Research Institute Leiden Observatory

(Onderzoekinstituut Sterrewacht Leiden)

Annual Report

Sterrewacht Leiden
Faculty of Mathematics and Natural Sciences
Leiden University

Niels Bohrweg 2
2333 CA Leiden

Postbus 9513
2300 RA Leiden

The Netherlands
http://www.strw.leidenuniv.nl

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I. Snellen, E. Gerstel, A. B. Nielsen, G. Calistro Rivera, H.J.A. Röttgering, D. Klaassen

STERREWACHT LEIDEN

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Sterrewacht
Leiden

Contents

Chapter 1

Review of major events

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Chapter 1

When science historians in 2050 will look back on the year 2014 and contemplate on its importance, they will immediately recognize that 2014 was the year that Europe took the bold step of starting to build the Extremely Large Telescope. In December 2014, the ESO council gave the green light for the construction of a 39-meter aperture optical and infrared telescope sited on Cerro Armazones in the Chilean Atacama desert. In 2050, it will be clear that the E-ELT for many decades was the premiere astrophysical facility that for example led to the discovery of many twins of our own earth.

Life at Leiden Observatory in 2014 will be remembered as another excellent year. With 16 PhD theses and 318 refereed papers, the scientific 'production' was fantastic. However, in 2050 it will not be those kinds of facts that count, it will be the true discoveries that have stood the face of time that will be remembered. An extensive overview of our scientific work can be found in this yearly report. Here I would like to give a few examples of some of the scientific progress that (hopefully) will indeed be remembered during the next decades.

A good example of significant progress was the first measurement of the rotation rate of an exo-planet. Using observations from ESO's Very Large Telescope (VLT) Ignas Snellen and his team determined, for the first time, the rotation rate of an exo-planet. This exo-planet - Beta Pictoris b - was found to have a day that lasts only eight hours. This is much quicker than any planet in the Solar System. This new result extends the relation between mass and rotation seen in the Solar System to exo-planets.

Much further into the universe live galaxies. With many stars, hot and cold gas, and dark matter, these objects are a real challenge to realistically simulate using large computers. Joop Schaye led an international team of astronomers to develop

simulations that produce galaxies that are much more realistic then previous generations of simulations. This is mostly due to the careful inclusion of strong galactic winds - gas winds that are blown out of galaxies. Basic properties such as the distribution of masses and sizes are in agreement with deep imaging observations carried out by the Hubble space telescope. Using multicolour observations in the context of the ZFOURGE survey, Caroline Straatman and Ivo Labbé discovered an early population of very massive galaxies that already stopped forming stars. Whether these objects are being reproduced by Joop Schayes new simulations clearly needs to be investigated in 2015.
Molecules and atoms are the basis of many of the physical processes that occur in the Universe and new ways of detecting these species are always welcome. A new way of studying carbon atoms is provided by the new powerful radio telescope LOFAR. Carbon atoms that are located in cold and sparse gas can have a single outermost electron orbiting at such a large distance from the nucleus that the system has a size comparable to a red blood cell. Such atoms emit radio recombination lines. Using the LOFAR radio telescope Leah Morabito together with the LOFAR team has for the first time discovered such large carbon atoms outside our Milky Way. Very complicated molecules can be found near forming stars. According to astrochemical models the smallest aromatic molecule (cyclopropenyl) should be highly abundant in the universe, but because the means to identify the molecule were lacking, it was not possible observe it. Dongfeng Zhao, Harold Linnartz and collaborators using measurements from our Sackler laboratory determined the chemical fingerprint enabling the search of the molecule using infrared observations.
The science event that rightfully obtained much public attention was ESA's Rosetta mission. It was the first time in history that a probe landed on a comet. At the old observatory, this was accompanied with a well-attended public event during which Ewine van Dishoeck explained the scientific importance of the project.
Also in 2014 many activities and events took place to inform the general public on the wonders of the universe. Public lectures, visits to school and TV and radio appearances took place. The old observatory remains to play a central role in our outreach activities. With the help of many students about 200 groups got a guided tour over the premises of the old observatory. Henk Hoekstra presented a very nice public lecture in the Academy building titled *'A Blown-up Universe'*. It reviewed why the measurements of the BICEP2 telescope might see something very interesting on the way the very early universe rapidly expanded. Neal J. Evans II (University of Texas at Austin) delivered this year's Oort lecture. His vivid

account on the question *'can we find out whether we are alone in the Universe'* captured the audience.
Led by George Miley and Pedro Russo, the Universe Awareness (UNAWE) project uses inspirational aspects of astronomy to introduce young children around the world to science and stimulate their sense of world citizenship and respect. In 2014, the European Union has granted 2 million euros for EU Space Awareness (EUSPACE-AWE). The project will show children and teenagers the opportunities offered by space science and engineering and inspire primary-school children when their curiosity is high and their value systems are being formed. One of the highlights of the UNAWE program was the publication of the children book 'Dummie de mummie en de ster Thoeban', written by Tosca Menten. In the exciting story the main character Dummie visits an observatory in Austria and discovers many mysteries of the Universe.
A very nice example of direct spinoff from techniques developed for astronomy was *'Rainbow Station'*. Designed to commemorate the 125th anniversary of the Amsterdam Central Station building, throughout 2015, a rainbow can be observed after sunset on the large bow construction that spans the platforms. *'Rainbow Station'* was designed by Studio Roosegaarde using a technique developed by Frans Snik and Michiel Rodenhuis This technique was based on a new kind of grating that they primarily developed to investigate exo-planets. The official opening took place on December 11 and attracted nation-wide press coverage.
In 2014, two well-received popular books were published. Harm Habing wrote on the late history of astronomy, covering the period from 1945 - 2000. It reviews how important phenomena like the big bang, black holes and exo-planets made it into important topics of observational and theoretical studies. Vincent Icke publish the book 'gravity does not exist' - a fascinating explanation of modern physics, put in a historical perspective
Particularly proud are we of all members of the Observatory. In September the Physics Centre Gothenburg gave the Lise Meitner Award, to Ewine van Dishoeck for "illuminating the molecular pathways that lead from dilute gas and microscopic dust particles to stars and planets". This prestigious prize is awarded every alternate year to one or several individuals for outstanding work in the fields of experimental, theoretical or applied nuclear science. Ewine was also elected member of the The Deutsche Akademie der Naturforscher Leopoldina. On 25 November 2014 Tim de Zeeuw received an honorary degree in astronomy at a ceremony in the Aula Magna of the University of Padova in Italy. During the event he gave a presentation with the title *'Exploring the Universe'*.

Simon Portegies Zwart was awarded the Wim Nieuwpoort prize for his outstanding achievements in high-performance computing. With his PhD student Tjarda Boekholt he designed novel algorithms for the optimal use of massively parallel computers for integrating planetary orbits in self-gravitating systems. He was also nominated for the Gordon Bell prize; the world's most prestigious prize for high-performance computing. Together with PhD student Jeroen Bédorf, (currently at CWI), he received this nomination for the world-record performance of 24.8 PetaFlops at >90% efficiency on the Oak Ridge National Laboratory Supercomputer Titan (#2 on Top500). While in the end Simon did not win the prize, he left competing teams from for example Intel and IBM behind - not bad at all!
In 2014 Jelle Kaastra was appointed as adjunct professor in high-energy astrophysics. This not only strengthens Leiden Observatory in this important area, but it also further cements our link to SRON. On November 4th Jelle delivered his very interesting inaugural lecture. Besides an excellent sketch of his work, he showed how he stood on the shoulders of many previous scientists, tracing back to Georgius Hermonymus who was appointed in 1476 as the professor of Greek at the Sorbonne in Paris.
Many of our students and postdocs obtain excellent position after their years in Leiden. This year, Matteo Brogi was awarded a prestigious Hubble Fellowship and Jayne Birkby the equally prestigious Carl Sagan Exoplanet Postdoctoral Fellowship.
Obtaining funding for research projects remains important. Fortunately, many staff members of the Observatory were successful in doing this. Koen Kuijken, Elena Rossi en Ivo Labb have been awarded a TOP NWO grant. John Tobin got a VENI fellowship to use ALMA to study the properties of discs around young stars in which planets are forming. Huub Röttgering and Joost Kok (Leiden Institute of Advanced Computer Science) were awarded a grant with the NWO call 'Big Bang, Big Data: Innovating ICT as a Driver for Astronomy' to study how well the future radio telescope SKA can be calibrated.
For me personally, 2014 was a good year. I am very grateful for the enormous dedication of Evelijn Gerstel, Alexandra Schouten, Erik Deul and many others of our support staff. With the day-to-day life at the Observatory so well taken care off. I could spend a significant amount of time to work on science projects. Most gratifying was to see that the enormous promise of the LOFAR radio telescope is really becoming a reality. Based on the hard work of many and in very good collaboration with for example the imaging tiger team at ASTRON, Tim Shimwell, Wendy Williams and Reinout van Weeren (now at Harvard) showed that for the

higher frequency LOFAR bands all the technical problems can be overcome and beautiful and deep thermal noise limited images can be made. This is opening the door to a large range of projects to study the nature of the earliest active galaxies and clusters.
With this in mind and the knowledge that the Observatory is doing very well, I am looking forward to a great 2015.

Huub Röttgering
Director.

Chapter 2

Research

Chapter 2
Research

2.1 Solar system

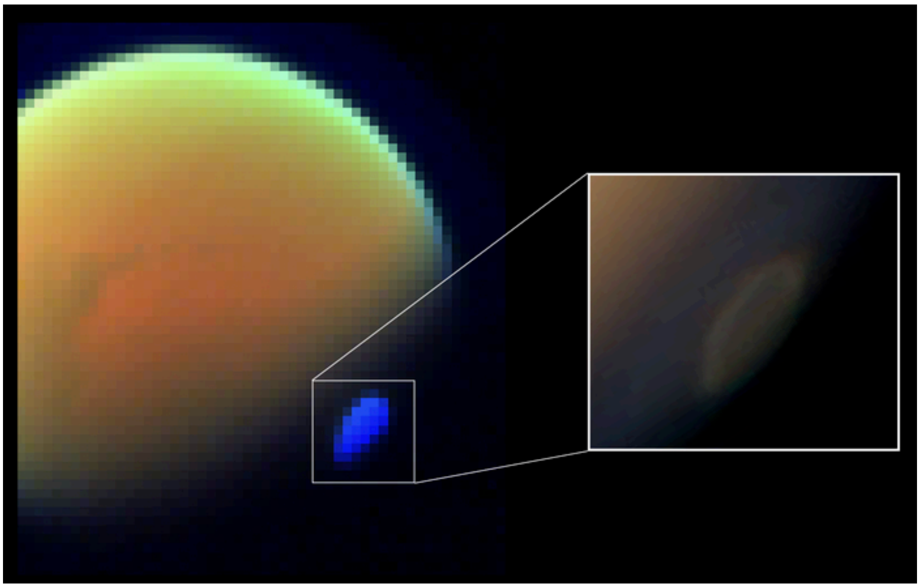
A mysterious cloud on Saturn's moon Titan

A mysterious cloud on Saturns moon Titan, which has been floating high above its southern pole since 2012, is composed of HCN ice particles. De Kok and collaborators found this unexpected result, published in Nature, from near-infrared reflectance spectra taken with the Cassini orbiter (see Fig. 2.1). Cassini images show the southern polar cloud since 2012 at an altitude of 300 km, where no cloud was expected to form. The clear signature of two HCN ice features in its near-infrared reflectance spectrum suggests that the temperature high above Titans southern pole must have been decreasing by roughly 50 degrees Kelvin in just a few months time. Models of Titans climate predicted a slow warming during this time instead. A possible cause of this rapid cooling is the accumulation of air with high concentrations of hydrocarbon and nitrile gases, which radiate strongly in the infrared, and hence can cool the atmosphere.

2.2 Exoplanets and proto-planetary disks

Length of Exoplanet Day Measured for First Time

An all-Leiden team, Snellen, Brandl, de Kok, Brogi, Birkby, and Schwarz have measured for the first time the rotation rate of an exoplanet. Beta Pictoris b has been found to have a day that lasts only eight hours. Observations with the CRIRES instrument on the VLT show it to spin with a velocity of 25 km sec^{-1}.



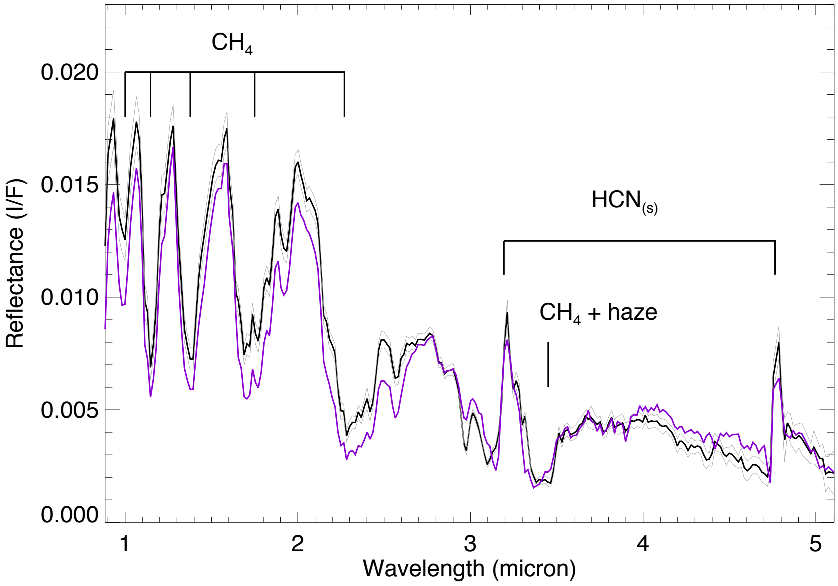


FIGURE 2.1: Upper panel: Spectral map of Titan (credit: NASA/ASI/University of Arizona/SSI/Leiden Observatory & SRON). Lower panel: The near-infrared reflectance spectrum of Titans southern polar cloud shows two large features of HCN ice, as well as absorption by methane gas and haze. Also plotted is a simple model spectrum that assumes scattering by HCN ice particles.

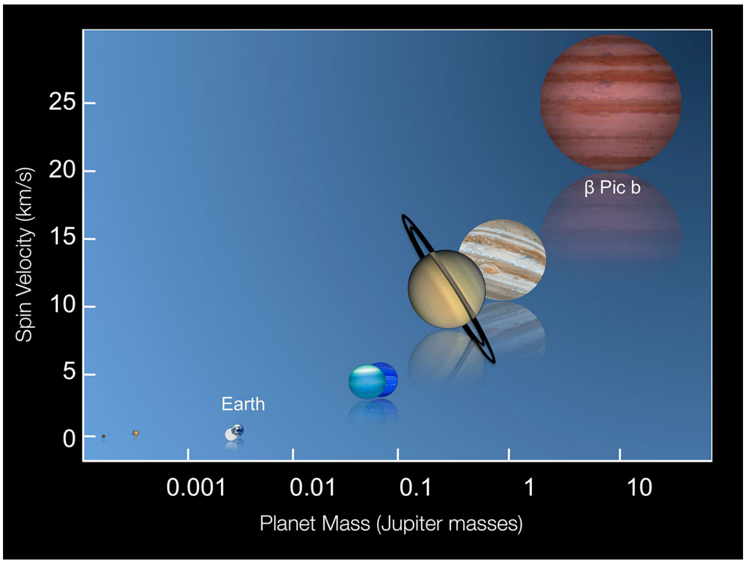


FIGURE 2.2: The spin rotation of exoplanet β pictoris b compared to that of the planets in our solar system (Credit: ESO/Snellen)

This is much quicker than any planet in the Solar System. This new result extends the relation between mass and rotation seen in the Solar System to exoplanets. Beta Pictoris b is a very young planet, only about 20 million years old (compared to 4.5 billion years for the Earth). Over time, the exoplanet is expected to cool and shrink, which will make it spin even faster. Snellen and his team made use of high-dispersion spectroscopy combined with high-contrast imaging to spatially separate the planet from the star. By very carefully removing the effects of the much brighter parent star they were able to extract the rotation signal from the planet. Similar techniques will allow astronomers to map exoplanets in detail in the future with the European Extremely Large Telescope (E-ELT).

High-contrast Imaging of sub-stellar companions

Direct imaging surveys around nearby stars are revealing a growing number of sub-stellar companions. These massive (a few up to 80 Jupiter masses) objects at large projected separations from their host stars form a complementary sample to the short period objects discovered by radial velocity and transit surveys. It is particularly interesting to examine if both groups of objects can form in a similar way or if these are really two physically distinctive populations. Determining the eccentricities of wide directly imaged companions could shed some light on this question. If these objects would have formed in-situ by core accretion in a disk, one would expect them to have low eccentricities due to the dampening effect that the disk material has on eccentricity excitations. Similarly, in-situ formation by gravitational instability of the protoplanetary disk is expected to form objects with low eccentricity. High eccentricities, on the other hand, would point towards dynamical interactions like planet-planet scattering events in the formation phase of these objects.

The Astrometric orbit of exoplanet GQ Lup b

GQ Lup is a classical T Tauri star of spectral type K 7. This means that it is young (only a few Myr old) and thus has not reached the main sequence in the Hertzsprung-Russel diagram. The youth of this star also means that it has a high rotation speed and chromospheric activity. It is located in the Lupus I cloud, a region of ongoing star formation approximately 140 pc away from the solar system. In 2005 a sub-stellar companion to GQ Lup was discovered by direct imaging with the ESO/VLT, the Hubble Space Telescope and the Subaru Telescope. This object is many times fainter than the star GQ Lup itself and is located at a small angular separation of only 0.7 arcsec (98 au of projected separation). Ginski and collaborators showed for the first time that GQ Lup b shows significant orbital motion around its host star. This was possible by the evaluation of high precision astrometric measurements undertaken with the ESO/VLT and the high resolution adaptive optics imager NACO over the course of a decade. The detection of this slow orbital motion made it possible to constrain the orbital elements of the system. The analysis yielded that GQ Lup b is most likely on an eccentric orbit, although circular orbits could not yet be ruled out.
From the distribution of inclinations an eccentricities of orbits that fit the astrometric measurements it was possible to deduce that an in-situ planet-like formation for the object can be ruled out. This was possible because the inclination of the star itself was already known and no orbits of GQ Lup b were found with low eccentricity that match this inclination of the star. The inclination of the star is most likely identical to the inclination of the protoplanetary disk in which an a planet would form via core accretion or gravitational instability. The object thus has likely formed either in a star-like fashion through gravitational collapse of the protostellar cloud or was scattered to its current position by another inner companion. However, there are no signs of such an inner companion known to date.

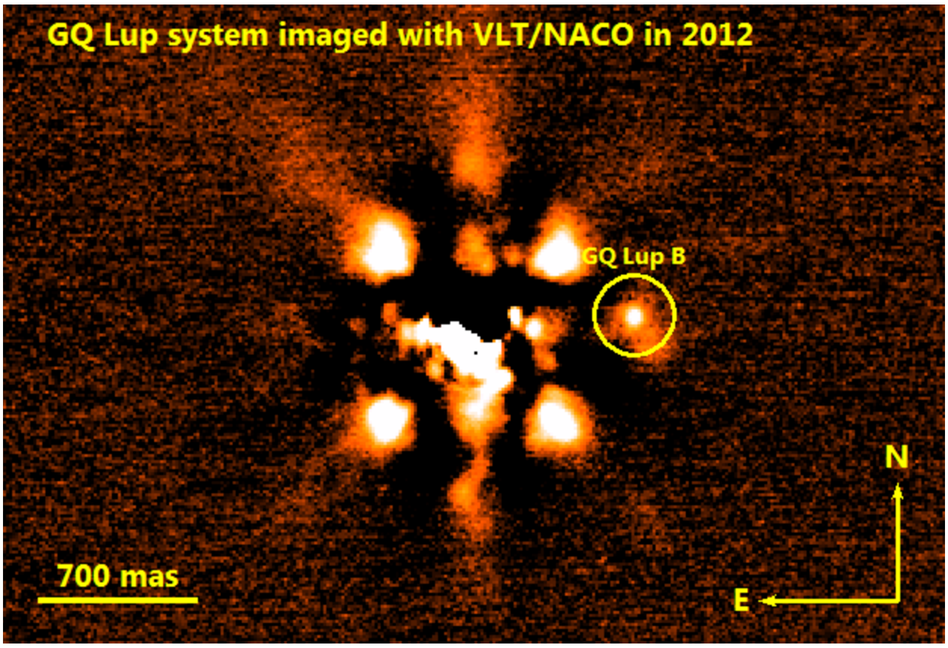


FIGURE 2.3: NACO/VLT observation of the exoplanet GQ Lup b by Ginski.

