	Funded by	Name	Funded by
C. Arasa Cid	NWO TOP CW	A. Kóspál	NWO-VIDI / NOVA
O.N. Berné	NWO SPINOZA / EU Adv ERC	L. Kristensen	UL
L. Birzan	NWO LOFAR, NOVA	E. Loenen	NOVA/NW1
C. Booth	NWO	M.A. Marosvolgyi	NOVA AMUSE
J.B. Bossa	NWO VICI	J. Meisner	EU OPTICON
C. Brinch	NWO ALLEGRO	R. Meijerink	NWO TAMASIS
G. Busso	UL/NOVA-GAIA	E. Meyer	NOVA
L.R. Carlson	EU Adv ERC	F. Molster	detachering NWO
A. Deep	UL/NOVA	B.D. Oppenheimer	NOVA /NWO VENI
B.A. Devecchi	NWO VICI	S.G. Patel	EU Adv ERC
A. van Elteren	NOVA AMUSE	F.I. Pelupessy	NOVA AMUSE
E. Gaburov	NWO VIDI	D.A. Rafferty	NWO LOFAR, NOVA
S. Giodini	NWO VIDI	F.L. Raicevic	NWO
M.A. Gurkan	NWO VENI	D. Risquez-Oneca	EU-ELSA / UL
J. Guss	SRON/UL	D. Schleicher	ESO ALMA
J. Holt	NWO	E. Semboloni	NWO VIDI
C. Hopman (0.2)	NWO, VIDI	E.D. Tenenbaum	NWO RUBICON
S. Ioppolo	NWO VICI	S. van der Tol	NWO LOFAR
M. Iwasawa	NWO-STARE	N. de Vries	NOVA AMUSE
A. Juhasz	NWO	S.M. Weinmann	EU Adv ERC
T. van Kempen	NOVA/ALLEGRO	J. Zhen	NWO VICI

Name	Funded by	Name	Funded by
N. Amiri	EU ESTRELA / ASTRON JIVE/UL	E.J.W. de Mooij	UL
J.E. Bast	Spitzer /NWO	M. Mosleh	EU ELIXIR / UL
J. Bedorf	NWO	S.V. Nefs	NWO
J. Bourne	EU-ITN Cosmocomp	J.B.R. Oonk	UL
M Brogi	NOVA	B. Pila Diez	NOVA
R.F.J. van der Burg	NWO	T.F. Prod'Homme	EU ELSA / UL
D. Caputo	NWO	A. Rahmati	NOVA
Y. Cavecchi	UL/NOVA	O. Rakic	NWO
N. Clementel	NWO	S. Rieder	NWO
S.H. Cuylle	EU-ITN LASSIE / UL	M.J. Rosenberg	NOVA
M.O. van Daalen	MPA / UL (0,0)	M. Sadatshirazi	UL
A.Elbers	ASTRON / UL	F.J. Salgado Cambiazo	EU A-ERC
E.C. Fayolle	NOVA	J. van de Sande	NOVA
G. Fedoseev	EU-ITN LASSIE	I. San Jose Garcia	EU-ITN Lassie
M. Fumagalli	EU A-ERC	C. Shneider	NWO
R. van Haasteren	NWO	R. Smit	NWO
D.S. Harsono	NOVA/SRON	D.M. Smit	NWO / guest
M.B. van Hoven	UL/NWO	A.H. Streefland	UL/FOM
M. Iacobelli	ASTRON/UL	D. Szomoru	EU A-ERC
K.M. Isokoski	NOVA	K.J.E. Torstensson	EU (ESTRELA) /UL /ASTRON
A. Karska	UL /MPE / EU ITN-LASSIE	E. van Uitert	UL/EU-starting grant
M. Khazandjian	UL	M.B.M. Velander	EU(DUEL) UL
C.J.H. Kruip	NOVA	S. Verdolini	UL
E. Kuiper	NWO	L. Vermaas	NOVA/UL
S. Krijt	UL	F. van de Voort	NWO VIDI
K. Maaskant	NOVA (2 jaar bij UvA)	K.S. Wang	NOVA
A. Madigan	NWO toptalent	R.J. van Weeren	UL/KNAW
J.R. Martinez Galarza	UL /NOVA	M.P.M. Weiss	UL / Teyler's Stichting
I. Martins e Oliveira	Spitzer / UL	U. Yildiz	UL
F. Maschietto	guest		

Support staff:

J.C. Drost	Management assistant
E. Gerstel	Institute manager
A. van der Tang	Secretary
L. van der Veld	Secretary
A.N.G.Pen-Oosthoek	Programme coordinator BSc and MSc

Computer staff:

E.R. Deul	Manager computer group
D. J. Jansen	Scientific programmer
T. Bot	Programmer
A. Vos	Programmer

NOVA office:

E. van Dishoeck	Scientific director
W.H.W.M. Boland	Managing director
K. Groen	Financial controller
J.T. Quist	Management Assistent
F. Molster	Project Manager (ESFRI, NWO)

MSc Students:

A.S. Abdullah
A.H. Bakker
T.C.N. Boekholt
N.A. Bremer
S. van den Broek
J. Figuera
R.T.L. Herbonnet
J. Hu
D.S. Huijser
M.P.H. Israel
R.M.J. Janssen
T.D.J. Kindt
M.J. van der Laan
M. Lameé
N. van der Marel
T.R. Meshkat
G.P.P.L. Otten
W.M. de Pous
C.M.S. Straatman
F.N. Vuijsje
S.T. Zeegers
C.H. Schönau

Senior BSc Students:

K.A.J.B. Beemster
Y.O. van Boheemen
S. Crezee
I.C. Icke
M.J. Luitjens
G.P.P.L. Otten
S.T. Zeegers

Staff changes in 2010:

Name		Funded by	Start	End
C.	Arasa Cid	NWO-TOPCW		31-12-2010
D.M.	Baneke	UL/Gratama St.		30-4-2010
I.M.	Bemmel, van	UL/EU SKADS		31-8-2010
O.N.	Berné	EU - A-ERC / NWO Spinoza	7-1-2010	
J.B.	Bossa	NWO	1-10-2010	
M.A.	Bourne	EU-COSMOCOMP	1-9-2010	
R.J.	Bouwens	EU - A-ERC	1-10-2010	
M.	Brogi	NOVA	1-6-2010	
D.P.	Caputo	NWO	31-5-2010	
L.R.	Carlson	EU-A-ERC / UL	4-10-2010	
N.	Clementel	NOVA	25-1-2010	
H.M.	Cuppen	SPINOZA / NOVA		30-9-2010
S.H.	Cuylle	EU-ITN LASSIE	1-9-2010	
A.	Deep	NOVA		31-12-2010
B.A.	Devecchi	NWO	1-3-2010	
G.	Fedoseev	EU-ITN LASSIE	15-10-2010	
M.	Fumagalli	EU - A-ERC	1-10-2010	
S.	Giodini	NWO-VIDI	1-9-2010	
D.J.	Groen	NWO		30-9-2010
C.H.J.M.	Groothuis	NOVA		8-1-2010
B.A.	Groves	NOVA		31-10-2010
M.R.	Haas	UL		5-6-2010
S.	Harfst	NWO		14-6-2010
M.E.B.	Härnquist-Edling	UL		31-10-2010
D.S.	Harsono	NWO SRON / NOVA	1-9-2010	
H.J.	Hildebrandt	EU-DUEL/NWO		31-8-2010
C.	Hopman (0.1 fte)	NWO	21-6-2010	
S.	Ioppolo (PhD)	NOVA		31-8-2010
S.	Ioppolo (postdoc)	NWO	1-9-2006	
M.	Iwasawa	NWO	21-7-2010	
A.	Johansen	NWO-VENI		1-5-2010
A.	Juhász	NWO	1-4-2010	
M.	Kazandjian	UL	15-1-2010	

Name		Funded by	Start	End
T.A.	Kempen, van	NWO-ALLEGRO	1-8-2010	
S.A.S.	Kendrew	NOVA-METIS		1-11-2010
M.A.	Kenworthy	UL	1-1-2010	
Y.	Levin	UL		3-7-2010
K.M.	Maaskant	NOVA	1-7-2010	
F.	Maschietto	NWO		9-4-2010
R.	Meijerink	NWO	1-1-2010	
E.	Meyer	NOVA	13-12-2010	
B.D.	Oppenheimer	NOVA		31-8-2010
B.D.	Oppenheimer	NWO	1-9-2010	
J.	Paardekooper	NOVA		31-8-2010
S.G.	Patel	EU - A-ERC	11-10-2010	
A.N.G.	Pen-Oosthoek	UL	18-1-2010	
B.	Pila Diez	EU-ITN LASSIE	1-10-2010	
R.F.	Quadri	NOVA		15-10-2010
M.	Raicevic	NWO	2-8-2010	
N.M.	Ramanujam	NOVA		31-3-2010
M.J.	Rosenberg	NOVA	27-9-2010	
E.M.	Rossi	UL/NOVA	1-1-2011	
F.J.	Salgado Cambiazo	EU – A-ERC	27-9-2010	
D.M.	Salter	NWO		30-11-2010
T.R.W.	Schrabback	NWO/KIDS		31-10-2010
D.M.G.	Serre	NOVA		30-4-2010
C.	Shneider	NWO	23-8-2010	
R.	Smit	NWO	1-11-2010	
A.H.	Streefland	FOM / UL	1-12-2010	
A.	Sulevski	UL		31-8-2010
E.D.	Tenenbaum	NWO-RUBICON	14-6-2010	
R.	Visser	NWO-Spinoza		31-12-2010
C.E.	Vlahakis	NWO		31-8-2010
S.M.	Weinmann	EU - A-ERC	1-9-2010	
J.	Zhen	NWO	15-11-2010	

