Research Institute Leiden Observatory

(Onderzoekinstituut Sterrewacht Leiden)

Annual Report 2011

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Cover:
Galaxy clusters grow by mergers with other clusters and galaxy groups. These mergers create shock waves within the intracluster medium (ICM) that can accelerate particles to extreme energies. In the presence of magnetic fields, relativistic electrons form large regions emitting synchrotron radiation, the so-called radio relics.
A prime example of these phenomena can be found in the galaxy cluster 1RXS J0603.3+4214 (z = 0.225), recently discovered comparing radio and X-ray large sky surveys. The deep radio image on the front cover taken with the Giant Metrewave Radio Telescope (India) shows that this cluster hosts a spectacularly large bright 1.9 Mpc radio relic (Courtesy: van Weeren and Röttgering, et al.). Initial numerical simulations (Brüggen, van Weeren, Röttgering) indicate that the 1.9 Mpc shock can be explained as originating from a triple cluster merging.
Studying such systems yield information on the physics of magnetic fields and particle acceleration as well properties of gas in merging clusters.

An electronic version of this annual report is available on the web at
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Production Annual Report 2011:
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Sterrewacht Leiden

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Review of major events

Chapter 1

1. Foreword

Welcome to this annual report, covering activities at Leiden Observatory in 2011.

The year started rather unusually: first with a partial solar eclipse on January 4, visible from Leiden, and a few days later with over 1000 professors taking part in a national protest march and extraordinary academic session in the Hague on January 21st to protest a new round of budget cuts facing the universities. Whilst one may question the direct effect of either of these happenings, it is a fact that the rest of the year was once again a very successful one for the Sterrewacht.

2011 marks the 150th anniversary of the completion of Frederik Kaiser's observatory building, on a bulwark of the city of Leiden adjacent to the botanical gardens. It also saw the completion of a thorough restoration of the building, which housed our institute until 1974 and which is now a listed historical monument. Most of the observatory building and the attached professors' houses will now be used for teaching by the faculty of law, but the historical telescopes on the roof and in the adjacent buildings remain in use for amateurs and outreach activities.

As part of the building work a new exhibition space has been created, accessible to all visitors of the botanical gardens. It contains an exhibition that shows the beauty of the universe and the role our institute plays in astronomy. The building and exhibition were festively opened by the Secretary of State for higher education, Mr Halbe Zijlstra, on October 26. (On the same occasion a very surprised Vincent Icke was granted a knighthood in recognition of his service to astronomy and the popularization of science, two aspects that also featured prominently in Kaiser's work.) With the completion of the restoration of the 'Oude Sterrewacht' a piece of our heritage has been returned to us, and to make sure all astronomy students appreciate this link with the past the first-year astronomy practicum course will be taught there, making use of a new teaching telescope to be installed in one of the smaller domes on the roof.

Outreach saw other important activities as well. The universe awareness programme UNAWE, which aims to educate young children, particularly disadvantaged ones, about our place in the universe, was rewarded with a large grant from the European Commission to develop its European activities. The founder of UNAWE, George Miley, was honoured by the European Astronomical Society with the award of the Lodewijk Woltjer lecture - as was Michael Perryman, adjunct professor in Leiden until 2009, with the Tycho Brahe Prize.

Scientifically and technically the year saw many successes. A few highlights: Rychard Bouwens led a study with the Hubble Space Telescope that turned up the most distant known galaxy yet, at a redshift of 10 - signalling how far observational cosmology has evolved, the surprise is not that the galaxy was found but that there were not more seen like it. Many results continue to come out of the Herschel satellite, including a discovery led by Kristensen and van Dishoeck of high-speed water bullets emitted by a sun-like star, and the discovery led by Hogerheijde of abundant water vapour in a proto-planetary disk. Personally I spent about two months on Paranal to take part in the commissioning of the OmegaCAM wide-field camera on the VLT Survey Telescope; since then its suite of scientific surveys has started. Many more scientific results from Sterrewachters are described in this annual report.

Also further afield new facilities continued to take shape: the LOFAR radio telescope centered on Drente continued its rollout and commissioning, and the ALMA sub-mm array started early science operations in the autumn with many Leiden proposals winning time in a very competitive proposal round. In October (as it happens, on the very day that the Nobel Prize for physics went to astronomers for discovering the accelerating expansion of the universe), ESA selected the Euclid cosmology mission for development, aiming for launch in 2019. The James Webb Space Telescope survived a rough ride in the US congress and is slated for launch in 2018. ESO continued to inch its way towards a decision to build the 39m European Extremely Large Telescope in Chile. With access to facilities such as these the future looks bright!

This year's Oort professor was James Binney (Oxford), who delivered a series of lectures related to our Milky Way Galaxy, and in particular what we may expect to learn from the Gaia mission that is due for launch in 2013. Avi Loeb (Harvard) spent a week at the Sterrewacht in the autumn, and delivered the Sackler lecture on the epoch of reionization.

Sterrewacht staff were once again very successful in obtaining important research grants, more important than ever for realizing our ambitions (over 2/3 of the Sterrewacht budget is now funded externally). Highlights are three grants from the European research council, one Advanced Grant to Ewine van Dishoeck and Starting Grants to Henk Hoekstra and Joop Schaye; an NWO-M investment grant for Simon Portegies Zwart's AMUSE project; and an NWO Graduate School pilot programme grant for the de Sitter programme, a joint initiative between the Sterrewacht and the Lorentz Institute for Theoretical Physics. But the greatest funding news of 2011 was the announcement that the NOVA 'top-research school' will continue to receive direct funding for a further five years, up to the end of 2018 at least: a vindication of the quality of the research that takes place at the Dutch university astronomy departments, and a consequence of the successful research assessment by a high-level visiting committee that took place in the year of 2010.

The NOVA continuation contrasts starkly with the saddest development for Dutch astronomy of 2011: the decision by the board of Utrecht University to close its 370-year old astronomy institute. Together with the remaining NOVA institutes a solution was found for relocating Utrecht staff: for Leiden this meant the addition of the astronomical instrumentation research group led by Christoph Keller. Both the instrumentation and exoplanet research at the Sterrewacht are significantly strengthened as a result, and after all the upheaval we are happy to be able to look forward to an exciting future for the new staff.

On the staff there were some other changes as well. Elena Rossi joined the Sterrewacht at the beginning of the year, as new assistant professor. Elena is a theoretician working mainly on the astrophysics of black holes. In 2011 Vincent

Icke, Jan Lub and Frank Israel reached retirement age, and in time-honoured fashion are maintaining a desk at the Sterrewacht, continuing and even reinvigorating their research. And it is a privilege to keep access to the wisdom of senior colleagues!

I started this introduction by mentioning some worries about the future of fundamental research and universities in the Netherlands. While there certainly is cause for concern, looking around at the Sterrewacht the picture is far from gloomy. Our institute continues to grow (now also encompassing the entire fourth floor of the Huygens building), opportunities abound, major new facilities are in the offing, bright PhD students continue to do top-notch research and find jobs around the world. Plenty of cause for optimism that the Sterrewacht will continue to flourish in 2012 and beyond.

Koen Kuijken
Scientific Director

Chapter 2

Research

Sterrewacht Leiden

Chapter 2

Research

2.1 Protoplanetary disks and exoplanets

Enormous reservoir of cold water in a circumstellar disk

Icy bodies may have delivered the oceans to the early Earth, yet little is known about water in the ice-dominated regions of extra-solar planet-forming disks. Using the Heterodyne Instrument for the Far-Infrared (HIFI) on board of the Herschel Space Observatory, Hogerheijde and his collaborators detected emission lines of both spin isomers of cold water vapor coming from the disk around the young star TW Hydrae. The rotational ground-state transition lines of ortho- and para-water showed up only after a total observing time of 17 hours, illustrating the weakness of the features. Detailed model calculations indicated that the lines detected probe a thin layer containing 0.005 Earth-oceans of water coating the surface of the disk. This cold water vapor is most likely originated from ice-coated solids near the disk surface, as ultraviolet photons liberated individual water molecules from the ice matrix. Small as it may be, the inferred amount of water vapor hints at a much larger underlying water-ice reservoir equivalent to several thousand Earth oceans in mass. Interestingly, the water's ortho-to-para ratio is much lower than commonly observed in solar system comets. Hogerheijde and his colleagues speculated that comets contain heterogeneous ice mixtures which they collected across the entire solar nebula during the early stages of planetary birth. This implies that primitive volatiles can be mixed across large distances in planet-forming disks. Planned follow-up observations with the Herschel Space Observatory will reveal if other protoplanetary disks have water vapor reservoirs comparable to that of TW Hya.

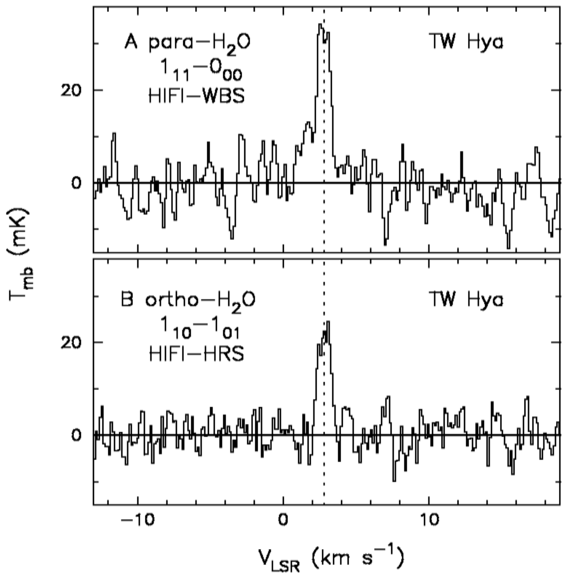

Figure 1. Detection of the rotational ground state transitions of para-H_2O (A) and ortho-H_2O (B) toward the TW Hya protoplanetary disk obtained with HIFI on-board the Herschel Space Observatory.

Single-peaked CO emission profiles from protoplanetary disks

Protoplanetary disks generally exhibit strong line emission from the CO fundamental J = 1-0 ro-vibrational band around 4.7 μm. The lines are usually interpreted as being formed in the Keplerian disk. Bast and van Dishoeck, in collaboration with Brown, Herczeg (both MPE, Germany) and Pontoppidan (StScI, USA) investigated a set of eight disks that surprisingly do not show a double-peaked profile but broad single-peaked emission lines instead (Fig. 2). The data were part of a large VLT-CRIRES program to survey about seventy disks at an unprecedented resolving power of 105. The lines are very symmetric, have high line/continuum ratios and have small central velocity shifts with respect to the star. The disks in this sub-sample are accreting onto their central stars at high rates relative to the parent sample and show emission lines from vibrationally excited states consistent with UV fluorescent excitation. Analysis of their spatial distribution showed that the lines are formed within a few AU of the central star. The most likely interpretation is that the broad-based centrally peaked line profiles originate from a combination of emission from the inner part (less than a few AU) of a disk –perhaps with enhanced turbulence- and a slow-moving disk wind, driven by either EUV emission or soft X-rays.

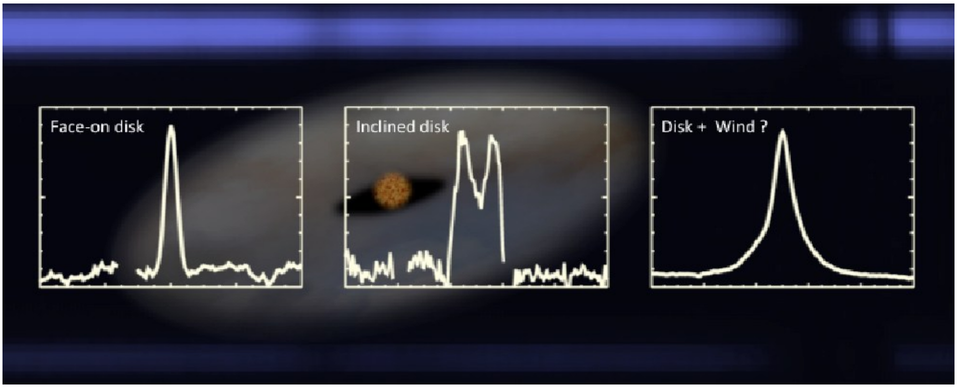

Figure 2. Observed VLT-CRIRES CO J=1-0 lines toward the young stars TW Hya, VV Ser and AS 205. With a Keplerian model, good fits can be found for TW HyA and VV Ser, but not for AS 205. This source is part of a new class of sources with broad-based single-peaked line profiles, probably due to a slow molecular disk wind from an inclined disk (from: Bast et al. 2011).

Embedded young circumstellar disks

Young circumstellar disks that are still embedded in dense molecular envelopes may differ from their older counterparts. They have been difficult to study because their lines can be confused with those from envelopes or outflows. However, CO ro-vibrational emission is a potentially powerful probe of the disk structure within a few AU of young protostars. Herczeg, Brown, van Dishoeck and Pontoppidan detected CO line emission at 4.7 μm from 14 low-mass young stellar objects (YSOs) with the CRIRES on the ESO-VLT. The observed profiles showed a range of intensities and shapes, but could generally be classified into contributions from a broad, warm component and a narrow, cool component. The broad emission component exhibited many of the same properties as CO infrared emission seen from more mature disks that arises in a disk with a slow wind (Fig. 2). Warm CO absorption is detected in the outflows of six objects with velocities up to 100 km/s, often occurring in discrete velocity components. The partially molecular nature of the wind at its origin favors a disk wind rather than a coronal or chromospheric wind.

Evolution of dust mineralogy from disks to planets

Oliveira and van Dishoeck, together with Olofsson (MPIA, Germany), Augereau (Grenoble, France), Pontoppidan and Merin (ESAC Madrid, Spain), used Spitzer Space Telescope measurements to study the dust grain mineralogy (composition, crystallinity, and grain size distribution) of a complete sample of protoplanetary disks in the young Serpens cluster. They compared their results to those obtained for the young Taurus region and sources that have retained their protoplanetary disks in the older Upper Scorpius and η Chamaeleontis stellar clusters, using the same analysis technique for all samples. This comparison allowed an investigation of the evolution with time of the grain mineralogy for an unprecedented sample of 139 disks with ages of a few million years. Disks in the different regions were found to have very similar distributions of mean grain sizes and crystallinity fractions (10-20%) despite the spread in mean age. Furthermore, there was no evidence of preferential grain sizes for any given disk geometry nor was there any indication that the mean cluster crystallinity fraction increases with mean age in the range of one to eight million years. The main implication was that a modest level of crystallinity is established in the disk surface early on (within less than one million years), reaching an equilibrium that is independent of processes occurring in the disk mid-plane.

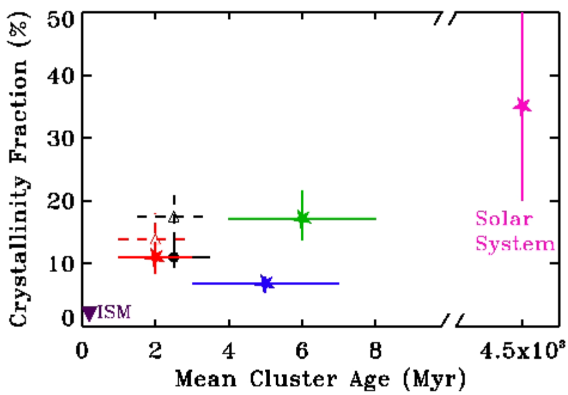

Figure 3. Mean crystallinity fraction vs. mean cluster age. Filled symbols represent mean warm crystallinity, and open symbols represent the mean cold crystallinity. *Data are presented for the Taurus, Serpens, Upper Scorpius and η Cha clusters. No evolution is seen in the 1-8 Myr period, whereas dust in the ISM and in solar system objects are significantly different. This implies that the crystallinity fraction in disks is established early, within one million years (from: Oliveira et al. 2011).*

Young stellar objects in the Lupus clouds

Mortier, Oliveira and van Dishoeck conducted an optical spectroscopic survey of a sample of 54 pre-main-sequence stars in the Lupus clouds using VLT-FLAMES. All objects showed an infrared excess as discovered by the Spitzer c2d program, and thus appeared to be surrounded by disks. With the derived effective temperatures and luminosities, they constructed Hertzsprung-Russell diagrams for the population. The sample consisted of mostly M-type stars, with ten per cent K-type stars. The mean population age was found to be between 3.6 and 4.4 million years, depending on the model, while the mean mass was determined to be about a third of a solar mass for either model. The distribution of spectral types was similar to that in Chamaeleon I and IC 348. Emission in the Hα line -occurring in half of the sample- was used to distinguish between classical and weak-line T Tauri stars and to determine mass accretion rates.

No exoplanets seen

Kenworthy's collaborations with ETH Zurich are producing the first papers using the anodising phase plate (APP) coronagraph on ESO's VLT. A search for exoplanets around debris-disk host stars has produced upper limits of several Jupiter masses. Kenworthy and Thalmann resolved a decades-old debate as to whether the Sirius stellar system harbours a brown dwarf companion in a six year orbit. It does not. Combining multi-epoch data from several telescopes with orbital simulations conclusively ruled out this hypothesis. High contrast imaging at large telescopes is limited by optical path differences within the instruments. Kenworthy and Codona showed for the first time that these optical differences can be measured and removed in post-processing, one step on the path to removing these aberrations in real time at the telescope.

M-dwarf eclipsing binaries

Stars with less than half the mass of the Sun, namely M-dwarfs, are the key target of many planet hunting surveys. Their smaller size, cooler temperature and lower luminosity means that if an Earth-size planet passes in front of them (a transit event), it blocks almost ten times more light than it would do if it passed in front of a Sun-like star. Planet signatures are therefore much easier to detect around M-dwarfs, making them our best chance for finding habitable worlds beyond the Solar System. From these transiting events, we can derive the planet's radius and even study its atmosphere. However, this characterization depends on a precise knowledge of the its host star's mass and radius. For Sun-like stars, this information is extremely well-produced by stellar evolution models, but for M-dwarfs, the models disagree with dynamically measured M-dwarf radii, being too small by up to 10%. This can significantly change the inference of any planetary companion's atmosphere, taking it from a water-rich atmosphere, to a hydrogen-dominated envelope. Double-lined, M-dwarf eclipsing binaries (MEBs) provide the most accurate and precise means for measuring stellar masses and radii (~2-3%).

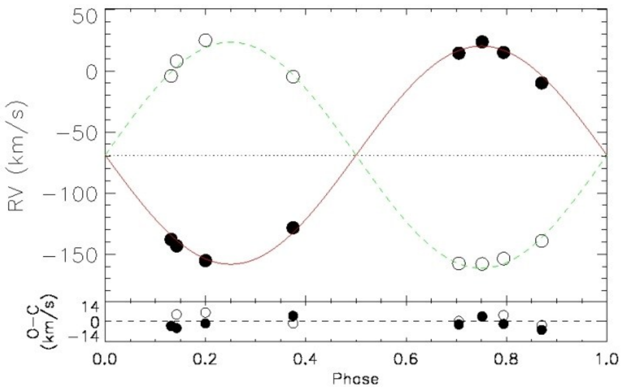

Figure 4. Radial velocity (RV) curve of the same M-dwarf eclipsing binary, both components are clearly identified. Primary (more massive) star RVs shown by solid circles and model fit shown with solid red line. Secondary star RVs shown by open circles and the dashed green line is the best fitting model. Residuals of model the fits are shown in lower panel. These data sets combined allow us to measure accurate masses and radii of the component stars.

In an attempt to better constrain the models for low-mass stellar evolutionary tracks, Jayne Birkby scoured the WFCAM Transit Survey light curves for MEBs, finding sixteen systems in relatively short 1-5 day orbits. The WFCAM Transit Survey (WTS) is an infrared photometric monitoring campaign of ~6,000 M-dwarfs in the Northern hemisphere, using the United Kingdom Infrared Telescope (UKIRT). The survey operates as a poor-weather back-up program in queue-scheduling mode, but produces high precision ground-based light curves (3-5 mmag for $12<J<16$ mag). Jayne and her collaborators performed spectroscopic follow-up of three of these new MEBs, and were able to characterize their masses and radii to 3-6% precision. All of these systems again showed inflation above model radii of ~3-12%. Some research into this radius anomaly has suggested that the strong magnetic fields found in short-period MEBs causes an inflation of the radii, and while Jayne's analysis of the literature data for MEB radii showed that the model discrepancies reduce at longer periods (where the magnetic activity is expected to be less), a smaller radius inflation still remains. It is possible that the effects of even very low-level magnetic activity have been underestimated. Given that a significant fraction of single M-dwarf stars in the Milky Way are magnetically active, it is clear that we must be able to precisely account for the effects of magnetic fields on the properties of M-dwarf stars, if we are to use them as a hunting-ground for the next Earth.

Searching for exoplanet atmospheres

Snellen, de Mooij, Brogi, and Nefs worked on the characterization of extrasolar planet atmospheres. They detected the secondary eclipse of the hot Jupiter HAT-P-1b at 2.2 μm using the William Herschel Telescope on La Palma. It was the shallowest eclipse detected from the ground so far. In addition, they used various telescopes around the world to observe the transit of super-Earth GJ1214b from the optical to the near-infrared. In these observations, they detected a hint of Rayleigh scattering at the shortest wavelengths. If real, this would imply that GJ1214b is a mini-Neptune with a hydrogen-based atmosphere.

2.2 Protostars

Water vapour in star-forming regions with Herschel (WISH)

WISH (PI: van Dishoeck) is a guaranteed-time program using the ESA Herschel Space Observatory's Heterodyne Instrument for the Far-Infrared (HIFI), designed to probe the physical and chemical structures of young stellar objects by observing emission from water vapor and related molecules, and to follow the water abundance from collapsing clouds to planet-forming disks. About 80 sources are targeted, covering a wide range of luminosities and evolutionary stages. The bulk of the WISH data was obtained in 2011 and ten new WISH papers were published, including an overview of the program. Within the international program, the Leiden team focused on low-mass protostars and protoplanetary disks.