The Atacama Large Millimeter/sub-millimeter Array and Allegro

The Atacama Large Millimeter / submillimeter Array (ALMA) entered a phase of steady Early Science Observing. Allegro staff were heavily involved in Quality Assurance of the data prior to their release to the PI. In addition, Allegro staff (Tilanus, van Kempen, Maud) contributed in Chile to the Extension and Optimization Campaign of ALMA, participating in the commissioning of the highest frequency (Band 10) receivers and preparation for the commissioning of baselines as long as 12 km. Tilanus took a leading role in facilitating the Early Event Horizon Telescope and BlackHoleCam projects, which includes phasing-up ALMA to an integral part of a world-wide millimeter-VLBI instrument.

Submm studies of planet-forming disks

Hogerheijde analysed Herschel observations of cold water and ammonia vapor in several planet-forming disks, and completed the JCMT Gold Belt survey telescope project resulting in numerous publications presenting submillimeter-continuum and CO line data of nearby star-forming regions, initial analysis of ALMA Cycle 2 data on the planet-forming disk around HD163296, and the analysis of SMA observations of comet P17/Holmes. The latter work, conducted together with Qi (Harvard), found two distinct componets in the coma of this active comet: one steadily outgassing from the nucleus' surface, the other probably deriving from evaporating icy particles that are released from the nucleus. Intriguingly, the HCN/CO ratio of both components is different by a factor 40, suggesting that the comet has a significant internal heterogeinty.

Gas structure inside dust cavities of transition disks

Transition disks are recognized by the absence of emission of small dust grains inside a radius of up to several 10s of AU. The gas content of these dust holes has not yet been determined, yet is of importance for constraining the mechanism leading to the dust holes. Bruderer (MPE), van der Marel, van Kempen, and van Dishoeck used ALMA Band 9 observations of ^{12}CO and C^{17}O 6-5 to constrain the gas surface density profile for the transition disk Oph IRS 48, previously shown to host a large dust trap. The overall gas mass is determined using the physico-chemical model code DALI and found to be low, less than a Jupiter mass. Two drops are found inside the dust hole: at 60 AU, the gas surface density drops by a factor of $\sim$12 compared with the outer disk, and inside 20 AU, the gas surface density drops by a factor of at least 110. This gas surface density profile points to the clearing of the cavity by one or more massive planets/companions rather than just photoevaporation or grain-growth.
The same data set also shows emission from warm formaldehyde at 674 GHz, spatially resolved as a semi-ring at $\sim$60 AU radius centered south from the star. The inferred H_2CO abundance by van der Marel and collaborators is $\sim10^{-8}$, derived by combining the above physical disk model with a non-LTE excitation calculation. This H_2CO detection demonstrates the start of complex chemistry in a planet-forming disk. Future ALMA observations are expected to push the abundance limits of other molecules by 1-2 orders of magnitude.

How to properly derive gas masses of disks?

The amount of gas in disks is a crucial parameter that determines its ability to form giant planets and that affects the dynamics of dust and its growth to planetary embryos. There are few reliable determinations of gas masses in disks, however. Miotello, Bruderer (MPE) and van Dishoeck developed new models which properly treat the isotope selective photodissociation of CO isotopologues in a full disk model for the first time. The chemistry, thermal balance, line and continuum radiative transfer are all considered together with a chemical network that treats ^{13}CO, C^{18}O and C^{17}O, as well as isotopes of all included atoms and molecules as independent species. The isotope selective processes lead to regions in the disk where the isotopologue abundance ratios of $C^{18}O/^{12}CO$, for example, are considerably different from the elemental $^{18}O/^{16}O$ ratio, which in turn can lead to underestimating disk masses by up to an order of magnitude or more if grains have grown to larger sizes. This may explain observed discrepancies in mass determinations from different disk mass tracers. Including CO isotope selective processes is therefore crucial for determining accurate gas masses of disks in the ALMA era.

Rotationally supported disks in the embedded phase

Disks are observed around pre-main sequence stars, but how and when they form is still heavily debated. Only a handful of rotationally supported disks have been identified to date in the embedded phase. Harsono, van Dishoeck, Hogerheijde, Jörgensen (Copenhagen) and collaborators used IRAM PdBI to obtain subarcsec observations of dust and gas toward four low-mass young stellar objects in Taurus. Three of them show evidence for disks from the gas kinematics. Similarities and differences between the gas and dust disk are discussed. Combined with literature data, the sizes and masses of such disks around embedded objects are best described with evolutionary models with an initial rotation of 10^{-14} Hz and slow sound speeds. Little CO is frozen out within 100 AU in these disks.

Methanol on the path from envelope to disk

Interstellar methanol is considered to be a parent species of larger, more complex organic molecules. Drozdovskaya, together with Walsh, van Dishoeck, Harsono and Visser (Michigan), made a 2D physicochemical simulation of infalling parcels of matter for a low-mass star-forming system to trace the chemical evolution from cloud to disc, with a focus on methanol. A comprehensive gas-grain chemical network is employed to compute the chemical abundances along infall trajectories for two cases: one in which the dominant disc growth mechanism is viscous spreading, and another in which continuous infall of matter prevails. The infall path influences the abundance of methanol entering each type of disc, ranging from complete loss of methanol to an enhancement by a factor of >10 relative to the prestellar phase. These simulations show that the comet-forming zone of disks contains less methanol than in the precollapse phase, which is dominantly of prestellar origin, but also with additional layers built up in the envelope during infall. Such intriguing links will soon be tested by upcoming data from the Rosetta mission.

Ice grains in protoplanetary disks

Icy grains in protoplanetary disks are the building blocks of planets. In order to understand the effect of dynamics on the ice composition in protoplanetary disks Furuya and Aikawa (Kobe university) developed a numerical model, which can take into account both state-of-the-art gas-ice chemistry and turbulent mixing in the vertical direction. Main focus was placed on icy complex organic molecules (COMs), such as methyl formate and dimethyl ether. The model shows that mixing enhances the production of icy COMs in the disk surface, and expands the icy COMs distribution both vertically and radially outward compared with that in the non-turbulent case. This shows the importance of dynamics for disk chemical evolution prior to planet formation.

The smallest grains in debris disks

It is often assumed that the lower end of the dust size distribution in debris disks is determined by the radiation pressure of the star. Krijt & Kama argue the amount of surface that can efficiently be created in individual collisions might prevent the formation of particles small enough for radiation pressure to be relevant in the first place. They derive an analytical prescription for this size limit and explore it as an explanation for recent observations of a number of systems, in which the minimum grain size is found to be significantly larger than the blow-out size.

2.3 Protostars

Water in star-forming regions with Herschel (WISH)

WISH is a large program on the Herschel Space Observatory using primarily the HIFI instrument. It is designed to probe the physical and chemical structures of about 80 young stellar objects using water and related molecules, and to follow the water abundance from collapsing clouds to planet-forming disks (PI: van Dishoeck). In addition, follow-up programs such as the William Herschel Legacy Line survey (WILL) on an additional 50 low-mass protostars allow statistical analyses. WISH and WILL involve collaborations across the world and include Mottram, San Jose Garcia, Karska, Harsono and Hogerheijde. About a dozen WISH

papers were published this year. A major review on 'Water from clouds to planets' led by Van Dishoeck was published in Protostars & Planets VI.
Most of the water emission is found to originate from shocks associated with the outflows. Mottram and the WISH team made an in-depth analysis of the physical parameters of these shocks. Water is the ideal tracer of outflows because it is present in high abundance. Velocity-resolved HIFI spectra of multiple water-transitions observed towards a large sample of nearby low-mass protostars have been decomposed into different Gaussian components, with each component related to one of three parts of the protostellar system: (i) a quiescent envelope, (ii) cavity shocks in a thin layer along the cavity wall (C-shocks) and (iii) spot shocks in the jet and at the base of the outflow (J-shocks). In contrast with CO, the water line ratios do not vary with velocity and are very similar for all sources. Non-LTE excitation and radiative transfer models have been used to constrain the physical conditions, which are found to be comparable for the cavity and spot shocks, and to originate in compact regions. With evolution, the lines become narrower and the emitting regions smaller but excitation conditions remain similar. The velocity of the wind driving the outflow, rather than the decrease in envelope density or mass, therefore seems to be the cause of the decrease in H_2O intensity with evolutionary stage.

Shockingly low water abundances in low-mass protostars

Karska, together with Kristensen (CfA), van Dishoeck, Mottram, Drozdovskaya and the WILL team, analyzed Herschel/PACS spectral maps of 22 objects in the Perseus molecular cloud. Line emission from H_2O, CO, and OH is tested against shock models from the literature. The observed line ratios are found to be remarkably similar and do not show variations with physical parameters of the sources (luminosity, envelope mass). Most ratios are also comparable to those found at off-source outflow positions. The data show good agreement with literature shock models when line ratios of the same species are compared and constrain pre-shock density and shock velocity. However, the observations consistently show H_2O-to-CO and H_2O-to-OH line ratios that are one to two orders of magnitude lower than predicted by the existing shock models. This is most likely caused by an overabundance of H_2O in the models since the excitation is well reproduced. Illumination of the shocked material by UV photons produced either in the star-disk system or, more locally, in the shock, would decrease the H_2O abundances and reconcile the models with observations.

The link between water gas and ice in protostellar envelopes

Schmalzl, in collaboration with Walsh, Mottram, van Dishoeck and others, determined the critical parameters in water chemistry and the contribution of water to the oxygen budget by observing and modeling water gas and ice for a select sample of low-mass protostars for which both forms of water have been observed. A simplified chemistry network, which is benchmarked against more sophisticated networks, has been developed that includes the necessary ingredients to determine the water vapour and ice abundance profiles. Comparing the model results to observations of Herschel-HIFI water lines and previously published water ice column densities allows determination of various parameters, i.p. FUV field, initial abundances, timescales, and kinematics. Surprisingly, the observed water ice abundances imply that only 10-30% of the volatile oxygen budget is locked up in ice. The keys to reproduce this result are a low initial water ice abundance after the (short) pre-collapse phase together with the fact that atomic oxygen cannot freeze-out and form water ice in regions with $T_{dust} > 15$ K.

HDO/H_2O in low-mass protostars and link with comets

The water deuterium fractionation has traditionally been used to infer the amount of water brought to Earth by comets. Persson, Jörgensen (Copenhagen) and van Dishoeck used IRAM PdBI to measure this ratio in the warm gas associated with deeply-embedded low-mass protostars, probing the critical stage when water is transported from clouds to disks. A direct and model independent HDO/H_2O abundance ratio is determined for each source on solar-system scales of 150 AU, and is found (surprisingly) to be at most a factor of 2 higher than those found for pristine solar system comets. These small differences suggest that little processing of water occurs between the deeply embedded stage and the formation of planetesimals and comets.
Together with Coutens (Copenhagen), D_2O has also been detected in one of the sources, with an D_2O/HDO ratio a factor of seven higher than the HDO/H_2O ratio. These results indicate that either the surface deuteration processes are poorly understood or that some of the water is formed by other processes than grain surface chemistry.

Water versus methanol in outflows

Water in outflows from protostars originates either as a result of gas-phase synthesis from atomic oxygen at T>200 K, or from sputtered ice mantles containing

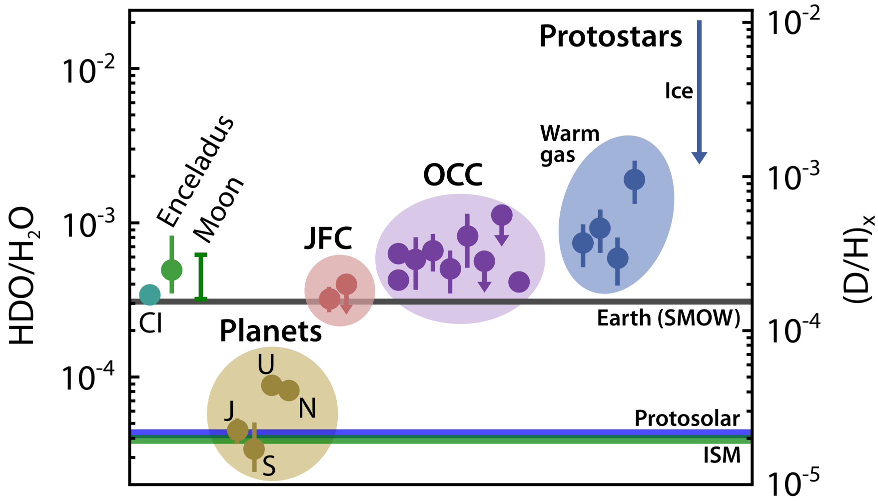


Figure 2.4: D/H ratio in water found in low-mass protostars compared with those observed in comets (Oort Cloud and Jupiter family) and in the Earth oceans, the giant planets, the solar nebula disk, and the interstellar medium. Values for carbonaceous meteorites (CI), the Moon and Saturns moon Enceladus are presented as well (based on Persson et al. 2014).

water ice. Suutarinen and Fraser (Open University), together with Kristensen (CfA), Mottram and van Dishoeck, quantified the contribution of the two mechanisms by comparing observations of gas-phase water to methanol (a grain surface product) toward three low-mass protostars. Herschel-HIFI data of water and CO were combined with JCMT data of CH_3OH lines and analyzed with RADEX non-LTE excitation simulations. Up to one order of magnitude decrease in the column density ratio of CH_3OH over H_2O and CO was found as the velocity increases in the line wings. This implies that gas-phase formation of H_2O is active at high velocities (above 10 km s-1 relative to the source velocity).

A distance limited sample of massive molecular outflows

One long standing question in massive star formation (M > 10 M_o) is whether they form from a scaled-up version of low-mass star formation. The best way to answer this question is to look for accretion discs around massive protostars. However, due to the distance of these sources the best observations to date only very marginally resolved elongated structures only with hints of rotation. Alternatively, common phenomena, such as molecular outflows can be investigated. Using the JCMT, 89 massive molecular outflow sources within 6 kpc of the Sun have been mapped by Maud and collaborators. The representative sample shows that outflow force (and indeed outflow mass, momentum and energy) all scale with independently established luminosities obtained from comprehensive SED fitting. When combined with a sample of low-mass outflow it becomes apparent that the scaling exists over 6 orders of magnitude and supports an up-scaled formation scenario for high mass stars. Furthermore, a simple model of the star formation regions as a cluster of IMF stars suggests all protostars up to 30 M_o in the cluster must be contributing to the outflows in order to match the observations.

Water deuteration in young protostars

To determine the amount of water deuteration (D/H ratio) in the warm gas of deeply-embedded low-mass protostars, radiative transfer modeling of interferometric observations of both $H_2{}^{18}O$ and HDO was carried out for three young protostars by Persson, Jörgensen (Denmark), van Dishoeck and Harsono. The results show a similar amount of water deuteration for the three sources, and slightly higher values than what is found in comets in our solar system. This shows that little processing of water takes place between the deeply-embedded phases and inclusion into cometary ices.
Doubly deuterated water (D_2O) was detected toward the deeply-embedded low-mass protostar NGC 1333 IRAS 2A with the Plateau de Bure Interferometer at high-spatial resolution by Coutens (Denmark), Jörgensen (Denmark), Persson, van Dishoeck, Vastel (France) and Taquet (USA/NL). The observed D_2O/HDO ratio is about 7 times higher than the derived HDO/H_2O ratio for the same source and similar scales ($\sim$100 AU), contradicting current grain surface chemical models for water formation.

Complext organic molecules around low-mass proto-stars

By observing the cluster of low-mass protostars in NGC 2071 using the Sub-Millimeter Array (SMA), van Kempen showed that complex organic molecules (COMs, species include formaldehyde, H_2CO, methanol, CH3OH, and methyl-cyanide, CH_3CN) commonly seen during embedded star formation originate from multiple small regions (<500 AU). Higher excited lines as seen by Herschel-HIFI are a sum of the emission of all three regions. COMs are created on the grain surfaces, but end up in the gas phase through sputtering of icy grain mantles affected by outflow activity. COMs can only survive this process in regions of high densities ($>10^7$ cm^3) and relatively high temperature (150-250 K). In regions of lower density and/or higher temperature, COMs are immediately destroyed by

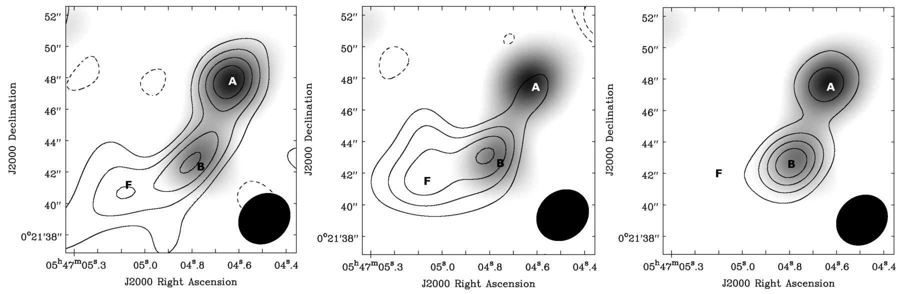


FIGURE 2.5: Comparison of COMs emission in NGC 2071 as observed with the SMA. Left: Formaldehyde, Middle: Methanol, Right: Methyl Cyanide.

shock products such as atomic hydrogen after evaporation. The lack of spatially extended emission confirms that organic molecules do not (re-)form through gas-phase synthesis. A comparison to water observations from Herschel (H_2O), which shows a strong line wing emission not seen for the COMs, reveals that water does reform quickly through gas-phase synthesis. Last but not least, by comparing the COMs emission of the various species, a difference in ice processing history was revealed. This difference is caused by the presence of a nearby protostar.

Magnetic field morphology of massive Young Stellar Objects

Van Langevelde, Surcis (JIVE), Vlemmings (Chalmers University of Technology) continued their work on measuring magnetic fields morphology close to massive YSOs (on AU scale) by using 6.7 GHz methanol masers. The targeted sources are part of a large sample of massive YSOs, the so-called flux-limited sample, that is composed of 31 sources. A statistical analysis of the results obtained reveals evidences that the magnetic fields around massive YSOs are preferentially oriented along the molecular outflow. One collaboration focused on the 22 GHz water masers around the massive young stellar objects (YSOs) W75N-VLA2 and W75N-VLA1. The two massive YSOs are separated by just 1300 astronomical units and are at two different evolutionary stages, The interferometric observations showed that the shell structure of the masers around VLA2 is expanding and increasing its ellipticity. Furthermore, the magnetic field around VLA2 has changed its orientation according to the new direction of the major-axis of the shell-like structure and it is now aligned with the magnetic field in VLA1. This confirms that the water masers around VLA2 are tracing the evolution from a non-collimated to a collimated outflow. The team also continued their collaboration with the theoretical chemistry group in Nijmegen (van den Avoird, Groenenboom, Lankhaar) on the Zeeman splitting of microwave methanol transitions. It was

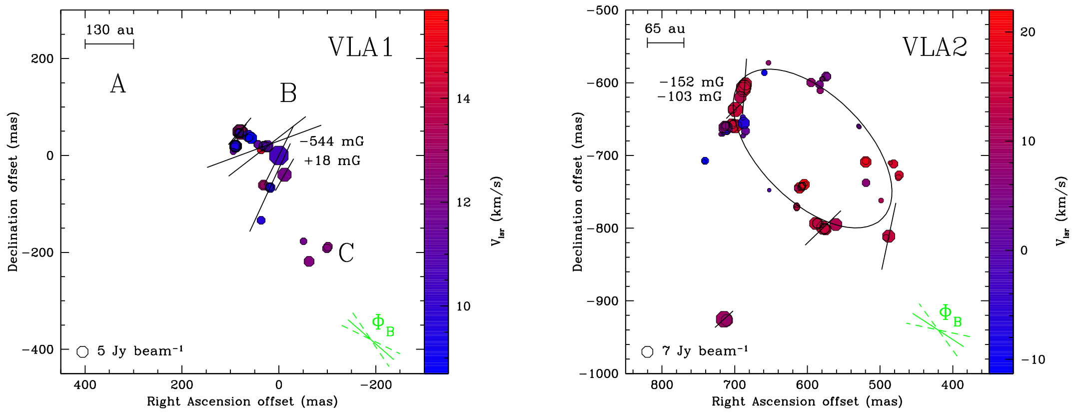


FIGURE 2.6: A close-up view of the 22 GHz water masers detected in W75N, around YSOs denoted by VLA1 (left panel) and VLA2 (right panel). The symbols represent the masers identified and the linear polarisation vectors are over plotted as well.

found that the results from earlier laboratory experiments were probably not significant as methanol will display non-linear effects in the magnetic fields that were used in the experiments. It was concluded that more thorough calculations of the hyperfine components involved were needed.