Appendix II

Committee membership

Committee membership

Appendix II

II.1. Observatory Committees

(As of December 31, 2010)

Directorate
(Directie onderzoekinstituut)
K. Kuijken (director of research)
F.P. Israel (director of education)
E. Gerstel (institute manager)

Observatory management team
(Management Team Sterrewacht)
K.H. Kuijken (chair)
E.R. Deul
J. Drost (minutes)
I. Snellen (outreach)
E. Gerstel
F.P. Israel
J. Lub (advisor)

Supervisory council
(Raad van Advies)
J.A.M. Bleeker (chair)
B. Baud
J.F. van Duyne
K. Gaemers
C. Waelkens

Research committee
(Onderzoek-commissie OZ)
M. Franx (chair)
A.G.A. Brown
M. Hogerheijde
W. Jaffe
P.P. van der Werf
vacancy

Research institute scientific council
(Wetenschappelijke raad onderzoekinstituut)

R. Bouwens
B. Brandl
J. Brinchmann
A.G.A. Brown
D. van Delft
E.R. Deul
E.F. van Dishoeck
M Franx
M. Fridlund
M. Garrett
H. Habing
M. Haverkorn
H. Hoekstra
M. Hogerheijde
V. Icke
F.P. Israel
W.J. Jaffe (chair)
P. Katgert
K.H. Kuijken
H.J. van Langevelde
R.S. Le Poole
Y. Levin
H.V.J. Linnartz
J. Lub
F. van Lunteren
G.K. Miley
S. Portegies Zwart
A. Quirrenbach
H.J.A. Röttgering
J. Schaye
I. Snellen
R. Stuik
A.G.G.M. Tielens
P.P. van der Werf
P.T. de Zeeuw

Institute council
(Instituutsraad)

E. Deul (chair)
J. Drost
W.J. Jaffe
H. Hoekstra
M. Hogerheijde
T. Pijloo
E. van Uitert

Astronomy education committee
(Opleidingscommissie OC)

E. van Uitert
M. Franx
E. van Dishoeck
J. Schaye
H. Röttgering
vacancy (minutes)
N.A. Bremer
T. Pijloo
M.C. Segers
A. Vreeker

Astronomy board of examiners
(Examencommissie)

J. Lub (chair)
J. Aarts (Physics)
F.P. Israel
I. Snellen
P.P. van der Werf

Oort scholarship committee

F.P. Israel
J. Schaye
S. Portegies Zwart

Mayo Greenberg Prize committee

G. Miley (chair)
H.V.J. Linnartz
E.F. van Dishoeck
J. Lub
P. Katgert

PhD admission advisory committee

J. Schaye (chair)
H.V.J. Linnartz
F.P. Israel

Graduate student review committee

(Commissie studievoortgang promovendi)

M. Franx (chair)
H. Linnartz
W. Boland
J. Schaye

Colloquia committee

J. Brinchmann
M. Kenworthy

Computer committee

A.G.A. Brown (chair)
M. Smit
B. Brandl

Library committee

W.J. Jaffe (chair)
J. Lub
F.P. Israel

Public outreach committee

F.P. Israel (chair)
J. van de Sande
V. Icke
F. van der Voort
R. van der Burg

Social committee

E. Fayolle
N. van der Marel
T. Meshkat
R. Meijerink
M. Rosenberg
I. Snellen
A. van der Tang

II.2. University Committees (non-Observatory)

(As on December 31, 2010)

Deul
Member Begeleidings Commissie ICT projecten
Chair Facultair Overleg ICT
Member Facultair Beleids Commissie ICT

van Dishoeck
Chair, Faculty Research Committee (WECO)
Member, Raad van Toezicht, Leiden Institute of Physics (LION)

Franx
Member, Faculty Research Committee (WECO)
Director, Leids Kerkhoven-Bosscha Foundation
Director, Leids Sterrewacht Foundation
Director, Jan Hendrik Oort Foundation

Hogerheijde
Member, Board of Directors, Leids Kerkhoven-Bosscha Fonds
Member, Board of Directors, Leids Sterrewacht Fonds
Member, Board of Directors, Jan Hendrik Oort Foundation

Icke
Member, Advisory Council, Faculty of Creative and Performing Arts
Member, Belvédère Committee

Israel
Member, board FWN Graduate School

Kuijken
Chairman, board of directors Leids Sterrewacht Fonds
Chairman, board of directors Oort Fonds
Member, board of directors Leidsch Kerkhoven-Bosscha Fonds
Member, board FWN Graduate School

Linnartz
Member, FMD/ELD user committee
Member, laboratory user group 'FWN nieuwbouw'
Member, Selection Committee, J. Mayo Greenberg Scholarship Prize
Chairman, SLA Exchange Foundation

Van Lunteren
Scientifc Board Scaliger Institute
Historical Committee of Leiden University
Studium Generale Committee Leiden University
Writer-in-residence Committee

Miley
Chairman, Selection Committee, J. Mayo Greenberg Scholarship Prize

Röttgering
Member, Joint Education Committee Physics and Astronomy
Member, Curatorium of the professorship at Leiden University 'Experimental Astroparticle physics'

Schaye
Member, education advisory committee new buildings

Snellen
Member, LUF International Study Fund (LISF) committee

Van der Werf
Member Faculty Council
Organist of the Academy Auditorium

Appendix III

Science policy functions

Science policy functions

Appendix III

Brandl
Member, NOVA Instrument Steering Committee
Principal investigator, METIS (mid-IR instrument for the E-ELT)
Dutch deputy co-I, JWST-MIRI
Co-I, KINGFISH Herschel Open Time Nearby Galaxies Key Project
Member, Spitzer-IRS instrument/science team
Deputy PI, Palomar AO camera (PHARO)

Brinchmann
Member, ESA Astronomy Working Group (AWG)
Member, ESO FP7 coordinating action on Wide-field imaging with the E-ELT
Member, OPTIMOS-DIORAMAS Science Team

Brown
Member, Organizing Committee IAU Commission 8
Member, IAU Commission 37
Member, Gaia Science Team
Member, EU MC RTN European Leadership in Space Astrometry (ELSA)
Member, Steering Committee ESF-RNP Gaia Research for European Astronomy Training (GREAT)

van Delft
Member, commissie wetenschapsgeschiedenis KNAW
Member, jury Huijbrechtsenprijs, Avond van wetenschap en maatschappij
Member, Nederlandse Maatschappij der Letterkunde
Member, (directeur) Hollandsche Maatschappij der Wetenschappen
Member, Interdisciplinary Program Board Lorentz Center / NIAS
Member, organisatiecomité KunstWetenschapSalon
Member, adviesraad tijdschrift NWT (Natuur, Wetenschap en Techniek)
Member, Raad van Advies Jaarboek KennisSamenleving
Ambassador Platform bètatechniek
Member, begeleidingscommissie Digitaal Wetenschapshistorisch Centrum,

Huygens Instituut
Member, comité van aanbeveling Science Café Leiden
Member, bestuur Nederlands Natuur- en Geneeskundig Congres
Member, Adviesraad Stichting Technolab, Leiden
Member, Raad van Toezicht Stichting RINO, Leiden

Van Dishoeck
Scientific Director, Netherlands Research School for Astronomy (NOVA)
Co-Editor, Annual Reviews of Astronomy & Astrophysics
Member, ALMA Board
Member, SRON Board
Member, Search committee SRON director
Member, National Committee on Astronomy (NCA)
Member, MPIA-Heidelberg Fachbeirat
Member, IRAM visiting committee
Member, Herschel-HIFI Science team
Co-PI, European JWST-MIRI consortium
Chair, IAU Working Group on Astrochemistry
Vice-president, IAU Commission 14
Coordinator, Herschel-HIFI WISH Key Program
Chair, Scientific Organising Committee, IAU Symposium 280, 'The Molecular Universe', Toledo, Spain

Haverkorn
Chair, Multi-wavelength coordination working group for ASKAP Survey POSSUM
Chair, LOFAR MKSP Galactic Magnetism working group
Member, LOFAR Cosmic Magnetism Key Science Project
Member, LOFAR Surveys Key Science Project
Member, management team Arecibo GALFACTS survey
Member, SOC workshop 'The Dynamic Interstellar Medium'
Chair, SOC/LOC LOFAR MKSP project meeting, April
PI, Southern Twenty-cm All-sky Polarization Survey
Co-I, Galactic Magneto-Ionized Medium Survey
Co-I, S-band Polarization All-sky Survey

Hoekstra
Member, Time Allocation Committee Island Telescopes
Member, Allocation Committee NWO "vrije competitie"

Hogerheijde
Member, ALMA Science Advisory Committee
Member, ALMA European Science Advisory Committee
Member, ALMA Science Integrated Project Team

Member, ALMA European Regional Center Coordinating Committee
Member, IRAM Programme Committee
Project Scientist for CHAMP+/Netherlands
Co-coordinator, JCMT Gould Belt legacy Survey
Secretary/treasurer, Board of Directors Leids Kerkhoven-Bosscha Fonds
Secretary/treasurer, Board of Directors Leids Sterrewacht Fonds
Secretary/treasurer, Board of Directors Jan Hendrik Oort Fonds