Kristensen, Yildiz, van Dishoeck, and the WISH team, discovered surprisingly strong water vapor emission in 'bullets' at velocities of more than 50 km/s from the source velocity, and associated with the molecular jet. The bullets showed little variation with excitation in H_2O profile shape. Inferred physical conditions are a temperature well in excess of 150 K and density higher than 100.000 per cc, similar to that of the broad outflow component. The H_2O/CO abundance ratio (0.05 to 1.0) is similar in the 'bullets' and the broad component, in spite of the difference in origin. The high H_2O abundance indicates that the bullets are rich in molecular hydrogen. This result was highlighted in several national and international press releases.

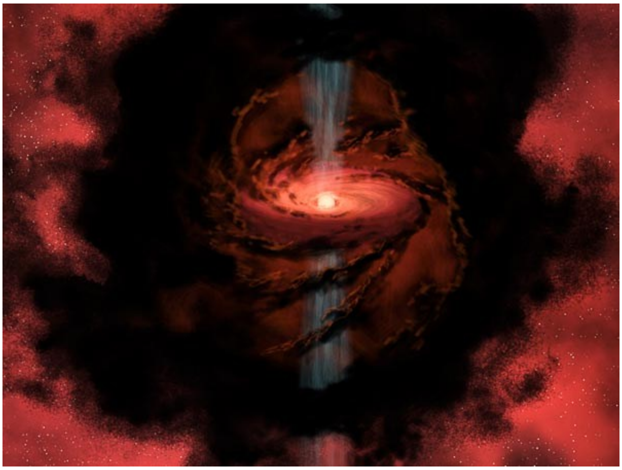

Figure 5. A star is born: Swirling gas and dust fall inward, spurring polar jets, shown in blue in this illustration. Illustration courtesy NASA/Caltech.

Kristensen, van Dishoeck, Yildiz, San Jose-Garcia, Karska, Harsono and collaborators also performed the first systematic survey of spectrally resolved water emission in 29 low-mass (corresponding luminosities less than 40 solar luminosities) protostellar objects using HIFI 557 GHz data. They used complementary far-IR and sub-mm continuum data (including Herschel-PACS data from WISH) to constrain the spectral energy distribution (SED) of each source. The observed line profiles were complex and consisted of several kinematic components, including inverse and normal P-Cygni profiles, and bullets. The H_2O/CO abundance ratio as a function of velocity is nearly the same for all outflows independent of source luminosity or envelope mass. It increases from 001 to 0.1 at velocities above 10 km/s. The different H_2O profile components showed a clear evolutionary trend: in the young Class 0 sources the emission is dominated by outflowing gas from an infalling envelope. When large-scale infall diminishes during the Class I phase, the outflow also weakens.

First hyper-fine-resolved FIR OH spectrum from an HII region

OH is an important molecule both in the H_2O chemistry and in the cooling budget of star-forming regions. As part of the WISH program, Wampfler (ETH), together with van Dishoeck, Kristensen and the WISH team, obtained the first hyper-fine-resolved high-resolution HIFI spectrum of the OH triplet at 1837.8 GHz (163.1 μm) toward the high-mass star-forming region W3 IRS5. The Herschel data allowed a direct comparison of OH/H_2O in different physical components. The line profile showed two components: a narrow (FWHM 4-5 km/s) and a broad (FWHM 30 km/s) component. The narrow emission line indicated an OH/H_2O abundance ratio of around 0.001 for temperatures over 100 K, and around unity for temperatures below 100 K. This is consistent with the current picture of the dense cloud chemistry with freeze-out and photodesorption. The broad component was attributed to emission from an outflow. Its abundance ratio of $OH/H_2O > 0.03$ can be explained by the presence of a fast J-type shock or a slower UV-irradiated C-type shock.

High-J CO survey of the NGC1333 low-mass protostars

The NGC1333 IRAS 4A and IRAS 4B sources drive prominent bipolar outflows. Most studies thus far have concentrated on the colder parts (temperature below 30 K) of these regions. Yildiz and collaborators used the new dual frequency 2×7 pixel 650/850 GHz array receiver CHAMP+ mounted on the APEX telescope to obtain a fully sampled 4'x4' map in the ^{12}CO J=6–5 line. APEX and CHAMP+ represent (prototype) ALMA and HIFI technology. They also collected complementary Herschel-HIFI and ground-based measurements of CO lines and their isotopologues, from J=1–0 up to 10–9 (upper energy level of about 300 K) at the same source positions and used these to construct velocity-resolved CO ladders and rotational diagrams. The CHAMP+ maps beautifully revealed the shocked gas entrained along the outflow walls, at typical temperatures of 100 K. At other positions, the J=6–5 line profiles are narrow indicating UV excitation. Narrow ^{13}CO J=6-5 data directly and for the first time revealed the UV heated gas distribution. Its mass was found to be comparable to that of the outflow, which implies that UV-heating can affect the gas as much as the outflows. Modelling of the $C^{18}O$ lines yielded evidence for a CO ice evaporation zone close to the protostars. However, the inner abundances were determined to be below the canonical value of CO/H_2=0.0027. This indicates some degree of CO processing into other species on the grains.

Complex molecules toward low-mass protostars

Complex organic molecules in the gas-phase are commonly detected toward high-mass hot protostellar cores, but detections toward low-mass sources are rare. To obtain a larger sample, Oberg (Harvard, USA), van der Marel, Kristensen and van Dishoeck targeted three low-mass protostars in Serpens with the IRAM 30m telescope. From infrared observations, these sources were known to be rich in CH_3OH ice. Based on the laboratory experiments by Oberg et al., they were thus predicted to have complex organic molecules. Indeed, CH_3CHO and CH_3OCH_3 are detected toward all sources, $HCOOCH_3$ toward two sources, but C_2H_5OH not at all. The derived abundances varied by an order of magnitude from source to source but the range of abundances compared well with other beam-averaged observations of low-mass sources. Unlike in previous studies, abundances were found to be of the same order of magnitude toward low- and high-mass protostars, but $HCOOCH_3$ was found to be relatively more important toward low-mass protostars. This is consistent with a sequential ice photo-chemistry, dominated by CHO-containing products at low temperatures and early times.

High-mass star formation ages

In the context of the formation of high mass stars, Klaassen and collaborators undertook a study to establish whether molecular infall and outflow tracers could be used to determine the relative ages of different stages of high mass protostellar evolution. They used SiO to trace recent outflow activity, and a combination of the optically thick HCO^+ with optically thin $H^{13}CO^+$ to trace infall activity.

Non-detections of SiO, or improper signatures in the HCO^+ isotopologues suggested that either outflow or infall (respectively) have stopped for that source. Their sample of 45 sources was taken to contain High Mass Protostellar Objects (HMPOs) which have yet to form HII regions, and two groupings based on the size of the HII region; Hyper-compact or Ultra-compact. The results of this study indicated that the intensity of the outflow shock tracer (SiO) increases with evolutionary stage, and that each source in the last stage with an infall detection also shows evidence of recent outflow activity.

Methanol masers and high-mass star-formation

Torstensson and van Langevelde obtained some significant results comparing data from the European VLBI Network (EVN) on methanol masers with the large-scale thermal methanol distribution, using JCMT HARP data at 338 GHz. For these sources an analysis had been made of the methanol excitation and this was also analysed in terms of an outflow originating from the central object, presumably where methanol is released into the gas phase. In a sub-sample with confined (young) outflows, this outflow appeared to be along the axis of the rings of methanol that were detected in collaboration with Bartkiewicz (Torun, Poland). Although limited to a few sources, this result constrained the motion of the methanol in these rings to be predominantly infall, as was earlier found for the archetypical source Cep A.

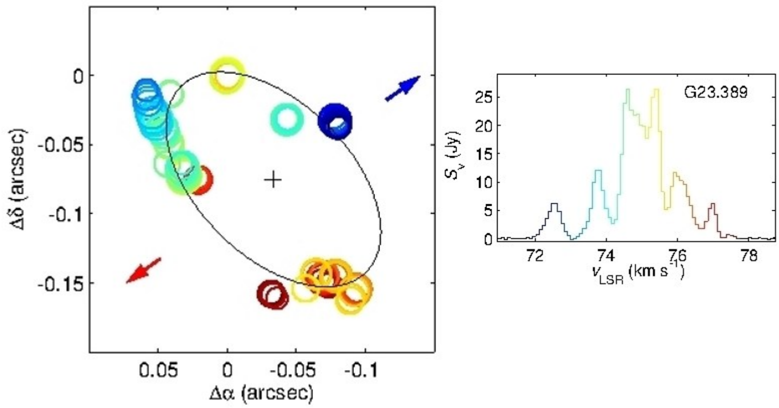

Figure 6. The ring of methanol masers (left) of G23.389+00.185 is oriented perpendicular to the much larger-scale outflow detected in thermal methanol lines (right).

The methanol masers featured in several other projects by van Langevelde and Torstensson. Together with Vlemmings (Bonn, Germany and Onsala, Sweden) and Surcis (Bonn, Germany) they made progress in interpreting the methanol and water maser Zeeman effect and observed linear polarization, for example in the source NGC7538-IRS1. In addition they carried out a project with Rygl (INAF-IFSI, Rome, Italy) and Brunthaler (MPI, Bonn, Germany) to measure parallax distance measurements and investigated the membership of methanol maser complexes in the Cygnus X region, demonstrating that AFGL 2591 is in fact a background object.

2.3 Evolved stars

Circumstellar matter around on evolved stars

Amiri completed, together with van Langevelde and Vlemmings (Bonn), her studies of the shaping of evolved stars circumstellar material using maser observations. They processed data from a multi-epoch survey on water masers in evolved stars. In this project six new water fountain candidates were identified. In particular, the detection of H_2O masers of the supposedly dead OH/IR star IRAS 18455+0448 are intriguing. As expected, they also found significant variability in flux density and spectral profile for the H_2O masers.

The observations suggested a good correlation between the stellar pulsation and the H_2O maser variability and led to an estimated lifetime of 60 years for the H_2O masers in the post-AGB phase.

Compact object accretion

At the centre of most local galaxies we infer the presence of a supermassive black hole with a mass in excess of one million times the mass of our Sun. Most of these black holes are quiescent: they do not seem to accrete mass at large, detectable, rates. Already more than 25 years ago, it was predicted that a star could be torn apart and feed a black hole, producing an observable flare. The same reasoning applies to much less massive compact stellar objects in the Milky Way. The resulting flares would flag the presence of an otherwise quiescent compact object, and teach us about the physics of the interaction and of the interacting bodies, and point out sources of gravitational waves. However, until recently, there had been no significant theoretical or observational progress. This changed at the end of 2010 and in 2011, when the first three multiwavelengths observations of apparent tidal disruption events were claimed.

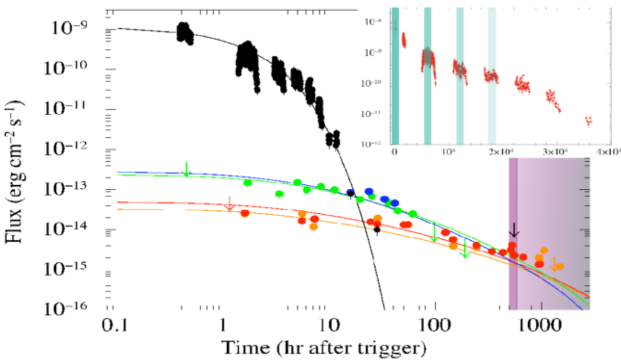

*Figure 7. GRB 101225A light curves in five energy bands: X-rays at 1 keV (black), ultraviolet at 2030 Å (green) and 2634 Å (blue), and optical at 6400 Å (R band, red) and 7,700 Å (I band, orange). Error bars, 1*σ*. The solid lines are the model by Lodato & Rossi 2010. The model is valid up to the shaded violet region. The insert highlights the early X-ray variability,which happens on a timescale consistent with the model. (from Campana et al. 2011, Nature, 480, 69)*

Rossi and a group of observers led by Campana modelled the data for one of these events, the flare occurring on December 25, 2010 (see Fig. 7). An absolute novelty was that they were able to fit data taken simultaneously in three bands (optical, UV and soft X-ray). This was the first multiwavelengths fitting of a tidal disruption event. They used the theoretical model by Rossi and Lodato (Milan, Italy), who predicted the monochromatic light-curves produced by the accreting matter in both the super-Eddington and sub-Eddington phases. The result was quite surprising: if the event was Galactic, the "Christmas burst" was the caused by a minor body (only the size of a big comet) falling onto a neutron star. The impact of comets onto the Sun has been observed several times, but this would be the first time that a similar event was observed outside our solar System. However, Rossi and collaborators could not quite rule out the possibility that the event was extra-galactic.

2.4 Milky Way and Local Group galaxies

Bayesian statistics and star-bursts in the Local Group

Martínez-Galarza, Brandl, and co-workers developed a novel approach, based on Bayesian analysis, to fit the Spitzer infrared spectrometer measurements of star-bursts using the spectral energy distribution (SED) models constructed by Groves and collaborators. They demonstrated the capabilities, potential and reliability of this novel technique using the well-known giant HII region complexes 30 Doradus in the Large Magellanic Cloud and NGC 604 in the spiral galaxy M33. Both galaxies are low-metallicity dwarf members of the Local Group. The in-depth analysis of these well-resolved local regions established that important physical parameters, such as cluster mass, cluster age, interstellar medium pressure, and covering fraction of photodissociation regions, can also be derived for any more distant unresolved starburst region. The new technique thus has a much more general application, of great importance to studies of the more distant universe.

Gas and dust in the Small Magellanic Cloud

Israel is a member of the large scientific collaborations (S4MC, SAGE, Heritage) studying the Magellanic Clouds in the infrared using the Spitzer and Herschel Space Observatories. This year saw the publication of some major results on the Small Magellanic Cloud (SMC).

The SMC is a unique laboratory for the study of the life-cycle of dust given its low metallicity (~1/5 solar) and proximity (~60 kpc). The so-called SAGE-SMC

Spitzer Legacy program has the goals of studying the dust present in the interstellar medium, the production of dust by evolved stars, and the consumption of dust by star formation. The full SMC was mapped, including the Body, Wing, and Tail in seven bands from 3.6 to 160 µm. The resulting mosaics and point source catalogues were made available to the community.

In a comparison of the infrared colors of the SMC and those of other nearby galaxies, it was found that the 8 to 24 µm ratio is somewhat lower and the 70 to 160 µm ratio is somewhat higher than the average. The global infrared spectral energy distribution shows that the SMC has a three times lower aromatic emission/PAH (polycyclic aromatic hydrocarbon) abundance compared to most nearby galaxies.

This was pursued by mid-infrared spectroscopic mapping of six SMC star-forming regions, yielding good detections of PAH emission in all of them, and greatly increasing the range of environments where PAHs have been spectroscopically detected in the SMC. The PAH emission in the SMC is characterized by low ratios of the 6-9 µm features relative to the 11.3 µm feature, and weak 8.6 and 17.0 µm features. From these observations and published laboratory studies, it was concluded that PAHs in the SMC are smaller and less ionized than those in higher-metallicity galaxies. Analysis of PAH destruction studies suggested that a size distribution shifted towards smaller PAHs is not the result of ISM processing, but reflects differences in the formation of PAHs at low metallicity. The observed PAH deficit may be a consequence of PAHs forming with smaller average sizes thereby being more susceptible to destruction under typical ISM conditions.

An important study involved the comparison of the atomic gas, the molecular gas, and the recent star formation rate (SFR) inferred from H-alpha in the SMC. The confusion of conversion factor effects and the impact of metallicity on the formation and star formation efficiency of molecular gas was avoided by using infrared dust emission and local dust-to-gas ratios to construct a map of the molecular gas distribution independent of CO emission. On scales of 200 pc to 1 kpc characteristic molecular gas depletion time are of the order of ~1.6 Gyr, as is also the case in large spiral galaxies on similar spatial scales. On much larger scales, this depletion time decreases to ~0.6 Gyr as a consequence of the presence of a diffuse H-alpha component, and on much smaller scales increases to ~7.5 Gyr as the H-alpha and H_2 distributions differ in detail. The systematic uncertainties are a factor of 2-3, and the impact of metallicity on the physics of star formation in molecular gas does not appear to be the governing factor.

The relation between the rate of star formation and the total (H_2+HI) gas surface density is steep (with a power-law index ~2.2), which resembles that observed in the outer disks of large spiral galaxies. At a fixed total gas surface density the SMC has a 5-10 times lower molecular gas fraction (and star formation rate) than large spiral galaxies. The recent models by Krumholz et al. and Ostriker et al. applied to the observations suggest that at all spatial scales the SMC should have a low fraction of cold, gravitationally-bound gas. A combined model that incorporates both large scale thermal and dynamical equilibrium and cloud-scale photodissociation region structure reproduces the SMC measurements and also implies the low fraction of cold atomic gas required in the SMC.

2.5 Nearby galaxies

Molecular gas in the edge-on star-forming galaxy NGC4631

Israel is part of a team using the JCMT to obtain sub-millimeter continuum and CO line maps of a statistically representative sample of late type galaxies. As part of this survey, a full map of the CO (J=3-2) emission covering the disk of the edge-on galaxy, NGC 4631 was obtained. This galaxy is known for its spectacular gaseous halo. The strongest CO emission occurs within a radius of 5 kpc, but weaker disk emission is detected out to radii of 12 kpc. This provides NGC4631 with the most extensive molecular component yet seen in this galaxy. The CO (J=3-2) emission more closely follows the hot dust component, rather than the cold dust. This is consistent with this CO transition being a good tracer of star formation. Star formation occurs throughout the disk, and is not particularly concentrated towards the center. At the center, excitation conditions are typical of galaxy disks rather than of central star-bursts. The SFE suggests long gas consumption timescales (more than a thousand million years).

The velocity field is dominated by a steeply rising rotation curve in the region of the central molecular ring followed by a flatter curve in the disk. A very steep gradient in the rotation curve is observed at the nucleus, providing the first evidence for a central concentration of mass: a dynamical mass of 50 million solar masses within a radius of 282 pc. The velocity field also shows anomalous features indicating the presence of molecular outflows; one of them is associated with a previously observed expanding CO shell. Consistent with these outflows is the presence of a thick (up to 1.4 kpc) CO disk. It appears that the interaction between NGC 4631 and its companion(s) has agitated the disk and also initiated star formation, which was likely higher in the past than it is now. These may be necessary conditions for seeing prominent halos.

Formation of massive clusters in NGC 7552

Brandl, van der Werf and Rosenberg completed their mid-infrared study of the nearby galaxy NGC 7552 which shows a remarkable circumnuclear ring of starburst activity. About one in five of all spiral galaxies display star-burst activity in nuclear rings, but little is known about the ways in which the star-burst ignites and propagates within the ring, in the end leading to the formation of massive stellar clusters. By combining observations from the VISIR and SINFONI instruments on the VLT, from the Hubble Space Telescope and from the Spitzer Space Telescope, they succeeded in identifying and characterizing several massive, young, and heavily embedded star clusters. Upon consideration of the dynamics in the nuclear region, they concluded that the inflow of interstellar gas along the bars to the nuclear region does not directly lead to the formation of massive clusters but that, instead, massive cluster formation is governed by the physical conditions prevalent in the local environment.

[FeII] emission and supernova rates in starburst galaxies

Supernovae are responsible for most of the chemical enrichment of the universe, notably by very heavy elements, and supernova rates are tied to the recent star formation history of a galaxy. Global supernova rates are often derived from the non-thermal radio continuum luminosity, but correlations between near-infrared iron ([FeII]) line emission and supernovae have also been noted.

In interstellar space, almost all iron is locked in dust grains. However, shock waves such as those created by supernovae can shatter dust particles and thus release the iron into the gas-phase where it is excited by the interstellar radiation field. This makes [FeII] line emission a useful diagnostic for tracing shocks. Nevertheless, a quantitative connection between near infrared [FeII] emission and supernova rates has been lacking for a long time.

In particular, it was not clear how radio continuum and [FeII] line emission could be reliably related to supernova rates. Such a relationship is desirable because near-infrared [FeII] observations are relatively straightforward to obtain, and could thus be used to estimate global supernova rates where individual radio supernova remnants cannot be resolved.

To this end, Rosenberg, Van der Werf and Israel studied the bright central regions of eleven near-by star-forming galaxies, using VLT-SINFONI observations. They performed a pixel-by-pixel analysis of the correlation between [FeII] emission, and supernova rates independently derived from observed Brackett-gamma equivalent widths and luminosity's evaluated with Starburst-99 models. The comparison of the [FeII] luminosity with these supernova rates revealed a tight linear correlation that is quantitatively well-established. They also found an intriguing hint that a qualitatively similar, but quantitatively different relation applies (U)LIRGs. This is under further investigation.

Water under extreme conditions

The ultra-luminous infrared galaxy Markarian 231, showing signs of both active black hole accretion and enhanced star formation, exhibits very strong rotational lines of water vapor in the far-infrared. The water line strengths are comparable to those of the CO rotational lines. High-redshift quasars also show such CO and H_2O line properties, but starburst galaxies, such as M82, lack the very strong H_2O lines although they do have show strong CO lines.

In order to understand the origin of these strong water lines, Meijerink, in collaboration with Cazaux and Spaans (both Groningen), explored the possibility of enhancing the gas phase H_2O abundance in environments exposed to strong X-ray emission, using bare interstellar carbonaceous dust grains as a catalyst. The assumptions in their study were two-fold: (1) cloud-cloud collisions cause C and J shocks, and strip the grains of their ice layers. (2) The presence of an internally-created UV field by processing X-rays from the accreting black hole does not allow to reform the ice.