2.4 Stars and compact objects

Chemistry in the envelopes of AGB stars

Li, Heays, Walsh, van Dishoeck and Millar (Belfast) re-investigated the chemistry in the envelopes of asymptotic giant branch (AGB) stars using new rates of the photodissociation of N_2 and CO, which are major reservoirs of nitrogen and carbon, respectively. For the first time, accurate N_2 and CO photodissociation shielding functions are used in a detailed chemical model of the envelope of the carbon-rich AGB star, IRC +10216, irradiated from the outside by an isotropic radiation field. The transition of N_2 to N (and also, CO to C to C^+) is shifted towards the outer envelope relative to previous models. This leads to different column densities and radial distributions of N-bearing species such as C_nN and HC_nN (n = 1, 3, 5, 7, 9). While differences remain between the IRC +10216 model and the observed molecular column densities, better agreement is found between the calculated and observed radii of peak abundance.

Faint red compact objects in WFC3 data from the Hubble Space Telescope

Holwerda worked on two related topics using Hubble data: the identification of Brown Dwarf stars belonging to our Milky Way and the sizes of extremely high-redshift objects. Both manifest as faint, small, red compact objects in Hubble WFC3 images and identifying the Brown Dwarfs reliably is critical if one wants to obtain clean samples of the high-redshift galaxies, which offer a view of the earliest epochs of galaxy formation.
The identification of M-dwarfs in Hubble data was the first step in identifying all types of Brown Dwarfs in the deep Hubble data which is aimed at identifying the highest redshift galaxies. Not only were 271 M-dwarfs identified and sub-typed, their photometric distances offered a way to gauge the size of our Milky Way for this stellar population. Remarkably, in one of these fields, an over-density of M-dwarfs was identified, which corresponded in both distances and position to the Sagittarius stellar stream, the remnant of an accreted satellite galaxy.
Not only will the successful identification of Milky Way dwarf stars, benefit the search for high-redshift galaxies future targets for the James Webb Space Telescope and the Atacama Millimeter Array but it sets the stage for the study of these very long-living stars in the halo and disk or our Milky Way. The future Euclid mission by ESA is a prime possibility to map the Brown Dwarf population and they may serve as reference stars in future JWST observations.

2.5 The Milky Way and nearby galaxies

Mass accretion onto supermassive black holes as a consequnce of a stellar tidal disruptions

Rossi's group has explored phenomena happening at the centre of galaxies, in order to predict observational consequences of the presence of the very massive black hole, and understand how this black hole intereacts with stars and shapes its own environment. Two highlights are reported.
If a star wanders too close to a supermassive black hole, the tidal force of the black hole exceeds the star's self-gravity and the star is torn apart. Afterwards, the stellar debris evolves to form a thin and eccentric stream of gas which falls back towards the disruption site. In the standard picture of such events, this debris is assumed to form an accretion disc. It then slowly spirals towards the black

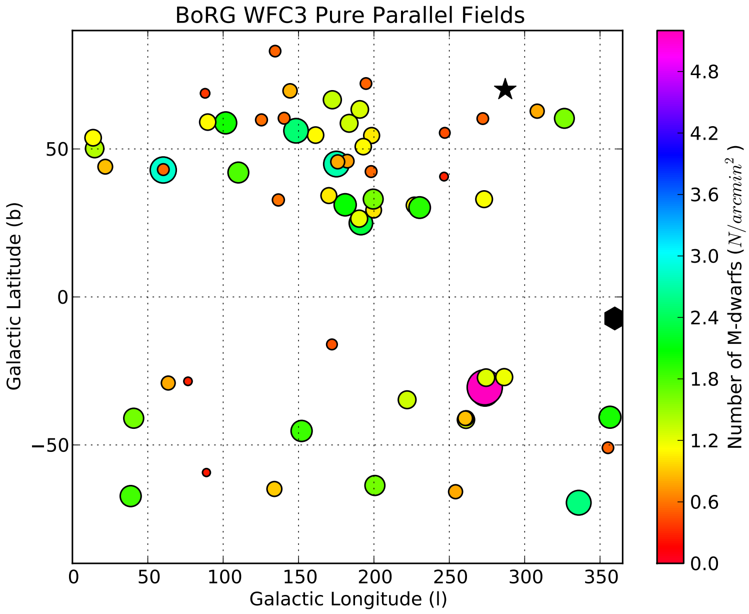


FIGURE 2.7: The number of Milky Way M-dwarfs, identified using both morphology and color. One fields stood out with 22 M-dwarfs (star). This is exactly in the middle of the Sagittarius stream. The implied photometric distances to most of these M-dwarfs agreed with the distance of the stream at that position. The rediscovery of this stream in a new population of stars implies EUCLID will have an unimpeded view of such streams at much higher contrast than optical surveys. The mean and spread of stars in these fields will also be of use for future JWST planning to gauge how many reference stars will be available for deep observations.

hole while releasing energy in the form of an electromagnetic signal observable in the UV to soft X-ray band. However, the mechanism driving the disc formation is still unclear. Bonnerot, Rossi, Lodato (Milan) and Price (Monash) performed hydrodynamical simulations of this process for stars on bound orbits (see Fig. 2.5). They found that the formation of the disc is mostly driven by relativistic apsidal precession which causes the stream to cross itself. This self-crossing induces the formation of shocks which heat the debris and cause them to move from their initial eccentric orbits to an accretion disc. They also pointed out that the structure of the disc depends on the cooling efficiency of the gas. If the cooling is efficient, the debris form a thin and narrow ring. If it is inefficient, they settle instead into a thick and extended torus. In addition, the time required for the disc to form was found to depend on the orbit of the star. If it has a larger eccentricity, the self-crossing occurs earlier and the disc forms faster. If it has a lower pericentre distance, it forms slower as relativistic apsidal precession is weaker.

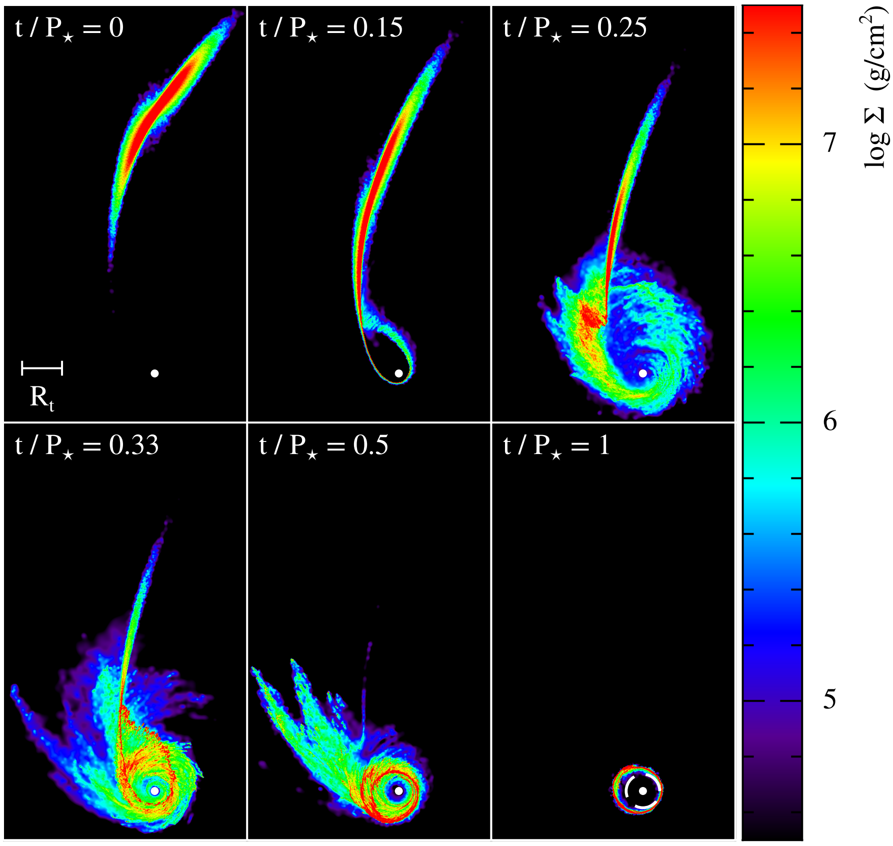


FIGURE 2.8: Snapshots of the disc formation at different times t / P_* = 0, 0.15, 0.5 and 1 where P_* is the period of the star. For this model, the cooling of the gas is efficient. The star has an eccentricity e = 0.95 and a pericenter distance $R_p = R_t$ / 5 where R_t is the tidal radius. For this orbit, P_* = 22 h. The colours correspond to the column density Σ of the gas whose value is indicated on the colour bar. The white point represents the black hole. The dashed white circle on the last snapshot represents the so called circularization radius at which the disc is theoretically expected to form. Due to relativistic apsidal precession, the stream of stellar debris self-crosses at t / P_* ≈ 0.15. It causes the formation of shocks which drive the formation of the disc. At t / P_* ≈1, the debris settle into a thin and narrow ring located at the circularization radius. Movies of the simulations are available at http://home.strw.leidenuniv.nl/~bonnerot/research.html

Studying quiescent Galactic Nuclei using Supernova Remnant dynamics as a tool

Quiescent galactic nuclei, like that of our Galaxy, have been observed to harbour supermassive black holes (SMBHs; masses in excess of 100,000 solar masses) and young populations of stars. Around these black holes, a slowly accreting, weakly radiating flow of gas is believed to be present, which is also observed in our Galactic Centre. When massive stars explode in such environment, the shape, radiative properties and lifetime of the supernova remnant (SNR) will be determined by the shape and density of the accretion flow and by the strong tidal forces of the SMBH, which tends to pull apart any extended gas structure that gets too close. Rimoldi, Rossi, Piran (HUJI, Jerusalem) and Portegies Zwart have investigated for the first time the fate of stellar explosions in a range of quiescent nuclear environments (see Fig. 2.5). Studying the evolution of young SNRs over a large range of initial conditions required the development of a new code that solves the evolution of shocks in arbitrary axisymmetric configurations, which is general enough to be used for many other problems. We use the results of these simulations to make predictions about outstanding and important problems in the field of galactic nuclei, such as the contributions of young SNRs to the nuclear X-ray emission in searches for quiescent SMBHs. The recent discoveries of a magnetar within the sphere of influence of the Galactic Centre SMBH as well as a new suspected SNR in the Galactic Centre have sparked additional interest in this topic in the community.

Gaia

The Gaia group in Leiden, led by Brown, participates in the operational phases of the data processing for ESA's Gaia mission. Launched in December 2013, Gaia aims at providing a stereoscopic census of the Milky Way by measuring highly accurate astrometry (positions, parallaxes and proper motions), photometry and radial velocities for 1 billion stars and other objects to 20th magnitude. The main activities this year were:

1) Brown participated in the commissioning of the Gaia scientific instruments. In his capacity as chair of the Gaia Data Processing and Analysis Consortium (DPAC) Executive he contributed to the coordination of commissioning activities, in particular the work of the so-called payload experts. Brown specifically supported the commissioning of the spectrophotometric instrument of Gaia, through

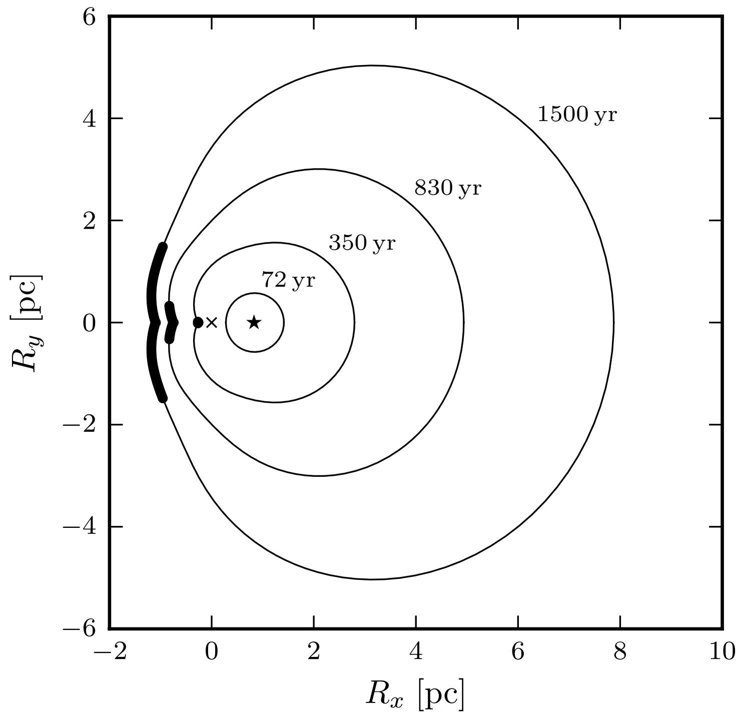


FIGURE 2.9: Morphological evolution of an SNR around an SMBH with $M_\bullet = 10^8\ M_\odot$. The supernova occurs at the location of the green star, and the SMBH is located at the black circle. Regions of the SNR that drop below the local Kelperian velocity of the SMBH are highlighted in red.

analysis of the data. Together with S. Jordan he developed a model that qualitatively explains the excess stray light seen in the Gaia instruments and how the level varies with the spin phase of the Gaia spacecraft. In preparation for the Gaia In Orbit Commissioning Review (mid-July 2014), Brown led the writing of the technical note containing the detailed DPAC assessment of the Gaia status and performances after the commissioning period.

2) Costigan and Hypki worked on the preparations for the publication of the Gaia Catalogue and archive. Costigan conducted an analysis of the existing DPAC requirements on the Gaia catalogue and archive and compared those to the use cases provided by members of the astronomical community. It was concluded that most of the user proposals are already covered by the existing requirements, meaning that the catalogue and data access facilities in preparation correspond to actual scientific needs.

Hypki worked on a prototype interface to the Gaia archive which in the future should allow users to run sophisticated data analysis procedures directly against the data stored in the archive at ESAC.

3) Van Elteren and Brown 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. Van Elteren maintained and updated the photometric processing modules in the Gaia Initial Data Treatment pipeline which was the first pipeline running during the Gaia commissioning period.

Depolarisation of galactic radio synchrotron emission

Shneider and Haverkorn studied depolarisation of radio synchrotron emission from galaxies using analytical calculations and numerical simulations. Taking into account galactic gaseous disks and haloes, and regular and turbulent magnetic fields, they showed that even radiopolarimetric observations at a limited frequency range can distinguish between various models and physical parameters (Fig. 2.5). Application of this method to nearby spiral galaxy M51 showed that the total magnetic field strength in the disk of M51 is approximately 18 microGauss, and the total field strength in the halo is about a factor 4 lower. Also, they find evidence for a significant anisotropic turbulent magnetic field in the galaxy disk.

Studying galactic structure using methanol masers

Quiroga-Nunez and van Langevelde started a project to investigate the use of methanol masers for studying Galactic structure. The approach is to set up a statistical simulation of the distribution and dynamics of the masers in the spiral arms of the Milky way. From this simulation a sample of observed masers could be drawn to test the results of large scale astrometry programmes done with the VLBA. Because the observations are limited to northern hemisphere objects in the near spiral arms it is important to test against possible biases. With the simulations one can also test the luminosity distribution of masers, which, among other things, is important for future astrometry projects.

MUSE opens its 24 eyes

The panoramic integral field spectrograph MUSE saw first light on the VLT in January and entered normal operations in October. MUSE provides spectra in 0.2"x0.2" regions across a field of view of 1'x1' and these 90,000 spectra per shot offer an unprecedented view of the cosmos. The first exposure of the MUSE

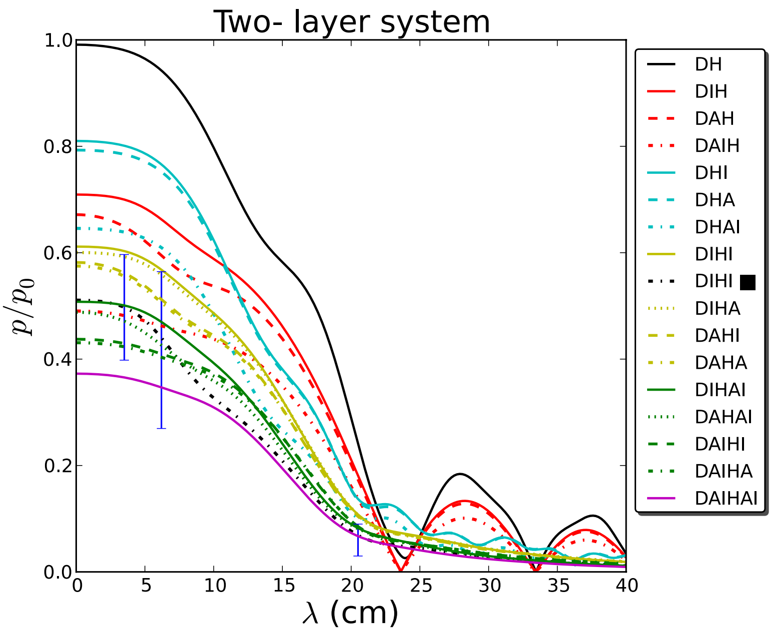


FIGURE 2.10: Normalised degree of polarisation as a function of observing wavelength for a disk-halo system. Various models include regular magnetic fields in the disk (D) and halo (H), while either of these components can contain isotropic (I) or anisotropic (A) turbulent magnetic fields. Even three frequency points as available for M51 (blue symbols) can distinguish between models.

commissioning was of Kapteyn's star - at a distance of 13 light years it was chosen because the light observed left the star at the time MUSE was conceived.

In stark contrast, the commissioning closed with a very deep exposure of the Hubble Deep Field - obtaining an ultra-deep image of a field previously studied with very deep Hubble Space Telescope imaging (involving Brinchmann). This provided a plethora of star forming galaxies across cosmic time - from an ultra-faint dwarf at z∼0.1 with stellar mass less than 10^6 solar masses to 26 distant Ly-alpha emitting galaxies that are not visible in the ultra-deep HST images (see Fig. 2.11).

In Leiden PhD student Carton contributed significantly to the analysis of MUSE commissioning data. In particular he looked at dithering strategies and the line spread function in MUSE. To do this he analysed in detail several planetary nebulae - an illustration of the analysis of NGC 3232 is shown in Figure 2.12. The left panel shows a colour image composed of [O III]5007 (blue), [N II]6584 (green) and [O I]6300 (red), while the right shows the inferred velocity field in the nebula.

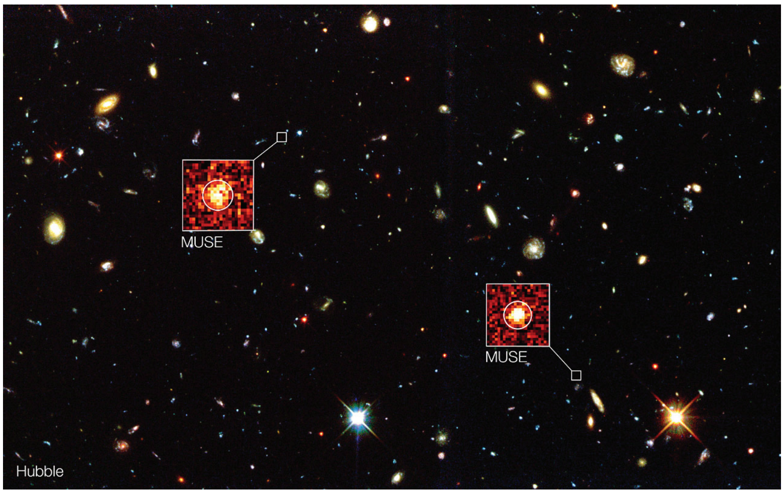


FIGURE 2.11: MUSE observations of the Hubble Deep Field showing examples of distant Ly-alpha emitting galaxies that are not visible in the deep HST images.