Israel
Member at large, NL-Lofar Astronomy Consortium
Coordinator-NL SCUBA2 Nearby Galaxies Legacy Survey
Member, IAU, Commissions 28, 40 and 51
Member, Science Team Herschel-HIFI
Member, Science Team APEX-CHAMP+
Member, Science Team JWST-MIRI
Member, Editorial Board Europhysics News
Member, LOCNOC

Kristensen
Member, Herschel User's Group (HUG)

van Langevelde
Member, consortium board European VLBI Network
Member, RadioNet Board and Executive Board
Coördinator, NEXPReS (Novel EXploration Pushing Robust e-VLBI Systems), board and management team
PI, RadioNet reserach activity ALBiUS (Advanced Long Baseline Interoperable User Software)
Member, board PrepSKA (Prepatory SKA studies)
Member, European SKA Consortium
Member, NOVA Instrumentation Steering Committee
Member, Dutch URSI committee
Member, board of directors Leids Kerkhoven Bosscha Fonds
Member, board of directors Leids Sterrewacht Fonds
Member, board of directors Jan Hendrik Oort Fonds
Member, SKA klankbordgroep NL
Member, Allegro steering committee

Linnartz
'SPIN' chair for Molecular Laboratory Astrophysics, Laser Center Vrije Universiteit, Amsterdam
Editor CAMOP (Comments on Atomic, Molecular and Optical Physics), part of Physica Scripta

Workgroup leader, FOM group FOM-L-027
Research coordinator, FP7 ITN 'LASSIE' (Laboratory Astrochemical Surface Science In Europe)
Member, NWO-EW/CW 'DAN' (Dutch Astrochemistry Network)
Member, NWO-EW 'Vrije Competitie' allocation committee
Member, NWO-CW 'Spectroscopy and Theory'
Member, NWO-FOM 'COMOP'' (Condensed Matter and Optical Physics)
Member, HRSMC research school
Chairman, Infrared Plasma Spectroscopy Meeting 2010APPENDIX III - Science Policy Functions

Lub
Secretary Nationaal Comité voor Astronomie (NCA)
Member Board of Editors Astronomy and Astrophysics

Van Lunteren
Education and Research Board Huizinga Institute

Miley
Vice President, International Astronomical Union (Education and Development)
Chair, International Universe Awareness Steering Committee
Chair, LOFAR Research Management Committee
Chairman, LOFAR Survey Science Group, Highest Redshift Objects
Chair, Review Committee, South African National Research Foundation Astro-Geosciences Facilities
Trustee, Associated Universities, Inc. (AUI- managing body of US National Radio Astronomy Observatory)
Member Executive Committee International Astronomical Union
Member, Advisory Panel on Astronomy to the South African Minister for Science and Technology
Member, European Research Council, Selection of Advanced Grant Awardees
Member, UK South Eastern Universities Physics Network (SEPNET) Scientific Advisory Committee
Member, LOFAR Astronomy Research Committee
Member, Board of Governors of the LOFAR Foundation
Member, Max Planck Institut fur Radioastronomie Fachbeirat
Member, Core Team, LOFAR Surveys Key Project

Portegies Zwart
Member, Rhine Network, pan-European N-body community
Member, PRACE Scientific Steering Committee
Member, Lorentz Center, Computational Science board member

Member, NWO, proposal call "Complexity" committee
Member, ESF, International review commission board representative, ASTROSIM
Virtual European Ambassador, MICA
Member, NWO-VIDI review committee
Member GAIA science advisory board
Member, KNAW computational science action group
Key researchers NOVA (Network 3)
Beta Ambassador for the Netherlands
NOVA ISC, reporting on AMUSE progress

Röttgering
Key researcher NOVA research school
Member, ASTRON Science Advisory Committee
Member, Science team MID-infrared Interferometric instrument for VLTI (MIDI)
Member, XMM Large Scale Structure Survey Consortium
PI, DCLA (Development and Commissioning of LOFAR for Astronomy)
Member, LOFAR Technical Working Group
Member, LOFAR Astronomy Development (LAD) board
Member, LOFAR Astronomy Research Committee (ARC)
Member, Selection panel NWO's Rubicon program.
Member, Spitzer warm legacy survey project SERVS
Member, Euclid consortium board
Member, ESO science team for Gravity and Matisse
Member, Herschel TAC

Schaye
Member of the steering committee, Virgo Consortium for cosmological supercomputer simulations
Co-Investigator, MUSE (Multi Unit Spectroscopic Explorer)
Key researcher, NOVA
Member, MUSE science team
Member, LOFAR Epoch of Reionization science team
Member, ISTOS science team (Imaging Spectroscopic Telescope for Origins Surveys)
Member, Xenia science team (A probe of cosmic chemical evolution)
NL-representative, Euro-VO Data Center Alliance, Theoretical astrophysics expert group
Member, Scientific Organizing Committee, "Cosmological reionization", Allahabad, India
Member, Scientific Organizing Committee, "Gas in galaxies: from cosmic web to molecular clouds", Seeon, Germany

Member, Scientific Organizing Committee, "The cosmic odyssey of baryons: accreting, outflowing and hiding", Marseille, France
Member, Scientific Organizing Committee, "The physics of galaxy formation", Durham, UK
PI, OWLS collaboration (OverWhelmingly Large Simulations)
PI, EAGLE collaboration (Evolution and Assembly of GaLaxies and their Environments)

Snellen
Member, PLATO consortium
Member, ECHO science team
Member, METIS consortium
Board member, Nederlandse Astronomen Club

Stuik
Associate member, OPTICON Key Technologies Network
Member, FP7 Network “Wide field imaging at the E-ELT: from GLAO to diffraction limit”

Tielens
Co-chair Scientific Organizing Committee, “PAHs and the Universe: A symposium to celebrate the 25th anniversary of the PAH hypothesis
Co-chair Scientific Organizing Committee, “Herschel and the Formation of Stars and Planetary Systems”
Member Scientific Organizing Committee, “Conditions and Impact of Starformation: New Results with Herschel and Beyond”
Member Scientific Organizing Committee, “COST - The Chemical Cosmos, Annual Conference”

Van der Werf
Member, James Clerk Maxwell Telescope Board
Principal Investigator, SCUBA-2 Cosmology Legacy Survey
Principal Investigator, Herschel Comprehensive ULIRG Emission Survey
Co-investigator, HIFI
Co-investigator, MIRI
Member, METIS Science Team
Member and co-chair of Galaxies Panel, ESO Observing Programmes Committee
Member, STFC Herschel Oversight Committee
Member, Scientific Organizing Committee of 2 international conferences
Member, TAMASIS Network

Appendix IV

Workshops, lectures and colloquia in Leiden

Workshops, lectures and colloquia in Leiden

Appendix IV

IV.1. Workshops

Most of the workshops were held in the Lorentz Center, an international center which coordinates and hosts workshops in the sciences. In 2010 the Leiden astronomers contributed to the following workshops there:

January 25 - 29
Analysing first imaging data from LOFAR
K. Chyzy, P. Best, R. Morganti, M. Jarvis, G. Brunetti, I. Snellen, P. Barthel, G. Miley, J. Conway, M. Bruggen, H. Röttgering, M. Lehnert

February 22 – 26
Formal theories of communication
J. van Benthem, R. Ramanujam, R. Verbrugge

March 8 – 12
Surveying the low frequency sky with LOFAR
K. Chyzy, P. Best, R. Morganti, M. Jarvis, G. Brunetti, I. Snellen, P. Barthel, G. Miley, J. Conway, M. Bruggen, H. Röttgering, M. Lehnert

April 19 – 23
How to weigh clusters of galaxies
H. Hoekstra, A. Babul, A. Mahdavi

May 3 – 13
Advanced School and Workshop on Computational Gravitational Dynamics
S. Portegies Zwart, S. McMillan, A. Quillen, J. Stadel

June 14 – 16
Emergence of the Hubble Sequence $1<z<3$
R. Ellis, M. Franx

June 21 – July 2
IPTA 2010: Detecting Gravitational Waves with Pulsars
P. Demorest, L.S. Finn, Y. Levin, B. Stappers, D. Stinebring

Additional meetings:

Feb 8
Star Formation: near and far
E.F. van Dishoeck

Apr 26 – 39
Lofar Busy Week
H. Röttgering

Apr 27 – 30
Herschel Wish Team Meeting 2010
E.F. van Dishoeck

May 2 – 3
Herschel DIGIT Meeting

Dec 13 – 17
Second AMUSE meeting and workshop
De Vries, Marosvolgyi

IV.2. Endowed Lectures

Date	**Speaker**	**Title**
Apr 29	Richard S. Ellis	Cosmic Dawn – The Search for the First Galaxies
Oct 28	Linda J. Tacconi	Gas Dynamics, Galaxy Assembly and Star Formation in the early Universe