Meijerink and co-workers first determined the formation rates of both OH and H_2O on dust grains at temperature of 10-60 K, using both Monte Carlo and rate equation simulations, and then derived analytic expressions for the formation of OH and H_2O using bare dust grains as a catalyst. They found that oxygen atoms arriving on the dust are released into the gas phase in the form of hydroxyl and water vapor. This conversion is relatively efficient due to the chemistry occurring on dust (about 30 percent for oxygen converted into hydroxyl and 60 per cent for oxygen converted into water. At temperatures above 40 K, the efficiencies rapidly decline.

They also added the acquired formation rates to their X-ray chemistry code, that allows calculation of the thermal and chemical structure of the interstellar medium near an active galactic nucleus. When the gas is mostly atomic, molecule formation on dust is dominant over the gas-phase route, which is then quenched by the low H_2 abundance. It is possible to enhance the warm (more than 200 K) water abundance by an order of magnitude in X-ray exposed environments. This helps to explain the observed bright water lines in nearby and high-redshift ULIRGs and Quasars.

Mechanical heating of molecular gas in galaxy centers

Many galaxy centers are characterized by compact and bright CO emission with a high kinetic temperature. These temperatures, and the specific excitation of certain molecules, are not easy to explain in a satisfactory way by assuming UV or X-ray photon heating. For this reason, Khazandjian, Meijerink, Pelupessy, Spaans and Israel have been studying the importance of turbulent heating on interpreting the observations and understanding the physical properties of these galaxy centers. As a first step, they considered equilibrium models of the interstellar medium (ISM). They modeled the ISM as a one dimensional photodominated region, taking into account the effect of additional turbulent energy dissipated through supernova induced shocks. They could show convincingly that mechanical heating must always be taken into account in interpreting basic ISM diagnostics, in any case whenever it exceeds 1% of the UV luminosity of the starburst region. They also concluded that the water abundance is enhanced by the high equilibrium temperatures, even to the extent that in some cases water column densities may approach those of CO (which is the second most abundant molecule after molecular hydrogen). Strong water lines have been detected with Herschel in starburst galaxies such as M82, and the observations thus confirm the idea that water can be an excellent diagnostic for turbulence in galaxy centers.

Dwarf galaxies in clusters

The first high-resolution semi-analytical model extending well into the dwarf regime was released in 2011. This made it possible, for the first time, to compare the properties of dwarf galaxies in nearby clusters with models. A first basic comparison was made by Weinmann and collaborators from China and Germany for the nearby Virgo, Coma, Fornax and Perseus clusters. They found that the models were in reasonable agreement with observations. Remaining open problems were 1) a quite large dwarf-to-giant ratio and 2) a quite large red fraction of satellite galaxies in the model. Both of these problems indicate that despite much effort in the recent years, models are still unable to correctly capture the evolution of satellite galaxies, perhaps hinting towards a fundamental problem in low mass galaxy evolution.

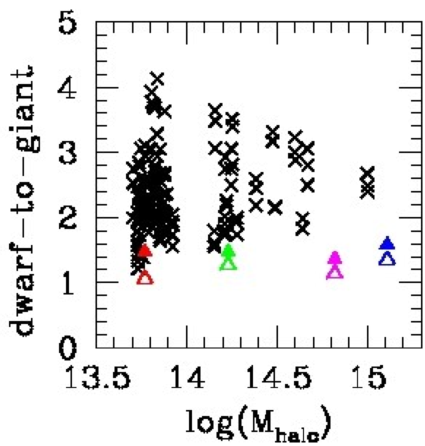

Figure 8. The ratio between dwarf galaxies (-19<M_r<-16.7) and giant galaxies (-19>M_r) in the Guo et al. (2011) model (black crosses), and in observations (filled and empty triangles).

AGN feedback

Holt continued to work on active galaxy nucleus (AGN) feedback in the form of outflows in young, radio-loud AGN, in collaboration with Tadhunter (Sheffield), Morganti (ASTRON) and Emonts (CSIRO). They presented a new method for measuring the gas densities in these sources, along with the first accurate calculation of the outflow energetics in a compact radio source and ultra-luminous infrared galaxy (ULIRG). Surprisingly, they had to conclude to energies significantly lower than required by theoretical models. The project has been extended to a larger sample of sources to determine the total energy in AGN-feedback (so far, only the warm ionized and cold atomic gas phases had been studied) and its dependencies on various AGN and host galaxy properties. This project has now won a significant amount of observing time on the Hubble Space Telescope, the ESO Very Large telescope, and the William Herschel Telescope.

2.6 Distant Galaxies

High redshift sub-millimetre galaxies

Van der Werf and Rahmati carried out a comprehensive analysis of the number counts of milometer galaxies, detected at 850 µm and shorter wavelengths. In their parametric model, they analyzed how each parameter is constrained by observational data. They found that the 850 μm source counts and redshift distribution depended strongly on the shape of the luminosity evolution function, but only weakly on the details of the spectral energy distribution of the galaxies. Based on this observation, they derived the best-fit evolutionary model using only the 850 μm counts and red-shift distribution as constraints. They then compared their best-fit model to observed source counts at shorter and longer wavelengths, and showed that their model on the one hand reproduced the 70 and 1100 μm source counts remarkably well, but on the other hand fell short in predicting the counts at intermediate wavelengths. Further analysis revealed that the discrepancy arises at low redshifts, indicating that revision of the adopted SED library towards lower dust temperatures (at a fixed infrared luminosity) is required. This modification is equivalent to a population of cold galaxies existing at low redshifts.

Van der Werf also collaborated with Smail (Durham, UK), Weiss (MPfIR, Germany), Walter (MPIA, Germany) and Wardlow (Irvine, USA) to derive photometric redshifts from 17-band optical to mid-infrared photometry of 78 robust radio, 24 μm and Spitzer IRAC counterparts to 72 of the 126 sub-millimetre galaxies (SMGs) selected at 870 μm by LABOCA observations in the Extended Chandra Deep Field-South (ECDF-S). The median photometric redshift of identified SMGs was z = 2.2, and 11 (~15%) high-redshift (z > 3) SMGs were identified. This confirmed that the bulk of the undetected SMGs are coeval with those detected in the radio/mid-infrared. At most ~15% of all the SMGs are below the flux limits of the IRAC observations and thus may lie at z > 3 and hence at most ~30% of all SMGs have z > 3. The team estimated that the full 870 μm population brighter than 4 mJy has a median redshift of 2.5. The median characteristic dust temperature of these SMGs is 37.4 K. The infrared luminosity function shows that SMGs at z = 2-3 typically have higher far-infrared luminosity's and luminosity density than those at z = 1-2. This is mirrored in the evolution of the star formation rate density (SFRD) for SMGs which peaks at z~2. The maximum contribution of bright SMGs to the global SFRD (~5% for 870 μm SNGs brighter than 4 mJy or 50% extrapolated to 1 mJy) also occurs at z~2.

Water emission from a QSO at z = 3.9

Van der Werf obtained, together with Meijerink, Loenen and Berciano Alba, Spaans (Groningen), Cox (IRAM, France), Weiss (MPIfR, Germany) and Walter (MPIA, Germany) the first detection of water emission in a high-redshift QSO. In total four rotational emission lines of water vapor were detected (Fig. 9).

While the lowest water lines are collisionally excited in clumps of warm, dense gas, the excitation of the higher lines turns out to be dominated by the intense local infrared radiation field. Since only collisionally excited emission contributes to gas cooling, water is not a significant coolant of the warm molecular gas. The derived excitation model requires the radiatively excited gas to be located in an extended region of high 100 μm opacity. Locally, such extended infrared-opaque regions are found only in the nuclei of ultra-luminous infrared galaxies. The authors proposed a model where the infrared-opaque circumnuclear cloud, which is penetrated by the X-ray radiation field of the QSO nucleus, contains clumps of massive star formation where the water emission originates. The radiation pressure from the intense local infrared radiation field exceeded the thermal gas pressure by about an order of magnitude, suggesting close to Eddington-limited star formation in these clumps.

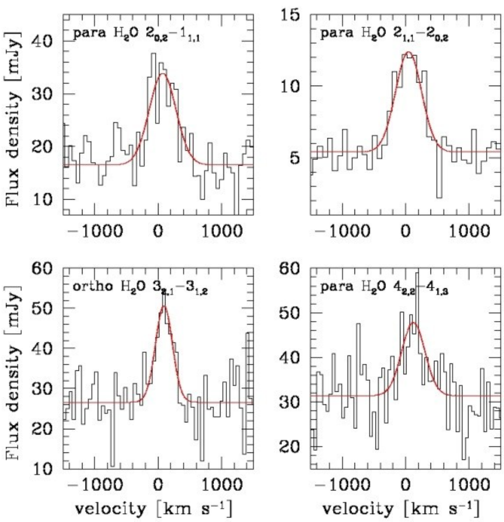

Figure 9. Spectra of water emission lines from a QSO at z=3.9. The horizontal axis shows velocity relative to z=3.911. The red curves indicate Gaussian fits to each spectrum.

Dusty gravitationally lensed galaxies at high redshift

Van der Werf worked with the Herschel ATLAS team in an observational study of gravitationally lensed high redshift galaxies discovered as part of Herschel ATLAS. This project is the largest open-time key project carried out on the Herschel Space Observatory, covering 570 deg of the extra-galactic sky, 4 times larger than all the other Herschel extragalactic surveys combined, in five far-infrared and sub-millimetre bands. A breakthrough was the first demonstration that blind CO redshifts can be obtained for these objects with wide-band spectrographs. This led to the detection of CO(1-0) with the Green Bank Telescope (led by Frayer) and higher CO lines with the IRAM Plateau de Bure Interferometer (led by Cox), as well as detection of [CII] emission with the SPIRE FTS on the Herschel Space Observatory (led by Valtchanov) in several objects.

Long-term monitoring of a lensed quasar

Loenen and Berciano Alba were monitoring on a long-term basis (over a period of about 4 years) two quasar images in the gravitational lens system B1600+434 at 8.5 GHz, using the Very Large Array (VLA). They used the resulting two light curves to determine an accurate time delay between the two images. Once the light curves were corrected for this time delay and their inherent difference in flux, they were used to investigate the presence of extrinsic variability. Any difference in variability between the two light curves is caused by the different light paths through the lens galaxy. The observed extrinsic variability can be ascribed to either scintillation/scattering by the ISM, or to micro lensing by massive compact objects in the lens galaxy.

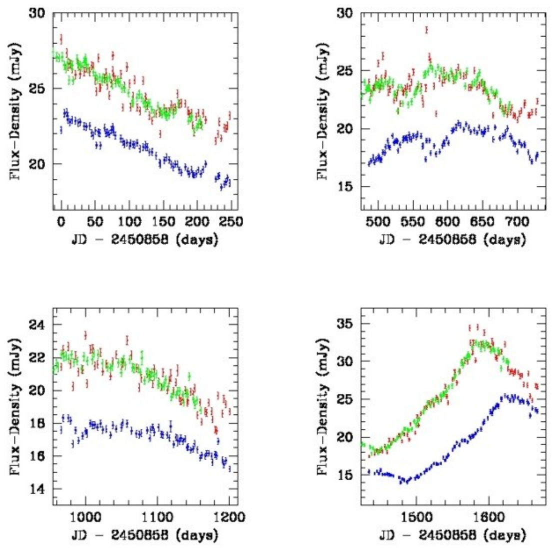

Figure 10. The red and blue points show the light-curves of the two quasar images in B1600+434. The green points represent the blue light-curve after correcting for the time

delay and flux ratio. The difference between the red and green points clearly illustrates presence of extrinsic variability.

Distant emission line galaxies

Shirazi and Brinchmann used a very large sample of 2865 emission line galaxies with strong nebular HeII 4686 emission in the Sloan Digital Sky Survey Data Release 7 in their attempt to investigate the origin of this line emission. Current stellar population models only yield significant HeII 4686 emission when the extreme-ultraviolet continuum is dominated by Wolf-Rayet stars. However, while Shirazi and Brinchmann found Wolf-Rayet emission in all metal-rich galaxies, they discovered that at lower metallicities a steadily increasing fraction of galaxies lacked signs of Wolf-Rayet emission. In order to understand this puzzling result, they explored a number of possible explanations.

They speculated that at very low metallicities stellar population models may be characterized by much higher temperatures than currently expected. This would, for instance, be the case if some stars rotate fast enough to evolve homogeneously. Such models might better explain the origin of the HeII 4686 line and also the metallicity trend of the He II star-forming sample better. Nevertheless, the case is far from closed, and a more definitive explanation of this unexpected behaviour awaits the completion of a significant follow-up effort.

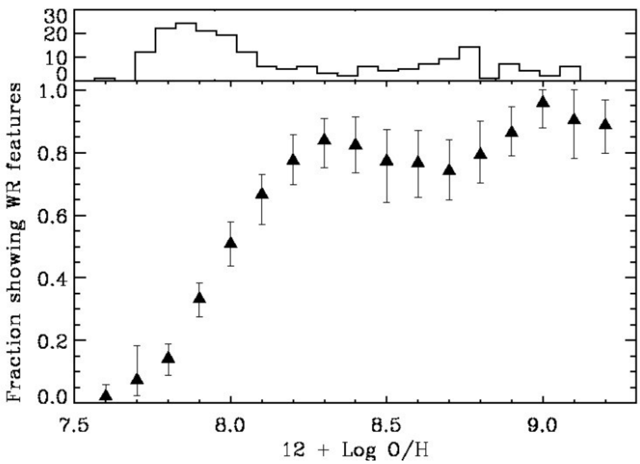

Figure 11. The fraction of objects with detected WR features in the HeII star-forming sample as a function of gas-phase oxygen abundance. The triangles show the median fraction in each abundance bin and the error bars the 16%-84% scatter around the

median. While essentially all high-metallicity star-forming galaxies with HeII 4686 nebular emission show WR features, this fraction drops rapidly at metallicities below 12 + log O/H ~ 8.2. The uncertainty in this transition abundance is 0.1 dex and depends on the metallicity calibration method adopted.

Galaxy mass functions

Giodini studied the stellar mass distribution of galaxies for 160 X-ray detected galaxy groups in the COSMOS survey and compared it with that of galaxies in the field, in order to investigate the effects of environment on the build-up of stellar mass. This was the deepest mass function ever studied for galaxy groups, describing the distribution of mass at redshift ~0.4 down to galaxy masses comparable to that of the Small Magellanic Cloud. She highlighted, for the first time, differences in the build-up of the passive population in the field, which imprint features in the distribution of stellar mass of passive galaxies with total masses less than 30 billion suns (Fig. 12). The gradual diminishing of the effect with increasing group mass indicates that the growing influence of the environment in bound structures is responsible for the build-up of a quenched component at the lower group masses.

In a different vein, the stellar mass distribution of star-forming galaxies is similar in all environments, and can be described by a single Schechter function in groups as well as in the field. Little evolution is seen up to redshift unity. Nevertheless, at z=0.2–0.4 low-mass groups tend to have a characteristic mass for star-forming galaxies which is 50% above that of higher-mass groups. This might be interpreted as a reduced effect of environmental processes in such systems. Giodini also analyzed the distribution of specific star formation as a function of stellar mass in groups and in the field, and found that groups showed on average a lower SFR at z<0.8. Accordingly, she found that the fraction of star-forming galaxies increases with red-shift in all environments, but at a faster pace in the denser ones.

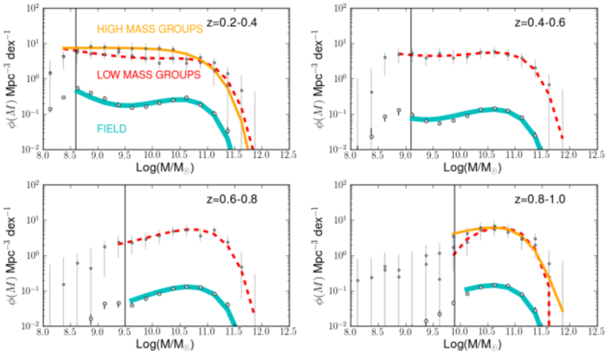

Figure 12. The build-up of the passive galaxies population in high/low mass groups and the field, as described by their galaxy stellar mass distribution.

Double-blind Hα + [OII] study at z~1.5

Sobral has conducted the first wide and deep dual narrow-band survey to select Hα and [OII] line emitters at z = 1.47 with the UKIRT and Subaru telescopes on Mauna Kea, Hawaii (USA). The Hα survey detected about 200 sources over 0.7 square degree, while the much deeper [OII] survey detected about 1400 emitters in a matched co-moving volume of 250.000 cubic mega-parsec. The combined survey resulted in the identification of 190 simultaneous Hα and [OII] emitters. The Hα and [OII] luminosity functions were shown to evolve significantly from z ~ 0 in a consistent way. Sobral found a star formation rate density of the Universe at z = 1.5 of 0.17 $M_{sun}/yr/Mpc^3$. Furthermore, by using a large comparison sample at z~0.1 extracted from the SDSS, Sobral calibrated the [OII]/Hα line ratios as probes of dust-extinction. Hα emitters at z~1.47 show on average one magnitude of extinction, similar to the SDSS sources at z~0. Although dust extinction and SFR are correlated, the relation evolves by about ~0.5 mag from z~1.5 to z~0, with z~0 relations over-predicting the dust extinction corrections at high-z by that amount. Stellar mass is found to be a much more fundamental extinction predictor, with the relation between mass and extinction being valid at both z~0 and z~1.5.

Star formation, environment, and stellar mass at z~1 from the HiZELS-Hα survey

Sobral studied environment and stellar mass of a large sample of star-forming Hα emitters at z= 0.84 from the High-z Emission Line Survey (HiZELS) split over two fields (COSMOS and UKIDSS UDS). By taking advantage of a truly panoramic coverage of a wide range of environments, ranging from the field to a rich cluster, he could show that both stellar mass and environment play crucial roles in determining the properties of star-forming galaxies. Specific star formation rates (sSFRs) decline with stellar mass in all environments, and the fraction of Hα star-forming galaxies declines sharply from 0.4 for galaxies with masses around 10 billion M_{sun} to effectively zero for galaxies with masses exceeding 300 billion M_{sun}. This confirms that mass-downsizing is generally in place at z~1. The fraction of star-forming galaxies also falls sharply as a function of local environmental density from 0.4 in the field to about zero in rich groups and clusters.

When star formation does occur in such high density regions, it is mostly dominated by potential mergers and, indeed, if only non-merging star-forming galaxies are considered, then the environment and mass trends are even stronger and are qualitatively similar at all masses and environments, respectively, as in the local Universe. The median SFR of Hα emitters at z = 0.84 increases with density for both field and intermediate (group or cluster outskirts) densities. Interestingly, Sobral only found the relation between median SFR and environment to be valid for low- to moderate-mass galaxies and not for the most massive star-forming galaxies. Overall, his observations provided a detailed view over a sufficiently large range of mass and environment to reconcile previous observational claims: stellar mass is the primary predictor of star formation activity at z~1, but the environment, while initially enhancing the median SFR of (lower mass) star-forming galaxies, is ultimately responsible for suppressing star formation activity in all galaxies above surface densities of 10-30 per square mega-parsec (group and cluster environments).

An elusive star-formation plateau

A recent puzzling discovery in extra-galactic astronomy was the observed plateau in the specific star formation rate of galaxies with stellar mass of about three billion solar masses at redshifts of 2 to 7. In collaboration with researchers in Germany and Israel, Weinmann showed that this plateau is in disagreement with basic predictions of semi-analytical models based on dark matter simulations. It was shown that even if these models are tuned freely it is very hard to reproduce the plateau, while at the same time matching other basic constraints like the evolution in the stellar mass function. This indicates that the plateau challenges current models at a rather basic level.

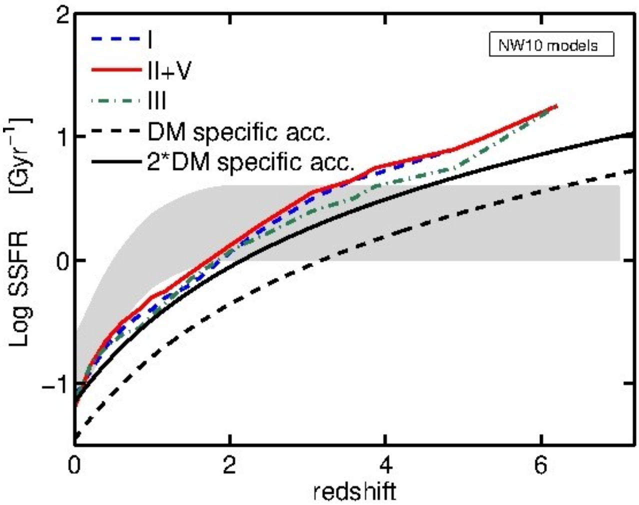

Figure 13. This figure shows the specific star formation rate plateau as observed (broad grey band) in comparison with several simple semi-analytical models (lines).

Star formation in high redshift galaxies

Whitaker, Labbe, Franx and collaborators used a large survey with the NEWFIRM camera on the Kitt Peak 4m telescope to reveal that galaxies nearly always show one of two distinct behaviours: they are either forming stars at a high rate or they are hardly forming any new stars at all. This "bi-modal" behaviour of galaxies had been seen in today's Universe, but the new study indicates that galaxies have behaved this way for nearly 12 billion years, or 85% of the history of the Universe.

Spitler, Labbe, and collaborators used the first data of the Z-FOURGE survey on Magellan to discover a distant galaxy cluster hiding in plain view. Galaxy clusters are the urban centers of the universe and can contain thousands of galaxies, yielding important clues on the influence of environment on galaxy evolution. The newly found cluster is one of the earliest examples found to date.

Search for extremely young galaxies

In collaboration with other members of the HUDF09 team, Bouwens conducted a search for z = 10 galaxy candidates using the deepest existing near-infrared observations. He reported one probable z = 10 candidate, which likely existed only 480 million years after the Big Bang. His team used the discovery of this candidate to constrain the luminosity function of galaxies at redshift 10, and as a gauge on the build-up and evolution of galaxies at early times. The discovery appeared in press in late January in the journal Nature and received substantial attention in the media.