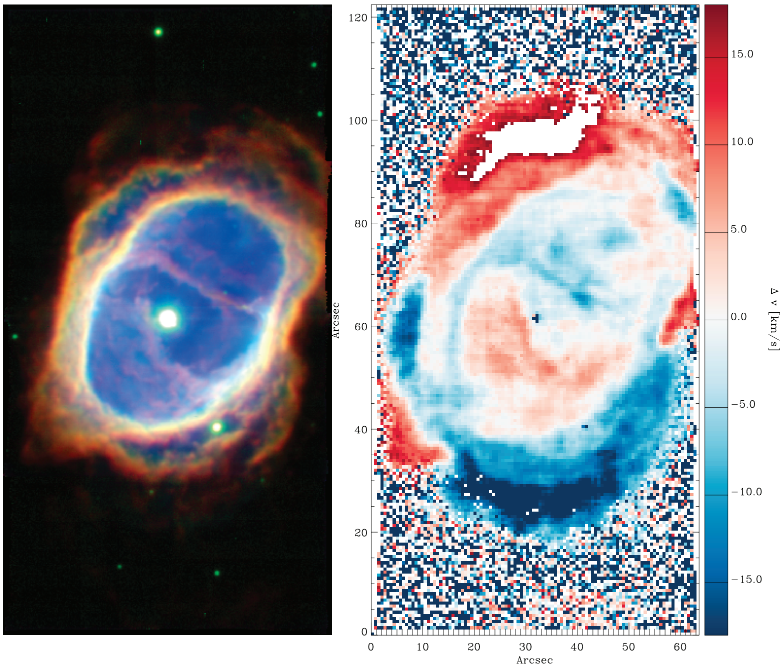


FIGURE 2.12: MUSE commissioning data of the planetary nebula NGC 3232. The left panel shows a colour image composed of [O III]5007 (blue), [N II]6584 (green) and [O I]6300 (red), while the right shows the inferred velocity field in the nebula.

Stars were Born in Significantly Denser Regions in the Early Universe

Brinchmann and PhD students Shirazi and Rahmati studied the physical properties of ionised regions in star forming galaxies at $z \sim 0$ and $z \sim 1-3$ using a combination of a density sensitive line ratios and a new ionisation parameter estimator based on the [O III]5007/[O II]3727 line ratio. They showed that galaxies at high redshift have significantly more extreme ionisation conditions to galaxies at low redshift with the same mass and star formation rate. They argued that the most natural interpretation of this result was that the star forming regions at high redshift are denser than their counter parts in the local Universe. This would be a natural consequence of a higher gas content of high redshift galaxies.

Dust and Gas in the Magellanic Clouds

As a member the HERITAGE Herschel Key Project, Israel was co-investigator of an extensive study of the dust content, and variations in the gas-to-dust ratio, in the Large and Small Magellanic Clouds. The Clouds are satellite galaxies of the Milky Way characterized by low abundances of heavy elements. The dust properties were studied using photometric data in five bands from 100 to 500 micron. Three simple models of dust emission were fit to the observations: a single temperature blackbody modified by a power-law emissivity (SMBB), a single temperature blackbody modified by a broken power-law emissivity (BEMBB), and two blackbodies with different temperatures, both modified by the same power-law emissivity (TTMBB). Investigating the origin of the submm excess (defined as the submillimeter emission above that expected from SMBB models fit to observations below 200 micron), the team found that the BEMBB model produced the lowest fit residuals. With gas masses from previous work, the newly calculated gas-to-dust ratios showed that the TTMBB fits would require much more dust than can possibly be present even if all heavy elements in the interstellar medium were condensed into dust grains. This indicates that the submm excess is more likely caused by emissivity variations than by a second population of colder dust. The team derived total dust masses of about 700,000 and 80,000 solar masses for the LMC and SMC, respectively.

As the spatial variation of the gas-to-dust ratio (GDR) provides information on the chemical evolution and lifecycle of dust in galaxies, the team also examined the relation between dust and gas on intermediate scales of 10-50 pc, based on the Herschel far-infrared data and H I 21 cm, CO, and Hα observations from other observatories. In the diffuse atomic ISM, they found gas-to-dust ratios to lie between 335 and 850 in the LMC, and 1050-3800 in the SMC. The atomic-to-molecular transition is located at dust surface densities of 0.05 M(sun)/pc^2 in the LMC and 0.03 M(sun)/pc^2 in the SMC, corresponding to A(V) ∼0.4 and 0.2 mag, respectively. Investigating the range of CO-to-H_2 conversion factors that best account for all the molecular gas in the beam of the observations, they found upper limits on XCO to be three times the local value in the Milky Way in the LMC twenty times the local MW value in the SMC. In the LMC, the dense gas has a lower dust-gas slope than the diffuse ISM by a factor ∼2. Coagulation of dust grains and the subsequent dust emissivity increase in molecular clouds, and/or accretion of gas-phase metals onto dust grains, and the subsequent dust abundance (dust-to-gas ratio) increase in molecular clouds could explain this. In the SMC, variations in the dust-gas slope caused by coagulation or accretion are degenerate with the effects of CO-dark H_2. Within the expected 5–20 times Galactic XCO range, the dust-gas slope can be either constant or decrease by a factor of several across ISM phases. Further modeling and observations are required to break the degeneracy between dust grain coagulation, accretion, and CO-dark H_2.

Gas and dust in the nearby Local Group galaxy M33

M33 is a Local Group spiral with slightly subsolar metallicity, which makes it an ideal stepping-stone to less regular and lower-metallicity objects such as dwarf galaxies and, probably, young-universe objects. Emission at a wavelength of 8 microns from polycyclic aromatic hydrocarbon (PAH) is widely used as a tracer of star formation rates. However, there are studies that challenge the accuracy and reliability of this emission as an SFR tracer. An international team of astronomers (HERM33ES), including Israel and Van der Werf, has been using the Herschel Space Observatory to analyze the infrared emission from the nearby spiral galaxy M33 on scales of 75 pc. They found that the 8 micron emission is better correlated with the emission at the much longer wavelength of 250 micron, which traces cold and inert interstellar dust, than with the emission at 24 micron which traces hot dust actively engaged in star formation. The L(8)/L(24) ratio is highly depressed in regions luminous at 24 micron associated with known HII regions. From a comparison of their results with the dust emission models by Draine and Li, the team speculated that increased stellar radiation from young stars is also destroying the dust grains responsible for the 8 micron emission, and that most of the 8 micron emission is consistent with heating by the diffuse interstellar medium, as also seems to be the case in M31.

In a different configuration, the team also studied the wavelength dependence of the dust emission as a function of position and environment across the disk of M33 using Spitzer and Herschel photometric data. They estimated the power-law exponent (β) of the dust emissivity taking care to properly treat the degeneracy between beta and the dust temperature (T). Both β and T are higher in the inner than in the outer disk, contrary to reported β - T anti-correlations found in other sources. In the cold + warm dust model, the warm component and the ionized gas (Hα) have very similar distributions across the galaxy, suggesting that the model indeed separates the components in an appropriate way. Both cold- and warm-dust column densities are high in star-forming regions and reach their maxima toward the giant star-forming complexes NGC 604 and NGC 595. β declines from close to 2 in the center to about 1.3 in the outer disk, and is positively correlated with star formation and with the molecular gas column, as traced by the Hα and CO emission. The lower dust-emissivity index in the outer parts of M 33 may be related to the reduced metallicity (different grain composition) and possibly to a different size distribution. Like most spirals, M 33 has a (decreasing) radial gradient in star formation and molecular-to-atomic gas ratio such that the regions bright in Hα or CO tend to trace the inner disk, which makes it difficult to distinguish between their effects on the dust. The assumption of a constant emissivity index beta is obviously not appropriate.

The molecular circumnuclear disk in Centaurus A

Israel, Meijerink, Loenen, van der Werf (all Leiden) and six other colleagues mostly in Bonn and Cologne (Germany), presented new carbon monoxide (CO) and neutral atomic carbon ([CI]) spectral line measurements of the compact circumnuclear disk in the center of NGC 5128 (Centaurus A) obtained with the Herschel Space Observatory, and also with the ground-based SEST, JCMT, and APEX (sub)millimeter telescopes in Chile and Hawaii. They found that the ladder of ^{12}CO line intensities in increasing transitions is quite different in Centaurus A from those of either star-burst galaxies or galaxies with an active nucleus (AGN). Another remarkable difference is that in the center of Cen A, the neutral carbon emission (relative to that of CO) is much stronger than in any other galaxy. The CO surface brightness of the compact circumnuclear disk (CND) exceeds that of the much more extended thin disk (ETD). Our radiative transfer models suggest that most of the CND gas is relatively cool (25 - 80 K) and not so dense ($\sim$300 per cm^3) if the heating is by UV photons. However, there is a small amount of gas in both the CND and the ETD with a much higher density of ∼30 000 per cm^3. Furthermore, the CND (but not the ETD) also hosts a high-excitation, high-density phase in the CND. The total gas mass of the Cen A CND is 85 million solar masses, uncertain by a factor of two. The CO-H_2 conversion factor is twice the local Milky Way value.

Molecular gas heating in Arp 299

Rosenberg, assisted by Meijerink, Israel, Van der Werf, Xilouris (Athens, Greece) and Weisz (Bonn, Germany) presented a study of the very luminous colliding galaxy group Arp 299 in which one component harbors an AGN and two more are experiencing intense star formation. Understanding the heating and cooling mechanisms in nearby (Ultra) luminous infrared galaxies provides insight into the driving mechanisms in their more distant counterparts. Molecular emission lines play a crucial role in cooling excited gas, and they were able to observe the rich molecular spectrum of the Arp 299 group with the Herschel Space Observatory. CO is the most abundant and one of the brightest molecules in the Herschel wavelength range. For Arp 299 A, they also obtained PACS spectrometer observations of high-J CO lines up to J=20-19 and JCMT observations of 13CO and HCN to discern between UV heating and alternative heating mechanisms. They immediately noted an important difference in the spectra of Arp 299 A and Arp 299 B+C, with source A having brighter high-J CO transitions. This is reflected in the respective spectral energy line distributions. Rosenberg and co-workers found that photon-dominated regions (PDRs) are unlikely to heat all the gas since a very extreme PDR is necessary to fit the high-J CO lines. In addition, this extreme PDR does not fit the HCN observations, and the dust spectral energy distribution shows that there is not enough hot dust to match the amount expected from such an extreme PDR. They therefore concluded that the high-J CO and HCN transitions are heated by an additional mechanism, namely cosmic ray heating, mechanical heating, or X-ray heating. In their exacting model analysis, they finally found that mechanical heating, in combination with UV heating, is the only mechanism that fits all molecular transitions. They used their results to constrain the molecular gas mass of Arp 299 A to three billion solar masses and further found that only 4 per cent of the total heating needs to be due mechanical effects (turbulence, shocks), with the rest due to UV photons..

Nearby starburst galaxies

Van der Werf, Rosenberg, and Meijerink studied the excitation mechanisms driving the near-IR H_2 rovibrational lines emission in the well-studied starburst galaxies NGC253 and Arp299, using data from HerCULES project, obtained with the SPIRE Fourier Transform Spectrograph on board the Herschel Space Observatory. By studying the CO excitation ladder and comparing the intensities to models, they investigated whether the gas is excited by UV radiation, X-rays, cosmic rays, or turbulent heating. ^{13}CO, HCN, and HNC line intensities were added in order to constrain the allowed parameter space. In NGC253, three ISM components are required. All of these can be represented by Photon-Dominated Region (PDR) models, but two of the three phases require an additional mechanical heating. In Arp299, the nuclear position shows the most highly excited CO ladder, and here likewise mechanical heating is required in order to reproduce the observed molecular intensities.

(Ultra)luminous infrared galaxies

Van der Werf collaborated with Papadopoulos (Cardiff) and Israel in a detailed analysis of the CO ladders in Arp193 and NGC6240, two classical merger/starbursts selected from the Herschel Comprehensive (U)LIRG Emission Survey (HerCULES). The high-J CO ladders were combined with ground-based low-J CO, 13CO, HCN, HCO+, and CS line data and used to probe the thermal and dynamical states of their large molecular gas reservoirs. The two CO ladders strongly diverge from J = 4-3 onward, with NGC6240 having a much higher CO line excitation than Arp193, despite their similar low-J CO SLEDs, infrared luminosities per gas mass, and HCN/CO ratios (proxies of star formation efficiency and dense gas mass fraction). In Arp193, one of the three most extreme starbursts in the local universe, the results indicate a small amount (∼5%-15%) of dense gas, unlike NGC6240 where most of the molecular gas (60%-70%) is dense. Strong star-formation feedback can drive this disparity in their dense gas mass fractions. In NGC6240, and to a lesser degree in Arp193, large molecular gas masses are found of which the thermal states cannot be maintained by UV photons from massive stars.

Van der Werf continued the exploitation of the Herschel Comprehensive (U)LIRG Emission Survey (HerCULES) in collaboration with Greve (University College London), presenting comprensive FIR-CO luminosity relations for the full CO rotational ladder from J = 1-0 up to J = 13-12 for a sample of 62 local ($z \leq 0.1$)

(Ultra) Luminous Infrared Galaxies. They extended the sample to high redshifts ($z > 1$) by including 35 submillimeter selected dusty star forming galaxies from the literature with robust CO observations, and sufficiently well-sampled FIR/-submillimeter spectral energy distributions, so that accurate FIR luminosities can be determined. The addition of luminous starbursts at high redshifts enlarge the range of the FIR-CO luminosity relations toward the high-IR-luminosity end, while also significantly increasing the small amount of mid-J/high-J CO line data (J = 5-4 and higher) that was available prior to Herschel. This new data set (both in terms of IR luminosity and J-ladder) reveals linear FIR-CO luminosity relations for J = 1-0 up to J = 5-4, with a nearly constant normalization. In the simplest physical scenario, this is expected from the (also) linear FIR-(molecular line) relations recently found for the dense gas tracer lines (HCN and CS), as long as the dense gas mass fraction does not vary strongly within our (merger/starburst)-dominated sample. However, from J = 6-5 and up to the J = 13-12 transition, an increasingly sublinear slope was found with increasing J. This is caused by a warm and dense gas component whose thermal state is unlikely to be maintained by star-formation-powered far-UV radiation fields (and thus is no longer directly tied to the star formation rate). Mechanical heating (e.g., supernova-driven turbulence and shocks), and not cosmic rays, is the more likely source of energy for this component. The global CO spectral line energy distributions, which remain highly excited from J = 6-5 up to J = 13-12, are found to be a generic feature of the (U)LIRGs in the sample, and further support the presence of this gas component.

Galactic outflows

Together with Garcia-Burillo (Madrid), Van der Werf investigated the fueling and the feedback of star formation and nuclear activity in the nearby Seyfert galaxy NGC1068, by analyzing the distribution and kinematics of the molecular gas in the disk, used the Atacama Large Millimeter Array (ALMA) to map the emission of a set of dense molecular gas tracers (CO(3-2), CO(6-5), HCN(4-3), HCO+(4-3), and CS(7-6)) and their underlying continuum emission in the central region with spatial resolutions ∼0.3” - 0.5” (∼20-35 pc). The sensitivity and spatial resolution of ALMA give an unprecedented detailed view of the distribution and kinematics of the dense molecular gas. Molecular line and dust continuum emissions are detected from a $r \sim 200$ pc off-centered circumnuclear disk (CND), from the 2.6 kpc-diameter bar region, and from the $r \sim 1.3$ kpc starburst (SB) ring. Most of the emission in HCO+, HCN, and CS stems from the CND. Molecular line ratios show dramatic order-of-magnitude changes inside the CND that are correlated with the UV/X-ray illumination by the active galactic nucleus (AGN), betraying ongoing feedback. A Fourier decomposition of the gas velocity field indicates that rotation is perturbed by an inward radial flow in the SB ring and the bar region. However, the gas kinematics from r $\sim$ 50 pc out to r $\sim$ 400 pc reveal a massive outflow in all molecular tracers. The tight correlation between the ionized gas outflow, the radio jet, and the occurrence of outward motions in the disk suggests that the outflow is AGN driven. The molecular outflow is likely launched where the ionization cone of the narrow line region sweeps the nuclear disk. The outflow rate estimated in the CND is an order of magnitude higher than the star formation rate at these radii. The power of the AGN is able to account for the estimated momentum and kinetic luminosity of the outflow. The mass load rate of the CND outflow implies a very short gas depletion timescale of $\leq$1 Myr. The CND gas reservoir is likely replenished on longer timescales by efficient gas inflow from the outer disk.

2.6 Distant galaxies and clusters

High redshift submillimetre galaxies

Van der Werf continued his collaboration with Smail and Swinbank (Durham), Weiss (MPIfR) and Walter (MPIA) on the first ALMA observations of a completely identified sample of submillimetre galaxies (SMGs): ALESS (ALMA follow-up of the LABOCA Extended Chandra Deep Field-South Survey). The ALMA data identify the counterparts of the SMGs detected earlier with the LABOCA instrument on the APEX submillimetre telescope. Given that many SMGs turn out to be double, triple or even quadruple sources, and that many previous optical identifications were shown to be incorrect, these results lead to a substantial revision of the population properties of SMGs. Four papers based on these results discuss the submillimetre properties of colour-selected galaxies, the far-infrared properties of SMGs, the redshift distribution and evolution of SMGs, and the far-infrared-radio correlation at high redshift.

Van der Werf is one of the four Principal Investigators (together with Smail, Dunlop, and Halpern) of the SCUBA-2 Cosmology Legacy Survey, the largest project ever carried out on the James Clerk Maxwell 15m submillimetre telescope. This survey produced its first results in 2013, and obtained the bulk of its final data volume this year. This resulted in papers on a cluster of star forming galaxies at redshift 1.6, and on the Lyman-alpha halo of an obscured SMG.

Van der Werf also worked on spectroscopic follow-up in the (sub)millimetre regime of various lensed high-redshift galaxies, in collaboration with Richard and Ivison (Edinburgh), and the Herschel-ATLAS team. These projects resulted in detections of [CII], and various CO lines in individual lensed high redshift galaxies, as well as a more general study of the star formation histories, extinction and dust properties of strongly lensed high redhsift galaxies. A highlight is the detection of a molecular outflow in a strongly lensed galaxy at redshift 2.3, using the redshifted OH 119 micron doublet, observed in the deepest spectrum ever taken with the Herschel SPIRE Fourier Transform Spectrograph.

Cosmological evolution of galaxy clusters

Hoekstra, Herbonnet, Muzzin, Babul (UVic), Mahdavi (SFSU), Cacciato and Viola completed the reanalysis of a sample of 50 massive clusters to calibrate the scaling relations of galaxy clusters, with a specific focus on improving cosmological constraints for Planck. This work involved extensive image simulations to quantify biases in shape measurements and a careful accounting of a range of other complications. Köhlinger, Hoekstra and Eriksen examined how well future surveys can determine cluster masses, and which sources of biases might limit such measurements. van Uitert (Bonn), Cacciato and Hoekstra completed a study of luminous red galaxies to study the evolution in the relation between stellar mass and halo mass using the overlap of SDSS with RCS2 imaging data.
Hoekstra, Cacciato and Sifon contributed to the Euclid work on intrinsic alignments of galaxies. Sifon led a study of such alignments in galaxy clusters. No alignments were detected, thus providing a key constraint in high mass halos. They also were involved in a series of review papers on the topic. Cacciato and Velliscig studied the expected alignment signals using cosmological hydrodynamic simulations, which provide the theoretical framework to compare to observations. Hoekstra and Kuijken were involved in a number of papers based on the weak lensing analysis of the CFHTLenS. These papers measured the three-point statistics, measured masses of galaxy clusters and studied the evolution of galaxies. Much effort was spent by Viola, Cacciato, Sifon, Brouwer, Kuijken and Hoekstra to obtain first results from the KiloDegree Survey. Sifon led a paper on the study of stripping of galaxies in groups, finding a clear dependence on the (sub)halo mass as a function of group-centric radius. Viola led a study on the properties of galaxy groups, which allowed him to constrain feedback models.