IV.3. Scientific Colloquia

Date	Speaker (affiliation)	Title
Jan 14	Anna Watts (Univ. of Amsterdam)	*Might of the living dead 0 the violent afterlife of neutron stars*
Jan 21	Mike Hudson (Univ of Waterloo)	*The star formation histories of red galaxies*
Jan 28	Huib Intema (Leiden Observatory)	*Radio Interferometry beyond metre-wavelengths: wide fields, ionosphere and interference*
Feb 11	Andrea Merloni (MPE Garching)	*The impact of supermassive black holes growth for structure formation and cosmology*
Feb 25	Ciska Kemper (Jodrell Bank Centre for Astrophysics, Manchester)	*The dusty interstellar medium of galaxies*
Mar 4	Pat Cote (Herzberg Institute of Astrophysics)	*Scaling Relations for Early-Type (Red Sequence) Galaxies in the Virgo and Fornax Clusters*
Mar 8	Sijme-Jan Paardekooper (DAMTP, Cambridge)	*New insights in planet migration*
Mar 10	Michela Mapelli (Univ of Milano-Bicocca)	*Galaxie clashes and peculiar galaxies*
Mar 12	Ciska Kemper (Jodrell Bank Centre for Astrophysics, Manchester)	*Written in stone: Dust formation in the universe*
Mar 15	Ian McCarthy (Kavli Institute for Cosmology, Cambridge)	*The Physics of the Intracluster Medium*
Mar 17	Elena Rossi (Hebrew Univ, Jerusalem)	*Formation and growth of Supermassive Black Holes*
Mar 18	Joel Bregman (Univ of Michigan)	*The Missing Baryons from Galaxies and Clusters*
Mar 19	Herma Cuppen (Leiden Observatory)	*Chemistry on interstellar grains as tools to constrain physical parameters in star forming regions*
Mar 22	Philip Chang (Canadian Institute for Theoretical Astrophysics)	*Morphological Mysteries on Multiple Scales*
Mar 23	Mario Soto Vicencio (Leiden Observatory)	*3-Dimensional Dynamics of the Galactic Bulge (PhD colloquium)*
Mar 24	Rubina Kotak (Queen's Univ Belfast	*Supernovae progenitors and dust production: variations on a theme*
Mar 25	Sara Seager (MIT)	*Exoplanet Atmospheres: from Discovery to Charactarization and Beyond*
Mar 26	Pedro Lacerda (Queen's Univ Belfast)	*The Frontier of our Solar System*
Apr 8	Sadegh Khochfar (MPE, Garching)	*The formation of massive galaxies: A tale of cold accretion and mergers*
Apr 28	Marc van der Sluys (Univ of Alberta	*Gravitational-wave astronomy with LIGO and Virgo*

May 12	Robert Wiersma (Leiden Observatory and MPA Garching)	*Simulating Enrichment of the Intergalactic Medium (PhD colloquium)*
May 27	John Bally (Department of Astrophysical and Planetary Sciences, Univ. of Colorado	*Massive Star & Cluster Formation from Orion, to the Galactic Center, and Beyond*
June 3	Maaike Damen (Leiden Observatory	*The build-up of massive galaxies*
June 10	Estelle Bayet (Univ College London)	*Extragalactic star formation activity*
June 17	Thimothy S. Beers (Michigan State Univ)	*The Metallicity Distribution Function(s) of Halo Stars as Revealed by SDSS/SEGUE*
Sep 7	Marcel Haas (Leiden Observatory)	*Nature versusnurture in galaxy formation simulations (PhD colloquium)*
Sep 24	Alicia Soderberg (Harvard Univ)	*A Panchromatic Approach to the GRB-SN Connection*
Sep 28	Derek Groen (Leiden Observatory)	*Simulating N-body systems on planet-wide infrastructures (PhD colloquium)*
Sep 30	Marijke Haverkorn (ASTRON/Leiden)	*Unraveling the magnetized interstellar medium*
Oct 5	Tomasso Treu (UC Santa Barbara)	*Dark matter and black holes over cosmic time*
Oct 7	Jordy Bouwman (Leiden Observatory)	*Spectroscopy and Chemistry of Interstellar Ice Analogues (PhD colloquium)*
Oct 21	Demerese Salter (Leiden Observatory)	*Millimeter Emission from Protoplanetary Disks: Dust, Cold Gas, and Relativistic Electrons (PhD colloquium)*
Nov 4	Ted Gull (NASA/GSFC)	*Eta Carinae: A Box of Puzzles … Some Solved by 3D Modeling, Others Await*
Nov 9	Sergio Ioppolo (Leiden Observatory	*Surface formation routes of interstellar molecules – A Laboratory Study (PhD colloquium)*
Nov 11	Rajesh Kochhar (Indian Institute of Science Education and Research Mohali, Chandigarh	*Scriptures, science and mythology: Ancient Indian astronomical interplay*
Nov 16	Daniel Savin (Columbia Univ)	*The Genesis Projects: Laboratory Studies in Molecular Astrophysics from the First Star to the Beginnings of Organic Chemistry*
Nov 25	Leonardo Testi (ESO)	*Circumstellar disks structure and evolution: the dawn of planetary systems*
Dec 2	Guinevere Kauffmann (MPA, Garching)	*Towards an Understanding of Gas Accretion and Star Formation in Galaxies*
Dec 14	Jan-Pieter Paardekooper (Leiden Observatory/MPE)	And there was light Voronoi-Delaunay radiative transfer and cosmic reionisation (PhD colloquium)
Dec 16	Scott Chapman (IoA, Cambridge)	*The extremes of the high-z ULIRG population: bright SMGs from the south pole telescope, and hot dust dominated Herschel ULIRGs.*

IV.4. Student Colloquia

Date	Speaker	Title
June 21	Daniel Harsono	*Star Formation in Serpens Molecular Cloud*
June 28	Marcel van Daalen	*The Effects of Baryons on the Matter Power Spectrum*
June 28	Annelies Mortier	*Properties of Stars with protoplanetary disks in the Lupus Cloud*
July 5	Wouter Schrier	*Optical secondary eclipse observations of an exoplanet*
July 5	Sweta Shah	*Mass-size relation of Galaxies from the Semi-Analytic Models*
Sep 6	Michiel Lambrechts	*The Rotation Measure Fingerprint of a Galactic Radio Loop*
Sep 20	Reinier Janssen	*Submicron Kinetic Inductance Detectors for SAFARI*
Sep 27	Juan David Delgado	*Accounting for noise biases in KSB+*
Sep 30	Alexander Shulevski	*LOFAR Observations of the Radio Galaxy 3C 61.1*
Oct 5	Renske Smit	*A study of scatter in Galaxy Cluster observations*
Oct 18	Arthur Bakker	*Mid-infrared spectroscopy of a deeply embedded massive YSO*

IV.5. Colloquia given outside Leiden

Amiri
W43A: magnetic field and morphology
Lake District, UK; June 20-25

Baneke
Dutch-American Coöperation in Space: the Story of ANS and IRAS
National Air and Space Museum, Washington DC, USA; Nov 30

Bast
Exploring the chemical and physical structure of terrestrial planet-forming zones in protoplanetary disks with CO line profiles
NASA Goddard Space Flight Center, Greenbelt, USA; Aug 5
New Probes of Physics and Chemistry in the Inner Regions of Planet-Forming Disks
ESA-ESTEC, Noordwijk, Netherlands; Oct 29

Berné
Properties of PAHs in the ISM and galaxies
Oxford University Astronomy Dpt., UK; Feb 10
PAHs in the universe
ESA-ESTEC, Noordwijk, Netherlands; Feb 3
The shape of the PAH spectrum in the universe
PAH Symposium, Toulouse, France; June 31
Fusion of mid-IR ground- and space-based observation using non-negative matrix factorization
IEEE-WHISPERS, Reijkyavik, Iceland, June 12

Bouwens
What we can learn about the build-up and evolution of galaxies at early times from the new WFC3/IR observations
Harvard University, USA; Dec 2
Idem, National Radio Observatory, USA; May 7
Idem, Herzberg Institute for Astronomy, Canada; Apr 20
Idem, Stanford University, USA; Jan 21
Early Galaxy Build-up: >100 z~7-8 galaxies with WFC3/IR and the evolution of the UV LF from z~7-8 to z~1
Penn State University, USA; June 8
High-Redshift Galaxy Formation with WFC3/IR: A guide to future work with JWST and the ELTs
Garching, Germany; Apr 14
Star Formation Rate Density at z>3
Tucson, USA; Mar 16
UV colors of z~2-7 Galaxies: Luminosity Functions of z~7-8 Galaxies
Austin, USA; Mar 11
UV colors of z~2-7 Galaxies: Luminosity Functions of z~7-8 Galaxies
Aspen, USA; Feb 8
z~7 Galaxies from ultra-deep WFC3/IR observations of the HUDF: What about their UV colors?
Washington, USA; Jan 6

Brandl
Mid-IR Instrumentation for the Future: METIS and MIRI
Cornell University, USA; Oct 4
Instrument concept and science case for the mid-infrared E-ELT imager and spectrograph METIS
San Diego, USA; July 2

Brinch
The ALMA challenge: Modeling high-resolution observations of young stars
University of Copenhagen, Copenhagen, Denmark; Apr 19

Brinchmann
The gas content of SDSS galaxies
ETH, Zürich, Switzerland; Apr 8

Devecchi
Formation of supermassive black hole seeds in high redshift nuclear clusters
ESO Garching, June 25

van Dishoeck
Molecules in star- and planet-forming regions: from ice cold to steaming hot
Cambridge University, Cambridge, UK; Jan 28
From protostars to protoplanets: synergy of IR and mm
European Southern Observatory, Santiago, Chile; Apr 6
Molecules in star- and planet-forming regions: from ice cold to steaming hot
ETH, Zürich, Switzerland; Apr 23
From molecules to planets
Star and planet formation center, Copenhagen, Denmark; May 10
A WISH come true: water in star-forming regions with Herschel
University of Michigan, Ann Arbor, USA; May 21
Idem, Caltech, Pasadena, USA; June 28
Idem, European Southern Observatory, Garching, Germany; Oct 19
Idem, University of Chile, Santiago, Chile; Nov 15