Bouwens and collaborators continued work on the luminosity function of galaxies at very high redshift. In particular, they used the new WFC3/IR observations over the CDF-South and the Hubble Ultra Deep Field to study the faint-end slope of galaxies at z = 5-8, and explored the implications for the reionization of the universe by galaxies. They concluded that galaxies could probably ionizer the universe for plausible values of the escape fraction and clumping factor. Bouwens and coworkers also used the ultra-deep WFC3/IR observations from the HUDF09 program and the wide-area WFC3/IR observations over the CDF-South GOODS field to study the rest-frame UV colors of galaxies in the early universe. They characterized the dependence of these UV colors on the red-shift and luminosity of galaxies, and found that the UV colors become bluer at higher redshift and lower luminosity's. They then used the derived UV color distributions to determine the approximate dust extinction in high-redshift galaxies and to apply a correction for this dust extinction.

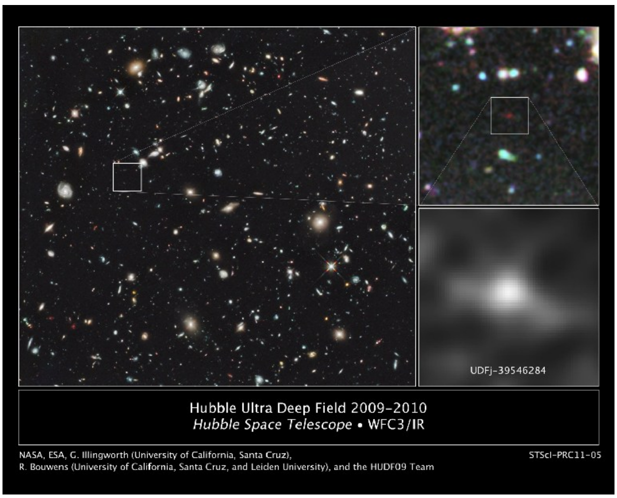

Figure 14. Image of a highly probable candidate galaxy found just 480 million years after the Big Bang. Left panel shows the position of the candidate galaxy within the Hubble Ultra Deep Field (the most sensitive near-infrared exposure ever obtained by humanity). The right images show zoom-in images of the candidate.

Proto Clusters

One of the most successful methods to push the search for galaxy clusters beyond z = 2 is targeting high-z radio galaxies. In the model of hierarchical galaxy formation the massive radio galaxies should be located in dense environments and are thus possible members of galaxy cluster progenitors. These structures are often referred to as 'protoclusters', because at these redshifts galaxy clusters are likely still in the process of formation and therefore have not yet virialised. Kuiper, Miley, Röttgering, Hatch (Nottingham) and Venemans (Heidelberg) carried out spectroscopic follow-up observations of Lyman Break Galaxies (LBGs) selected in the field surrounding the radio galaxy MRC 0316-257 at z ~ 3.13. A combined analysis of all the data indicated that two proto-clusters might be present in this field. Simple merger dynamics indicated that the observed relative velocity of 1600 km/s can be reproduced if the two structures have masses of $5x10^{14}$ solar mass and have starting separations of around 2.5 to 3 Mpc. Kuiper, Miley, Röttgering, Hatch (Nottingham) and Venemans (Heidelberg) and others used the recently commissioned red tunable filter on the Gran Telescopio Canarias in the search for protoclusters galaxies in the field centered on the z = 4.413 radio galaxy 6C0140+326. Using 3 differentt wavelength tunings they found a total of 27 unique candidate Ly emitters. With the 6C0140+326 field being denser by a factor of 9 ± 5 than a blank field, this is one of few known.

The environment of the high-z radio galaxy PKS 1138-262 at z ~ 2.2 is a prime example of a forming galaxy cluster. Kuiper, Miley, Röttering, Nesvadba (Paris), Hatch (Nottingham) and others used deep SINFONI integral field spectroscopy to perform a detailed study of the kinematics of the galaxies within 60 kpc of the radio core. The velocity distribution of the confirmed satellite galaxies shows a broad, double-peaked velocity structure with σ = 1360 ± 206 km/s. A similar broad, double-peaked distribution was found in a previous study targeting the large scale protocluster structure, indicating that a common process is acting on both small and large scales. Comparison to the Millenium simulation indicates that the protocluster velocity distribution is consistent with that of the most massive haloes at z ~ 2.

Hatch (Nottingham), Kuiper, Miley, Röttgering, and Venemans (Heidelberg) and others carried out a study of Hα emitters in two dense galaxy proto-clusters surrounding the radio galaxies MRC1138-262 z = 2.2 and 4C +10.48 z = 2.35. The star formation rate density is on average 13 times greater in the proto-clusters than the field with the total star formation rate within the central 1.5 Mpc proto-cluster of the protoclusters exceeding 3000 solar mass per year. However, no significant difference in the shape of the Hα luminosity functions were found, implying that environment does not substantially affect the strength of the Hα line from strongly star forming galaxies. The proto-cluster emitters are typically 0.8 mag brighter in rest-frame R continuum than field emitters, implying they are twice as massive as their field counterparts at the same redshift. The proto-cluster galaxies also have lower specific star formation rates than field galaxies, meaning the emitters in the dense environments formed more of their stars earlier than the field galaxies. The conclusion is that galaxy growth in the early Universe was accelerated in dense environments, and that cluster galaxies differed from field galaxies even before the cluster had fully formed.

Colliding massive clusters: probing particle acceleration in Mpc-sized shocks

Galaxy clusters grow by mergers with other clusters and galaxy groups. These mergers create shock waves within the intracluster medium (ICM) that can accelerate particles to extreme energies. In the presence of magnetic fields, relativistic electrons form large regions emitting synchrotron radiation, so-called radio relics. Behind the shock front, synchrotron and inverse Compton (IC) losses cause the radio spectral index to steepen away from the shock front. In a binary cluster merger, two shock waves are generated which move diametrically outwards along the merger axis. Two radio relics can then form on both sides of the cluster center.

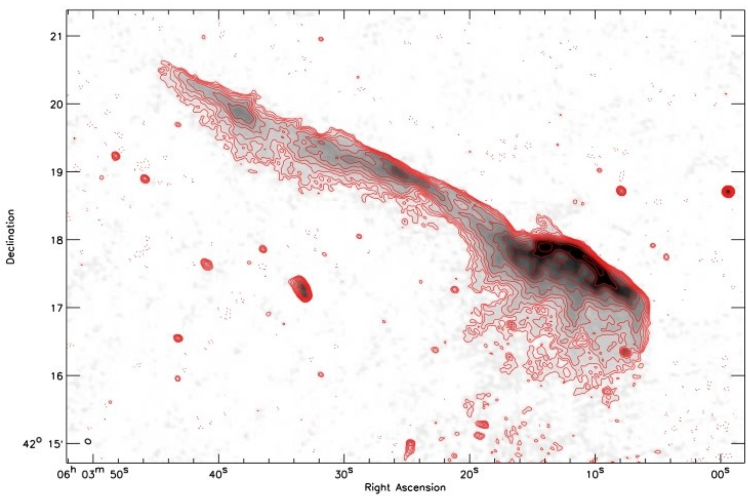

Figure 15. GMRT 610 MHz image of the 1.9 Mpc shock in the the new radioselected galaxy cluster 1RXS J0603.3+4214 (z = 0.225). The beam size is 5.1`` x 4.1``

and the map noise is 26 μJy/beam.

A prime example that van Weeren et al. studied is the cluster CIZA J2242.8+5301, where very clear spectral steepening in the downstream region is observed. The main relic has a total extent of 1700 kpc, while its width is only 55 kpc. Together with the high observed polarization fraction, this implies the relic is seen very close to edge-on which makes it easier to constrain the merger geometry. van Weeren, Röttgering, Brüggen (Bremen), and Hoeft (Tautenburg) carried out hydrodynamical simulations of idealized binary cluster mergers with the aim of constraining the merger scenario for this cluster. From their simulations, they find that CIZA J2242.8+5301 is probably undergoing a merger in the plane of the sky (less then 10 from edge-on) with a mass ratio (M1 : M2) of about 2 : 1, and an impact parameter. 400 kpc. They conclude that double relics relics can set constraints on the mass ratios, impact parameters, timescales, and viewing geometry of binary cluster mergers, which is particularly useful when detailed X-ray observations are not available. Since only a few dozen diffuse cluster radio sources are known, while models predict that a much larger number of these sources exist, van Weeren, Röttgering, Brüggen (Bremen), and Hoeft (Tautenburg) carried out an extensive observing campaign to create a large sample of diffuse radio sources in galaxy clusters. They carried out radio continuum observations with the Westerbork Synthese Radio Telescope (WSRT), Giant Metrewave Radio Telescope (GMRT) and Very Large Array (VLA) of clusters with diffuse radio emission visible in NVSS and WENSS survey images. Optical images were taken with the William Herschel and Isaac Newton Telescope (WHT, INT). 6 new radio relics, including a probable double relic system, and 2 radio halos were discovered. By constructing a sample of 35 radio relics they found that relics are mostly found along the major axis of the X-ray emission from the ICM, while their orientation is perpendicular to this axis. Furthermore, tentative evidence was found for an increase of the cluster's relic fraction with X-ray luminosity and redshift. Finally, the location and orientation of radio relics with respect to the ICM elongation is consistent with the scenario that relics trace merger shock waves. van Weeren, Röttgering, Intema and others carried out detailed Westerbork Synthesis Radio Telescope (WSRT) and Giant Metrewave Radio Telescope (GMRT) radio observations between 147 MHz and 4.9 GHz of a new radio-selected galaxy cluster 1RXS J0603.3+4214 (z = 0:225). The cluster hosts a large bright 1.9 Mpc radio relic, an elongated ~ 2 Mpc radio halo, and two fainter smaller radio relics (See Fig. 15 and 16). The large radio relic has a peculiar linear morphology. This relic has a clear spectral index gradient from the front of the relic towards the back, in the direction towards the 2 cluster center. Parts of this relic are highly polarized with a polarization fraction of up

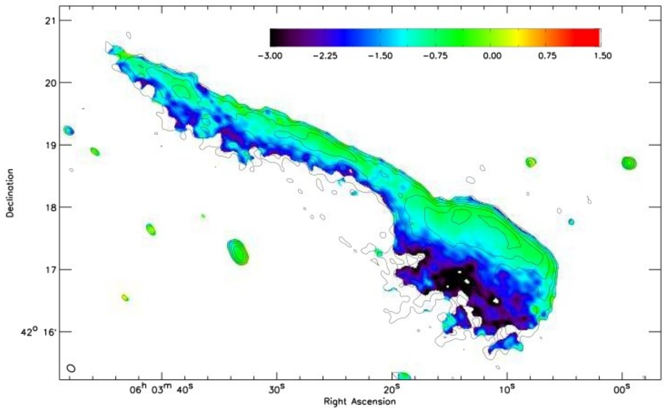

Figure 16. GMRT 610325 MHz spectral index map. Contour levels from the GMRT 325 MHz image are drawn at [1, 4, 16, 64, . . .] x 6σ rms and the spectral index map has a resolution of 7.9`` x 6.2``. Pixels below 5 σ rms are blanked.

Evolution of powerful radio galaxies

Rigby, Ker, Best (Edinburgh), Röttgering and others carried out a number of investigations related to the statistical evolution of powerful radio sources. The CENSORS 1.4 GHz radio sample was combined with additional radio data from the Parkes All–Sky, Parkes Selected Regions, Hercules and VLA COSMOS samples to provide comprehensive coverage of the radio power vs. redshift plane. The modelling reveals clear declines in comoving density at z > 0:7 for lower luminosity sources (log P = 25-26); these turnovers are still present at log P > 27, but move to z > 3, suggesting a luminosity–dependent evolution of the redshift turnover, similar to the 'cosmic downsizing' seen for other AGN populations. The existence of a correlation between observed radio spectral index and redshift has long been used as a method for selecting high redshift radio galaxy candidates. Using 9 highly spectroscopically complete radio samples, selected at different frequencies and flux limits, the efficiency of this method was determined. Furthermore an efficient method for selecting high-z radio sources was presented, based purely on combining their observed radio properties of and angular size and K-band magnitude.

2.7 Large-scale Structure and Cosmology

Dark energy, dark matter, and cluster mass

To learn more about the nature of dark energy ever larger surveys are required. Ground based projects such as the Kilo Degree Survey, which started in the fall of the year provide an important step forward, the ultimate measurement requires a space based telescope. Hoekstra is one of the coordinators for the weak lensing science of Euclid, which was approved by ESA for adoption. Although Euclid will provide the exquisite measurements needed to extract the cosmological signal from the data, the interpretation also requires a good understanding of the large-scale structure. Semboloni, Hoekstra and Schaye studied the impact of baryon physics on the interpretation of the cosmic shear signal and found that ignoring this would lead to large biases in the case of Euclid.

To study the properties of the dark matter halos around galaxies, van Uitert and Hoekstra analyzed data from the RCS2 which overlapped with the SDSS. Thanks to the increased depth of the RCS2 the scaling relations between virial mass and stellar mass or luminosity could be extended to higher masses. Together with Jee (UC Davis) and others, Hoekstra completed a study of the masses of distant clusters of galaxies which had been observed with the HST. This work extends the red-shift range where scaling relations between mass and X-ray properties have been measured to z~1. The results suggest only a mild evolution with redshift. Galaxy formation and matter power spectra: a challenge for precision cosmology.

Upcoming weak lensing surveys, such as LSST, EUCLID and WFIRST, aim to measure the matter power spectrum with unprecedented accuracy. In order to fully exploit these observations, models are needed that, given a set of cosmological parameters, can predict the non-linear matter power spectrum at the level of 1 per cent or better for scales corresponding to co-moving wave-numbers $0.1 < k < 10$ h/Mpc. Van Daalen, Schaye, Booth and Dalla Vecchia employed the OWLS simulations to investigate the effects of various baryonic processes on the matter power spectrum. In addition, they examined the distribution of power over different mass components, the back-reaction of the baryons on the cold dark matter and the evolution of the dominant effects on the matter power spectrum. They found that single baryonic processes are capable of changing the power spectrum by up to several tens of per cent. Their simulation that includes AGN feedback, which they consider to be their most realistic simulation as, unlike those used in previous studies, it has been shown to solve the over-cooling problem and to reproduce optical and X-ray observations of groups of galaxies, predicts a decrease in power relative to a dark matter only simulation ranging, at z=0, from one per cent at k = 0.3 h/Mpc to 10 per cent at k = 1 h/Mpc and to 30 per cent at k = 10 h/Mpc. This contradicts the naive view that baryons raise the power through cooling, which is the dominant effect only for k > 70 h/Mpc. Therefore, baryons, and particularly AGN feedback, cannot be ignored in theoretical power spectra for k > 0.3 h/Mpc. It will thus be necessary to improve our understanding of feedback processes in galaxy formation, or at least to constrain them through auxiliary observations, before we can fulfill the goals of upcoming weak lensing surveys.

Improving the accuracy of measurements with Euclid

Semboloni aimed to improve the accuracy of weak lensing measurements and predictions for ongoing and future weak lensing missions such as KiDS and Euclid. She worked actively to show the feasibility of the Euclid mission (selected by ESA in the autumn of 2011) which will investigate the nature of the dark energy using weak lensing measurements. The precision of Euclid is such that aspects that could be neglected before now have to be taken into account. For instance, the accuracy of the shear estimation is beset by limitations that are caused by the colour of galaxies varying across their profile (generally referred to as "colour gradient"). This information is lost once the light is convolved with a chromatic point spread function (PSF). The PSF deconvolution which is necessary to estimate shear can only be done with limited accuracy. Yet, this issue is important for Euclid as it is designed with a broad-band filter. Semboloni studied ways to improve the quality of the interpretation of cosmic shear statistics. In particular, she showed that a strong baryonic feedback, which is actually supported by observations, can bias the analysis of current and future weak lensing data-sets if not correctly modelled. She extended the halo-model approach which is generally used to forecast the power spectrum of matter fluctuations and to predict the amplitude of cosmic shear statistics so that it is possible to account for the modifications of an eventual baryonic feedback. She showed that by using this model, the cosmological constraints from cosmic shear tomography are affected by a bias which is comparable with the statistical error of Euclid. If one ignores the feedback the bias is much higher. Semboloni also has been studying the intrinsic alignment signal using simulations. Although the study is still ongoing her preliminary results shows that for future missions we need studies that are much more accurate than the ones done in the past. This motivated her to submit a proposal, recently approved, to carry out N-body simulations aiming to address those aspects which were ignored in previous studies.

Why do star formation rates drop at z = 2?

The cosmic star formation rate is observed to drop sharply after redshift z = 2. Van de Voort, Schaye, Booth, and Dalla Vecchia used two large simulations to investigate how this decline is related to the evolution of gas accretion and to outflows driven by AGN. They found that the drop in the star formation rate follows a corresponding decline in the global cold-mode accretion rate density onto halos, but with a delay of the order of the gas consumption time-scale in the interstellar medium. In contrast to cold-mode accretion, which peaks around z=3, the hot mode continues to increase to about z=1 and remains roughly constant thereafter. By the present time, the hot mode strongly dominates the global accretion rate onto haloes. Star formation does not track hot-mode halo accretion because most of the hot halo gas never accretes onto galaxies. AGN feedback plays a crucial role by preferentially preventing the gas that entered halos in the hot mode from accreting onto their central galaxies. Consequently, in the absence of AGN feedback, gas accreted in the hot mode would become the dominant source of fuel for star formation and the drop-off in the cosmic star formation rate would be much less steep.

Correlation structure of dark matter halo properties

Jeeson-Daniel, Dalla Vecchia, Haas, and Schaye investigated the correlation between nine different dark matter halo properties using a rank correlation analysis and a Principal Component Analysis for a sample of halos spanning five orders of magnitude in mass. They considered mass and dimensionless measures of concentration, age, relaxedness, sphericity, tri-axiality, substructure, spin and environment, where the latter was defined in a way that makes it insensitive to mass. They found that concentration is the most fundamental property. Except for environment, all parameters are strongly correlated with concentration. Concentration, age, substructure, mass, sphericity and relaxedness can be considered a single family of parameters, albeit with substantial scatter. In contrast, spin, environment and triaxiality are more independent, although spin does correlate strongly with substructure and both spin and triaxiality correlate substantially with concentration. Although mass sets the scale of a halo, all other properties are more sensitive to concentration.

The cosmic distribution of metals predicted by simulations

Wiermsa, Schaye, and Theuns (Durham, UK) used simulations to investigate how a range of physical processes affect the cosmic metal distribution. In all models stars and the warm-hot intergalactic medium (WHIM) constitute the dominant repository of metals, while for $z > 2$ the ISM is also important. In models with galactic winds, predictions for the metallicities of the various phases vary at the factor of 2 level and are broadly consistent with observations. The exception is the cold-warm intergalactic medium (IGM), whose metallicity varies at the order of magnitude level if the prescription for galactic winds is varied, even for a fixed wind energy per unit stellar mass formed, and falls far below the observed values if winds are not included. At the other extreme, the metallicity of the intracluster medium (ICM) is largely insensitive to the presence of galactic winds, indicating that its enrichment is regulated by other processes. The mean metallicities of stars (about the same as that of the sun), the ICM (about a tenth solar), and the WHIM (also about a tenth solar) evolve only slowly, while those of the cold halo gas and the IGM increase by more than an order of magnitude from $z = 5$ to 0. Higher velocity outflows are more efficient at transporting metals to low densities, but actually predict lower metallicities for the cold-warm IGM since the winds shock-heat the gas to high temperatures, thereby increasing the fraction of the metals residing in, but not the metallicity of, the WHIM. Besides galactic winds driven by feedback from star formation, the metal distribution is most sensitive to the inclusion of metal-line cooling and feedback from AGN. They concluded that observations of the metallicity of the low-density IGM have the potential to constrain the poorly understood feedback processes that are central to current models of the formation and evolution of galaxies.

Galaxy redshifts from absorption by the intergalactic medium

Rest-frame UV spectral lines of star-forming galaxies are systematically offset from the galaxies' systemic redshifts, probably because of large-scale outflows. Rakic, Schaye, Steidel, and Rudie (both Caltech, USA) calibrated galaxy redshifts measured from rest-frame UV lines by utilising the fact that the mean H I Ly-α absorption profiles around the galaxies, as seen in spectra of background objects, must be symmetric with respect to the true galaxy redshifts if the galaxies are oriented randomly with respect to the lines of sight to the background objects. They found that Ly-α emission and ISM absorption redshifts require systematic shifts of about 295 km/s and 145 km/s, respectively. For the small subset (less than 10 per cent) of galaxies for which near-IR spectra have been obtained, their method gives consistent results. However, they found that the the Ly-α offset is larger for this subset of galaxies, which implies that no single number appropriately describes the whole population of galaxies. Their method can be used to provide accurate redshift calibrations and will enable studies of circumgalactic matter around galaxies for which rest-frame optical observations are not available.

Gas accretion onto galaxies and their gaseous halos

Van de Voort, Schaye, Booth, Haas, and Dalla Vecchia studied the rate at which gas accretes onto galaxies and halos and investigated whether the accreted gas was shocked to high temperatures before reaching a galaxy. They found that gas accretion is mostly smooth, with mergers only becoming important for groups and clusters. The specific rate of the gas accretion onto halos is, like that for dark matter, only weakly dependent on the halo mass. For halo masses M_{halo} much larger than 100 billion solar masses, it is relatively insensitive to feedback processes. In contrast, accretion rates onto galaxies are determined by radiative cooling and by outflows driven by supernovae and AGN. Galactic winds increase the halo mass at which the central galaxies grow the fastest by about two orders of magnitude to halo masses of about 1000 billion solar masses. Gas accretion is bi-modal, with maximum past temperatures either of the order of the virial temperature or less than 100.000 K. While gas accretion onto halos can be robustly predicted, the rate of accretion onto galaxies is sensitive to uncertain feedback processes. Nevertheless, it is clear that galaxies, but not necessarily their gaseous halos, are predominantly fed by the gas that did not experience an accretion shock when it entered the host halo.