Distribution of dark matter in the universe

Kuijkens research groups focus continues to be the distribution of dark matter in the universe. The Kilo-Degree Survey on the ESO VLT Survey Telescope is ongoing and much of the year was spent producing and validating the first gravitational lensing measurements. Much of this effort was done by Brouwer, de Jong, Helmich, Irissari, and Viola. Initial results concentrate on the mass distribution around galaxy groups, the crucial mass scale where large-scale structure and galaxy formation theory meet. In April, after a succesful review at ESO, continuation of the survey was granted.
Pila-Díez completed her analysis of star counts from deep CFHT images that 'skew' the halo. She obtained new measurements of the radial density variation and ellipticity of the halo, confirming a significant steepening of the density of the halo beyond $\sim$30 kpc. She also recovered many of the known substructures of the halo, as well as tentative evidence for a third wrap of the Sagittarius stream − this would greatly extend the length of the stream that has been identified, and make it an even stronger probe of the Galactic gravitational potential than it already is.
Together with Rakich (ESO), Kuijken has been analysing the optical performance of the VST, and developed a novel algorithm for measuring the alignment of the secondary mirror during observations. Implementation of this new procedure is expected to improve the reliability of the VST operations significantly.
In preparation for the first cosmic shear analyses of KiDS, Kohlinger developed a power spectrum estimation algorithm, and applied this to the CFHTLenS survey. The aim is to study the impact of baryonic feedback processes on the matter power spectrum, as well as search for the signature of neutrinos.
Looking forward to the Euclid space mission, Viola analysed the noise bias in shape measurement algorithms, in particular the effect of the galaxy ellipticity distrbutions, and the dependence on galaxy size and signal to noise ratio.

Evolution of the steep spectrum radio luminosity function

Rigby, Röttgering and collaborators investigated the evolution of the steep spectrum radio luminosity function (RLF) over the radio power range $10^{24} < P_{1.4GHz} < 10^{28}$ W/Hz, and quantified its high redshift cut-off. This was done using a grid-based modelling method, without making assumptions about the high redshift RLF behaviour, and included various radio source samples, source count measurements and determinations of the local RLF as constraints. The coverage of the radio power vs. redshift plane at the lowest radio powers was ensured thanks to the

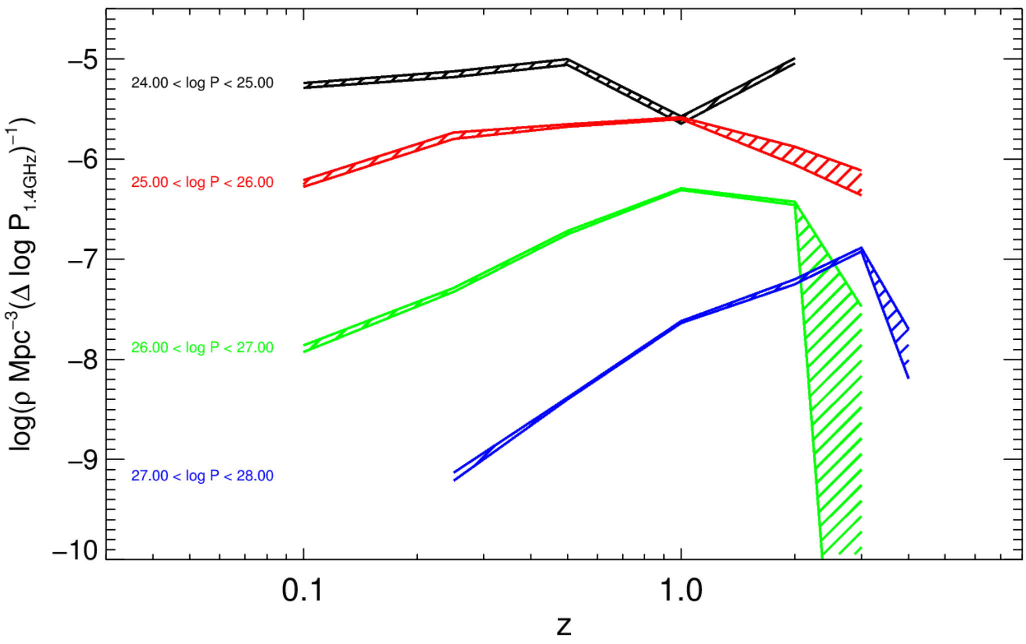


FIGURE 2.13: The best-fit model steep-spectrum RLFs as a function of redshift, plotted together to illustrate the changing position of the space density peak with radio luminosity.

inclusion of the Subaru/XMM-Newton Deep Field sample: a 0.8 sq. deg. survey, with a 1.4 GHz flux density limit of 100 μJy and 99% redshift completeness. The modelling results reveal that high redshift declines in space density are still present at P $< 10^{25}$ W/Hz (Fig. 2.6). The redshift of the space density peak for the most powerful sources ($> 10^{26}$ W/Hz) increases with luminosity, whereas at lower radio luminosities it remains constant, within the uncertainties. This 'cosmic downsizing' behaviour is similar to that seen for optically-selected quasars, and is interpreted as representing the transition from radiatively efficient to inefficient accretion modes in the steep-spectrum population; a conclusion supported by simple models for the space density evolution of the two radio galaxy classes which are able to successfully reproduce the observed variations in peak redshift.

Proto-clusters: the progenitors of nearby massive galaxy clusters

Proto-clusters are large conglomerates of galaxies at z >2 that are believed to be the progenitors of nearby massive galaxies. Rigby, Röttgering, Zhang, McGee, Miley and collaborators built on their search for far-infrared protocluster-associated galaxy over densities around high redshift radio galaxies (HzRGs) to develop

a technique to blindly locate similar structures in blank field Herschel surveys. Studying these $z > 2$ ancestors of local galaxy clusters is key for tracing the emergence of large-scale structure and to understand the evolution of galaxies in dense environments. Targeting HzRGs has proved to be an efficient tool for selecting these over dense regions which will eventually grow into today's massive clusters. However, the numbers studied remain small and potentially biased.
The pilot programme has identified >15 blindly-selected proto-cluster candidates within 135 sq. deg. of the Herschel-ATLAS survey with source excesses equal to or greater than the largest over densities ever seen at $z > 2$. These candidates are being observed with a range of facilities (WSRT, GMRT, VLA and WHT) to confirm their nature. A major element of this investigation is combining the radio and far-infrared data to obtain improved photometric redshift estimates. We have demonstrated the effectiveness of this method using sources with known redshifts in the COSMOS field.

Carbon radio recombination lines

Morabito, Oonk, Salgado, Tielens, Röttgering and collaborators used the Low Frequency Array (LOFAR) to discover extragalactic low frequency carbon radio recombination lines (CRRLs) in M82. This is the first extragalactic detection of RRLs from a species other than hydrogen, and below 1 GHz. These low frequency CRRLs (< 500 MHz) trace the cold, diffuse phase of the interstellar medium, which is otherwise difficult to observe. The CRRLs were detected in absorption in the frequency range of 48-64 MHz, corresponding to quantum levels of n=468-508. The 8.5-sigma detection was achieved by stacking the 22 individual CRRL transitions in this frequency range to provide an average line profile. The total line profile appears to be correlated with the 21 cm neutral hydrogen line profile reconstructed from neutral hydrogen absorption in the direction of supernova remnants in the nucleus. The narrow width and centroid velocity of the feature suggests that it is associated with the nuclear starburst region. It is therefore likely that the carbon RRLs are associated with cold atomic gas in the direction of the nucleus of M82. Detections of radio recombination lines with LOFAR has prompted an examination of theoretical models of the interstellar medium, since comparison of observed line properties with theoretical models can be used to constrain electron temperature and density of the gas. Morabito and collaborators investigated the calculation of spontaneous transition rates between levels, an important component of the models. Calculating these rates relies on accurate bound-bound oscillator strengths, which can be cast in terms of the Gaunt factor. The Gaunt factor contains terminating hypergeometric functions that cannot be calculated with sufficient accuracy for high quantum levels (n>50) by standard machine-precision methods. Methods to overcome the accuracy problem have been developed, which include asymptotic expansions and recursion relations. By employing modern arbitrary-precision computational methods to tabulate the Gaunt factor for transitions up to quantum level n=2000, Morabito and collaborators provided sufficiently accurate values for the Gaunt factor for a large enough range of quantum numbers to enable accurate modelling of low frequency Carbon radio recombination lines.

Merging Clusters of galaxies

CIZA J2242.8+5301 is a binary merging cluster that hosts a large, thin, arc-like radio relic, nicknamed the 'Sausage'. These radio relics trace relatively strong shock fronts within which electrons are accelerated to such a high speed that they start emitting synchrotron radiation. Stroe, Harwood (Hatfield), Hardcastle (Hatfield) and Röttgering performed spatially resolved spectral fitting to the available radio data for this radio relic, using a variety of spectral ageing models. This resulted in a consistent set of parameters for the shock and radio plasma. Standard particle acceleration at the shock front implies a Mach number M=2.90, which matches X-ray measurements. The shock advance speed is Vshock ≈2500 km s^{-1}, which places the core passage of the two subclusters 0.6-0.8 Gyr ago. Under the assumption of freely ageing electrons after acceleration by the 'Sausage' shock, the spectral ages are hard to reconcile with the shock speed derived from X-ray and radio observations. Re-acceleration or unusually efficient transport of particles in the downstream area and line-of-sight mixing could help explain the systematically low spectral ages.

Stroe et al. also observed this cluster with the Arcminute Microkelvin Imager at 16 GHz and presented the first high radio-frequency detection of diffuse, non-thermal cluster emission. The northern radio relic is unequivocally detected. While the low-frequency (<2 GHz) spectrum of the northern relic is well represented by a power law, it clearly steepens towards 16 GHz. This result is inconsistent with diffusive shock acceleration predictions of ageing plasma behind a uniform shock front. The steepening could be caused by an inhomogeneous medium with temperature/density gradients or by lower acceleration efficiencies of high energy electrons.

For the CIZA J2242.8+5301 ('sausage') and 1RXS J0603.3+4213 ('toothbrush') clusters (z∼0.2) Stroe et al. investigated the role of mergers and shocks in shaping the H galaxy luminosity function, using custom-made narrow-band filters matching the cluster redshifts mounted on the Isaac Newton Telescope. By comparing the 'sausage' cluster with blank fields and other clusters, they uncover an order of magnitude boost in the luminosity function in the relic areas. This suggests that cluster mergers may play an important role in the evolution of cluster galaxies through shock-induced star formation.

LOFAR observations of the Boötes and 3C 295 field

Van weeren (CfA), Williams, Tasse (Paris), Röttgering and the LOFAR team presented Low Frequency Array (LOFAR) Low Band observations of the Boötes and 3C 295 fields. The images made at 34, 46, and 62 MHz are the deepest images ever obtained in this frequency range. In total, between 300 and 400 sources are detected in each of these images, covering an area of 17-52 deg^2. There is clear evidence for spectral flattening using the individual flux measurements of sources between 34 and 1400 MHz and by calculating the spectral index averaged over the source population. To select ultra-steep spectrum ($\alpha < -1.1$) radio sources that could be associated with massive high-redshift radio galaxies, spectral indices were computed between 62 MHz, 153 MHz, and 1.4 GHz.

The relationship between specific star formation rate and metallicity gradient from KMOS.

Results at high redshift ($z = 1 - 2$) have shown puzzling evidence for inverted metallicity gradients. However, by using the new KMOS instrument and the first statistical sample of z ∼1 galaxies, where it was possible to measure metallicity gradients and other properties, Sobral and collaborators found that the gradient strongly depends on star-forming activity. The more active a star-forming galaxy, the higher the metallicity gradient. In extreme cases, galaxies indeed show a positive gradient. Such gradients and such high activity is easily explained by merging activity, but the results also have important consequences to interpret the fundamental mass-metallicity relation.

Distant galaxy luminosity functions

Significant progress was made by Bouwens in observational determination of the luminosity function of galaxies at rest-frame ultraviolet wavelengths (Fig. 2.14).

The luminosity function of galaxies contain information of the prevalence of galaxies across cosmic time and can be used as a way of looking at the build-up rate of galaxies. Bouwens finished a study providing new constraints on the evolution of the luminosity function using the most comprehensive data set available to the present, leveraging some 900 arcmin^2 of observations from the Hubble Space Telescope over the five CANDELS fields. Significant evidence was presented for a systemic flattening of the luminosity function towards later points in cosmic time, as well as providing evidence for there being a substantial number density of luminous galaxies as early as 700 million years after the Big Bang. Both findings were consistent with the expected evolution based on the growth of the collapsed dark matter structure (halos) from theoretical simulations.
As part of work for her thesis project with Bouwens, Smit also demonstrated the utility of long exposures with the IRAC camera on the Spitzer Space telescope for making important inferences regarding the distances of galaxies emitting their light close to the beginning of the universe. She obtained such precise distance information by leveraging the fact that galaxies at particular distances tend to show unusually blue colors observed through the 3.6 micron and 4.5 micron filter on the IRAC camera. This is due to the impact of strong emission lines excited by many hot young stars contribute to the light seen in one IRAC band, but which do not significantly contribute to light seen in the other IRAC band. Such colors occur for galaxies that lie in a specific redshift information, specifically with redshifts of 6.7-6.9. Renske Smit identified 20 such galaxies with such IRAC colors over the 900 arcmin^2 area covered by the CANDELS program. Each of these galaxies likely exists at approximately the same distance from us. Knowing the redshifts of the distant sources can make them easier to study with Atacama Large Millimeter Array to look for cooling lines such as [CII].

Quiescent galaxies in the early universe

Using very deep near-IR medium band imaging taken as part of the FourStar Galaxy evolution Survey (led by Labbé), combined with high resolution observations from HST/WFC3 from CANDELS and 3D-HST, Labbe and collaborators studied the properties and evolution of galaxies with suppressed star formation rates in the early universe.
Straatman and Labbé used ZFOURGE to discover the highest redshift (z $\sim$4) examples of massive quiescent galaxies galaxies. The medium-band imaging was very important as it increased the sampling of the spectral energy distribution

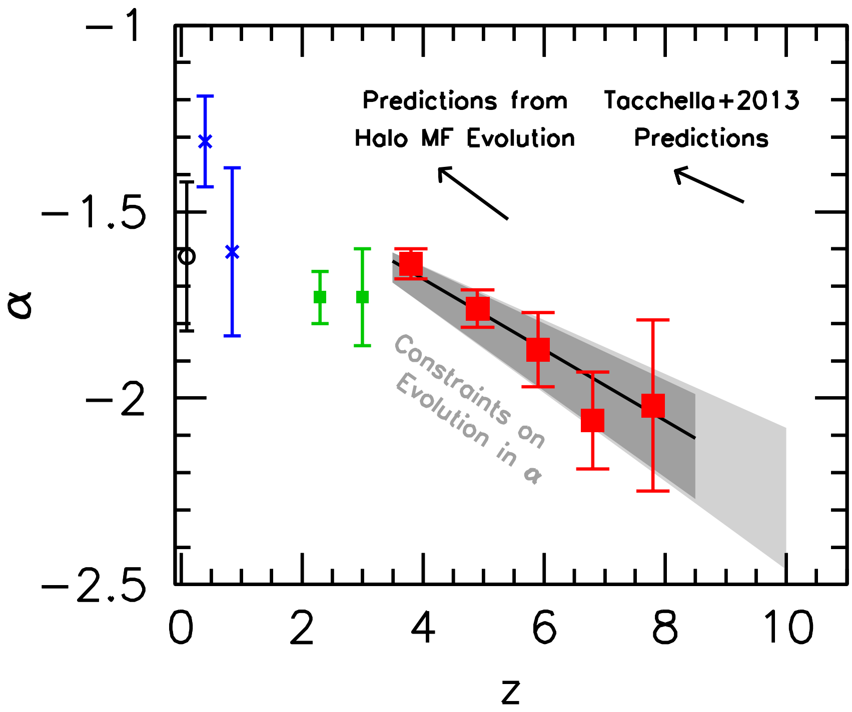


FIGURE 2.14: Measurement of the slope α of the luminosity function of galaxies at rest-frame ultraviolet for galaxies versus redshift. The slope of the luminosity tells us how the prevalence of galaxies changes with the luminosity of galaxies. As expected from simulations, steeper slopes (i.e., more negative numbers for α) are observed at earlier times in the history of the universe, consistent with a greater prevalence of very small galaxies in the early universe. The shaded grey contours shown here indicate the 68% confidence intervals on the derived evolution.

near the Balmer/4000 Å break, which improved the estimates of the photometric redshift and stellar population age. Surprisingly, the galaxies made up a large fraction (∼40%) of all massive galaxies at these redshifts, suggesting that quenching in the early universe was very efficient, even at such high redshift. Stellar population modeling indicated the galaxies were already old (∼0.8 Gyr) and that they likely formed most of their stars before redshift z∼5. The absence of large numbers of UV-bright galaxies at these redshifts suggest that the star formation in the progenitors of these galaxies was obscured by dust.

Labbé and collaborators also derived the deepest measurements to date of the galaxy stellar mass function (SMF) at $0.2 < z < 3$. Using the deep data of CANDELS and ZFOURGE it was possible to split the build-up into star forming and quiescent galaxies. This allowed them, for the first time, to directly observe the rapid buildup at the low-mass end of the quiescent SMF. Since $z = 2.5$, the

total stellar mass density of quiescent galaxies has increased by a factor of $\sim$12, whereas the mass density of star-forming galaxies only increases by a factor of 2.2. Kawinwanichakij, Papovich, Labbé and others also investigated the distribution of satellite galaxies around central massive galaxies at redshift $1 < z < 3$ in ZFOURGE/CANDELS. The goal is to use the satellites as tracers of the underlying dark matter mass distribution and to try to understand the relationship between the host dark matter haloes and the central galaxies. The main result is that massive central galaxies with low star forming activity ("quiescent") have a two times higher number of satellites compared to actively star forming galaxies. The excess number indicates that quiescent centrals have on average two times larger halo masses. A simple model in which the probability of quenching is correlated with halo mass can explain this trend, but it also means that there may still be star forming galaxies found at very large halo masses: i.e. it is unlikely that there exists a strict quenching threshold mass beyond which no star formation is possible.
Fumagalli, Labbé, Franx, and collaborators investigated the star formation rates of quiescent galaxies at $0.3 < z < 2.5$ using 3D-HST WFC3 grism spectroscopy and Spitzer far-infrared data. Usually, fitting stellar population models to the UV-to-near-infrared SED indicate very low star formation rates, but a caveat is that star formation obscured by dust may have been missed. Observations in the infrared are needed to determine this. Using Spitzer infrared data taken with MIPS at 24 micron Fumagalli measured the dust-obscured star formation rates. While higher than those indicated by SED fitting, they were still very low: 20-40 times lower than those of actively star forming galaxies. The true SFRs may be even lower as the infrared can also originate from processes other than star formation (such as circumstellar dust). The results show that quenching is very efficient at high redshift.

2.7 Theoretical studies of galaxies and large scale structure

The relation between galaxies and gas clouds seen in absorption

Rahmati & Schaye combined cosmological, hydrodynamical simulations with accurate radiative transfer corrections to investigate the relation between strong neutral hydrogen absorbers and galaxies at redshift 3 (Fig. 2.15). While they found

good agreement with observations, the simulations showed that interpretation of the observed correlations between absorbers and galaxies may be in error because the galaxies nearest to the absorbers are typically far too faint to be detectable with current instrumentation. The simulations predict that the detected nearby galaxies are typically not the galaxies that are most closely associated with the absorbers; thus, causing the impact parameters, star formation rates and stellar masses of the observed galaxy counterparts to be biased high.
Turner, Schaye, together with collaborators from the California Institute of Technology, studied metal absorption around 854 redshift $z = 2.4$ star-forming galaxies taken from the Keck Baryonic Structure Survey. The galaxies lie in the fields of 15 hyperluminous background quasi-stellar objects, with galaxy impact parameters ranging from 35 proper kpc (pkpc) to 2 proper Mpc (pMpc). They presented the first galaxy-centred 2D maps of the median absorption by O VI, N V, C IV, C III, and Si IV, as well as updated results for H I. At small galactocentric radii they detected a strong enhancement of the absorption relative to randomly located regions that extends out to at least 180 pkpc in the transverse direction, and 240 km/s along the line of sight (LOS, about 1 pMpc in the case of pure Hubble flow). Transverse to the LOS there is no evidence for a sharp drop-off in metals distinct from that of neutral hydrogen. However, along the LOS the enhancement in the absorption is more extended for O VI, C IV, and Si IV than for H I. Limiting the sample to the 340 galaxies with redshifts measured from nebular emission lines did not decrease the extent of the enhancement along the LOS compared to that in the transverse direction. This ruled out redshift errors as the source of the observed redshift-space anisotropy and thus implies that the signature of gas peculiar velocities has been detected (Fig. 2.16).