Elbers
Early radio astronomy in the Netherlands
ASTRON, Dwingeloo, The Netherlands; Jan 27
Funding radio astronomy in The Netherlands: 1945-1960
British Society for the History of Science, Aberdeen, Scotland; July 23
Funding radio astronomy in postwar Netherlands: Dutch radio astronomers and the Organisation for Pure Scientific Research
Belgian Society for Logic and Philosophy of Science, Brussels, Belgium; Sep 6
Science and national prestige: early Dutch radio astronomy
European Society for the History of Science, Barcelona, Spain; Nov 18
Funding the new field of radio astronomy in postwar Netherlands
Centre for History of Science (Ghent University), Ghent, Belgium; Dec 3
Mineralogie aan de Universiteit Gent van 1817 tot heden
Mineralogische Kring Antwerpen, Schilde, Belgium; Dec 3

Fayolle
Thermal Desorption of Ices Around Protostars
LPMAA - Univ. P&M Curie, Paris, France; Mar 18

Groves
Fitting the SEDs of Galaxies
Institute d'Astrophysics Paris, France; Jan 19
Starburst SED modeling near and far
Royal Astronomical Society, London, UK; Mar 12

Gürkan
An Application of Fractals to Stellar Dynamics
Sabanci University, Istanbul, Turkey; Feb 24
Idem, Department of Astrophysics, Radboud University Nijmegen; Nov 09

Hoekstra
Weak lensing by large scale structure
Oskar Klein Center, Stockholm, Sweden; Aug 31
Measuring masses: from galaxy clusters down to galaxies
UVic, Victoria, Canada; Nov 26

Icke
Eta Carinae, Past and Present
Invited Lecture, APN5 Conference; June 23
Cosmology Requires New Physics
FMF Congres, Groningen, Netherlands; Nov 18
Communicating Science
Keynote speech, Bucharest, Romania; Dec 6

Ioppolo
Laboratory Pathways to Molecular Complexity in Space: The Case of Water
NAC, Nijmegen-Cuijk, Netherlands; May 20
Laboratory Study of Surface Reactions in Interstellar Ice Analogues: HCOOH Formation at Low Temperatures,
ECOSS 27, Groningen, The Netherlands; Aug 30
Surface Formation Routes of Interstellar Molecules: The Case of Water
Jena University, Eisenach, Germany; Oct 15

Israel
Anomalous Dust in Late-Type Galaxies
Zermatt Symposium, Zermatt, Switzerland; Sep 21
Idem, CalTech, Pasadena, USA; Nov 2

Kenworthy
Thermal Imaging of Extrasolar Planets
Dutch Astronomy Meeting; May 20
Developing Achromatic Coronagraphic Optics for LMIRCam and the LBT
SPIE Instrumentation Conference, San Diego, USA; July 3
Looking for Planets around A Stars with Thermal Imaging
Nijmegen, Netherlands; Sep 14
Direct and Coronagraphic Thermal Imaging of Extrasolar Planets
Amsterdam, Netherlands; Sep 24
The Arizona MMTO survey for giant planets around A stars
Spirit of Lyot Conference, Paris; Oct 25
Direct Imaging of Extrasolar Planets at Thermal Wavelengths
University of Nottingham; Nov 3

Kóspàl
Irregular variability during early stellar evolution: what can we learn about the circumstellar material?
Institute of Astronomy, University of Cambridge, Cambridge, United Kingdom; June 24
Észleljünk ALMA-val!
Konkoly Observatory, Budapest, Hungary; Dec 21

Kristensen
Mapping molecules in star-forming regions: paving the way for Herschel and tracing energetics
ESO Garching, Munich, Germany; Apr 6

Linnartz
Unlocking the chemistry of the heavens
Astronomical Institute Jena, Jena, Germany; Feb 12
Pathways towards molecular complexity in space
NASA-AMES, Moffett Field; Mar 19
Unlocking the chemistry of the heavens
ACS meeting, San Francisco; Mar 24
Pathways towards molecular complexity in space
NEVAC 2010, Delft, Netherlands; Apr 8
News from the DIB front; ISM/CSM meeting
Amsterdam, Netherlands; June 2
Animations in astronomy, Kliksymposium
Amsterdam, Netherlands; Sep 19
Solid state astrochemistry in the Netherlands

Kick-off meeting Dutch Astrochemistry Network, Utrecht, Netherlands; Sep 28
Astrochemistry and laboratory astrophysics
Radboud University, Netherlands; Oct 28
Unlocking the chemistry of the heavens
Academia dei Lincie, Rome, Italy; Nov 4
Plasma techniques in laboratory astrophysics
WELTPP2010, Rolduc, Netherlands; Nov 25

Loenen
Exciting CO in Mrk 231: Black Hole Accretion or Star Formation?
Herschel First Results Symposium, Noordwijk, The Netherlands; May 7
idem, Molecules in Galaxies, Oxford, United Kingdom; July 26
Herschel observations of Messier 82, Great Barriers in High Mass Star Formation
Townsville, Australia; Sep 13

van Lunteren
Georg Marcgraf and the Seventeenth-Century Scientific Revolution
Symposium Georg Marcgraf in Dutch-Brazil, Leiden; Sep 23
Causality, contingency and human agency in the history of science: some methodological considerations
Colloquium Exploring New Vistas in Historiography of Science, Leiden; Oct 7

Madigan
A new instability of eccentric stellar disks around supermassive black holes
AEI, Berlin, Germany; Jan 27
Secular stellar dynamics near massive black holes
Monash University, Melbourne, Australia; Dec 7

Martínez-Galarza
SED modeling as a probe of physical conditions in Starbursts: 30 Doradus as a benchmark
Lowell Observatory, Flagstaff, AZ, USA; Nov 23
New developments in starburst SED modeling: using 30 Doradus as a benchmark
Arizona State University, Tempe, AZ, USA; Nov 22
Idem, National Optical Astronomy Observatory (NOAO), Tucson, AZ, USA; Nov 19

Miley
Probing the Early Universe with Radio Galaxies
IAC, Teneriffe, Spain; Jan 26
The IAU Strategic Plan: Astronomy for the Developing World
SAAO, Cape Town, South Africa; July 28

Oliveira
Tracing the Evolution of Dust in Protoplanetary Disks
STScI, Baltimore, USA; Nov 15
Idem, UT Austin, Austin, USA; Nov 17
Idem, IfA, Honolulu, USA; Nov 19
Idem, UC Berkeley, USA; Nov 22

Portegies Zwart
Real Science in Virtual Worlds
KNAW, invited talk; Mar 18

Rakic
Gas in the Vicinity of Star-Forming Galaxies at z~2-2.5
UC Santa Cruz, USA; Nov 30
Idem, UC San Diego, USA; Dec 6
Idem, CfA Harvard, USA; Dec 10

Risquez
Serial Register Analysis Planning
University of Barcelona, Barcelona, Spain, Oct 18
The Gaia Attitude Model
University of Barcelona, Barcelona, Spain, June 7

Schaye
Self-regulated evolution of galaxies and supermassive black holes
Institute of Astronomy, Cambridge, UK; Apr 29
Idem, University of Texas, Austin TX, USA; Nov 22

Schleicher
Dynamos during primordial star formation
KIPAC, Stanford, USA; June 15
Magnetizing the Universe: Dynamo amplification and 21 cm constraints
MPE, Garching, Germany; June 22
Dynamos during primordial star formation
IAP, Paris, France; Sept 1

Semboloni
Weak lensing statistics
Albert Einstein Institute (MPI), Berlin, D; March
COSMOS: three-point shear statistics
NAC, Netherlands; Apr

Weak lensing statistics
University of British Columbia, CA; June
COSMOS: three-point shear statistics
Edinburgh, UK; July 23

Snellen
Transiting extrasolar planets
University of Bristol, Bristol, UK; Dec 6

Tielens
Astromaterial sciences
Physics department, University of Basel, Switzerland; Mar 18
PAHs and star formation
Pannekoek Institute, University of Amsterdam; Netherlands; Apr 23
Large Molecules in Space
Chemistry department, University of Gothenburg, Sweden, Oct 12
Nanomaterials in space
Physics department, University of Gothenburg, Sweden; Oct 26
PAHs and star formation
Astronomy Department Stockholm University, Sweden; Nov 18

Van Uitert
Weak lensing in the RCS2 survey
DUEL meeting, Ringberg, Germany; Jan
Idem, NAC, Cuijk, The Netherlands; May
*Idem, I*nstitute for Astronomy, Edinburgh, UK; July
Idem, DUEL meeting, Sorrento, Italy; Oct 2010

Visser
Chemical Evolution from Cores to Disks
University of Michigan, Ann Arbor, MI, USA; Jan 19
Idem, University of Texas, Austin, TX, USA; Jan 20
Idem, CalTech, Pasadena, CA, USA; Jan 26
Idem , CfA, Cambridge, MA, USA; Jan 29
Idem , NASA Goddard, Greenbelt, MD, USA; Feb 1
Idem , Carnegie Institution, Washington, D.C., USA; Feb 2
Modelling the Hot Gas Observed in Low-Mass YSOs with Herschel
TU Delft, Netherlands; Nov 24

van de Voort
The growth of haloes and galaxies
CRAL, Lyon, France; May 28

van Weeren
Shock acceleration in CIZA J2252.8+5301
UNS CNRS OCA Laboratoire Cassiopee, Nice, France; Nov 16
The largest collision in the Universe
University of Groningen, Groningen; Nov 9