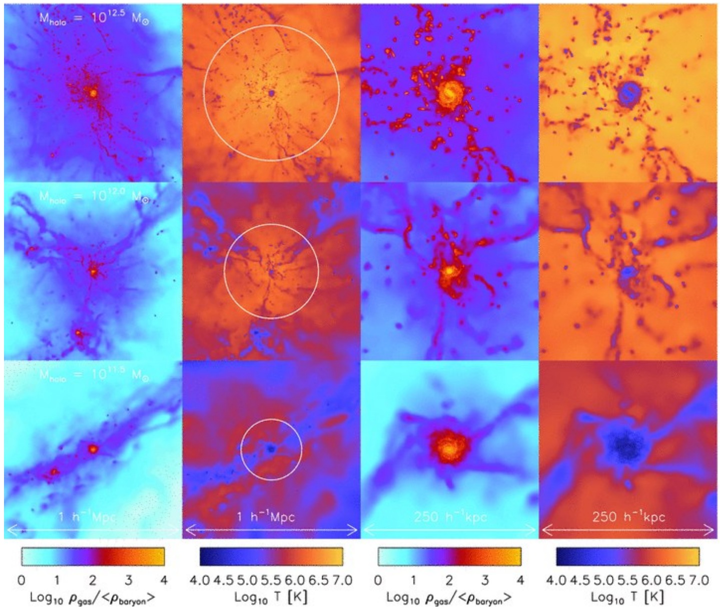

Figure 17. Predicted gas over-density (first and third columns) and temperature (second and fourth columns) in a cubic region of 1/h co-moving Mpc (first and second columns) and 250/h co-moving kpc (third and fourth columns) centered on halos of log M_{halo}/M_{sun} = 12.5, 12.0, and 11.5 (from top to bottom) at z = 2. The white circles indicate the virial radii of the halos. Cold, dense streams bring gas to the centre. The temperature of the hot gas increases with halo mass. Hot accretion dominates for high-mass halos, cold accretion for low-mass halos. The galaxies in the centre of these halos are discs, surrounded by cold gas. This cold gas is in clumps (top row), disrupted streams (middle row), or smooth streams (bottom row).

Understanding scaling relations for supermassive black holes

The growth of the supermassive black holes (BHs) that reside at the centre of most galaxies is intertwined with the physical processes that drive the formation of the galaxies themselves. The evolution of the relations between the mass of the BH, m_{BH}, and the properties of its host therefore represents crucial aspects of the galaxy formation process. Booth and Schaye used a cosmological simulation, as well as an analytical model, to investigate how and why the scaling relations for BHs evolve. They found that a simulation that reproduces the observed z=0 relations between m_{BH} and the properties of its host galaxy, as well as the thermodynamic profiles of the intragroup medium, also reproduces the observed evolution in the ratio m_{BH}/m_{stars} for massive galaxies, although the evolution of the relation with velocity dispersion was in apparent conflict with observations. The simulation predicts that the relations between m_{BH} and the binding energies of both the galaxy and its dark matter halo do not evolve, while the ratio m_{BH}/m_{halo} increases with redshift. A simple, analytic model in which the mass of the BH is controlled by the gravitational binding energy of its host halo, quantitatively reproduces the latter two results. Finally, they could explain the evolution in the relations between m_{BH} and the mass and binding energy of the stellar component of its host galaxy for massive galaxies at low redshift ($z < 1$) if these galaxies grow primarily through dry mergers.

Quasar-driven winds and the over-cooling in galaxy groups and clusters

Galaxy groups are not scaled-down versions of massive galaxy clusters. The hot gas in groups is, on average, less dense than the intracluster medium, implying that one or more non-gravitational processes (e.g. radiative cooling, star formation and/or feedback) has had a relatively larger effect on groups. McCarthy (Cambridge, UK), Schaye, and collaborators compared a number of cosmological hydrodynamic simulations from the OWLS project to isolate and quantify the effects of cooling and feedback from supernovae AGN on the gas. Only runs that include AGN feedback were able to successfully reproduce the optical and X-ray properties of groups and low-mass clusters. Interestingly, they found that the gas that constitutes the present-day intragroup medium is that which was not strongly heated by AGN. Instead, the low median density/high median entropy of the gas in present-day groups is achieved by the ejection of lower entropy gas from low-mass progenitor galaxies at high redshift (primarily $2 < z < 4$). This corresponds to the epoch when super-massive black holes accreted most of their mass, typically at a rate that is close to the Eddington limit (i.e., when the black holes are in a 'quasar mode').

Multi-frequency, thermally coupled radiative transfer with TRAPHIC

Pawlik and Schaye presented an extension of TRAPHIC, their method for radiative transfer of ionizing radiation in smoothed particle hydrodynamics simulations. The new version keeps all advantages of the original implementation: photons are transported at the speed of light, in a photon-conserving manner, directly on the spatially adaptive, unstructured grid traced out by the particles, in a computation time that is independent of the number of radiation sources, and in parallel on distributed memory machines. They extended the method to include multiple frequencies, both hydrogen and helium, and to model the coupled evolution of the temperature and ionization balance. They tested their methods by performing a set of simulations of increasing complexity and including a small cosmological reionization run. The results are in excellent agreement with exact solutions, where available, and also with results obtained with other codes. They used the new implementation to show that close to ionizing sources the grey approximation asymptotes to the multi-frequency result if photoheating rates are computed in the optically thin limit, but that the grey approximation breaks down everywhere if, as is often done, the optically thick limit is assumed.

2.8 Computational Astrophysics

The research group for Computational Astrophysics Leiden (CAstLe) studies the universe by means of simulation. The specific areas of research in astrophysics include the evolution of binary (and higher order multiple) stars, the dynamical evolution of dense stellar systems and of galactic nuclei. From a computational point of view the research group aims at simulation environments for solving the equations for gravitational dynamics, stellar structure and evolution, hydrodynamics and radiative transfer. Calculations are performed on computers built by the research group, graphical processing units, supercomputers and grid environments.

Fujii and Portegies Zwart conducted large-scale simulations of young and massive star clusters and their role in producing high velocity OB runaway stars. As many as one in five of all massive stars in the Milky Way have unusually high velocities, the origin of which has puzzled astronomers for half a century. Fujii and Portegies Zwart argued that these velocities originate from strong gravitational interactions between single stars and binaries in the centre of star clusters. The ejecting binary forms naturally during the collapse of a young star cluster. Their model replicated the key characteristics of OB runaways in our galaxy, and it explains the presence of very massive runaway stars around young star clusters, such as R136 and Westerlund 2. The high proportion and the distributions in mass and velocity of runaways in the Milky Way are reproduced if the majority of massive stars are born in dense and relatively low-mass (five to ten thousand solar mass) clusters.

Gieles and Portegies Zwart could finally, after a long decade started by Blaauw in 1964, establish a consensus how to properly distinguish star clusters and stellar associations. In Galactic studies, a distinction can usually be made between (open) star clusters and associations. However, this not trivial for barely resolved objects at distances of several mega-parsecs. Gieles and Portegies Zwart provided an objective definition by comparing the age of the stars to the crossing time of the stellar agglomerates. They found that a satisfactory separation can be made where this ratio equals unity. Stellar agglomerates for which the age of the stars exceeds the crossing time are bound, and are referred to as star clusters. Alternatively, those for which the crossing time exceeds the stellar age are unbound and are referred to as associations. This definition is useful whenever reliable measurements for the mass, radius and age are available.

Science with AMUSE

Pelupessy and Portegies Zwart examined the evolution of embedded clusters using advanced computer simulation models, including the effects of gravitational dynamics, hydrodynamics and stellar evolution as well as the energetic feedback from young stars. They found that gas dynamics plays a crucial role determining the structure and survival of stellar clusters.

The AMUSE environment was used to conduct the simulations. Version 5.1 of the AMUSE software package (van Elteren, Pelupessy, de Vries, Marosvolgyi and Portegies Zwart) was released on 21st of december. This release marks the conclusion of the first development cycle of AMUSE funded by NOVA and includes interfaces to 31 codes including 3 radiative transfer codes, the last domain to be added in this development cycle.

2.9 Instrumentation developments

VLT adaptive optics: 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 has been designed and manufactured at several research institutes and companies in Europa and is currently being integrated at the lead institute, the Centre de Recherche Astrophysique de Lyon (CRAL, France). The MUSE consortium consists of seven institutes. NOVA, by way of Leiden Observatory, is mainly involved in the interface between MUSE and its Adaptive Optics system (GALACSI), the preparations for scientific operation of MUSE -- such as 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.

ASSIST--the Adaptive Secondary Setup and Instrument STimulator is the test system for the VLT Adaptive Optics Facility (AOF) and will allow for verification of the operation of the various hardware and software systems for the AOF without the need for--sometimes long--on-sky testing. ASSIST was delivered to, and integrated at the ESO headquarter in Garching, Germany, with support from NOVA-ASTRON. Initial test results show excellent performance, although final testing will take place once integrated with ESO's Deformable Secondary Mirror.

VLT interferometry: MATISSE and 2nd Generation Fringe Tracker

MATISSE is a 4-telescope interferometer for ESO's VLTI, capable of making mid-infrared images with a spatial resolution of 3 milli-arcsec. Jaffe is the Dutch Co-Principal Investigator. In 2011, MATISSE passed and important milestone: the Optical Final Design Review. The overall Final Design Review will take place in April 2012. After this, actual construction of MATISSE will begin, aiming for completion in 2015.

The capabilities of the ESO interferometers can be considerably augmented with a 4-telescope Second Generation Fringe Tracker, in some ways analogous to the Adaptive Optics system for a single telescope. The NOVA design group, led by Jaffe, submitted one of two design studies to ESO in October 2011. At a review in December the NOVA design was evaluated as much more sensitive than the competing design, but some doubts were expressed about the risks involved in building such a novel design.

Omegacam operational at ESO!

Kuijken's research in 2011 was dominated by the commissioning of the OmegaCAM wide-field camera on the ESO VLT Survey Telescope on Paranal, Chile. As PI of the instrument consortium, he took part in four two-week commissioning runs of the instrument between March and August. First light was achieved on March 27, and commissioning completed in August ready for ESO to incorporate the instrument and telescope into Science Operations.

OmegaCAM, which was built by a consortium of institutes (Leiden and Groningen in the Netherlands, München, Göttingen and Bonn in Germany, Padua and Naples in Italy, and ESO itself) is a CCD mosaic camera, which placed at the focus of the 2.6-meter VST, records images of a square degree at a pixel scale of 0.2 arc seconds, almost 300 million pixels in total. It is the largest wide-field camera in the Southern hemisphere, and the only one permanently mounted on a dedicated survey telescope. An overriding design driver for the telescope and camera was image quality: Paranal is a superb seeing site and the VST/OmegaCAM take full advantage. The telescope has active primary and secondary mirrors, and the camera contains a sophisticated auto-focus system which can be used to maintain the focus and shape of the optics so that sharp images are obtained over the full field of view. The system is capable of delivering images with point spread function smaller than 0.6 arc seconds over the full field of view, with minimal ellipticity.

OmegaCAM is to be used for three large public surveys performed by different teams. The largest of these is the Kilo-Degree Survey (KiDS), which is led by Kuijken, and involves astronomers in Leiden, Groningen, Bonn, Munich, Naples, Paris, Edinburgh, Cambridge and London. The aim of KiDS, which is closely coordinated with the VIKING survey on the VISTA near-IR survey telescope, is to image 1500 square degrees of extra-galactic sky in 9 colours, in order to map the (dark) matter distribution around and between galaxies using weak gravitational lensing. The combination of the OmegaCAM/VST image quality and the multi-band photometry will allow an unprecedented study of the three-dimensional large-scale structure, a key probe of the cosmological model. The first observations for KiDS were taken in the last months of 2011. By the time the survey is completed in 2015 a total of twenty terabytes of raw image data will have been taken with OmegaCAM for this project, and processed using the dedicated data processing and archiving system set up at OmegaCen at the Kapteyn Institute in Groningen. Postdoc Jelte de Jong joined the Leiden group in May to coordinate the data taking and processing for KiDS.

The KiDS project is one of several efforts worldwide to study the cosmological model through gravitational lensing and large scale structure. This type of survey will culminate with the ESA Euclid mission, a dedicated satellite which will measure gravitational lensing and near-infrared photometry for most of the extra-galactic sky to exceptional precision and uniformity. Surveys such as KiDS will not only be invaluable pilots towards this ultimate survey, but are also required to provide the bulk of the colors of the galaxies needed for the final analysis.

GAIA

The Leiden GAIA group, led by Brown, is involved in the preparations for the data-processing for ESA's GAIA space mission. Scheduled for launch in 2013, GAIA aims at providing a stereoscopic census of the Milky Way by performing highly accurate astrometry (positions, parallaxes and proper motions), photometry and radial velocities for one billion stars and other objects to 20th magnitude. In 2011, work concentrated on three main themes.

First, 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 2011, the focus was on developing the algorithms and corresponding Java-code to the point that they can be used in large scale-tests of the photometric processing pipeline. Busso finished the implementation of the module which subtracts from the spectra the astrophysical background as well as the instrumental background due to charge release (caused by charge injections for the mitigation of the charge transfer inefficiency). The teams in Italy worked on the development of the module that assesses the crowding level and decides whether deblending is needed for particular observations. They also experimented further with various deblending algorithms.
The photometric data collected by GAIA can suffer from various problems during the actual mission, especially in crowded fields where data can get truncated or partially lost. Because of the extremely large number of images to process (typically 100 billion) these problems needs to be identified and dealt with fully automatically. Busso and Brown conducted a study of how to deal with this problematic data in the pipeline. Their recommendations will be implemented in the pipeline software.

Second, a major concern for the GAIA mission is the effect of radiation damage to the CCDs (due to solar wind and cosmic-ray protons). The consequence will be an increased level of charge transfer inefficiency (CTI) resulting in 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 completed his PhD research on the theoretical and empirical modelling of radiation damage effects. Prod'homme, Holl (Lund), Lindegren (Lund), and Brown conducted two detailed studies to demonstrate that the astrometric performance of GAIA can still be achieved in the presence of CTI. In the first study, they showed that the image location performance of GAIA (central to the astrometric performance) can indeed be recovered, to within about 10 per cent of the theoretical limit, by using an approach in which the PSF image is carefully modelled before fitting it to the data. This forward modelling approach will be a central element in the radiation damage mitigation strategy. In the second study, they investigated in detail how residual CTI induced errors will propagate into the astrometric solution for GAIA. Their conclusion was that a combination of CTI countermeasures in the hardware, the sophisticated estimate of the image location described above, and feedback from the astrometric solution to the PSF calibration and image location algorithms will preserve the overall GAIA astrometric performance, again to within 10 per cent of the CTI-free case.

Seabroke (London) and Prod'homme conducted a study of the functioning of one of the hardware countermeasures, the so-called supplementary buried channel (SBC). This CCD feature confines electrons generated by faint sources to a smaller volume in the CCD which leads to a mitigation of the CTI effects. They found that the SBC may not be fully functional in a significant fraction of the GAIA CCDs. However, they also showed that the astrometric accuracy loss for faint sources will be no more than 10 per cent.

Finally, GAIA may reach its astrometric accuracy goals only when the spacecraft attitude is known to the highest precision. 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. For this reason, Risquez developed detailed simulations of GAIA's attitude, incorporating all of the relevant physical effects, in collaboration with van Leeuwen (Cambridge) and Keil (Bremen). In 2011, he improved the model and used it to provide realistic simulated data to the GAIA community. These data enabled a study of the effect of different perturbations on the astrometry. He also assessed in detail the effect of not having access to the instantaneous spacecraft attitude due to the finite integration time for the observations. This will lead to unmodelled noise in the reconstructed attitude and to differences in the measured spacecraft attitude for bright and faint stars. Risquez assessed the optimum interval for spline knots when modelling the attitude with B-Splines.

Wavelength calibration of JWST-MIRI

Martínez-Galarza, Meyer and Brandl participated in the completion of the flight hardware of the Mid-Infrared Instrument (MIRI) which is scheduled to fly onboard the James Webb Space Telescope (JWST). This is the successor to the

Hubble Space Telescope, and it presently scheduled for launch in 2018. The extensive MIRI test campaigns took place on July 24, at the Rutherford Appleton Laboratory in the UK. Martínez-Galarza and Meyer subsequently analyzed the test data with respect to the ground calibration of the wavelength map, spectral resolving power, wavelength stability, and spectral line shapes. Compliance with instrument requirements was confirmed, and the results were presented to ESA and NASA in December 2011.

2.10 Laboratory astrophysics and basic processes

Simulations of water ice photodesorption

Arasa and van Dishoeck, collaborating with Kroes (LIC, Leiden), Andersson (SINTEF Norway) and Cuppen (RU, Nijmegen), investigated the UV photo-dissociation of amorphous D_2O ice at temperatures up to 90 K using molecular dynamics simulations and analytical potentials. As for H_2O, the main processes after UV photo-dissociation are trapping and desorption of fragments or D_2O molecules. The main processes and conclusions were the same as for H_2O ice. The average D_2O photo-desorption probability is larger than that of H_2O by a factor of 1.4-2.3 depending on ice temperature. This is entirely due to a larger contribution of the D_2O kick-out mechanism because D has more momentum, and transfers it more easily to D_2O than H does to H_2O ice. The total calculated OD + D_2O yield showed better agreement with experimental yields than that for H_2O ice.

2.11 The Raymond and Beverly Sackler Laboratory for Astrophysics

The Sackler Laboratory for Astrophysics has a long tradition of studying the influence of ultraviolet-induced physical and chemical processes on interstellar ice analogues. The initial experiments by Prof. Greenberg hinted at the solid state formation of complex organics upon UV-irradiation of a sample comprising most of the observed interstellar ice components. More recently, Oberg and collaborators showed in a number of dedicated ultra-high vacuum experiments that interstellar ice analogues efficiently photo-desorb upon UV irradiation, explaining the presence of gas phase species at temperatures below their accretion value. In addition, they showed that photo-dissociation in an ice (such as CH_3OH) can trigger a complex chemical network, ultimately providing a solid state pathway to form more complex molecules as CH_3OCH_3 and $(CH_2OH)_2$.

Photo-desorption of CO ice

This work has now been extended by a new series of experiments, focusing on the wavelength dependence of these processes. Information on the average UV photo-desorption yield of astrophysically important ices thus far existed only for broad-band UV lamp experiments, emitting around Ly-α (121.6 nm). UV fields around low-mass pre-main sequence stars, near shocks and in many other astrophysical environments are, however, often dominated by discrete atomic and molecular emission lines, differing from Ly-α. It is therefore crucial to also consider the wavelength dependence of photo-desorption yields and mechanisms. In 2011, for the first time, the wavelength-dependent photo-desorption of pure CO ice between 90 and 170 nm was explored in a collaborative experiment joining the research groups of Fillion (Paris, France) and Linnartz (Leiden). Fayolle, Oberg, and others performed experiments at the DESIRS beamline of the SOLEIL synchrotron facility in Paris using a mobile ultra-high vacuum setup. SOLEIL is a unique facility that provides tunable synchrotron radiation. In these experiments, the ice photo-desorption was simultaneously probed by infrared absorption spectroscopy in reflection mode of the ice and by quadrupole mass spectrometry of the gas phase. The experimental results revealed a strong wavelength dependence directly linked to the vibronic transition strengths of CO ice, implying that photo-desorption is induced by electronic transition (DIET). The observed dependence on the ice absorption spectra implied relatively low photo-desorption yields at 121.6 nm, where CO barely absorbs, compared to the high yields found at wavelengths coinciding with transitions into the first electronic state of CO around 150 nm; the CO photo-desorption rates thus depend strongly on the UV profiles encountered in different star formation environments.

These experiments move experiments on the UV photochemistry of interstellar ice analogues into a new field. Whereas in the past only broad band applications were studied, it has now become clear that wavelength dependent effects should not be neglected.

Figure. 18. The logo of LASSIE, a 6.05 MEuro interdisciplinary EU training network on laboratory astrochemistry. With 28 PhD students, 4 postdocs and 12scientific groups as well as 6 industrial partners LASSIE stands for the worldwide largest research network focusing on astrochemical reactions in the solid state.

These efforts are part of a larger research program focusing on the chemical processes in interstellar ice analogues, embedding an EU FP7 interdisciplinary training network 'LASSIE' (Laboratory Astrochemical Surface Science in Europe) and work within the Dutch Astrochemistry Network. A major part of the work is financed through a NWO-VICI grant (Unlocking the chemistry of the heavens, Linnartz).

Chapter 3

Education, popularization and social events

Education, popularization and social events

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3.1. Education

Teaching and training of students is a major priority of Leiden Observatory. In 2011, 32 freshmen started their studies in astronomy. Of this number, 7 (22%) were women, and 16 (50%) pursued a combined astronomy/physics or astronomy/mathematics degree. The Observatory registered a total number of 76 BSc students at the end of the year, of which 38 (52%) aimed at a combined astronomy/physics degree or astronomy/mathematics degree; 15% of all BSc students is female. There were 44 MSc students, including 20 (45%) women and 16 (36%) 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. Twenty students passed their pro-pedeutical exam, of which thirteen completed the requirements in the nominal one year. There were 13 BSc exams, and 14 MSc exams.

Pen continued as the education coordinator taking care of the daily running of tasks. Hoekstra continued as BSc study adviser and Portegies Zwart 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 (Snellen, Brown and Hogerheijde) 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, 9 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, Cuylle and Szomoru).