The impact of baryonic processes on observational cosmology

The observed clustering of galaxies and the cross-correlation of galaxies and mass provide important constraints on both cosmology and models of galaxy formation. Even though the dissipation and feedback processes associated with galaxy formation are thought to affect the distribution of matter, essentially all models used to predict clustering data are based on collisionless simulations. Van Daalen, Schaye, and collaborators used large hydrodynamical simulations to investigate how galaxy formation affects the autocorrelation functions of galaxies and subhaloes, as well as their cross-correlation with matter. They showed that the changes due to the inclusion of baryons are not limited to small scales and are

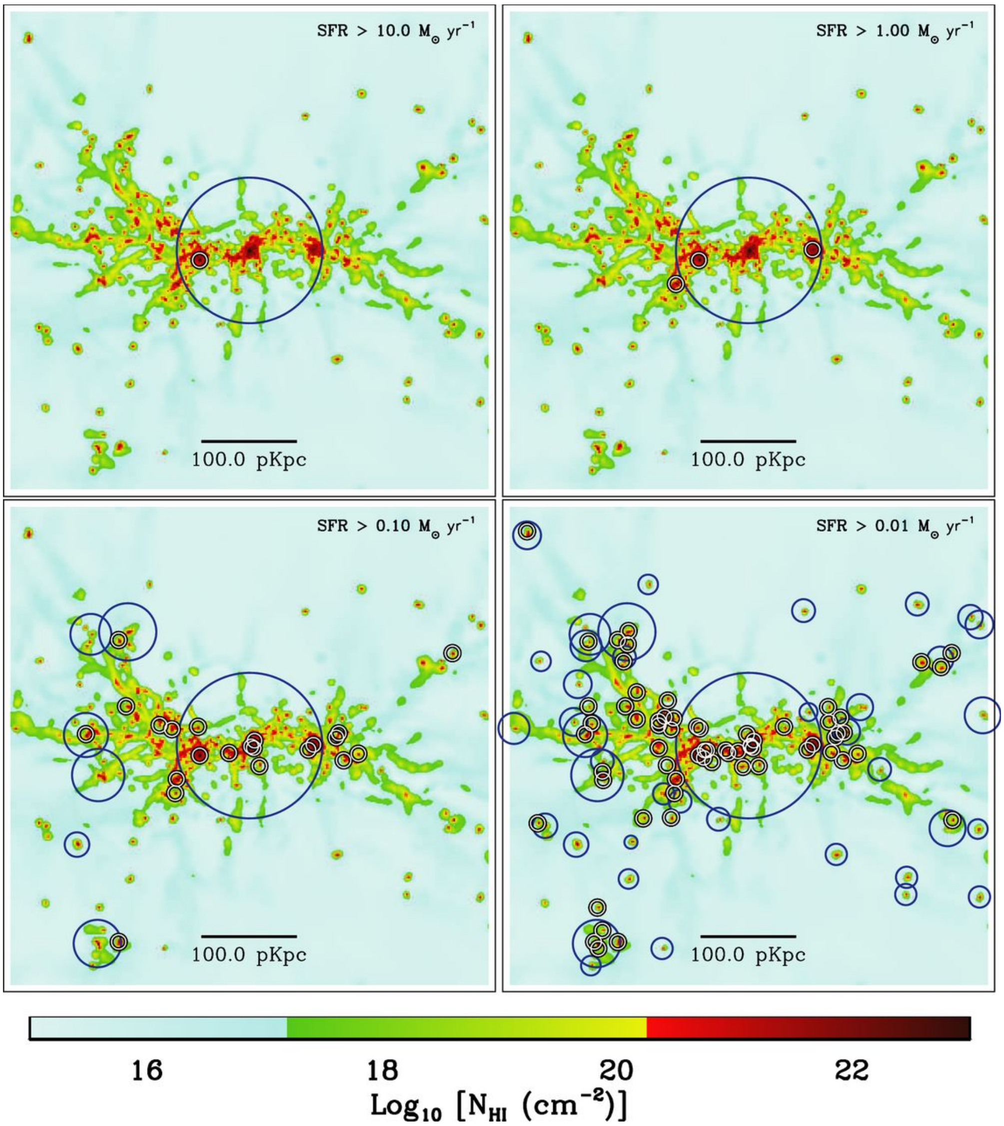


FIGURE 2.15: The simulated H I column density distribution around a massive galaxy (stellar mass 10^{10}solar masses) at redshift 3 (taken from Rahmati & Schaye 2014). Circles indicate the positions of galaxies. The size of each dark circle indicates the virial radius of a central galaxy while the small white circles all have the same size and indicate the locations of satellite galaxies. Panels from top left to bottom right show galaxies with star formation rate >10, >1, >0.1 and >0.01 solar masses per year, respectively. As the star formation threshold threshold decreases, more galaxies are detected and the typical impact parameter between galaxies and absorbers decreases.

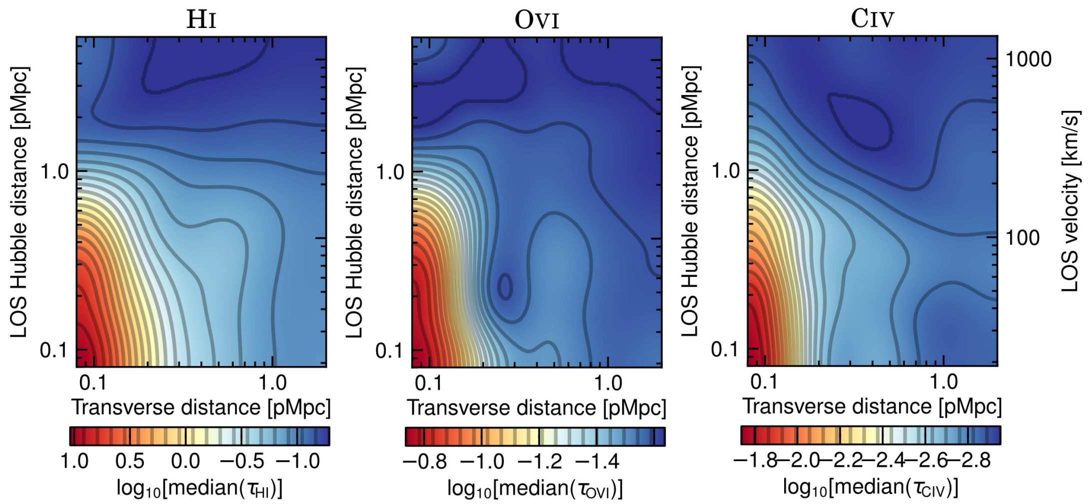


FIGURE 2.16: Median H I, O VI, and C IV optical depth (i.e. absorption strength) around redshift z=2.4 star-forming galaxies (taken from Turner et al. 2014). Absorption is clearly strongly enhanced near the galaxies, both for hydrogen and for heavy elements. The anisotropy is not due to galaxy redshift errors, but reflects peculiar velocities of the gas relative to those of the galaxies.

even present in samples selected by subhalo mass. While the inclusion of baryons boosts the clustering at fixed subhalo mass on all scales, the sign of the effect on the cross-correlation of subhaloes with matter can vary with radius. They showed that the large-scale effects are due to the change in subhalo mass caused by the strong feedback associated with galaxy formation. However, on scales smaller than one Mpc significant differences remain after accounting for the change in subhalo mass. They concluded that predictions for galaxy-galaxy and galaxy-mass clustering from models based on collisionless simulations will have errors greater than 10 per cent on sub-Mpc scales.

Velliscig, van Daalen, Schaye, Cacciato and collaborators used cosmological hydrodynamical simulations to investigate how the inclusion of physical processes relevant to galaxy formation changes the properties of haloes. They found that gas expulsion and the associated dark matter (DM) expansion induced by supernova-driven winds are important for group-sized haloes, lowering their masses by up to 20 per cent relative to a DM-only model. AGN feedback, which is required to prevent overcooling, has a significant impact on halo masses all the way up to cluster scales. Baryon physics changes the total mass profiles of haloes out to several times the virial radius. The decrease in the total halo mass causes a decrease in the halo mass function of about 20 per cent. This effect can have important consequences for the abundance matching technique as well as for most semi-analytic models of galaxy formation. The effect of baryon physics (AGN feedback in particular) on cluster number counts is about as large as changing the cosmology from Wilkinson Microwave Anisotropy Probe 7 to Planck, even when a moderately high-mass limit of 10^{14} solar masses is adopted. Thus, for precision cosmology the effects of baryons must be accounted for.

Non-equilibrium chemistry and cooling in the diffuse interstellar medium

An accurate treatment of the multiphase interstellar medium (ISM) in hydrodynamic galaxy simulations requires that we follow not only the thermal evolution of the gas, but also the evolution of its chemical state, including its molecular chemistry, without assuming chemical (including ionization) equilibrium. Richings, Schaye, and Oppenheimer (Colorado) presented a reaction network that can be used to solve for this thermo-chemical evolution. The model follows the evolution of all ionization states of the elements that dominate the cooling rate, along with important molecules, and accounts for dust grains, cosmic rays, UV radiation, and self-shielding. They found that, at temperatures below ten thousand degrees Kelvin, recombination lags increase the electron abundance above its equilibrium value at a given temperature, which can enhance the cooling rate by up to two orders of magnitude. The cooling gas also shows lower molecular hydrogen abundances than in equilibrium, by up to an order of magnitude. They also used their model to test prescriptions from the literature that are used to implement the atomic to molecular phase transition in simulations.

Feedback processes regulating galaxy growth

Rosdahl is interested in the physical feedback processes that regulate the growth of galaxies, which he studies with the use of 3-dimensional simulations. He is particularly interested in the effects of stellar radiation feedback, which has been suggested in many recent theoretical works as an important mechanism in galaxy self-regulation. Rosdahl has in the past developed an implementation of ionising radiation-hydrodynamics in the widely used cosmological simulations code RAMSES. Over the last two years, he has added physics to this implementation relevant for radiation feedback on galactic scales, namely momentum transfer from the radiation onto the gas, and dust-radiation interactions.
Rosdahl has then used these numerical methods to study stellar radiation feedback in disk galaxies of various masses, each run over several rotation periods. The results are that radiation feedback has an important effect of gently smoothing out the inter-stellar medium in low-mass galaxies, while the effect of radiation

feedback becomes negligible in massive galaxies. The main effect of the radiation is from photoionisation heating, which typically heats the gas to about 10,000 Kelvin, while radiation pressure is unimportant (Fig. 2.17).

2.8 Astrobiology

The Astrobiology Group, led by Pascale Ehrenfreund, was relocated to the Observatory from the Leiden Institute of Chemistry in April.

A major activity of Ehrenfreund and Elsaesser is their involvement in space projects such as EXPOSE and OREOcube, the latter being a joint ESA/NASA cubesat mission currently in preparation for launch to the International Space Station (ISS), where it will monitor the photodegradation of biomarkers. In July, samples containing amino acids and pigments embedded in mineral matrices were launched to the ISS as part of the EXPOSE-R2 mission, where they will be exposed to solar and cosmic radiation.

Another focus of the Astrobiology Group is the stability and detection of biomolecules in environments on Earth which resemble conditions on other planets in our solar system, e.g. Mars. Monaghan took up the post of PDRA for the MASE (Mars Analogues for Space Exploration) project. MASE is a collaborative research project supported for four years (2014−2017) by the Seventh Framework Programme of the EC, the aim of which is to study and characterise several analogue sites across Europe for their utility as Mars analogues. These sites were chosen due to their similarity to environments that may have existed on early Mars, or are still persisting on Mars today, e.g. very high salt concentrations in Englands Boulby Mine; cold, acidic waters and permafrost in Iceland; and sulphide ground waters in Germany.

Elsewhere in the MASE consortium, organisms from these environments are being isolated and subjected to stress tests, including artificial fossilisation. Several life detection instruments, designed for future planetary exploration missions, are being assessed and improved based on field work tests and lab analyses. At Leiden the focus is on the site context: characterising and contrasting the various environments as clearly as possible by analysing samples for a range of compounds and elements, including amino acids and nucleobases. This is being done through extraction and chromatographic purifications at our laboratories at Leiden and ESA-ESTEC. Quantification of these extracted compounds is taking place using GC and LC mass spectroscopy.

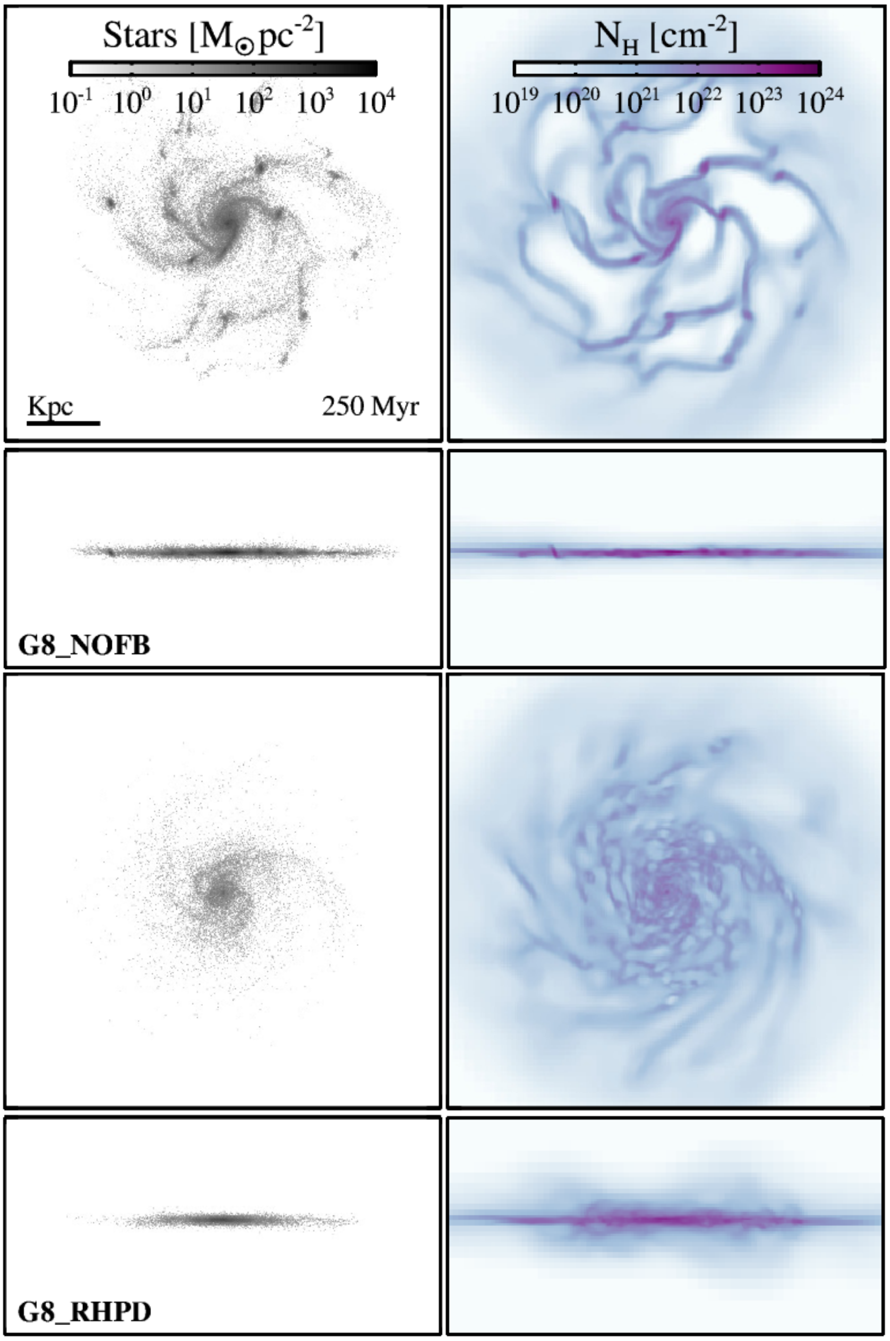


FIGURE 2.17: Maps of stars (left) and hydrogen column density (right), face-on (top) and edge-on (bottom), in a galactic disk about a hundred times less massive than the present-day Milky-Way. In the top part, the galaxy is run without any feedback from stars, while in the lower part radiation feedback from stars is included. The effect of the radiation feedback is to smooth out the gas distribution and substantially decrease the formation of stars.

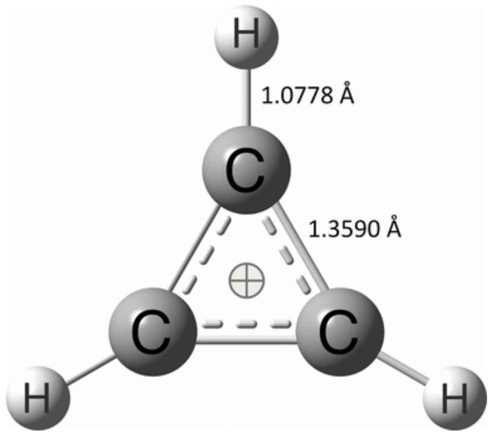


FIGURE 2.18: A model of the smallest aromatic molecule, the cyclo-propenyl cation c-$C_3H_3^+$, a molecule that is considered to be a key species in the formation of hydrocarbons in the interstellar medium.

2.9 Laboratory astrophysics, Astrochemistry

The Raymond and Beverly Sackler Laboratory for Astrophysics

With eight separate experiments, the Sackler Laboratory for Astrophysics is one of the largest laboratory facilities, worldwide, fully dedicated to astronomical research. It is a place where physical methods are used to answer chemical questions of astronomical relevance. The experimental studies comprise ultra-high resolution spectroscopy of molecular radicals of astronomical interest, the photo-processing and atom bombardment of interstellar ice analogues and photo-dissociation dynamics of PAHs. These measurements allow to interpret, to guide and to initiate astronomical surveys and the resulting parameters are needed as input for astrochemical models. A view on the different setups is available from http://www.laboratory-astrophysics.eu.
This year was very successful with several scientific highlights, also reflected by their accompanying press releases. Bossa and coworkers showed in a dedicated spectroscopic and laser interferometric study that interstellar ices may be much more porous than assumed so far. This is an important finding, as interstellar surface chemistry scales with the available surface area and obviously, a higher level of porosity offers a larger catalytic surface. Zhao, Doney and Linnartz managed to record the very first spectra of the smallest aromatic molecule, the cyclo-propenyl

cation c-$C_3H_3^+$ (see Fig. 2.9), a molecule that is considered to be a key species in the formation of hydrocarbons in the interstellar medium and that can be searched for in space now. Zhen et al., using the newest setup in the Sackler Laboratory (iPoP an instrument to study the Photodynamics of PAHs) showed that it is possible to transform large polycyclic aromatic hydrocarbons into fullerenes, graphene flakes and carbon cages by irradiating them in an ion trap and stripping off separate H-atoms and C_2-units. This finding is important, as it offers a pathway to explain the observation of fullerenes in space. Moreover, it shows that interstellar chemistry may not only follow bottom-up (from small to large) reaction schemes, but also their reverse; top-down.

It was also a year in which experiments jumped out of the laboratory. Several setups have been (re)constructed fully mobile in order to perform experiments at large scale research facilities, such as synchrotrons and free electron lasers. Ligterink and Cruz-Diaz constructed CRYOPAD2, an updated version of a very successful instrument to study the photoprocessing of interstellar ices (Common project van Dishoeck en Linnartz). I-PoP (common project Tielens and Linnartz) was successfully used at the VUV DESIRS beamline at SOLEIL. In this way it has become possible to perform experiments using highly intense monochromatic light in regions of the electromagnetic spectrum not accessible with regular laboratory setups.

The Sackler team also looked outside the laboratory. Close collaborations with astronomical observers, as well as three nights on UVES at the VLT by Linnartz and Zhao, resulted in the best detections of C_3, OH^+ and SH in translucent interstellar clouds, so far.