Wehres
The Red Rectangle proto planetary nebula
Laser Center VU Amsterdam, The Netherlands; Apr 26
Optical Spectroscopy of interstellar and circumstellar molecules - a combined laboratory and observational study
Kapteyn Astronomical Institute, The Netherlands; Feb 7
Idem,, Joint Institute for laboratory Astrophysics (JILA), University of Colorado at Boulder, USA; Feb 15
idem, Nasa Ames, USA; Feb 18

Weiss
Teylers Museum in de 19de Eeuw: Kabinet voor Liefhebbers, Laboratorium voor Wetenschappers, of Museum voor het Publiek?
Teylers Museum, Haarlem, Netherlands; Mar 11
The Masses and the Muses
Huygens Institute, The Hague, Netherlands; May 7
Talk3, Visitors Welcome: Teylers Museum around 1800, British Society for the History of Science
Aberdeen, Scotland; July 24
With a Little Tacit Encouragement
Teylers Museum, Palaeontological and Mineralogical Collections, Museums and Galleries History Group, Leeds, England; Sep 10
You say musaeum, I say museum
History of Science Society, Montréal, Canada; Nov 5

Van der Werf
Fingerprinting (Ultra)luminous infrared galaxies
Institute for Astronomy, Edinburgh, Scotland; Sep 15
Idem, Oxford University, Oxford, England; Oct 5
Idem, John Moores University, Liverpool, England; Nov 3

Appendix V

Grants

Grants

Appendix V

Baneke
Guggenheim Fellowship, Smithsonian Institution, '*Dutch-American Cooperation in Space?'*, $ 10.500

Berné
British Council Partnership Fellowship, £ 650

Brown
Marie Curie Initial Training Network, EU, '*Gaia Research for European Astronomy Training*', € 4.250.000 (13 partners, € 500.000 to Leiden)

Van Delft
FOM, '*PhD project Kistemaker*'; € 100.000

van Dishoeck
Dutch Astrochemistry network, NWO, '*Photodissociation and excitation in protoplanetary disks*', € 203.693
Profileringsfondsen, UL, '*Fundamentals of Science*', € 1.000.000 (together with Leiden Institute for Physics (LION) and Mathematical Institute (MI)

Franx
Spinoza, NWO, € 2.500.000

Icke
'Bezoekersbeurs', NWO '*The Astrophysics of Eta Carinae*'. Visitor: Prof. dr. T. Gull. €5.445

Kenworthy
EU-IRG, *'Direct Imaging of Extrasolar Planets from LBT and VLT to E-ELT'* , € 100.000

van Langevelde
Combination of Collaborative Project and Coordination and Support Action, EC DG-INFSOC, '*Novel EXploration Pushing Robust e-VLBI Systems (NEXPReS'*); € 3.500.000 (NEXPReS is comprised of 15 partner institutes in eleven countries and is coordinated by JIVE, ASTRON).

Linnartz
VICI, NWO, '*Unlocking the Chemistry of the Heavens*', € 1.500.000
FP7 ITN, EU, '*LASSIE: Laboratory Astrochemical Surface Science in Europe*', € 6.050.000 (13 partners, € 500.000 to Leiden)
Dutch Astrochemistry Project, NWO, '*Shining light on molecules*', € 200.000
Van Gogh, Frans Nederlandse Academie, Laboratory astrophysics, € 3600

Oppenheimer
VENI, NWO, '*Fourteen Billion Years of Baryonic Galaxy Formation'*. €250.000

Röttgering
NWO-TOP, NWO, '*Probing the formation and evolution of galaxies and clusters of galaxies with LOFAR*', € 750.000
ASTRON, 2 LOFAR PhD projects, € 300.000
NWO, Humboldt fellowship for Prof. Brüggen, € 16.000

Schaye
PI, NWO open competition, '*Simulating cosmological reionization*', € 221.635

Schleicher
HPC Europa2, *EU, 'Simulating the Central Regions of Active Galaxies at High Redshift'*; € 1.700 + 50k CPU hrs

Snellen
Vrije competitie, NWO, *'The atmospheres of extrasolar planets'*, € 201.600

Tenenbaum
Rubicon, NWO, '*Ultraviolet Induced Chemistry in Interstellar Ices*', € 55.000

Tielens
ERC-advanced grant, European Research Council, *'The Role of Large Polycyclic Aromatic Hydrocarbon Molecules in the Universe'*, € 2.400.000
Dutch Astrochemistry Project, NWO, *'Astronomical implications'* , € 104.000

Van der Werf
Distinguished Visitor Grant, Scottish Universities Physics Association, *Molecular gas in submillimetre galaxies*, GBP 7000

Appendix VI

Observing time

Observing time

Appendix VI

VI. Observing time

Amiri
Green Bank Telescope, *The role of the magnetic field on the mass loss in AGB stars*, 6 hrs
JCMT Observations, *High rotational transition of SiO masers in evolved stars*
Effelsberg Observations, *On the lifetime of H2O masers at the tip of the Asymptotic Giant Branch, September 2009*, 15 hrs

Berne
Herschel, *Spectrocopic survey of the extraordinary disk Gomez's Hamburger*, 10 hrs
VLT-VISIR, *The evolution of very small dust particles in Gomez's Hamburger*, 11 hrs

Bouwens
VLT, *Spectroscopy of a Uniquely Bright, Gravitationally Lensed Galaxy at z~7.4-8.0*, 10 hrs

Brandl
VLT, *Solving the Mystery of the X-ray Superbubbles in 30 Doradus*, 16 hrs

Brinchmann
WHT, *What are the sources of He II ionising radiation in low metallicity galaxies?*, 2 nights
WHT, *Dual-AGN - pursuing parsec-scale black hole mergers*, 2 nights

van Dishoeck
APEX, *Origin and evolution of warm dense gas around low-mass protostars*, 31 hrs

Haverkorn
Parkes, *Southern Twenty-cm All-sky Polarization Survey*, 374 hours

Hoekstra
INT, *Multi-colour imaging of nearby clusters of galaxies*, ~18 nights

Hogerheijde
JCMT, *A deep dive for methanol in the protoplanetary disks of TW Hya and HD163296*, 26 hrs
Herschel Space Observatory, *Deep HIFI searches for cold water vapor in protoplanetary disks*, 46.8 hrs
Submillimeter Array, *Separated at Birth? A Detailed Study of the Two Protoplanetary Disks in the VV CrA Binary System*, 2 tracks priority B

Holt
VLT, *The impact of AGN feedback in young, radio-loud AGN*, 2 nights
WHT, *Outflows in heavily obscured AGN*, 8 hrs

Israel
IRAM 30m, *Dense Gas in Galaxy Nuclei*, 38 hrs
JCMT 15m, *Dense Gas in Galaxy Nuclei*, 68 hrs
JCMT 15m, *Molecular Gas and Dust in the Taurus Clouds*, 52 hrs
ESO APEX, *Infalling Molecular Gas in Centaurus A*, 13 hrs

Kóspàl
WHT/LIRIS, *First IR spectra of three newly discovered young eruptive stars*, 4 hrs
IRAM PdBI, *CO mapping of FUors: infalling envelopes and outflows*, 8 hrs

Kristensen
IRAM-30m, *Search for complex molecules in the Serpens core*, 25 hrs

Meijerink
Herschel, *Gas excitation through black hole accretion and star formation in the centers of active galaxies*, 22.4 hrs

De Mooij
WHT, *Optical to near-infrared dayside spectra of a sample of hot-Jupiters*, 6 nights
WHT, *Characterising the atmosphere of the transiting Super-Earth GJ1214b*, 1 night
NTT, *The near-infrared spectral energy distribution of the exoplanet WASP-18b*, 4 nights

Nefs
Isaac Newton Telescope (INT), *Follow-up of candidate exoplanets transiting red dwarf stars*, 13 nights
Anglo Australian Telescope (AAT), *On the road to transiting super-Earths with the WTS Survey*, 2 nights

Röttgering
GMRT, *A coherent 3 Mpc-size radio relic: evidence for a triple merger?*
GMRT,*The discovery of an extreme radio relic: evidence for diffuse shock acceleration induced by a cluster merger*, 26hrs
Herschel, *SPIRE and the formation and evolution of galaxy clusters*, 16,7h
XMM,*The toothbrush-relic: evidence for a coherent 3-Mpc scale shock wave ?*, 8300sec
XMM, *Diffusive shock acceleration induced by a cluster merger?*, 12800sec

Snellen
VLT, *A CRIRES survey of hot Jupiters atmospheres*, 155 hrs

Tenenbaum
JCMT, *The Origin of Methylamine in Hot Cores*, 43 hrs

Tielens
Herschel Space Observatory, *Physical conditions in PDRs*, 23 hrs

Visser
JCMT, *HCN and CN as UV tracers of YSO envelope-outflow interactions*, 76 hrs

Wang
JCMT, *A (more) systematic search for disks around massive YSOs (II)*, 29 hrs

van Weeren
WSRT, *A giant radio relic in the merging galaxy cluster RX J0649.3+1801*, 39 hrs
WSRT, *A coherent 3 Mpc-size radio relic: evidence for a triple galaxy cluster merger?*, 78 hrs
GMRT, *The first high-resolution polarization study of an extreme radio relic*, 32 hrs
WHT, *Dynamics of galaxy clusters with megparsec-scale shocks in the ICM*, 2 nights

Van der Werf
Herschel, *Herschel spectra of low-z QSOs: measuring feedback, radiation pressure and star formation*, 28.1 hrs
IRAM, *Plateau de Bure Interferometer*, *Search for H2O, H2O+ and OH+ in the z=3.91 lensed QSO APM08279+5255*, 8 hrs.