The astronomy curriculum is monitored by the 'Education committee' (Opleidingscommissie), which advises the Director of Studies on all relevant matters, and which was chaired by Röttgering. Under the authority of the Education Committee, the lecture course monitoring system was continued. In this system, students provide feedback to lecturers during and after the course. The quality of curriculum and exams is the responsibility of the board of Examiners (Examencommissie) chaired by Lub. 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 Portegies Zwart and Hoekstra as members.

3.2. Degrees awarded in 2011

3.2.1. Ph.D. degrees

A total of 9 graduate students successfully defended their Ph.D. theses in 2011 and were duly awarded their Ph. D. degree: They are:

Name: R. van Weeren
Titel thesis: Radio Emission from Merging Galaxy Clusters
Supervisor: Röttgering
Graduation Date: 20-12-2011

Name: K. Torstensson
Titel thesis: Methanol Masers and millimetre lines
Supervisor: Van Langevelde
Graduation Date: 6-12-2011

Name: T. Prod'homme
Titel thesis: From Electrons to Stars: Modelling and mitigation of radiation damage effects on astronomical CCDs
Supervisor: Brown
Graduation Date: 22-11-2011

Name: N. Amiri

Titel thesis: Developing Asymmetries in AGB Stars: Occurence, Morphology and Polarization of Circumstellar Masers
Supervisor: Van Langevelde
Graduation Date: 26-10-2011

Name: C. Kruip
Titel thesis: Connecting the Dots - Analysis, Development and Applications of the SimpleX algorithm
Supervisor: Icke
Graduation Date: 20-10-2011

Name: R. van Haasteren
Titel thesis: Gravitational Wave Detection and data analysis for Pulsar Timing Arrays
Supervisor: Portegies Zwart
Graduation Date: 11-10-2011

Name: J.B.R. Oonk
Titel thesis: Cool Gas in Brightest Cluster Galaxies
Supervisor: Jaffe
Graduation Date: 6-10-2011

Name: E.J.W. de Mooij
Titel thesis: Ground-Based Observations of Exoplanet Atmospheres
Supervisor: Snellen
Graduation Date: 28-09-2011

Name: I. Martins e Oliveira
Titel thesis: Observational Constraints on the Evolution of Dust in Protoplanetary Disks
Supervisor: van Dishoeck
Graduation Date: 07-06-2011

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

The following 14 students were awarded Master's degrees in 2011:

Name	**Date**	**Present position**
Marinus Israel	29-03-11	PhD Leiden Observatory
Nienke van der Marel	12-04-11	PhD Leiden Observatory
Tiffany Meshkat	09-06-11	PhD Leiden Observatory
Caroline Straatman	22-06-11	PhD Leiden Observatory

Willem de Pous	22-06-11	PhD Leiden Observatory
Casper Schönau	30-08-11	-
Mehdi Lamee	30-08-11	PhD University of Minnesota
Nadieh Bremer	30-08-11	Deloitte als Junior Consultant Advan[illegible] Analytics
Ainil Abdullah	31-08-11	PhD Leiden Observatory
Tjarda Boekholt	31-08-11	PhD Leiden Observatory
Reinier Janssen	30-09-11	PhD TUD
Giles Otten	30-09-11	PhD Leiden Observatory
Joana Figuira	14-10-11	PhD Universitat Politecnica de Catalunya
Jiting Hu	22-11-11	PhD Leiden Observatory (applying)

3.2.3. Bachelor’s degrees

A total of 13 students obtained their Bachelor's degree:

Name	Date	Present Position
Vincent Oomen	18-2-2011	MSc Programme, Astronomy
Arthur Vromans	18-2-2011	MSc Programme, Astronomy
Shannon Vlaar	17-6-2011	MSc Programme, LION
Niek Kouwenhoven	17-6-2011	MSc Programme, LION
Niek Wisse	17-6-2011	MSc Programme, Astronomy
Rick Vooys	17-6-2011	MSc Programme, Mathematics
Jens Hoeijmakers	17-9-2011	MSc Programme, Astronomy
Sebastiaan Smeets	17-9-2011	MSc Programme, Astronomy
Jeroen Sprangers	17-9-2011	MSc Programme, Astronomy
Jurriaan Kloek	17-9-2011	MSc Programme, LION
Marijke Segers	17-9-2011	MSc Programme, Astronomy
Esther Schreuders	17-9-2011	MSc Programme, Mediatechnology
Cornelis Goksu	17-9-2011	-

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. Linnartz
2	Astronomy lab 1	H. Hoekstra
3	Modern astronomical research	M. Kenworthy
4	Stars	X. Tielens
4	Astronomy lab 2	P. van der Werf
5	Observational techniques 1	B. Brandl
5	Radiative processes	E. Rossi
5-6	Bachelor research project	I. Snellen & P van der Werf
5-6	Introduction observatory	E.R. Deul & P van der Werf

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

Astrochemistry	E. van Dishoeck
Astronomy from space	M. Fridlund
Computational astrophysics	S. Portegies Zwart
Data Base & Data Mining	J. Brinchmann
Detection of Light	M. Kenworthy
IAC 2010: History of Astronomy	F. Verbunt
Large Scale Structure & Galaxy Formation	J. Brinchmann
Observational Cosmology	R. Bouwens
Origin and evolution of the universe	K. Kuijken
Star Formation	E. van Dishoeck
Stellar structure and evolution	J. Schaye

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, as shown by a letter of motivation. Students that are selected 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 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), 10 (2009/10) and 25 (2010/11).
The astronomy LAPP-TOP was developed by Van der Werf from 2002 onward. From 2005-2008 the project was coordinated by Snellen. From 2008-2009 it was

coordinated by Franx. Since 2010 the project is coordinated by Lub. In eight sessions the following subjects were covered:

Extrasolar planets	I. Snellen
The Milky Way and other galaxies	J. Schaye
Practicum I	A. Brown
Gas and Radiation	V. Icke
Cosmology	H. Hoekstra
Practicum II	
Black Holes	P. van der Werf
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 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 2011
For teachers:
04 Feb ‘Instituutsdag’ for pupils visiting CERN afterwards (preparation)
08 Feb Educational seminar
14 Mar Meeting with pupils and teachers: Einsteins Birthday. 100 participants coming from 20 schools.
18 May Meeting with teachers. Theme: Biophysics. 42 participants.
10 Oct Regional educational seminar
01 Nov Meeting with teachers. Theme: Granular and Disordered Media. 57 participants.

For School classes:
21 Jan Ostrea, Goes
25 Mar De Populier, Den Haag
04 Apr Visser tHooft, Leiden
27 Apr Ger. Scholengem., Middelharnis
28 Apr Wateringseveld, Den Haag
18 May Hermann Wesselink, Amsterdam
07 Oct BonaVentura, Leiden
24 Oct Kings College School, Londen
11 Nov VCL Den haag
29 Nov DaVinci, leiden
19 Dec Meeting with girls (45) in the Old Observatory. Theme: Women between the stars

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

van Dishoeck
‘Building planets and the ingredients for life between the stars’ (Leonardo symposium, Delft; Mar 8)
‘Water in het heelal’ (KNVWS, Hilversum; Oct 13

'Innovatie eist ruimte voor lange termijn'(Science Guide; Mar 16)
'Pieken met de EL&I topgebieden?'(VSNU Cafe, Den Haag; Mar 24)
'Verrassingen uit de ruimte' (Goed om te weten, OC&W, p. 8-13; Apr)
'NOVA planetarium' (Girlsday, Amsterdam; Apr 13)

Elbers
'Astronomie in Nederland'(radio interview VPRO programma Onvoltooid Verleden Tijd; broadcast Jan 16)

Hoekstra
'Wat doet een sterrenkundige?' (Weekendschool, Den Haag; Mar 13)
'Het onstaan van het heelal en waar gaat het heen?'(Science Cafe, Leiden; Apr 26)
'De donkere kant van het heelal'(De Leidsche Flesch, Leiden; Oct 5)
'BNR nieuws'(radio interview; Apr 12)

Hogerheijde
'Herschel Space Observatory Finds Oceans of Water in Planet-Forming Disk Around Nearby Star' (NASA press release 11-355)

Israel
'Maan in aspecten'(Leraren, Space Expo, Noordwijk; Jan 15)
'Last ride of the Space Shuttle'(VPRO Radio; Feb 24)
'Intelligent life in the Milky Way' (VSV Leonardo da Vinci, Delft; Mar 8)
'De geschiedenis van de Sterrewacht'(Sterrewacht, Leiden; Oct 26)

Kenworthy
'Kings College' (Oct 24)
'Direct Imaging of Extrasolar Planets' (Raad van Advies; May 16)
'The Discovery of Extrasolar Planets', (King's College School Visit, Leiden; Oct 24)

Kristensen
'Young star shooting water bullets'(SRON press release; May 31)
'Star Found Shooting Water "Bullets"' (National Geographic Daily News; June 13)
'Baby Star Blasts Jets of Water Into Space' (Inside Science News Service; June 21)

Kuijken
'Eerste Beelden van de VLT Survey Telescope' (Volkskrant newspaper; June 8)

'Gravitational Lensing: Studying the Dark Universe with Light Rays' (BBVA Series 'Science of the cosmos, science in the cosmos', Madrid; Dec 14)
'El Boson de Higgs no explica la materia oscura ni, menos aun, la materia oscura' (ABC newspaper interview, Spain; Dec 15)
'Los mapas del cielo del proyecto KIDs estaran llenos de joyas astronomicas' (Agencia Sinc, interview, Spain; Dec 15)

Linnartz
Interview, Radio 1 (Hilversum), February
'Scheikunde tussen de sterren' (Studievereniging Christian Huygens, TUE Delft; Maart)

Van Lunteren
'Galilei en de Sterrenboodschapper'(Ouderdag Leidsche Fles, Leiden; Apr 16)
'Bouwkunst en wetenschap in de negentiende eeuw' (Boekpresentatie 'De wetten van de bouwkunst?', Spui25, Amsterdam; June 23)
'The Fundamental Physiks Group: Hoe een handjevol hippies de fysica Veranderde' (Symposium De randen van de wetenschap, Leiden Nov 9)

Portegies Zwart
'Virtual environments in science' (KNAW)
'Kinderen vragen' (NEMO, Amsterdam)
'Dag van de Sterren' (NEMO, Amsterdam)
Interview Radio 1, Teleac Hoe?Zo!
St Bavoschool Haarlem, group 3 and 5
ter Kleefschool Haarlem group 6

Rieder
'Het heelal in een supercomputer van hier naar Tokyo' (De Leidsche Fles, Leiden; May 11)
'Een wereldwijde kosmossimulatie' (Bessensap, Den Haag; June 6)

Rossi
'A Foreign view'(Vrouwen tussen de sterren, public talk at the Old Observatory, Leiden; Dec 19)

Snellen
'Exoplaneten en buitenaards leven'(talk, Amsterdam; Jan 17)
'Exoplaneten' (studium generale, Delft; Feb 2)
'Exoplaneten' (talk, Venlo; Mar 25)

'Exoplaneten' (talk, Bilthoven; Mar 29)
'Exoplanets' (Amsterdam; Apr 20)
'Extraterrestrial Life'(tv – Helder; Mar 11)
'Search for Habitable Earths' (tv – Eenvandaag; Sep 16)

Yildiz
'Yildiz Olusumu - Low-Mass Star Formation' (14th National Stargazing Festival, Antalya, Turkey; July 9)

3.5. Universe Awareness program

A child's early years are widely regarded to be the most important for their development and the formation of their value systems (see article: Too Young to Learn?). The idea behind the UNESCO- and IAU-endorsed education program EU Universe Awareness (EU-UNAWE) is to use astronomy and space sciences to inspire children aged 4-10 years – especially those from underprivileged communities. The goals are twofold: to encourage children to develop an interest in science and technology and to help broaden their minds, thereby stimulating a sense of global citizenship and tolerance.

EU-UNAWE is a 3-year program that was launched in January 2011. It was officially presented during a public event held at the European Parliament in Brussels, Belgium, on 24 May 2011. Six countries were chosen to build national EU-UNAWE programs: Germany, Italy, the Netherlands, the United Kingdom, South Africa and Spain.

The EU-UNAWE National Project Managers (NPMs) for each of these countries are tasked with running workshops that will give primary school educators the ideas, resources and confidence that they need to bring astronomy and space science topics into the classroom. Currently, more than 200 teachers have attended EU-UNAWE workshops in five countries. Furthermore, the NPMs are developing innovative new educational resources for engaging young children in astronomy and space sciences. Several of these resources are already being used in classrooms across Europe. While these resources are developed within the FP7 Consortium, an important goal of EU-UNAWE is to create an international network that will provide a platform for sharing ideas, best practices and resources between educators from around the world. The EU-UNAWE website, which was launched in June 2011, is the central hub for the international network and it hosts all of the programme's educational resources. More information: www.eu-unawe.org

3.6. IAU Strategic Plan: Astronomy for the Developing World

As Vice President of the International Astronomical Union, Miley continued to lead the implementation of the IAU Strategic Plan 2010 – 2020 "Astronomy for the Developing World". This Plan foresees a substantial expansion of programs, 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 plan, the large expansion and strategic approach will require a more suitable organisational structure.

A key component of the IAU Plan is the creation of a small IAU Office of Astronomy for Development (OAD) to coordinate and manage the implementation of the Plan. This office, a joint venture between the IAU and the South African National Research Foundation hosted by the South African Astronomical Observatory in Cape Town. The OAD began work on 1 March, with Kevin Govender as Director and Miley as Chair of the Steering Committee. It was inaugurated by the South African Minister of Science and Technology in April.

The OAD has a very active first nine months. A call for potential volunteers sent to IAU members by Govender and Miley resulted in almost 350 pledges to volunteer. Other activities were a successful stakeholders workshop at the OAD in December and the preparation of an announcement of opportunity for regional nodes that are an essential ingredient of the IAU bottom-up plan. In addition, Miley gave several talks to committees in the European Parliament about the importance of astronomy for capacity building and development, particularly in Africa.

3.7. The Leidsch Astronomisch Dispuut 'F. Kaiser'

L.A.D. 'F. Kaiser' has organized several activities in 2010 to encourage the contacts between Astronomy students from different years. Examples are movie nights, dinners and an excursion to ESTEC. Furthermore, over 50 people (bachelor, master and PhD students and a few staff members) participated in our annual soccer tournament on July 1st. At the end of August, Tiffany Meshkat left the board. The new board (as of September 1st) consists of Bart Bijvoets, Joris Hanse and Chris Lemmens. The new board continues the organization of activities for all Astronomy students in 2012. In addition, it will resume its most "stellar" activity: organizing guided tours and observation nights in the reopened Old Observatory, just like L.A.D. 'F. Kaiser' did in the past.

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 were recently restored and a few weeks before the official reopening 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 a newsletters with Sterrewacht news and were offered an electronic member dictionary.

Appendix I

Observatory staff

Sterrewacht Leiden

Observatory staff

Appendix I

(As on December 31, 2011)

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
M. Franx
V. Icke (0.0)
F.P. Israel (0.0)
K. Kuijken (Director)
H.V.J. Linnartz
G.K. Miley (0.0)
S. Portegies Zwart
H.J.A. Röttgering
J. Schaye
A.G.G.M. Tielens
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)
C.W.M. Fridlund**	(J.H. Oortfonds)
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

* Director Boerhaave Museum
** Staff scientist ESTEC/ESA
***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
P. Katgert (0.0)
M.A. Kenworthy
H.J. van Langevelde (0.0)**
I.F.L. Labbé
Y. Levin (0.0)***
J. Lub (0.0)
R.S. Le Poole (0.0)
R. Quadri (0.0)
E.Rossi
W.J. Jaffe
I.A.G. Snellen
R. Stuik (NOVA, Muse)
P.P. van der Werf

Emeriti:
W.B. Burton
A.M. van Genderen
H.J. Habing
I. van Houten-Groeneveld
K. Kwee
A. Ollongren
C. Van Schooneveld

* Staff, Radboud University Nijmegen
** Director, JIVE, Dwingeloo
***Monash University, Melbourne, Australia

Postdocs and Project Personnel and longterm visiting scientists:

Name	Funded by	Name	Funded by
J.L. Birkby	NWO-VC	E. Meyer	NOVA
L. Birzan	NWO LOFAR, NOVA	M. Moerchen	ESO (guest)
J.B. Bossa	NWO VI	F. Molster	detachering NWO
G. Busso	UL/NOVA-GAIA	J.C. Mottram	NWO-VC
L.R. Carlson	EU ERC	A.V. Muzzin	NWO-SPINOZA
R.A. Crain	NWO-VI	B.D. Oppenheimer	NWO-VI
B.A. Devecchi	NWO-VI	S.G. Patel	EU-ERC
A. van Elteren	NOVA AMUSE	F.I. Pelupessy	NOVA AMUSE
S. Giodini	NWO-VI	A. Petrignani	EU-ERC
J. Guss	SRON/UL	D.A. Rafferty	NWO LOFAR, NOVA
J. Holt	NWO-SPINOZA	F.L. Raicevic	NWO-VC/EU-ITN COSMOCOMP
S. Ioppolo	NWO-VI	D. Risquez-Oneca	NOVA
M. Iwasawa	NWO-VI	P.M. Rodrigues Dos Santos Russo	EU-EUNAWE
J.T.A.de Jong	NWO-SPINOZA	M. Schmalzl	NOVA
A. Juhasz	NWO-ALLEGRO	E. Semboloni	NWO-VI
J.K. Katgert-Merkelijn	guest	D.R. Serrano Sobral	NOVA
T. van Kempen	NOVA/ALLEGRO	S. Taylor-Muzzin	NWO-SPINOZA
P.D. Klaassen	NWO-ALLEGRO	S. van der Tol	NWO LOFAR
L. Kristensen	UL	N. de Vries	NOVA AMUSE
E. Loenen	NOVA	A.J. Walsh	NWO-VI
R. Mathar	guest	R.J.van Weeren	NWO-ASTRON
T.P.K. Martinsson	NOVA	S.M. Weinmann	EU-ERC
R. Meijerink (0.0)		J. Zhen	NWO-VI

PhD students:

Name	Funded by	Name	Funded by
A.S. Abdullah	EU-ERC	M. Mosleh	EU ELIXIR / UL
H.E. Andrews Mancilla	EU-ERC	S.V. Nefs	NWO
J.E. Bast	guest	B.B. Ochsendorf	EU-ERC
J. Bedorf	NWO	G.P.P.L. Otten	NWO-ESFRI ELT
T.C.N. Boekholt	NWO	B. Pila Diez	NOVA
M Brogi	NOVA	W.M.de Pous	NWO
R.F.J. van der Burg	NWO	A. Rahmati	NOVA
D. Caputo	NWO	A.J. Richings	UL (Huygens) / EU-ITN COSMOCOMP
Y. Cavecchi	UL/NOVA	S. Rieder	NWO
N. Clementel	NWO	A.J. Rimoldi	NWO
S.H. Cuylle	EU-ITN LASSIE	M.J. Rosenberg	NOVA
M.P. van Daalen	UL (Huygens)	M. Sadatshirazi	UL
A.Elbers	ASTRON / UL	F.J. Salgado Cambiazo	EU ERC
E.C. Fayolle	NOVA	I. San Jose Garcia	EU-ITN Lassie
G. Fedoseev	EU-ITN LASSIE	J. van de Sande	NOVA
M. Fumagalli	EU -ERC	C. Shneider	NWO
D.S. Harsono	NOVA/SRON	R. Smit	NWO
M. Iacobelli	NWO/UL	D.M. Smit	guest
K.M. Isokoski	NOVA	C.M.S. Straatman	NWO
M.P.H. Israël	NWO-ESFRI ELT	A.H. Streefland	UL/FOM
A. Karska	UL /MPE	A. Stroe	NWO
M. Kazandjian	UL	D. Szomoru	EU-ERC
S. Krijt	UL	M.L. Turner	EU-ITN COSMOCOMP
M.A. Kulkarni	NWO-ESFRI ELT	E. van Uitert	UL/EU-reintegr grant
A.L.M. Lamberts	NWO-AStrochemie	M.B.M. Velander	NWO
X. Li	NWO-Astrochemie	M. Velliscig	EU-ITN COSMOCOMP
N. Lopez Gonzaga	NWO	S. Verdolini	UL
K. Maaskant	NOVA	L. Vermaas	NOVA/UL
N.v.d. Marel	NOVA	F. van de Voort	NWO
C.A. Martinez Barbosa	EU-ITN GREAT	K.S. Wang	NOVA
J.R. Martinez Galarza	UL /NOVA	M.P.M. Weiss	UL / Teyler's Stichting
F. Maschietto	guest	W.L. Williams	NWO
T.R. Meshkat	UL/EU-reintegration grant	U. Yildiz	UL

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
A. Vos	Programmer
N. Verbeek	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:

Arthur Bakker
Babs Beemster
Saskia van den Broek
Axel Buddendiek
Mason Carney
Pablo Castellanos Nash
Maria Drosdovskaya
Jeroen Franse
Luc Harms
Arisa Hatagaya
Ricardo Herbonnet
Jens Hoeijmakers
James Hunter
David Huijser
Ingrid Icke
Sara Khalafinejad
Margriet van der Laan
Paul Langelaan
Carla Natario
Vincent Oomen
Paula Andrea Ortiz Otalvaro
Tjibaria Pijloo
Jaya Ramchandani
Marijke Segers
Sebastiaan Smeets
Arthur Vromans
Siebe Weersma
Sascha Zeegers