Other projects comprise a combined experimental and theoretical study (in collaboration with Cuppen) by Lamberts et al. that shows that water in space very likely is not formed through a solid state scheme involving H_2+O. Instead the prominent role of O/O_2/O_3+H has been confirmed. In similar hydrogenation experiments it was shown by Fedoseev et al. that hydroxylamine (NH_2OH) can be effectively formed upon NO hydrogenation and that complex species, such as glycolaldehyde and ethylene glycol can be formed in HCO backbone recombination reactions upon H-atom additions to solid CO. The latter finding is important, as it explains the observation of COMs (complex organic matter) in dark interstellar clouds, i.e., regions where UV photoprocessing is not at play yet.

Astrochemistry of dust, ice and gas

Van Dishoeck wrote an overview of the astrochemistry of dust, ice and gas and their interplay, aimed at non-specialists. The importance of basic chemical physics studies of critical reactions is illustrated through a number of recent examples. Much of the chemistry in star- and planet-forming regions is now thought to be driven by gas-grain chemistry rather than pure gas-phase chemistry, and a critical discussion of the state of such models is given. Recent developments in studies of diffuse clouds and PDRs, cold dense clouds, hot cores, protoplanetary disks and exoplanetary atmospheres are summarized, both for simple and more complex molecules.

Isotope selective photodissociation of N_2

Heays, together with van Dishoeck, Ubachs (VU), Gredel (Heidelberg) and Lewis (Canberra), studied the photodissociation rates of $^{14}N^{15}N$ by ultraviolet continuum radiation and in a field of cosmic-ray induced photons. High-resolution theoretical cross sections of N_2 were used from an accurate quantum-mechanical model of the molecule based on laboratory experiments. Shielding functions for $^{14}N^{15}N$ by $^{14}N_2$, H_2, and H are presented. Incorporating these into an interstellar cloud model, an enhancement of the atomic $^{15}N/^{14}N$ ratio over the elemental value is obtained due to the self-shielding at an extinction of about 1.5 mag. This effect is larger in regions where grain growth has reduced the opacity of dust and is particularly significant in a protoplanetary disc model with grain growth where it can lead to a ^{15}N enhancement of a factor of 10 for species like HCN.

2.10 Instrument development

Infrared Interferometry

Jaffe worked on infrared interferometers; interpreting data on Active Galactic Nuclei and Young Stellar Objects from existing instruments, and developing advanced instruments.

With VLT/MIDI observations of the nearby Seyfert 2 galaxy, NGC 1068, Jaffe and Lopez-Gonzaga developed new insights into the dusty accretion regions within a few parsecs of the central black hole. The observations showed that much of the dust that was warmed by nuclear radiation lay along the polar axis of the galaxy. This is contrary to the Unified AGN models that claim that the dust is

concentrated in the equatorial plane. Similar results were found for the Circinus Seyfert 2 galaxy in a collaboration with Tristrm (ESO).
Together with a team lead by Panic (Cambridge), Jaffe also contributed to interpreting MIDI data from the transition-disk young star HD 100546. The data showed that the source is highly asymmetric and variable on year time scales, probably as a result of perturbations of the disk by a proto-planet.
Together with a collaboration led by the Observatoire de Cote de Azur (Nice), Jaffe worked on the development of the MATISSE interferometer, intended for installation at ESO Chile in 2016. The instrument improves MIDI by increasing its wavelength range, accuracy, and speed. Jaffe is Project Scientist; his chief contributions were developing tools to evaluate proposal feasibility, and leading the development of a Fringe Tracker that will greatly increase the sensitivity and accuracy of MATISSE.

2.11 History of Science

Van Delft holds an one day a week appointment as professor in the history of science located at Leiden Observatory. His research this year focussed on the Leiden cryogenic laboratory, W.J. de Haas and Paul Ehrenfest. Van Delft is supervising three PhD-projects: Op weg naar Urenco: Jacob Kistemaker en zijn laboratorium voor massaspectrografie 1945-1960 (together with Van Lunteren), Ruska and the early history of the electron microscope and ASMI and high tech innovation in the Netherlands (together with Van Lente, Maastricht University).

Chapter 3

Education popularization and social events

Education, popularization and social events

Chapter 3

3.1 Education

Teaching and training of students is a major priority of Leiden Observatory. This year, 74 freshmen started their studies in astronomy. Of this number, 22 (30%) were women, and 31 (42%) pursued a combined astronomy/physics or astronomy/mathematics/computer science degree. The Observatory registered a total number of 125 BSc students at the end of the year, of which 54 (43%) aimed at a combined astronomy/physics degree or astronomy/mathematics degree; 30% of all BSc students is female. There were 47 MSc students, including 9 (20%) women and 12 (26%) of foreign nationality. 24 students passed their propedeutical exam, of which 19 completed the requirements in the nominal one year. There were 18 BSc exams, and 15 MSc exams.

The accreditation of all specialisations of the BSc and MSc programmes was renewed this year, following a successful review by a visiting committee. In its written report, the visiting committee stated that it "recognizes the profile of a proud institute which is strongly focused on research.", adding "The Sterrewacht has an excellent international reputation. The committee is very positive about this profile." The specific recommendations by the committee have been discussed amongst Observatory staff and in the Education committee, resulting in actions that will be carried out in 2015.

Pen continued as the education coordinator taking care of the daily running of tasks. Kuijken (1st year students) and Franx (2nd and 3rd year students) continued as study advisers. Schaye continued as 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, Hogerheijde, Schaye and Portegies Zwart) 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 Practical Astronomy course, students were taken to the Artis Planetarium in Amsterdam for an introduction to coordinate systems, time and constellations in the sky (Hogerheijde). As part of the second-year training in practical astronomy, 19 students were offered the opportunity to take part in a specially arranged observing trip to the Isaac-Newton-Telescope on La Palma, Canary Islands (Hoekstra and Otten). In the BSc programme, students in the 2nd and 3rd year have to write a Study Plan, which must be approved by the Study Advisor. 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 Linnartz. 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. In the MSc programme, the Astronomy & Instrumentation stream is now taught fully by Leiden staff. This has resulted in a number of new courses in the MSc programme. Jose Visser was appointed to specifically support the PR for this track.

Quality control of all aspects of the exams is the responsibility of the Board of Examiners (Examencommissie) chaired by Snellen. Admission to the master-curriculum for students without a BSc in astronomy from a Netherlands university requires a recommendation by the Admissions committee (Toelatingscommissie) chaired by Portegies Zwart and having Schaye and Kenworthy as members.

Given the increase in student numbers, and the increased amount of administration per student, a review of the required amount of support for the Observatory teaching programme was carried out in 2014, by Arianne Pen and Paul van der Werf, later joined by Jose Visser. This exercise involved also visits to different departments within the Faculty of Science, in order to look at their organisational structure. In the end this review resulted in a formulation of the structure and role of a newly formed Education Office. This plan, which will lead to significant professionalisation of the support of our education programme, will be implemented in 2015

3.2 Degrees awarded

3.2.1 Ph.D. degrees

A total of 16 graduate students successfully defended their Ph.D. theses and were awarded their Ph.D. degree. They are:

Name:	Nicola Clementel
Graduation Date:	18-12-2014
Supervisors:	Icke/Madura
Thesis title:	Casting light on the Carinae puzzle.

Name:	Gleb Fedoseev
Graduation Date:	10-12-2014
Supervisors:	Linnartz/Ioppolo/Cuppen
Thesis title:	Atom Addition Reactions in Interstellar Ice - new pathways towards molecular complexity in space

Name:	Marcel Van Daalen
Graduation Date:	09-12-2014
Supervisor:	Schaye
Thesis title:	Galaxy formation and the structure of the Universe

Name:	Gerard van Harten
Graduation Date:	08-12-2014
Supervisor:	Keller
Thesis title:	Spectropolarimetry for planetary exploration

Name:	Theo van Hengel
Graduation Date:	22-10-2014
Supervisors:	Van Lunteren en Gaastra
Thesis title:	The Diving Dutchman

Name: Jesse van de Sande
Graduation Date: 01-10-2014
Supervisor: Franx
Thesis title: Dawn of the Red and Dead: Stellar Kinematics of Massive Quiescent Galaxies out to $z = 2$

Name: Agata Karska
Graduation Date: 24-09-2014
Supervisor: Van Dishoeck
Thesis title: Feedback from deeply embedded low- and high-mass protostars: Surveying hot molecular gas with Herschel

Name: Daniel Harsono
Graduation Date: 24-09-2014
Supervisor: Van Dishoeck
Thesis title: Unveiling Protostellar Disk Formation around Low-Mass Stars

Name: Marissa Rosenberg
Graduation Date: 18-09-2014
Supervisor: Israel
Thesis title: Causing a stir: radiative and mechanical feedback in starburst galaxies

Name: Jeroen Bedorf
Graduation Date: 02-09-2014
Supervisor: Portegies Zwart
Thesis title: The Gravitational Billion Body Problem

Name: Tim van Werkhoven
Graduation Date: 26-06-2014
Supervisors: Keller/Snellen
Thesis title: Lasers, lenses and light curves: adaptive optics microscopy and peculiar transiting exoplanets

Name: Koen Maaskant
Graduation Date: 23-06-2014
Supervisor: Tielens
Thesis title: Tracing the evolution of protoplanetary disks

Name: Matteo Brogi
Graduation Date: 05-06-2014
Supervisor: Snellen
Thesis title: Atmosheres of hot alien Worlds

Name: R.F.J. van der Burg
Graduation Date: 14-05-2014
Supervisor: Kuijken
Thesis title: The distribution of stellar mass in galaxy clusters over cosmic time

Name: M. Iacobelli
Graduation Date: 25-02-2014
Supervisors: Röttgering/Haverkorn
Thesis title: Exploring the magnetic, turbulent Milky Way through radio waves

Name: S. Verdolini
Graduation Date: 20-02-2014
Supervisor: Tielens
Thesis title: Modeling interstellar bubbles: near and far

3.2.2 Master degrees

The following 15 students were awarded Masters degrees:

Name	**Date**	**Next Position**
Saskia van den Broek	25-02-14	PhD in Leiden
Arisa Hatagaya	28-02-14	Technical Product Manager at InnerBalloons
James Hunter	28-02-14	Contractor bij European Patent Office
Luc Harms	31-03-14	Python Developer at InnerBalloons
Kirstin Doney	24-06-14	PhD in Leiden
Chaoli Zhang	26-08-14	Internship at Peking University.
Geert Jan Talens	26-08-14	PhD Leiden
Joris Voorn	26-08-14	Junior trader Northpool bv
Jorryt Matthee	26-08-14	PhD in Leiden
Pawel Biernacki	26-08-14	PhD in Zurich
Steven Duivenvoorden	26-08-14	PhD Sussex University
Leandra Swiers	30-09-14	Travelling
Ritse Heinsbroek	30-09-14	Commercial Business Intelligence Specialist at bol.com
Niek Wisse	31-10-14	ICLON Education
Luuk Visser	17-12-14	ASML in Veldhoven

3.2.3 Bachelor degrees

A total of 18 students obtained their Bachelor's degree:

Name	Date	Next Position
Pim Overgaauw	31-01-14	MSc Astronomy, Leiden
Martijn Oei	31-08-14	MSc Astronomy, Leiden
Alex Pietrow	31-08-14	MSc Astronomy & Instrumentation, Leiden
Nikki Zabel	31-08-14	MSc Astronomy, Leiden
Qian Qian Lin	31-08-14	MSc Astronomy & SBB, Leiden
Stijn DeBackere	31-08-14	MSc Theoretical Physics, Leiden
David Doelman	31-08-14	MSc Astronomy, Leiden
Kasper van Dam	31-08-14	MSc Astronomy, Leiden
Bart Verhaar	31-08-14	MSc Astronomy, Leiden
Bavo Croiset	31-08-14	MSc Astronomy, Leiden
Leindert Boogaard	31-08-14	MSc Astronomy, Leiden
Leon Trapman	31-08-14	MSc Astronomy, Leiden
Ferry Kruidenberg	31-08-14	MSc Astronomy, Leiden
Annemieke Verbraek	31-08-14	MSc Computer Science, TU Delft
Danielle van der Werff	31-08-14	MSc Embedded Systems, Tu Delft
Marthijn Sunder	31-08-14	MSc Theoretical Physics in Utrecht
Ali Karisli	31-08-14	Master Science Education, TU Delft
Rene Smeede, van der	31-08-14	Unknown

3.3 Academic courses and pre-university programmes

3.3.1 Courses taught in the academic year 2013/2014

Bachelor course	**Teacher**
Introduction astrophysics	H. Linnartz
Astronomy lab 1	I. Snellen
Planetary systems	M. Hogerheijde
Modern astronomical research	M. Kenworthy
Stars	H. Röttgering
Stars and Cosmology	M. Franx
Astronomy lab 2	H. Hoekstra
Astronomical observational techniques	C. Keller
Radiative processes	A. Patruno & R. Meijerink
Python cursus	E. Deul
Bachelor research project	B. Brandl

Master course	**Teacher**
Galaxies: Structure, Dynamics and Evolution	Bouwens
Radio Astronomy	Garrett
Distance Measurement in Astronomy	De Grijs
Stellar Dynamics	Portegies Zwart
Origin and Evolution of the Universe	Kuijken
Astrochemistry	Van Dishoeck
Detection of Light	Kenworthy
Large Scale Structure and Galaxy Formation	Brinchmann
Star and Planet Formation	Van Dishoeck
Stellar Structure and Evolution	Tielens
Science and the public: contemporary and historical perspectives	Van Lunteren

3.3.2 Pre-university programme

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 a program of choice. In eight sessions the following subjects were covered:

Course title	**Teacher**
Extrasolar planets	I. Snellen
The Milky Way and other galaxies	J. Schaye
Practicum I	A. Brown
Building moleculs and planets in the universe	E. van Dishoeck
Black Holes	P. van der Werf
Practicum II	V. Icke
Cosmology	H. Hoekstra
Excursion to the radio telescopes in Westerbork and Dwingeloo	

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

3.3.3 Contact.VWO

Contact.VWO has been in existence since May 2007. Buisman and Van der Hoorn (physics teachers in secondary schools) both work one day a week for the Physics and Astronomy Departments in order to intensify the contacts between secondary schools and the university. Van der Hoorn organizes twice per year a production and mailing of posters and organizes three times per year an informative meeting for physics teachers 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 deals with visiting school classes as well as individual help, assisting >50 pupils with practical work. He also has organized a training session for the module Measuring galaxies (Meten aan Melkwegstelsels) which is part of the high school curriculum track Nature, Life and Technology (Natuur, Leven en Technologie). Furthermore Contact.VWO answers requests for assistance by high 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. Contact.VWO works in close cooperation with the Regionaal Steunpunt Leiden, directed by Jacqueline Hoornweg.

Date	**Activities at Leiden University in 2014 for teachers**
16 jan	Meeting with teachers: theme: Astrophysics: Babies or Monsters? After dinner: several minor items on the edge of secondary school and university.
24 jan	Instituutsdag for pupils visiting CERN afterwards (preparation)
14 mar	Meeting with pupils & teachers: Einsteins Birthday
14 may	Meeting with teachers: special edition: visits to our laboratories. After dinner: several minor items on the edge of secondary school and university
6 nov	Meeting with teachers: theme: Astrophysics: the role and the evolution of water in formation of new stars and planets. After dinner: several minor items on the edge of secondary school and university
9 Oct	HiSPARC teachers workshop
29 oct	Educational Seminar Astronomy
	For School classes: a one day program on Exoplanets
14 Jan	Montaigne Lyceum (The Hague)
29 jan	Pentacollege CSG Jacob van Liesveldt (Hellevoetssluis)
7 april	Hermann Wesselink (Amstelveen)
23 May	Stedelijk Gym SAcience4U (Leiden)
02 Jun	Leo Kanner (Leiden)
06 Jun	Rijnlands (Oegstgeest)
	Further information: http://www.physics.leidenuniv.nl/edu/contactpuntvwo/index.asp

3.4 Popularization and media contacts

Brown

Gaia - Een stereoscopische kaart van de Melkweg, KNVWS Papendrecht, September 5

Gaia - Een stereoscopische kaart van de Melkweg, Almere, November 8

Een miljard sterren in 3D, Museumnacht Leiden, May 17

Sterrenkunde, IMC Weekendschool, Den Haag, December 7

Sterrenkunde, Spacekamp, Noordwijk, May 2

Sterrenkunde, Spacekamp, Noordwijk, August 27

Van Delft

Philips Research. Honderd jaar uitvindingen die ertoe doen, Docentenbijeenkomst Natuurkunde, January 16

Philips Research. 100 Years of Inventions That Matter, This weeks discoveries, January 21

Philips Research. Honderd jaar uitvindingen die ertoe doen. Philips Museum Eindhoven, January 26

De toekomst van Museum Boerhaave, gezelschap Van Braam van Vloten, March 8

De Vrienden van Museum Boerhaave, Leiderschapsdag Dutch Space, March 11

Boekpresentatie IJzeren longen, warme harten, March 13

Leve het vrijdagmiddagonderzoek!, What's New? De Nieuwe Zakelijkheid, March 1

Golden Ages of Arabia and Holland, Museum Boerhaave, March 27

Boerhaave aan de Vecht, Oud-Zuylen, March 29

Philips Research. 100 jaar uitvindingen die ertoe doen. Museumweekend, April 6

De toekomst van Museum Boerhaave, Rotary Oegstgeest, April 9

De toekomst van Museum Boerhaave, Gerard Philips Gezelschap, April 15

Golden Ages of Arabia and Holland, Aramco Board, April 16

Museum Boerhaave, Society and the Real Thing, Micheletti Award, April 26

Honderd jaar NatLab, gezelschap slechtzienden, May 10

De oorsprong van elektronische muziek, Summerjazz. Leidse Hout, June 1

Philips Research. 100 Jaar uitvindingen die ertoe doen. KIVI, August 26

Aftrap Isis in Nederland, Descartes Instituut Utrecht, September 10

Opening Hit & Run. Ed van der Elsken fotografeert het Philips NatLab, September 12

Röntgen tegen de tering, Nacht van Kunst & Kennis, September 20
Video 2000: een superieure ramp, Nacht van Kunst & Kennis, September 20
The oldest Dutch telescope, ImPhys Science Day, October 7
Vriendendag Boerhaave aan de Vecht, Oud-Zuylen, October 11
Beelden van beta's: Faust, Frankenstein, Kamerlingh Onnes, RINO, October 24
Het anatomisch Theater van Museum Boerhaave, Museumprijs Zuid-Holland, November 20
Chaos, Veenproef Scheltema, November 24
Opening Ik zie, ik zie, November 30
Museum Boerhaave en innovatieve geneeskunde, Vita Valley 10 jaar, December 15
Wim Brand, VPRO-boeken, January 2
Omroep Max, March 17
NTR, Kennis van nu, 0 kelvin, July 2
Interviews, Met het oog op morgen, Radio een journaal, NTR, Unity FM, Sleutelstad, etc.