Appendix VII

Scientific publications

Scientific publications

Appendix VII

VII.1. Ph.D. Theses

Bouwman, J. ; Spectroscopy Chemistry of Interstellar Ice Analogues;

Damen, M. ; The build-up of Massive Galaxies;

Haas, ; NatureNurture in Galaxy Formation Simulations;

Ioppolo, S. ; Surface formation routes of interstellar molecules;

Lopes Beirao, P., ; Interstellar Medium Conditions in Starburst Galaxies;

Paardekooper, J. P., ; And there was light: Voronoi-Delaunay radiative transfercosmic reionisation;

Raat, A. J. P., ; The Life of Governor Joan Gideon Loten (1710-1789);

Salter, D. M., ; Millimeter Emission from Protoplanetary Disks;

Soto Vicencio, M., ; 3-Dimensional Dynamics of the Galactic Bulge;

Wiersma, R. ; Simulating the Chemical Enrichment of the Intergalactic Medium;

VII.2. Publications in refereed journals

Abbas, U., and 49 co-authors, including **Brinchmann, J.**; The VIMOS-VLT Deep Survey: evolution in the halo occupation number since z ~ 1; *MNRAS*; 2010; **406**; 1306

Acke, B., and 7 co-authors, including **Bouwman, J., Tielens, A. G. G. M.**; Spitzer's View on Aromatic and Aliphatic Hydrocarbon Emission in Herbig Ae Stars; *ApJ*; 2010; **718**; 558

Alibert, Y., and 25 co-authors, including **Fridlund, M., Röttgering, H.J.A.**; Origin and Formation of Planetary Systems; *Astrobiology*; 2010; **10**; 19

Allison, R. J., and 4 co-authors, including **Portegies Zwart, S. F.**; The early dynamical evolution of cool, clumpy star clusters; *MNRAS*; 2010; **407**; 1098

Amblard, A., and 71 co-authors, including **van der Werf, P., Vlahakis, C.**; Herschel-ATLAS: Dust temperature and redshift distribution of SPIRE and PACS detected sources using submillimetre colours; *A&A*; 2010; **518**; L9

Amiri, N., and 2 co-authors, including **van Langevelde, H. J.**; The magnetic field of the evolved star W43A; *A&A*; 2010; **509**; A26

Baan, W. A., and 2 co-authors, including **Loenen, A. F.**; Evolution of the ISM in luminous infrared galaxies; *A&A*; 2010; **516**; A40

Baes, M., and 31 co-authors, including **Vlahakis, C.**; The Herschel Virgo Cluster Survey. VI. The far-infrared view of M 87; *A&A*; 2010; **518**; L53

Baes, M., and 41 co-authors, including **van der Werf, P., Vlahakis, C.**; Herschel-ATLAS: The dust energy balance in the edge-on spiral galaxy UGC 4754; *A&A*; 2010; **518**; L39

Baneke, D. ; Teach and Travel: Leiden Observatory and the Renaissance of Dutch Astronomy in the Interwar Years; *Journal for the History of Astronomy*; 2010; **41**; 167

Bartko, H., and 21 co-authors, including **Levin, Y.**; An Extremely Top-Heavy Initial Mass Function in the Galactic Center Stellar Disks; *ApJ*; 2010; **708**; 834

Beirão, P., and 40 co-authors, including **Brandl, B. R., Groves, B.**; Far-infrared line imaging of the starburst ring in NGC 1097 with the Herschel/PACS spectrometer; *A&A*; 2010; **518**; L60

Bendo, G.J., and 23 co-authors, including **Israel, F. P., van der Werf, P., Vlahakis, C.**; The JCMT Nearby Galaxies Legacy Survey - III. Comparisons of cold dust, polycyclic aromatic hydrocarbons, molecular gas and atomic gas in NGC 2403; *MNRAS*; 2010; **402**; 1409

Benz, A. O., and 68 co-authors, including **van Dishoeck, E. F., Hogerheijde, M. R., Kristensen, L. E., Tielens, A. G. G. M., van Kempen, T. A., Visser, R.**;

Hydrides in young stellar objects: Radiation tracers in a protostar-disk-outflow system; *A&A*; 2010; **521**; L35

Berciano Alba, A., and 4 co-authors, including **Garrett, M. A.**; Radio counterpart of the lensed submm emission in the cluster MS0451.6-0305: new evidence for the merger scenario; *A&A*; 2010; **509**; A54

Bergin, E.A., and 63 co-authors, including **Hogerheijde, M. R., Brinch, C., Kristensen, L. E., van Dishoeck, E. F., Panić O. van Kempen, T. A., Visser, R., Tielens, A. G. G. M.**; Sensitive limits on the abundance of cold water vapor in the DM Tauri protoplanetary disk; *A&A*; 2010; **521**; L33

Bergin, E.A., and 58 co-authors, including **Wang, S., Tielens, A. G. G. M.**; Herschel observations of EXtra-Ordinary Sources (HEXOS): The present and future of spectral surveys with Herschel/HIFI; *A&A*; 2010; **521**; L20

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Bacon, R., and 67 co-authors, including **Brinchmann, J., Serre, D., Schaye, J., Stuik, R.**; The MUSE second-generation VLT instrument; *Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series*; 2010; **7735**;

Balcells, M., and 23 co-authors, including **Brown, A. G. A.**; Design drivers for a wide-field multi-object spectrograph for the William Herschel Telescope; *Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series*; 2010; **7735**;

Bois, M., and 24 co-authors, including **de Zeeuw, P. T., Weijmans, A.**; Formation of Slowly Rotating Elliptical Galaxies in Major Mergers. A Resolution Study; *American Institute of Physics Conference Series*; 2010; **1240**; 405

Brandl, B. R., and 18 co-authors, including **Molster, F., Kendrew, S., van Dishoeck, E. F., van der Werf, P. P.**; Instrument concept and science case for the mid-IR E-ELT imager and spectrograph METIS; *Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series*; 2010; **7735**;

Brandl, B. R., and 4 co-authors,; METIS: A Mid-infrared E-ELT Imager and Spectrograph; *The Messenger*; 2010; **140**; 30

Brinchmann, J. ; Challenges in Stellar Population Studies; *IAU Symposium*; 2010; **262**; 3

Busso, G., and 1 co-author; The UV spectrum of the Galactic Bulge; *IAU Symposium*; 2010; **262**; 311

Callier, P., and 55 co-authors, including **Serre, D., Stuik, R.**; The MUSE project from the dream toward reality; *Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series*; 2010; **7738**;

Cappellari, M., and 12 co-authors, including **de Zeeuw, P. T.**; Testing Mass Determinations of Supermassive Black Holes via Stellar Kinematics; *American Institute of Physics Conference Series*; 2010; **1240**; 211

Cappellari, M., and 24 co-authors, including **de Zeeuw, P. T., Weijmans, A.**; Scaling relations in early-type galaxies from integral-field stellar kinematics; *Highlights of Astronomy*; 2010; **15**; 81

Carbillet, M., and 2 co-authors, including **Jolissaint, L.**; The Software Package PAOLAC: an embedment of the analytical code PAOLA within the CAOS problem-solving environment; *Adaptative Optics for Extremely Large Telescopes*; 2010 ;

Ciesla, L., and 80 co-authors, including **Vlahakis, C.**; SED fitting of nearby galaxies in the Herschel Reference Survey; *SF2A-2010: Proceedings of the Annual meeting of the French Society of Astronomy and Astrophysics*; 2010; ; 31

Coccato, L., and 12 co-authors, including **Kuijken, K. H..**; Kinematic properties of early type galaxy halos using planetary nebulae; *Highlights of Astronomy*; 2010; **15**; 68

Cortesi, A., and 13 co-authors, including **Kuijken, K. H.**; Revealing S0 Galaxies' Formation Histories Using the Stellar Kinematics of the Faint Outer Disks; *American Institute of Physics Conference Series*; 2010; **1240**; 289

Cunningham, C., and 2 co-authors, including **Molster, F.**; The OPTICON technology roadmap for optical and infrared astronomy; *Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series*; 2010; **7739**;

Davies, R., and 45 co-authors, including **Deul, E., Kuijken, K.**; Science and Adaptive Optics Requirements of MICADO, the E-ELT adaptive optics imaging camera; *Adaptative Optics for Extremely Large Telescopes*; 2010; ;

Davies, R., and 45 co-authors, including **Deul, E., Kuijken, K.**; MICADO: the E-ELT adaptive optics imaging camera; *Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series*; 2010; **7735**;

De Marchi, G., and 2 co-authors, including **Portegies Zwart, S. F.**; On the temporal evolution of the stellar mass function of Galactic clusters; *IAU Symposium*; 2010; **266**; 81

de Zeeuw, P. T. ; In Memoriam Christine Nieuwenkamp; *The Messenger*; 2010; **142**; 48

Deep, A., and 3 co-authors, including **Jolissaint, L.**; Use of AO PSF models for the Study of Resolved Stellar Populations; *Adaptative Optics for Extremely Large Telescopes*; 2010; ;