Staff changes in 2011

Name			position	Start	End
A.S.		Abdullah	PhD student	03-10-2011	
N.		Amiri	PhD student		31-10-2011
H.E.		Andrews Mancilla	PhD student	15-09-2011	
J.E.		Bast	PhD student		30-09-2011
O.N.		Berné	Postdoc		30-09-2011
J.L.		Birkby	Postdoc	01-04-2011	
T.C.N.		Boekholt	PhD student	10-10-2011	
C.M.		Booth	Postdoc		30-09-2011
T.		Bot	Programmer		01-03-2011
M.A.		Bourne	PhD student		31-03-2011
C.		Brinch	Postdoc		31-08-2011
R.A.		Crain	Postdoc	01-09-2011	
E.		Gaburov	Postdoc		31-01-2011
M.A.		Gürkan	Postdoc		31-07-2011
R.	van	Haasteren	PhD student		30-04-2011
R.	van	Haasteren	Postdoc	01-05-2011	31-08-2011
M.E.B.		Härnquist	Library		21-08-2011
C.		Hopman	Postdoc		31-12-2011
M.B.	van	Hoven	PhD student		30-09-2011
M.P.H.		Israël	PhD student	01-05-2011	
J.T.A.	de	Jong	Postdoc	01-06-2011	
P.D.		Klaassen	Postdoc	15-10-2011	
A.		Kóspál	Postdoc		30-09-2011
S.		Krijt	PhD student	01-01-2011	
C.J.H.		Kruip	PhD student		31-07-2011
C.J.H.		Kruip	Postdoc		31-10-2011
E.		Kuiper	PhD student		30-09-2011
M.A.		Kulkarni	PhD student	12-09-2011	
I.F.L.		Labbé	Research assistant professor	01-03-2011	
A.L.M.		Lamberts	PhD student	15-01-2011	
X.		Li	PhD student	09-02-2011	
N.		Lopez Gonzaga	PhD student	02-11-2011	
A.		Madigan	PhD student		30-11-2011
N.	v.d.	Marel	PhD student	06-05-2011	
M.A.		Marosvolgyi	Postdoc		31-12-2011
C.A.		Martinez Barbosa	PhD student	01-11-2011	
I.		Martins E Oliveira	PhD student		31-05-2011
I.		Martins E Oliveira	postdoc	01-06-2011	31-08-2011

Name			**position**	**Start**	**End**
T.P.K.		Martinsson	postdoc	01-11-2011	
J.A.		Meisner	postdoc		30-04-2011
T.R.		Meshkat	PhD student	22-08-2011	
E.J.W.	de	Mooij	PhD student		30-09-2011
J.C.		Mottram	postdoc	24-10-2011	
A.V.		Muzzin	postdoc	07-09-2011	
B.B.		Ochsendorf	PhD student	05-09-2011	
J.B.R.		Oonk	PhD student		31-03-2011
G.P.P.L.		Otten	PhD student	01-11-2011	
A.		Petrignani	postdoc	15-02-2011	
W.M.	de	Pous	PhD student	01-09-2011	
T.F.		Prod'Homme	PhD student		14-11-2011
O.		Rakic	PhD student		30-09-2011
A.J.		Richings	PhD student	01-09-2011	
A.J.		Rimoldi	PhD student	20-07-2011	
P.M.		Rodrigues Dos Santos Russo	postdoc	01-01-2011	
E.M.		Rossi	Tenure Track	01-01-2011	
I.		San Jose Garcia	PhD student	01-01-2011	
M.		Schmalzl	postdoc	01-04-2011	
D.R.		Serrano Sobral	postdoc	01-09-2011	
C.M.S.		Straatman	PhD student	01-08-2011	
A.		Stroe	PhD student	01-10-2011	
S.		Taylor-Muzzin	Communication advisor	19-09-2011	
E.D.		Tenenbaum	postdoc		13-06-2011
K.J.E.		Torstensson	PhD student		28-02-2011
M.L.		Turner	PhD student	01-09-2011	
E.	van	Uitert	PhD student		31-12-2011
M.B.M.		Velander	PhD student		30-09-2011
M.		Velliscig	PhD student	01-09-2011	
N.		Verbeek	programmer	01-09-2011	
A.J.		Walsh	postdoc	01-01-2011	
R.J.	van	Weeren	PhD student		21-09-2011
R.J.	van	Weeren	postdoc	01-10-2011	
W.L.		Williams	PhD student	17-01-2011	

Appendix II

Committee membership

Sterrewacht Leiden

Committee membership

Appendix II

II.1. Observatory Committees

(As on December 31, 2011)

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 (until oct 1)

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)
S. Portegies Zwart
H. Hoekstra

Graduate student review committee

(Promotie begeleidingscommissie)

X. Tielens (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, 2011)

Brown
Member, Faculteitsraad

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

van Dishoeck
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, Committee of Education Directors, School of Sciences
Member, Board of Graduate School, School of Sciences
Member, BKO review committee, UL

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

Linnartz
Member, FMD/ELD user committee
Member, laboratory user group 'FWN nieuwbouw'

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

Portegies-Zwart
PRACE, member of the Scientific Steering Committee
Lorentz Center, Computational Science board member
ESF, International review commision board
ASTROSIM, representative of the Netherlands
NWO-VIDI, review committee
GAIA, member of the science advisory board
KNAW, computational science action group
MSc, Studie advisor
Huygens fellowship, Selection committee
NOVA ISC, AMUSE progress representtive
Quatar NSF, Quatar national science foundation, external advisor
IAU Member of Division VII Galactic System
IAU Member of Division VII Commission 37 Star Clusters & Associations
Huygens vervangings commissie
NWO Network3 meeting in Leiden, organizer

Snellen
Member, LUF International Study Fund (LISF) committee
Member , PR committee, Faculty of Science

Van der Werf
Member Faculty Council
Organist of the Academy Auditorium

Appendix III

Science policy functions

Sterrewacht Leiden

Science policy functions

Appendix III

Bouwens
Panel Member, Hubble Space Telescope Time Allocation Committee

Brandl
PI, METIS (mid-IR instrument for the E-ELT)
Deputy co-PI MIRI (mid-IR instrument for the JWST)
Co-I KINGFISH Herschel Open Timen Nearby Galaxies Key Project
Member, NOVA Instrument Steering Committee (ISC)
Member, GranteCan/FRIDA CDR review board
Member, ESFRI board
Member, METIS Chopper CDR review board
Member, METIS cooler review board
Member, METIS immersed grating review
Member, MIRI FM test team

Brinchmann
Legacy Science Coordinator, Euclid mission
Member, MUSE Science team
Coordinator, MUSE data management
Panel chair, Herschel Time Allocation Committee
Member, Island Observatories TAC

Brown
Member, Organizing Committee IAU Commission 8
Member, IAU Commission 37
Member, Gaia Science Team
Member, EU Marie-Curie ITN Gaia Research for European Astronomy Training (GREAT)
Member, Steering Committee ESF-RNP Gaia Research for European Astronomy Training (GREAT)

van Delft
Member, National UNESCO committee
Member, History of Science committee 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, Advisory Board NWT Magazine (Natuur, Wetenschap en Techniek)
Ambassador Platform bètatechniek
Chairman, bestuur Nederlandsch Natuur- en Geneeskundig Congres
Chairman, Board Stichting Technolab, Leiden
Member, Raad van Toezicht Stichting RINO, Leiden
Member, Ondernemersfonds 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, National Committee on Astronomy (NCA)
Member, MPIA-Heidelberg Fachbeirat
Member, Herschel-HIFI Science team
Chair, Visiting committee, astronomy department, Harvard University
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
Co-chair SOC, Special Session ``A new era for studying interstellar and intergalactic magnetic fields'', General Assembly of International Astronomical Union, Beijing, July 2012
Member SOC, conference ``Understanding Galactic and extragalactic foregrounds: A road to success for cosmological experiments'', Zadar, Croatia, May 2011
Principal Investigator, Southern Twenty-centimeter All-sky Polarization Survey (STAPS)
Principal Investigator Galactic Science, Southern Polarization All-Sky Survey (S-PASS)
Chair, LOFAR Galactic Science Working Group Magnetism Key Science Project

Member management team, Galactic Arecibo L-band Feed Array Continuum Transit Survey
Chair, Working Group for Multi-wavelength Coordination for ASKAP Survey Science Project POSSUM
Consortium member, Galactic Magneto-Ionic Medium Survey
Scientific referee for ApJ, ApJL, A&A, MNRAS

Hoekstra
Member, Time Allocation Committee Island Telescopes
Member, Science Advisory Committee, Isaac Newton Group

Hogerheijde
Member, ALMA Science Advisory Committee
Member, ALMA European Science Advisory Committee
Member, ALMA European Regional Center Coordinating 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, ALMA Proposal Review Committee
Member, Deutsche Forschungs Gemeinschaft Review Panel Physics Interstellar Medium
Member at large, NL-0LOFAR Advisory Committee-
Member, IAU Comissions 28, 40 and 51
Member, Science Team Herschel-HIFI
Member, Science Team JWST-MIRI
Member, Science Team APEX-Champ+
Member, Editorial Board Europhysics News
Coordinator-NL SCUBA2 Nearby Galaxies Legacy Survey

Kenworthy
Kenworthy, reviewer, National Science Foundation

Kristensen
Member, Herschel User's Group (HUG)

Kuijken
Scientific Delegate from the Netherlands, ESO Council
Member, Scientific Strategy Working Group, ESO Council
Chair, ESO contact committee

Member and Vice-chair (since September 2011), Netherlands Committee for Astronomy
Member and Chair (since April 2011), NOVA Board
Principal Investigator, ESO KiDS Survey
Principal Investigator, OmegaCAM project
Co-investigator, ESO VIKING Public Survey
Co-investigator, Planetary Nebulae Spectrograph project
Board Member, Physics Society Diligentia (the Hague)
Board Member, Kapteyn Fonds (Groningen)

van Langevelde
Member consortium board European VLBI Network
Member RadioNet Board and Executive Board
Coordinator 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
NOVA Instrumentation Steering Committee
Dutch URSI committee
Chairman board of directors Leids Kerkhoven Bosscha Fonds
Member board of directors Leids Sterrewacht Fonds
Member board of directors Jan Hendrik Oort Fonds
SKA klankbordgroep NL
Allegro steering committee

Linnartz
'SPIN' chair for Molecular Laboratory Astrophysics, LCVU.
Editor CAMOP (Comments on Atomic, Molecular and Optical Physics / Physica Scripta).
External advisor, RSC/RAS Astrophysical Chemistry Group.
Member, European Task Force for Laboratory Astrophysics.
Research coordinator, FP7 ITN 'LASSIE' (Laboratory Astrochemical Surface Science In Europe).
Theme coordinator NWO-EW/CW 'DAN' (Dutch Astrochemistry Network).
Workgroup leader, FOM group FOM-L-027.
Member, NWO-CW 'Spectroscopy and Theory'.
Member, NWO-FOM 'COMOP'' (Condensed Matter and Optical Physics).
Member, HRSMC research school.

Van Lunteren
Education and Research Board Huizinga Institute

Portegies Zwart
NWO, Advisory board national platform computational science
Key researchers NOVA (Network 3)
VPRO Noorderlicht, science advisory board
European Ambassador, Meta Institute for Computational Astrophysics,
Beta Ambassador for the Netherlands

Rossi
Member of the observatory sceince team for LOFT (Large Observatory for X-ray timing) : tidal disruption and gamma-ray bursts working groups.
Member of the organizing committee for the 4th International summer School in Astroparticle physics ``Nijmegen12".

Schaye
Member of the steering committee, Virgo Consortium for cosmological supercomputer simulations
Co-Investigator, MUSE (Multi Unit Spectroscopic Explorer)
Key researcher, NOVA (the Dutch research school for astronomy)
Member, MUSE science team
Member, LOFAR Epoch of Reionization science team
Member, Editorial Board, Scientific Reports
Member, astronomy program board, Lorentz Center
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, ESA ECHO science study team
Member, METIS consortium
Board member, Nederlandse Astronomen Club

Member, Telescope Allocation Committee, NASA Hubble Space Telescope - cycle 19

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

Appendix IV

Workshops, lectures and colloquia in Leiden

Sterrewacht 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 2011 the Leiden astronomers contributed to the following workshops there:

Feb 21 - 25
Probing the Radio Continuum Universe with SKA Pathfinders
Norris, Rottgering

Feb 28 - Mar 4
Herschel and the Characteristics of Dust in Galaxies
Xander Tielens, Frank Israel

Apr 4 - 8
100th Anniversary of Superconductivity: Hot Topics and Future Directions
de Visser, Golden, Prassides, van der Marel, Zaanen

May 2 - 6
Workweek: Towards understanding imaging data from LOFAR
Huub Röttgering, Roberto Pizzo

July 25 - 29
Groups and Clusters of Galaxies: Confronting Theory with Observations
Arif Babul, Graham Smith, Christoph Pfrommer, Henk Hoekstra

Dec 5 - 9
Isotopes in Astrochemistry: An Interstellar Heritage for Solar System Materials?

Stefanie Milam, Steven Charnley, Ewine van Dishoeck, Conel Alexander

Dec 12 - 16
Modeling and Observing Dense Stellar Systems
Simon Portegies Zwart, Steve McMillan, Marco Spaans, Piet Hut, Inti Pelupessy, Arjen van Elteren

Additional Meetings:

Jan 24-26
WISH team meeting
E. F. van Dishoeck

Dec 15-16
WISH team meeting
E. F. van Dishoeck

IV.2. Endowed Lectures

Mar 21
Oort lecture ' What makes spiral galaxies tick?'
James J. Binney

Nov 24
Sackler lecture ' The Cosmic Dawn and Reionization'
A. Loeb

IV.3. Scientific Colloquia

Date	Speaker (affiliation)	Title
Jan 13	Simon Lilly (ETH Zurich)	*Mass and environment as drivers of galaxy evolution and the origin if the Schechter function*
Jan 20	Erik Hog (Niels Bohr Institute, Copenhagen)	*Astrometry Lost and Regained: From a modest experiment in Copenhagen in 1925 to the Hipparcos and Gaia space missions*
Jan 27	Cornelis Dullemond (IfTA Heidelberg)	*Planet Factories*
Feb 2	Elmar Kording (Nijmegen)	*X-ray binaries: Miniature scale models of quasars?*
Feb 10	Morten Andersen (ESTEC)	*The Initial Mass Function in resolved young stellar clusters*
Feb 11	Nadine Wehres (Leiden Observatory/Kapteyn Astronomical Institute)	*Optical Spectroscopy of Interstellar and Circumstellar Molecules - a combined laboratory and observational study (PhD colloquium)*
Feb 17	Olivier Witasse (ESTEC)	*Mars Express Scientific Highlights*
Feb 24	Raymond Oonk (Leiden Observatory)	*Cool gas in Brightest Cluster Galaxies (PhD colloquium)*
Mar 9	Chris Martin (Caltech)	*UV tracers of the Hidden Side of Galaxy Evolution*
Mar 3	Lars Hernquist (CFA Harvard)	*Collective Origin of Spiral Structure in Disk Galaxies*
Mar 17	Ben Moore (ITP Zurich)	*Our Galaxy, the Local Group and the Virgo Cluster*
Apr 14	Guinevere Kauffmann (MPA Garching)	*Towards an Understanding of Gas Accretion and Star Formation in Galaxies*
Apr 21	Isa Oliveira (Leiden Observatory)	*Observational Constraints on the Evolution of Dust in Protoplanetary Disks (PhD colloquium)*
Apr 28	Mike Garrett (ASTRON)	*Understanding the nature of Hanny's voorwerp*
May 12	Saskia Hekker (UvA)	*Asteroseismology of red giants with CoRoT and Kepler*
May 26	Paul Kalas (University of California, Berkeley)	*HST Imaging of Formalhaut: Direct detection of an extrasolar planet and Kuiper Belt around a nearby star*
June 8	Rutger van Haasteren (Leiden Observatory)	*Gravitational-wave detection and pulsar timing (PhD colloquium)*
June 9	Fabian Walter (MPIA)	*Gas, Star Formation and Resulting Gas Depletion Times in Nearby Galaxies: New Insights from HERACLES and THINGS*

June 14	Ernst de Mooij (Leiden Observatory`	*Ground-based observations of exoplanet atmospheres (PhD colloquium)*
June 16	Olivera Rakic (Leiden Observatory)	*Gas in the Vicinity of Star-Forming Galaxies at z~2-2.5 (PhD colloquium)*
June 23	Ralph A.M.J. Wijers (Astronomical Institute 'Anton Pannekoek')	*The extreme physics of gammaray bursts*
June 30	Thibaut Prod'homme (Leiden Observatory)	*From electrons to stars: Modelling and mitigation of radiation damage effects on astronomical CCDs (PhD colloquium)*
Sep 1	Chael Kruip (Leiden Observatory)	*Analysis, development and applications of the SimpleX algotithm (PhD colloquium)*
Sep 15	Malin Velander (Leiden Observatory)	*Studying galaxy dark matter haloes with weak lensing(PhD colloquium)*
Sep 29	Alan Tokunaga (Institute for Astronomy, Hawaii)	*Small Telescopes in the Era of the ELTs*
Oct 13	Ann-Marie Madigan (Leiden Observatory)	*The dynamics of stars near massive black holes (PhD Colloquium)*
Oct 17	Nikta Amiri (Leiden Observatory)	*Developing Asymmetries in AGB Stars: Occurrence, Morphology and Polarization of Circumstellar Masers (PhD colloquium)*
Oct 20	Markus Janson (Princeton University)	*How do Most Planets Form?*
Oct 25	Reinout van Weeren (Leiden Observatory)	*Radio Relics: probes of galaxy cluster mergers*
Oct 27	Chris Evans (UK Astronomy Technology Centre, Edinburgh)	*Massive stars: From the VLT to the ELT*
Nov 3	Jayne Birkby (Leiden Observatory)	*Observations of Thermal Emission and Reflected Light from Exoplanets using Ground-Based Telescopes*
Nov 3	Thomas Giesen (University of Koln)	*High Resolution Laboratory Spectroscopy of Interstellar Molecules*
Nov 10	Mark McCaughrean (ESTEC)	*Standing on the shoulders of giants: star and planet formation with the VLT, JWST, and the E-ELT*
Nov 17	Thom Theuns (ICC, Durham)	*Simulations of galaxy formation*
Nov 23	Kalle Torstensson (Leiden University)	*Methanol Masers and millimetre and millimetre lines: a common origin in protostellar envelopes (PhD colloquium)*
Dec 1	Giuseppe Lodato (Dipartimento di Fisica, Milano)	*Modeling the light curve of tidal disruption events*
Dec 8	Gianfranco Brunnetti (INAF)	*Bon-thermal emission from galaxy clusters and connection with cluster-cluster collisions*
Dec 12	Edo van Uitert (Leiden Observatory)	*Weak gravitational lensing in the RCS2 (PhD Colloquim???)*
Dec 15	Charlie Conroy (Harvard Smithsonian Center for Astrophysics, Cambridge)	Measuring the IMF in distant galaxies

IV.4. Student Colloquia

Date	Speaker	Title
Feb 28	Marinus Israel	*Millimeter emission from protoplanetary disks*
Mar 21	Tiffany Meshkat	*HD 189733b spectroscopy: The Methane Controversy*
Mar 28	Nienke van der Marel	*Polarization in optical interferometry*
May 2	Nadieh Bremer	*Finding a simple tracer of halo mass for individual galaxies*
May 4	Caroline Straatman	*The clustering of metal lines in QSO absorption spectra*
May 9	Willem de Pous	*A star formation rate dependent stellar initial mass function in cosmological simulations*
May 16	Paul Langelaan	*Stellar Clusters and the changing tide*
May 23	Tjarda Boekholt	*High-precision core collapse in star clusters*
May 30	Joana Figueira	*Modeling the evolution of an hierarchical triple stellar system*
June 22	Jiting Hu	*Star formation history in merger cluster Abell 2163*
June 27	Ainil Abdullah	*Massive Black Hole in Nuclear Star Cluster*
Aug 22	Tjarda Boekholt	*High-Precision N-body Simulations*
Sep 13	Joana Figueira	*Modeling the evolution of Xi Tauri's inner hierarchical triple stellar system*
Sep 19	Caspar Schonau	*Young stellar objects and the distribution and kinematics of the isotopologues C18O and 12CO in Core A of the molecular cloud serpens*
Sep 20	Gilles Otten	*Detecting Hot Jupiters using consumer cameras*
Sep 26	Margriet van der Laan	*Properties of young X-ray selected stars in the Serpens Cloud*
Oct 31	David Huijser	*Solar modulation of cosmic rays*
Nov 15	Arthur Bakker	*Radio source counts*

IV.5. Colloquia given outside Leiden

Amiri
Magnetic Fields And Developing Asymmetries In Circumstellar Masers
AAS meeting, Boston, USA; May 24
Idem, IAUS 283 meeting, Tenerife, Spain; July 27
Idem, NRAO, Socorro, USA; July 14
Idem, University of New Mexico, Albuquerque, USA; July 15

Birkby
Observations of Optical Secondary Eclipses of Transiting Hot Jupiters with the GTC
Extreme Solar Systems II
Jackson Hole, Wyoming, USA; Sep 15

Bouwens
What we can learn about the build-up and evolution of galaxies at early times from the new WFC3/IR observations
University of Maryland, College Park, USA; Mar 2
Science Prospects for Euclid: The High Redshift Universe
Groningen, Netherlands; Apr 6
What we can learn about the build-up and evolution of galaxies at early times from the new WFC3/IR observations
Groningen, Netherlands; Apr 16
Using the new WFC3/IR camera on HST to discover how the first galaxies build up and evolve
Groningen, Netherlands; Apr 20
First Galaxies, what we can learn about the first galaxies from current observations
Marseille, France; May 3
What we can learn about the build-up and evolution of galaxies at early times from the new WFC3/IR observations
Nijmegen, Netherlands; June 14
What we can learn about early galaxy formation from current observations
Tegensee, Germany; June 27
The First Galaxies (z>5)
Durham, United Kingdom; July 22
Galaxy Build-up and Evolution in the First 2 Gyr of the universe
Cambridge, United Kingdom; July 25
Idem, Potsdam, Germany; Sep 14
High Redshift Galaxies
Heidelberg, Germany; Sep 22
Probing Early Galaxy Build-up with CLASH
Heidelberg, Germany; Oct 17