Deep, A., and 10 co-authors, including **Boland, W., Molster, F., Stuik, R.**; Alignment and integration of ASSIST: a test bench for VLT adaptive optics facility; *Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series*; 2010; **7793**;

Emsellem, E., and 22 co-authors, including **de Zeeuw, P. T., Weijmans, A.**; The ATLAS3D Project: A Paradigm Shift for Early-Type Galaxies; *American Institute of Physics Conference Series*; 2010; **1240**; 335

Falcón-Barroso, J., and 11 co-authors, including **de Zeeuw, P. T.**; The Kinematics of Core and Cusp Galaxies: Comparing HST Imaging and Integral-Field Observations; *The Impact of HST on European Astronomy*; 2010; ; 127

Garrett, M. A., and 5 co-authors; The Square Kilometre Array (SKA) - Phase 1 Design Concept; *ISKAF2010 Science Meeting*; 2010; ;

Giodini, S. ; The Baryonic Budget of Galaxy Groups in the COSMOS field; *Galaxy Clusters: Observations, Physics and Cosmology*; 2010; ; 27P

Girard, J. H. V., and 15 co-authors, including **Kenworthy, M. A.**; Status and new operation modes of the versatile VLT/NaCo; *Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series*; 2010; **7736**;

Gladysz, S., and 8 co-authors, including **Jolissaint, L.**; Suppressing stellar residual light on extremely large telescopes by aperture modulation; *Adaptative Optics for Extremely Large Telescopes*; 2010; ;

Gouliermis, D. A., and 15 co-authors, including **Brandl, B.**; A Hubble View of Star Forming Regions in the Magellanic Clouds; *The Impact of HST on European Astronomy*; 2010; ; 71

Guillard, P., and 18 co-authors, including **Kendrew, S.**; Optical performance of the JWST/MIRI flight model: characterization of the point spread function at high resolution; *Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series*; 2010; **7731**;

Gvaramadze, V. V., and 2 co-authors, including **Portegies Zwart, S.**; High-velocity runaway stars from three-body encounters; *IAU Symposium*; 1/1/2010; **266**; 413

Hayward, C. C., and 7 co-authors, including **Groves, B.**; Testing star formation rate indicators using galaxy merger simulations and radiative transfer; *IAU Symposium*; 2010; **262**; 257

Heald, G., and 16 co-authors, including **van Weeren, R. J., Rafferty, D., Birzan, L.**; Recent LOFAR imaging pipeline results; *ISKAF2010 Science Meeting*; 2010 ;

Herpin, F., and 5 co-authors, including **van Dishoeck, E. F.**; Herschel/HIFI reveals the first stages of stellar formation; *SF2A-2010: Proceedings of the Annual meeting of the French Society of Astronomy and Astrophysics*; 2010; ; 221

Hogerheijde, M. R. ; Structure and life time of circumstellar disks; *EAS Publications Series*; 2010; **41**; 113

Israel, F. P. ; Dense Star-forming Gas and Dust in the Magellanic Clouds; *EAS Publications Series*; 2010 **40**; 299

Jaffe, W. ; Extragalactic Astronomy; *JENAM 2010, Joint European and National Astronomy Meeting*; 2010; ;

Jolissaint, L., **Kendrew, S.**; Modeling the Chromatic Correction Error in Adaptive Optics: Application to the Case of Mid-Infrared Observations in Dry to Wet Atmospheric Conditions; *Adaptative Optics for Extremely Large Telescopes*; 2010 ;

Jolissaint, L. ; Synthetic modeling of astronomical closed loop adaptive optics; *Journal of the European Optical Society - Rapid publications, 5, 10055*; 2010; **5**;

Kamble, A. P., and 7 co-authors, including **Garrett, M. A.**; WSRT Radio Observations of SN 2010br; *The Astronomer's Telegram*; 2010; **2612**; 1

Kamble, A. P., and 8 co-authors, including **Garrett, M. A.**; WSRT Radio Observations of PTF10bzf; *The Astronomer's Telegram*; 2010; **2479**; 1

Kendrew, S. ; SpS1-High-resolution infrared spectroscopy at high and low altitudes; *Highlights of Astronomy*; 2010; **15**; 536

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Kenworthy, M. A. and 7 co-authors.; An apodizing phase plate coronagraph for VLT/NACO; *Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series*; 2010; **7735**;

Kenworthy, M. A., and 5 co-authors.; Developing achromatic coronagraphic optics for LMIRCam and the LBT; *Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series*; 2010; **7734**;

Kenworthy, M. A., and 7 co-authors; A New Coronagraph for NAOS-CONICA -- the Apodising Phase Plate; *The Messenger*; 2010; **141**; 2

Koechlin, L., and 5 co-authors, including **Serre, D.**; The Fresnel Interferometric Imager; *Pathways Towards Habitable Planets*; 2010; **430**; 278

Kristensen, L., **van Dishoeck, E. F.**; Water in Star-Forming Regions with Herschel (WISH): overview; *38th COSPAR Scientific Assembly*; 2010 **38**; 2479

Kroes, G., and 18 co-authors, including **Brandl, B.**; METIS opto-mechanical design and packaging study; *Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series*; 2010; **7735**;

Kruijssen, J. M. D., and 4 co-authors, including **Pelupessy, F. I., Portegies Zwart, S. F., Icke, V.**; Simulations of Interacting Galaxies Covering More Than Ten Orders of Magnitude; *Galaxy Wars: Stellar Populations and Star Formation in Interacting Galaxies*; 2010; **423**; 203

Kruijssen, J. M. D., and 1 co-authors, including **Portegies Zwart, S. F.**; The Relation Between the Globular Cluster Mass and Luminosity Functions; *Galaxy Wars: Stellar Populations and Star Formation in Interacting Galaxies*; 2010; **423**; 151

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Kuijken, K. H. ; Dark Haloes as Seen with Gravitational Lensing; *Galaxies and their Masks, A Conference in Honour of K.C. Freeman, Edited by by David L. Block, Kenneth C. Freeman, Ivânio Puerari. New York: Springer, 2010. ISBN: 978-1-4419-7316-0, p.361-372*; 2010 ; 361

Le Fèvre, and 22 co-authors, including **Brinchmann, J.**; DIORAMAS: a wide-field visible and near-infrared imaging multi-slit spectrograph for the EELT; *Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series*; 2010; **7735**;

Lenzen, R., and 24 co-authors, including **Brandl, B. R., Molster, F., van Dishoeck, E. F., van der Werf, P., Kendrew, S., Stuik, R., Jolissaint, L.**; METIS: system engineering and optical design of the mid-infrared E-ELT instrument; *Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series*; 2010; **7735**;

Levin, Y. ; Stellar discs near the Galactic Center; *Dynamics from the Galactic Center to the Milky Way Halo*; 2010; ;

Loupias, M., and 19 co-authors, including **Stuik, R.**; MUSE instrument global performance analysis; *Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series*; 2010; **7738**;

Lundgren, R., and 22 co-authors, including **de Zeeuw, T.**; APEX: five years of operations; *Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series*; 2010; **7737**;

Martin, C., and 12 co-authors, including **Israel, F. P.**; The Herschel Inner Galaxy Gas Survey (HIGGS): Early Results; *38th COSPAR Scientific Assembly*; 2010 **38**; 2481

Martínez-Galarza, J. R., and 7 co-authors, including **Kendrew, S., Brandl, B.**; Wavelength calibration of the JWST-MIRI medium resolution spectrometer; *Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series*; 2010; **7731**;

Mei, S., and 11 co-authors, including **Franx, M.**; Stellar populations and morphology on the red sequence at z~1; *American Institute of Physics Conference Series*; 2010; **1241**; 236

Meisner, J.A., and 6 co-authors, including **Jaffe, W. J., Le Poole, R. S.**; The polarization-based collimated beam combiner and the proposed NOVA fringe tracker (NFT) for the VLTI; *Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series*; 2010; **7734**;

Minier, V., and 14 co-authors, including **Israel, F. P.**; The Antarctic Submillimetre Telescope; *EAS Publications Series*; 2010; **40**; 269

Molinari, S., and 142 co-authors, including **Berné, O.,**; From Clouds to Young Stellar Objects and back again: the all-in-one view from the Herschel infrared Galactic Plane Survey; *38th COSPAR Scientific Assembly*; 2010; **38**; 2488

Morganti, R., and 3 co-authors, including **Holt, J.**; Cold and Warm Gas Outflows in Radio AGN; *IAU Symposium*; 2010; **267**; 429

Müller, A., and 16 co-authors, including **Jaffe, W.**; First results using PRIMA FSU as a fringe tracker for MIDI; *Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series*; 2010; **7734**;

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Oliveira, I., and 3 co-authors, including**, van Dishoeck, E. F.**; Evolution of Dust in Protoplanetary Disks; *Disks, Meteorites, Planetesimals*; 2010; ; 6003

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Oonk, J. B. R.,, and 3 co-authors, including**, Jaffe, W.**; FUV Emission in Cool-Core Clusters; *IAU Symposium*; 2010; **267**; 463

Pawlik, A. H., and 2 co-authors, including **Schaye, J.**; Keeping the Universe Ionised: Photoheating and the High-redshift Clumping Factor of the Intergalactic Gas; *New Horizons in Astronomy: Frank N. Bash Symposium 2009*; 2010; **432**; 230

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Ronayette, S., and 17 co-authors, including **Kendrew, S.**; Performance verification of the MIRI imager flight model at CEA; *Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series*; 2010; **7731**;

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VII.4. Popular articles

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