Brinchmann
Galaxy & AGN science with Euclid: an overview
Dutch Euclid data, Groningen, Netherlands; Apr 7
MUSE data management
MUSE consortium meeting, Aussois, France; May 20
Estimating gas masses from optical spectroscopy
Nice, France; June 7
The gas content of SDSS galaxies
Lyon Observatory, Lyon, France; June 17
The history of star formation in the Universe
Alpbach ESA summer school, Alpbach, Austria; July 19
Galaxy evolution with Euclid
Euclid consortium meeting, Bologna, Italy; Aug 5

Van Delft
Heike Kamerlingh Onnes and the Road to Superconductivity
APS March Meeting Dallas, USA; Mar 21
History and Significance of the Discovery of Superconductivity by Kamerlingh Onnes in 1911
2nd New York State Superconductor Technology Summit 2011, Schenectady NY, USA; Aug 4
Heike Kamerlingh Onnes and the Road to Superconductivity
Vortex Matter in Nanostructured Superconductors VII, Rhodes, Greece; Sep 12
The Leiden Cryogenic Laboratory and the Discovery of Superconductivity
Centenary Talk Daresbury Laboratory, UK; Nov 17
Idem, Rutherford Appleton Laboratory, UK; Nov 18

van Dishoeck
A WISH come true: water in star-forming regions with Herschel
University of Colorado, Boulder, USA; Feb 23
Idem, Harvard University, Cambridge, USA; Feb 16
Idem, University of Helsinki, Helsinki, Finland; Mar 29
Idem, University of Arizona, Tucson, USA; May 6
Building planets and the ingredients for life between the stars: Hewish lecture
Cambridge University, Cambridge, UK; June 15
Water in space: from pre-stellar cores to planet-forming disks
University of Cologne, Cologne, Germany; Oct 10

Elbers
Talk 'Radioastronomie aan de astronomen' vroege radioastronomie in Nederland, Dutch and Flemish PhD students history of science, Kerkrade, Netherlands; Jan 27
De geschiedenis van de voedselproductie

Museum for the history of sciences, Ghent, Belgium; May 1
Big Science, Little Science: the origin of Dutch radio astronomy
Dutch historians of science, Woudschoten, Netherlands; June 18
The relations between Dutch radio astronomers and their Soviet colleagues during the heyday of the Cold War
University of Notre Dame, Indiana, US; July 7
Radio astronomy for the astronomers: early radio astronomy in theNetherlands
British Society for the History of Science, Exeter, UK; July 16
Early radio astronomy in Netherlands: astronomers take the lead
Huizinga Instituut, Barchem, Netherlands; Oct 7
Beyond American hegemony: Dutch radio astronomy in the early post-war period
Danish National Committee for the History and Philosophy of Science, Aarhus, Denmark; Dec 14

Giodini
Galaxy groups: the power of a multiwavelength approach
Kaptein Institute, Groeningen, Netherlands; Nov 2
Studying Galaxy Groups: a window on the assembly of visible matter in the Universe
NAC, Texel, Netherlands; May 19

Haverkorn
Early results from diffuse spectro-polarimetry: S-PASS and LOFAR
Conference "Understanding Galactic and extragalactic foregrounds", Zadar, Croatia; May 23
Early MKSP Science Results: the Fan Region
LOFAR Magnetism Key Science Project Meeting, Newcastle University, Newcastle, UK; Apr 5
Extended continuum emission and the magnetic field of the Milky Way
Raman Research Institute, Bangalore, India; Mar 1

Hoekstra
Measuring masses: from galaxy clusters down to galaxies, IAP, Paris, France, Mar 4
A look at the dark side of the Universe, API, Amsterdam, March 25
idem, ICE, Barcelona, Spain, June 6
Cosmology and more with Euclid, CITA, Toronto, Canada, Oct 21
idem, University of Victoria, Canada, Nov 24
The discovery of dark energy, TU Delft, Delft, Dec 8

Iacobelli
The LOFAR view of the Fan region
Bologna Radioastronomy Institute (IRA), Italy; Nov 25
LOFAR commissioning activities: progress and results

Bonn Max Planck Institute for Radioastronomy (MPIFR), Germany; Mar 12

de Jong
Kilo Degree Survey status
Durham University, UK; Dec 5

Kenworthy
Direct Imaging of Extrasolar Planets in the Thermal Infrared
Kapetyn Institute, Groningen; Apr 4
Idem, ESTEC Seminar, Katwijk; Sep 11
Adaptive Optics Astronomical Observations
Delft University; June 6

Kristensen
Water as tracer of the stormy stages of star formation
Observatorio Astronomico Nacional, Madrid, Spain; Feb 22
Water bullets from low-mass protostars
University of Copenhagen, Copenhagen, Denmark; Mar15
Idem, University of Michigan, Ann Arbor, USA; Apr 5
Where is the water in low-mass young stars?
IAU Symposium 280, Toledo, Spain; May 30
Shocks and protostars: observations, models and predictions
Center for Astrophysics, Cambridge, USA; Nov 3

Kuijken
GAAP: PSF Gaussianization and shear measurement
E-science institute, Edinburgh, UK; Jan 26
Introduction to the ESO telescopes
ESO-Chile, Vitacura, Chile; Aug 24

Labbe
Galaxy evolution with Z-FOURGE
Pasadena, USA; Mar 15
The FourStar Galaxy Evolution Survey
Pasadena, USA; Apr 28
Idem, Texas, USA; June 20
Stellar populations at the highest redshifts
United Kingdom; July 26

van Langevelde
EXPReS & NEXPReS an evolution pathway for VLBI into the SKA era
NRAO, Charlottesville; Jan 29

Recent results on Methanol masers
NRAO, Charlottesville; July 12
Progress with e-VLBI in the EVN and correlators at JIVE
URSI General Assembly, Istanbul; Aug 18
Magnetic field measurements around young and old stars using masers
JAN65, Nijmegen; Aug 26

Linnartz
Unlocking the chemistry of the heavens
Gothenburg, Sweden; Feb
Solid state pathways towards molecular complexity
Toledo, Spain; May/June

Loenen
Exciting CO
Kapteyn Astronomical Institute, Netherlands; Feb 22
Idem, FIR2011: Star formation and feedback in galaxies as revealed by far infrared and submillimeter wavelengths, London, UK; Sep 16

van Lunteren
De Christelijke wortels van de moderne natuurwetenschap
Descartes Centre, Utrecht; Feb 22
Einstein's search for a unified field theory
Descartes Centre, Utrecht; Mar 22
Natuurwetenschap als spiegel van de cultuur
Het Wereldbeeld, Amsterdam; Mar 29
Ontstaan en ontwikkeling van de bètadisciplines
Congres Disciplinevorming, Utrecht; June 9
Dutch skies, global laws, Woudschoten Conference? Locations of Knowledge?
Zeist; June 18
Science and Religion: a historical perspective
First National Congress on Science and Religion, ForumC, Amsterdam; Nov 10
De Akademie en de natuurwetenschappen
Descartes Colloquium, Utrecht; Nov 22

Madigan
Gas and Dust in Protoplanetary Disks
Penn State University, USA; May 1
Gas and Dust in the Universe
ASIAA, Taipei, Taiwan; June 10
Idem, ESO Garching, Munich, Germany; July 10
Depressions and instabilities: the dynamics of stars near massive black holes

ICRAR Perth, Australia; Jan 20
The dynamics of stars near massive black holes
Swinburne University, Australia; Mar 03
Secular stellar dynamics near massive black holes
ITC, Harvard, Boston, USA; Apr 19
Idem, UCLA, USA; Apr 27
The hazardous lives of stars near massive black holes
Technische Universiteit Eindhoven; May 19
The dynamics of stars near massive black holes
UC Santa Cruz, USA; Nov 7
Idem, UC Berkeley, USA; Nov 9
Idem, CITA, Canada; Nov 15
Idem, Northwestern, USA; Nov 17

van der Marel
Cold complex organic molecules toward low-mass protostars and outflows
ESAC, Madrid, Spain; Aug 11

Petrignani
Progress on the intra-cavity FT-ICR MS
FOM Institute for Plasma Physics Rijnhuizen, Nieuwegein, Netherlands; Oct 15
The IR spectra of highly stable PAH ions at FELICE
Radboud University Nijmegen, Nijmegen, Netherlands; Sep 26

Portegies-Zwart
Multi physics simulations of gas-rich star clusters
Kapteiyn Institute, Groningen, Netherlands; Sep 26
The evolution of embedded star clusters
Heidelberg, Germany; Sep 20
New horizons in computational astrophysics
Heidelberg, Germany; July 5
The Multiscale Software Environment
Cefalu, Italy; June 16
AMUSE, Radbout U. Nijmegen, Netherlands; Apr 29
AMUSE, Radbout U. Nijmegen, Netherlands; Nov 1
AMUSE + IBIS demo SuperComputer 2011, San Diego, USA; Nov 15
High-performance asatro supercomputing
ASCI, Netherlands Simulating dense stellar systems, Garching, Germany; May 12-13
The evolution of embedded star clusters, Dublin, Ireland; Apr 14-15
The formation of millisecond binary pulsars in eccentric binaries;
NWO Network3; Apr 12

High performance Computational astrophysics in Netherlands
Kobe, Japan; Aug 23-25
The Multipurpose Software Environment, Cefalu, Sicily; June 13-18
Gravity on GPUs
International Symposium "Computer Simulations on GPU" , Mainz, Germany; June 1
Bonsai: A parallel GPU Tree-Code
Conference "Advances in Computational Astrophysics: Methods, tools and outcomes" , Cefalu, Italy; June 17

Rieder
CosmoGrid: A high-resolution cosmological simulation
CAMK, Warsaw, Poland; July 15

Rossi
Black Hole recoil: the first light
Aspen Center for Physics, Aspen, USA; June, 1
Summary of my research, Amsterdam University, Netherlands; June, 17
Tidal events: the Super-Eddington phase, Oxford University, Oxford, UK; Sep 21
Gamma-Ray Bursts and Tidal disruption events
"LOFT Science Meeting", Amsterdam, Netherlands; Oct 27
Hyper-velocity stars, Lund Observatory, Sweden; Nov 10

van de Sande
The stellar velocity dispersion of a compact massive galaxy at z=1.8 using X-Shooter
Nederlandse Astronomen Conferentie (NAC), Texel, Netherlands; May 19

Schaye
Galaxy formation in the OWLS universe
Ringberg, Germany; Apr 18-22
Modelling the gaseous cosmic web probed by QSO absorbers
Seeon, Germany; June 14-18
Conference summary
Conference "The cosmic odyssey of baryons: accreting, outflowing and hiding", Marseille, France; June 20-24
SPH simulations of the formation and evolution of galaxie
Durham, UK; July 18-22
Coupling galaxy formation with the evolution of the intergalactic medium
Heidelberg, Germany; Sep 21-22
Coupling galaxy formation with the evolution of the intergalactic medium
University of Nottingham, Nottingham, UK; Oct 5
Idem, Massachusetts Institute of Technology, USA; Nov 22

Semboloni
Light deflection by large-scale structures: how to unveil the "dark" side of the Universe
Osservatorio di Monteporzio; Catone, Frascati (Roma), Italy; Nov
"*Effect of baryonic feedback on cosmic shear tomography*"
University of Porto, Porto, Portugal; Aug

Snellen
Transiting extrasolar planets
University of Toronto, Canada; Apr 29
Transiting extrasolar planets
University of Amsterdam, Netherlands; Mar 18

Sobral
The Star-formation History of the Universe and its Drivers
ESO, Santiago, Chile; Sep 20
The roles of galaxy mergers, mass and the environment at the peak of the cosmic star formation history
Conference: Galaxy Mergers in an Evolving Universe, Hualien, Taiwan; Oct 25
The nature and evolution of star-forming galaxies over the last 11 Gyrs
NOVA Network 1 Meeting, Groningen, Netherlands; Nov 2

Torstensson
Tasseomancy of methanol masers - early stages of high-mass star formation
NAC, Texel, Netherlands; May 20

van Weeren
Radio relics as probes of galaxy cluster mergers
Cavendish Laboratory, Cambridge, UK; Aug 9
Idem, IfA, Edinburgh, UK; Aug 22
Idem, JHU, Baltimore, USA; Aug 29
Idem, CfA, Boston, USA; Aug 31
Idem, NASA Goddard, Washington DC, USA; Sep 1
Idem, NRL, Washington DC, USA; Sep 2
Idem, NRAO, Charlottesville, USA; Sep 6
Idem, UC Berkeley, Berkeley, USA; Sep 8

Weinmann
Star formation in cluster galaxies in the SDSS
Workshop on "Star formation in cluster galaxies", Nice, France; June
The properties of central and satellite galaxies in theory and observations
INAF Trieste, Trieste, Italy; June
The properties of satellite galaxies -- theory vs. observations

AG Meeting, Heidelberg, Germany; Sep
The trouble with sub-M galaxies*
NOVA workshop, Groningen, Netherlands; Nov

Yildiz
Star-Formation in the IR/submm
Ataturk University, Erzurum, Turkey; Apr 2
Low-Mass Star Formation and WISH, ALMA/ESO, Santiago, Chile; June 24

Appendix V

Grants

Grants

Appendix V

Bossa
Marie Curie Actions, FP7-PEOPLE-2011-IEF, NATURALISM - Novel analysis toward understanding the molecular complexity in the Interstellar medium,
€ 192,000 (together with **Linnartz**)

Brinchmann
Vrije Competitie, NWO, 'Resolving metals in intermediate redshift galaxies',
€ 239,000

Brown
NOVA Phase-3 Instrumentation Programme, extension of 'Photometric instrument algorithms for the Gaia mission',
€ 310,000

van Dishoeck
Vrije competitie, NWO, 'Water in star-forming regions with Herschel',
€ 209,206
Advanced ERC, EU, 'Astrochemistry and the origin of planetary systems',
€ 2,500,000

Fayolle
Van Gogh travel grant,
€ 2,000 (together with **Linnartz**)

Hoekstra
Starting grant, ERC, ‘Analysis of the Dark Universe through Lensing Tomography’,
€ 1,317,000

Icke
NCF Research Grants, ‘Radiative transfer in optically active cosmic flows’, NCF,
€ 23,000

Kuijken
Graduate School Pilot Programme, NWO, 'The de Sitter Cosmology Programme',
€ 800,000 (together with Instituut Lorentz, LION)

Miley
Vrije Competitie, NWO, ‘Kinematic and physical evolution of protoclusters’,
€ 222,000

Portegies Zwart
Middel-groot, NWO, The Astrophysics Multipurpose software environment,
€ 480,000

Portegies Zwart / Icke
Leraar in Onderzoek, NWO, ‘Astrofysica van de Voelsprieten’(J. Neuteboom)
€ 5,000

Schaye
Starting grant, ERC, 'Studying the gas around galaxies with the Multi Unit Spectroscopic Explorer and hydrodynamical simulations',
€ 1,496,000

Snellen
LUF/Gratama Fonds, 'Een moderne sterrenkijker voor studentenpractica op de oude Sterrewacht',
€ 24,205

Appendix VI

Observing time

Sterrewacht Leiden

Observing time

Appendix VI

VI. Observing time

Amiri
Effelsberg, On the life time of H2O masers at the tip of the asymptotic giant branch (45 hrs/3 nights)

Bouwens
Spitzer, CLASH: Coherent Views of the Galaxy Formation Puzzle over z~3-10 Through the Looking Glass, 70 hrs
VLT, Spectroscopic Confirmation of a Few Bright (and One Uniquely Bright) z~7 Galaxy Candidates in the CDF-South GOODS with FORS, 9 hrs
VLT, Spectroscopic Confirmation of a Large Sample of Bright z~6.1-6.8 Lyman Break Galaxy Candidates in the CANDELS UDS Field with FORS2, 17 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 - NAOMI imaging", 5 nights in 2011A, 1 night in 2011B
WHT, "The resolved properties of emission-line Lyman-break analogs at z<0.1", 2 nights
INT, "The adaptive optics deep field", 12 nights

van Dishoeck
ALMA, Do transitional disks still contain cold gas?, 3.2 hrs
Herschel, Water in low-mass protostars: the William Herschel line Legacy, 132 hrs
APEX, Separating the wheat from the chaff: which are the truly embedded

sources?, 8 hrs
APEX, Completing the SEDs: constraining disk properties of cold disks, 9 hrs

Fumagalli
WHT-LIRIS, The nature of star forming galaxies at z = 1 from the 3D-HST survey, 3 nights

Hogerheijde
Herschel Space Observatory, A deep HIFI search for cold para-water vapor in three protoplanetary disks, 87.6 hrs

Holt
HST, AGN feedback in young, radio-loud AGN, 2 orbits
VLT, The impact of AGN feedback in young, radio-loud AGN, 2 nights
VLT, The impact of AGN feedback in young, radio-loud AGN, 0.5 nights
WHT, AGN feedback in young, radio-loud AGN, 2 nights
WHT, AGN feedback in young, radio-loud AGN, 2 nights

Kenworthy
VLT, Transmission Spectroscopy of Fomalhaut's Debris Disk, 4 hours

Kristensen
JCMT, HDO/H2O toward low-mass protostars in Serpens, 31h
Herschel, Disentangling energetic feedback in low-mass protostars with CO 16-15, 14.1h
Herschel, Disentangling the water chemistry of the spectacular outflow BHR71, 19.5h

Kuijken
VLT Survey Telescope, The Kilo-Degree Survey, 400 nights

Labbe
Magellan, Z-FOURGE survey, 14 nights

Loenen
Pico Veleta, CN: ideal diagnostic tool for extra-galactic ISM?, 20 hrs
JCMT, Radiative and mechanical feedback in Luminous IR Galaxies, 120 hrs

de Mooij
WHT, 'exoplanet atmospheres', 6 nights

Nefs
WHT, 'WTS survey follow-up', 1 night

Snellen
INT, 'exoplanet atmospheres', 4 nights

Sobral
NTT/SofI, "The nature and evolution of luminous H-alpha emitters at z~0.8-2.2", 4 nights
CFHT/WIRcam, "Exploring the z~1-9 Universe and its large-scale clustering with the widest, contiguous narrow-band survey", 2 nights
TNG/NICS, "The nature and evolution of luminous line emitters at the peak of the star-formation history", 3 nights

Portegies Zwart
NCF Huygens, CosmoGrid data analysis, 10000 hrs
NCF Huygens, CosmoGrid data analysis, 90000 hrs
NCF Huygens, Gravitational Lensing and shear analysis, 40000 hrs

San Jose-Garcia
JCMT, Mapping CO and its isotopologues across the WISH sample of YSOs: from Low- to High-mass, 22 hrs

Wang
JCMT, A (more) systematic search for disks around massive
YSOs (II), 34 hrs

Yildiz
JCMT, Characterizing the embedded YSO population in Taurus, 17 hrs
JCMT, Characterizing the embedded YSO population in Ser and CrA, 64 hrs

Appendix VII

Scientific publications

Scientific Publications

Appendix VII

VII.1. Ph.D. Theses

Amiri, N.; Developing asymmetries in AGB stars : occurrence, morphology and polarization of circumstellar Masers.

van Haasteren, R.; Gravitational Wave detection & data analysis for Pulsar Timing Arrays.

Kruip, C.; Connecting the dots : analysis, development and applications of the SimpleX algorithm.

de Mooij, E. J. W.; Ground-based observations of exoplanet atmospheres.

Oliveira, I.; Observational Constraints on The Evolution of Dust in Protoplanetary Disks.

Oonk, J. B. R.; Cool gas in brightest cluster galaxies.

Prod'homme, T.; From electrons to stars : modelling and mitigation of radiation damage effects on astronomical CCDs.

Torstensson, K. J. E.; Methanol masers and millimetre lines : a common origin in protostellar envelopes.

van Weeren, R. J.; Radio emission from merging galaxy clusters : characterizing shocks, magnetic fields and particle acceleration.

VII.2. Publications of refereed journals

Aalto, S., and 3 co-authors, including **Meijerink, R.**; H_3O^+ line emission from starbursts and AGNs; *A&A*; 2011; **527**; A69

Abdo, A. A., and 10 co-authors; Multi-wavelength Observations of the Flaring Gamma-ray Blazar 3C 66A in 2008 October; *ApJ*; 2011; **726**; 43

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Aielli, G., and 113 co-authors, including **Lu, H.**, **Rossi, E.**; Mean Interplanetary Magnetic Field Measurement Using the ARGO-YBJ Experiment; *ApJ*; 2011; **729**; 113

Albrecht, S., and 4 co-authors, including **Snellen, I. A. G.**, **de Mooij, E. J. W.**; The Banana Project. III. Spin-Orbit Alignment in the Long-period Eclipsing Binary NY Cephei; *ApJ*; 2011; **726**; 68

Alexander, D. M., and 20 co-authors, including **Rafferty, D. A.**; X-Ray Spectral Constraints for z~2 Massive Galaxies: The Identification of Reflection-dominated Active Galactic Nuclei; *ApJ*; 2011; **738**; 44

Aliu, E., and 87 co-authors, including **Fumagalli, M.**; Multiwavelength Observations of the Previously Unidentified Blazar RX J0648.7+1516; *ApJ*; 2011; **742**; 127

Altamirano, D., and 14 co-authors, including **Cavecchi, Y.**; Discovery of an Accreting Millisecond Pulsar in the Eclipsing Binary System SWIFT J1749.4-2807; *ApJ*; 2011; **727**; L18

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Amiri, N., and 2 co-authors, including **van Langevelde, H. J.**; The kinematics and magnetic fields in water-fountain sources based on OH maser observations; *A&A*; 2011; **532**; A149

Ammons, S. M., and 10 co-authors, including **Bouwens, R. J.**; AGN Unification at z ~ 1: u - R Colors and Gradients in X-Ray AGN Hosts; *ApJ*; 2011; **740**; 3

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