Van Dishoeck
Bouwstenen voor leven tussen de sterren, Leiden, Prometheus studievereniging, February 12
Amsterdam, Chemie studievereniging, March 4
Maastricht, Studium Generale, April 10
Leiden, Studium Generale, November 3
From IRAS to ISO and Herschel: development of infrared astronomy, Leiden, Book presentation Habing, February 18
Waar komt het water op aarde vandaan? Leiden, LWSK, September 16
Den Haag, de Sphinx vereeniging, October 16
Leiden, Docentenbijeenkomst, November 6
Leiden, Studium Generale, November 10
Rosetta: op zoek naar onze oorsprong, Leiden, Oude Sterrewacht, November 12
Building Bridges: my career in the exciting interdisciplinary field of astrochemistry, Clare McMahon Diversity lecture, Queens' University, Belfast, UK, November 11
Sweet results form ALMA, Tokyo, Public lecture, December 7
Astronomers looking for clues to water's origins (Phys Org, March 27)
E-ELT ground-breaking ceremony (Euronews tv, July 17-24)
Ewine van Dishoeck lid Duitse Academie voor Wetenschappen (NOVA/Leiden

press release, March 27)
Ewine van Dishoeck receives Gothenburg Lise Meitner Physics award 2014 (NOVA/Leiden press release, September 15)
Educative iPad game Planet Challenge released internationally (NOVA/Leiden press release, September 22)
Eerste de Zeeuw-van Dishoeck afstudeerprijs voor sterrenkunde (NOVA/Leiden press release, November 25)

Franse
Kosmologie & Wat houdt de 'Big Bang theorie' nou eigenlijk in?, talk, Leiden, May 23
Idem, talk, Leiden, October 29
Idem, talk, Leiden, November 21

Haverkorn
De LOFAR telescoop: nieuwsgierigheid van nu geeft oplossers van morgen, presentatie als tafelwetenschapper, Avond van Wetenschap & Maatschappij, Den Haag, October 6
Als vrouw in een mannenwereld, presentatie Gendermiddag Facultaire Studenten Raad, Nijmegen, April 17
Trek je ruimtepak aan! We gaan op reis!, MysteryX presentatie voor basisscholieren, Nijmegen, September 10
EenVandaag/Wetenschap op woensdag, radio interview, October 8
Video about my research, published on various websites/youtube and advertised in the Volkskrant, December 4

Hoekstra
Cosmology, Big History, UvA, Amsterdam, January 11 & 14 idem, Big History, Erasmus University College, Rotterdam, September 12
Een opgeblazen heelal?, UL, Leiden, April 4
Een opgeblazen heelal?, LWSK Leiden, October 28
Een opgeblazen heelal?, Amsterdam, November 25

Kama

Interview on the Estonian Public Broadcasting radio show Hallo, kosmos!, Estonia; December 28
Space is big, we are small: thoughts on small countries in large astrophysics projects, seminar Estonian Space Technology & Research for the European Community at the Permanent Representation of Estonia to the European Union, Brussels; December 9
From atoms to planets, National Astronomy Meeting of Estonia, Toila, Estonia; August 9
Planets and life in the Universe, International Day of Cosmonautics, Tallinn, Estonia; April 12
Interview on the Estonian Public Broadcasting television show Ringvaade, Estonia; April 11

Keller
The Sun - Our Star, lecture, Tricht, October 7

de Kok
Atmosferen van exoplaneten, NVWS lecture, Arnhem, October 15

Kuijken
Een korte geschiedenis van het heelal, KNAW minisymposium, Amsterdam, April 7
Gravitational Lensing: studying the dark side of the universe with light rays, public lecture at Medellin Science centre, Medellin, Colombia; August 21

Labbé
Galaxies from the dawn of time, public lecture, Melbourne, Mar 25
Astronomen vinden superheldere jonge sterrenstelsels, press release, Jan 2014
Extreem verre, maar volwassen sterrenstelsels ontdekt, press release, Mar 2014

Linnartz
Press release: Moleculaire striptease verklaart Buckyballs in de ruime, December 2014
Press release; Moleculaire vingerafdruk gemeten van kleinste aromatische molecuul, August 2014
Popular lecture, Vereniging Oud Sterrewachters, Leiden, June 2014

Popular lecture, Rotary club, Leiden, June 2014
Education elementary school, Geleen, February 2014
Press release, Astrochemici hebben ijs in de gaten, January 2014

Van Lunteren
Wetenschap en maatschappij, Studium Generale Leiden, January 16
Nederland en de meter: Nederlandse bemoeienissen met het metrieke stelsel, Winterlezing Teylers Museum Haarlem, February 23
Natuurwetenschap in een moderne samenleving, Koninklijk Zeeuws Genootschap der Wetenschappen, Middelburg, March 7
De tragikomische geschiedenis van de meter, Leidse studentenvereniging Catena, April 2
De aard van wetenschappelijke ontdekkingen, Carmel College Salland, Raalte, April 8
Wetenschap als spiegel van de maatschappij, Ouderdag Leidsche Fles, Leiden, April 12
De Gouden Eeuw van de Nederlandse sterrenkunde, lezing sterrewacht Leiden, May 3
De electrificatie van de samenleving in tien ontdekkingen, Veenfabriek Leiden, May 13
Hollandse luchten, wereldwijde wetten: de Britse creatie van de wet van Buys Ballot, lunchlezing Leidsche Fles, May 14
De aard van wetenschappelijke ontdekkingen, zomerschool Bas Haring, Leiden, July 1
Wereldbeeldmachines 1: het mechanisch uurwerk, Studium Generale, Leiden, September 8
Wereldbeeldmachines 2: de balans, Studium Generale, Leiden, September 15
Wereldbeeldmachines 3: de stoommachine, Studium Generale, Leiden, September 22
Wereldbeeldmachines 4: de informatieverwerker, Studium Generale, Leiden, September 29
Wetenschap als spiegel van de maatschappij, Historisch genootschap Amsterdam, October 3
De maatschappij van vandaag is de wetenschap van morgen, tafelwetenschapper op de Avond van Wetenschap en Maatschappij in de Ridderzaal, Den Haag, October 6

De aard van wetenschappelijke ontdekkingen: mythe en werkelijkheid, woensdagavondgezelschap Utrecht, October 8

van der Marel
Chemie in de ruimte, Amsterdams dispuut, Amsterdam, January 10
Planeetvorming met ALMA, Kijk Live!, Amsterdam, January 21
Chemie in de ruimte, WSK Zaanstreek, Oostzaan, April 24
Planeetvorming, ScienceBattle, Delft, May 23
Sterren en planeten, Agnus Dei Kerk, Waalre, November 29

Otten
Op zoek naar exoplaneten, talk, Old Observatory, Leiden, October 26

Portegies-Zwart
Klokhuis vragendag, NEMO, Amsterdam, May 17

Rossi
My career choice @Physics Ladies Day, "Speed dating with high-school girls", Leiden, October, 31

Röttgering
LOFAR, een nieuwe grote radiotelescoop in Nederland, Haagse Hogeschool, Delft, March 5

Schaye
Interview Radio 1, December 30
Interview Radio West, December 30

Snellen
Press release, Length of Exoplanet Day Measured for First Time, 30 April

Sobral
Press release: Cosmic web accelerates galaxy evolution, UCR, IA, FCUL
Time-travelling in 3D 15 Schools (>1500 students) around Lisbon (Space week)
Time-travelling and galaxy evolution: now in 3D! Observat orio Astron omico de Lisboa, Portugal

Toonen

The evolution of binary stars, Nijmegen, April 16

Van der Werf

De Oerknal, Gymnasium Hilversum, May 26

3.5 Universe Awareness programme

Miley continued as International Coordinator of the Universe Awareness (UNAWE) programme, Russo as UNAWE International Project Manager and Arends as UNAWE Netherlands Project Manager.

Universe Awareness (www.unawe.org) is a programme initiated by the Sterrewacht that uses inspirational aspects of astronomy to target children aged 4 to 10, particularly those from disadvantaged backgrounds. The goals are twofold − to use the excitement of astronomy to interest them in science and technology and to use the perspective and enormity of the Universe to foster tolerance and a sense of world citizenship at an age when their value system is forming. UNAWE components are teacher training, production of outstanding educational materials and an interdisciplinary network.

UNAWE is now active in more than 60 countries. UNAWE was started with the help of a KNAW Academy professorship and seed funding by Minister van der Hoeven. UNAWE was a cornerstone project of the UN-ratified International Year of Astronomy IYA2009 and is an important part of the IAU Strategic Plan 2010 - 2020 Astronomy for Development. The EU Universe Awareness project was completed in 2014. EU-UNAWE, a project to implement UNAWE in 5 European countries and South Africa from 2011 - 2014, was funded (2M Euro) by the Space programme of the European Commission (Industry and Enterprise Directorate). The project overachieved all its targets and was highly evaluated. It featured several innovations.

• About 2000 teachers were trained and an estimated 65,000 children were reached.

• Almost 200 hands-on resources that motivate and encourage learning were produced. Flagship UNAWE resources include the inflatable UNAWE Earthball and the Universe-in-a Box (UiB) activities. More than 10,000 Earthballs and 1,000 Universe-in-a-Box were manufactured and distributed throughout the world. During 2014 a successful crowd funding campaign raised almost 17,000 Euro to fund the global distribution.

• A UNAWE spinoff devised by Russo and implemented during 2014 was included: Space Scoop an astronomy news service for children and teachers.

• This year a UNAWE project was carried out in three schools in underprivileged districts of Rotterdam with the support of a 20k Euro grant from the Gratama Foundation and the LUF. In each school, astronomy lessons were given by a pair of students - an astronomy PhD candidate and a teacher-training student.

• A UNAWE astronomy training video for Dutch elementary school teachers was produced jointly by the Sterrewacht and Stichting Methodelink (Schippers), a private foundation which has developed a teacher portal that is heavily used by Dutch school teachers. The video featured Erik Arends with UNAWE's Universe in a Box and was produced with funding of 15k Euro from the NWO Humanities Department KIEM Creative Industry programme.

3.5.1 AstroEDU - Open-access platform for peer-reviewed astronomy education activities

astroEDU, developed during the EU-UNAWE project, is a platform that allows educators to discover, review, distribute, improve and remix astronomy education activities, and offers a free peer-review service by professionals in education and science. astroEDU targets activity guides, tutorials and other activities in the area of astronomy education, prepared by teachers, educators and education specialists. Each of the astroEDU activities has been peer-reviewed by an educator and an astronomer to ensure a high scientific and educational standard. All reviewed materials are then stored in a free online database, using a framework which enables broad distribution in a range of different formats from print-friendly PDFs to mobile device document formats. astroEDU is funded by the Office of Astronomy for Development and Royal Astronomical Society of the UK. In 2014 astroEDU was awarded the Scientix AWARD for best European Educational Resource in Science. Russo is managing editor of the astroEDU.

3.5.2 EU Space Awareness

During 2014 Miley, Russo and Brinchmann were successful in obtaining 2M Euro from the European Commission for a new astronomy-related project, EU Space Awareness. EUSPACE-AWE was among two of the 16 submitted proposals to be funded in response to a Horizon 2020 Call also by the EC Space Directorate. The project is being implemented from 2015 to 2018 and is designed to use the excitement of space to attract young people into science and technology and stimulate European and global citizenship. Although Universe Awareness will be part of the project, the scope of Space Awareness was extended to target young people between ages 4 and 18 in order to comply with the work programme of the Call. Leiden will coordinate the project that includes 9 full partners and 15 additional dissemination nodes.

The project will show teenagers the opportunities offered by space science and engineering and inspire primary-school children when their curiosity is high, their value systems are being formed and seeds of future aspirations are being sown.

EUSPACE-AWE will conduct a range of activities. These will: 1. acquaint young people with topical cutting-edge research and role-model engineers, 2. demonstrate to teachers the power of space as a motivational tool and the opportunities offered by space careers, 3. provide a repository of innovative peer-reviewed educational resources, including toolkits highlighting seductive aspects of Galileo and Copernicus and 4. set up a space career hub and challenging contest that will appeal to teenagers. Attention is being paid to stimulating interest amongst girls and ethnic minorities and reaching children in underprivileged communities, where most talent is wasted.

3.5.3 TEMI: Teaching Enquiry with Mysteries Incorporated

Russo and Miley began working on TEMI, a new 3-year teacher training project being coordinated on Queen Mary University London to help improve science and mathematics teaching practices across Europe, by giving teachers new skills to engage with their students, exciting new resources and the extended support needed to effectively introduce enquiry based learning into their classrooms. Innovative training programmes called enquiry labs are being implemented across Europe, working with teacher training institutions and teacher networks. These will be based around the core scientific concepts and emotionally engaging activity of solving mysteries, i.e. exploring the unknown. The main role of the Sterrewacht in the project is to deliver the TEMI teacher training programme in the Netherlands and promote its outcome to policy-makers, local teacher networks, and other professional bodies.

3.6 Astronomy for Development

Miley, an Emeritus Vice President of the International Astronomical Union, continued to oversee the implementation of the IAU Strategic Plan 2010 - 2020 Astronomy for the Development, of which he was the architect. The plan is being implemented by the IAU Office of Astronomy for Development (OAD) in Cape Town, a joint venture between the IAU and the South African National Research Foundation. This year Miley rotated from Chair to Vice Chair of the OAD Steering Committee and remained Chair of the IAU Extended Development Oversight Committee. Thanks to the work of the OAD Director, Kevin Govender, the implementation of the plan is proceeding according to schedule. The three OAD Task Forces Universities + Research, Schools + Children and Public Outreach are having a global impact and dealt with a heavily oversubscribed Call for Proposals. Russo is co-chair of the Task Force on Schools and Children. The first IAU Regional Nodes of the OAD (East Asia and South East Asia) are operating. Additional regional nodes were created in Africa and South America and other ROADs are expected to come into operation during the next few years. This year both Miley and Russo gave several talks about the importance of astronomy for capacity building and development.

As part of the IAU Astronomy for Development programme, two astronomers from the DPR Korea visited Leiden from September 2013 to March 2014 as part of the IAU Astronomy for Development programme. During their stay, Dr. Kim Mun Song and Dr. Kim Kyong Chol of Pyongyang Observatory worked on Westerbork and CCD data. They were hosted by Miley and Russo and their visit was funded by the J. Mayo Greenberg Scholarship Prize, the Kruytbosch Legacy, the Leids Universiteits Fonds and Leiden Observatory.

3.7 The Leidsch Astronomisch Dispuut F. Kaiser

The association L.A.D. 'F. Kaiser' is named after the founder of Leiden Observatory, Frederik Kaiser. The major goal of the L.A.D. is to improve the social interactions between undergraduate students and Observatory personnel. Curently the association has about 150 members, with the board of 2014-2015 consisting of a praeses (Iosto Fodde), quaestor (Nicholas Rasappu), ab-actis (Lisa Pothoven), assessor Sterrewacht (Brecht Simon) and assessor events (Ronnie Douma).

Our yearly football tournament, in which more than hundred players participated last summer, was a great success! We started the following academic year with an introductory dinner in Amsterdam for nearly 70 first-year students. We combined a movie night with pizza and went on an excursion to Airbus Defence & Space. A lecture on the history of the old observatory with stories and anecdotes was given by Sascha Zeegers (Leiden University) and students went to observe in the old observatory.

Another main goal of L.A.D. F. Kaiser is to popularize astronomy amongst the public, something which we achieve by means of tours and open days in the old observatory. This year we have done 171 tours for about 2600 people and helped with events like the Study Orientation Day for new students and Museum Night. The board assisted with the Rosetta exposition where a live stream of the landing of Rosetta on a comet could be watched. One of our committees organized the successful Kaiser Spring Lectures (Kaiser Lente Lezingen). None of these public events would have been possible without the efforts of the student tour guides and volunteers, who we would like to thank for their commitment.

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, an invitation to attend the Sterrewacht BBQ in July and an annual meeting in November. This year, the annual meeting was held at the Louwman Museum in The Hague and involved a visit of the Louwman Collection of

Historical Telescopes. The members received a guided tour by Mr Louwman. The meeting was attended by 25 members. VO-S members also received newsletters with Sterrewacht news and were offered an electronic member dictionary.

Appendix I

Observatory staff

Observatory staff

Appendix I

(Between January 1st and December 31st, 2014)

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

Full Professors

E.F. van Dishoeck	
M. Franx	
C.U. Keller	
K.H. Kuijken	
H.V.J. Linnartz	
F.H. van Lunteren	(UL (0.5) / VU (0.3), Teijler's hoogleraar)
S.F. Portegies Zwart	
H.J.A. Röttgering	
J. Schaye	
I.A.G. Snellen	
A.G.G.M. Tielens	
P.P. v.d. Werf	
P.T. de Zeeuw	(0.0, Director General ESO)

Affiliate Professors

D. van Delft[a]	(Stichting tot beheer Museum Boerhaave, Museum Boerhaave; Director Boerhaave)
N.J. Doelman	(J.H. Oortfonds)
C.W.M. Fridlund[b]	(J.H. Oortfonds; Staff scientist ESTEC / ESA)
M.A. Garrett[c]	(Director ASTRON)
J. S. Kaastra[d]	(Senior Scientist SRON)
H. J. van Langevelde[e]	(Director JIVE, Dwingeloo)

Associate Professors, Assistant Professors, senior researchers

R.J. Bouwens		M.R. Hogerheijde	
B.R. Brandl		M.A. Kenworthy	
J. Brinchmann		I.F.L. Labbé	
A.G.A. Brown		E.M. Rossi	
M. Haverkorn[a]	(0.0)	R. Stuik	
H. Hoekstra		R.P.J. Tilanus	(0.0)

[a] Staff Radboud University Nijmegen

Emeriti

A.M. van Genderen	W. J. Jaffe
H.J. Habing	J. Lub
I. van Houten-Groeneveld	G.K. Miley
V. Icke	R.S. Le Poole
F.P. Israel	

Postdocs and Project Personnel and longterm visiting scientists

Name	*Funding source*	*Name*	*Funding source*
H. Alvaro Galue	NWO-VI	T.P.K. Martinsson	NOVA
E.F.H. Arends	EU-EUNAWE, TEMI, OC&W	L.T Maud	NWO-ALLEGRO
M. Balogh	guest	S.L. McGee	NWO-VC
F.C.M. Bettonvil	(0.0 ASTRON)	R. Meijerink	NWO-TAMPAIS, SPINOZA
J.L. Birkby	NWO-VC	J.A. Meisner	NOVA
J.B. Bossa	EU- IEF	E.P. Monaghan	EU-MASE
M. Brogi	NWO-VC	J.C. Mottram	NWO-VC, EU-ERC
M. Cacciato	NWO-VI, EU-ERC	A.V. Muzzin	NWO-SPINOZA
A. Candian	NWO, EU-ERC	J. Neuteboom	guest(NWO-LIO)
L.R. Carlson	EU-ERC	J.B.R. Oonk	NWO-TOP1
E. Costantini	guest (SRON)	A. Patruno	NWO-VI
G. Costigan	EU-GENIUS	F.I. Pelupessy	NWO-M
R.A. Crain	NWO-VC, EU-ERC	M.V. Persson	EU-ERC
G.A. Cruz Diaz	NOVA	A. Petrignani	EU-ERC
C.R. D'Angelo	NWO-VI	J.T. Pijloo	guest, Nijmegen
N. Drost	(0.0, E-science Center)	P.A. Pinilla Ortiz	KNAW
A.K. van Elteren	guest, RU-Nijmegen	S. Plöckinger	EU-ERC
M.B. Eriksen	EU-ERC	E.E. Rigby	NWO-TOP, EU-HELP
G. Fedoseev	NOVA	M. Rodenhuis	STW
K. Furuya	guest	P.M. Rodrigues Dos Santos Russo	EU-EUNAWE,TEMI, OC&W
C. Ginski	NOVA	N. Roos	guest
I.R. Guerra Aleman	NWO-SPINOZA	K.J. Rosdahl	EU-ERC
S. Guha Niyogi	NWO-SPINOZA	M.L. Sadatshirazi	guest
R.H. Hammerschlag	guest (STW)	E. Schmalzl	NOVA
D. Harsono	EU-ERC	G. Sikkema	UL-RUG
G. v. Harten	UL/SRON	M. Schmalzl	NOVA
A.N. Heays	UL	T.W. Shimwell	EU-ERC

E.M. Helmich	NWO-M	D.R. Serrano Goncalves Sobral	NWO-VI
B. Holwerda	NWO-VC	F. Snik	NWO-ESFRI-ELT
A.P. Hypki	EU-GENIUS	J.F.P. Spronck	NWO-VI
N. Irisarri Mendez	NWO-M	M. Stefanon	NWO-TOP2
H. Jager	guest, NOVA	I.M. Stweart	NWO-ALLEGRO
L. Jilkova	BELSPO, NWO-VI	L.A. Straka	EU-ERC
J.T.A. de Jong	NWO-M	J.J. Tobin	EU-ERC/NWO-VI
A. Juhasz	NWO-ALLEGRO	S.G.M Toonen	NWO-VI
J. Katgert-Merkelijn	guest	L. Venema	guest (ASTRON)
M. Kama	KNAW	S. Verdolini	EU-ERC
T.A. van Kempen	NOVA, NWO-ALLEGRO	M. Viola	NWO-VC, EU-ERC
P.D. Klaassen	NWO-ALLEGRO	N. de Vries	NWO-M
R.J. de Kok	NWO-VI/NWO-PEPSCI	C. Walsh	EU-ERC
K.C. Kom	guest, Greenberg fellow	I. Yoon	NOVA/NWO-ALLEGRO
M.L Kom	guest, Greenberg fellow	D. Zhao	NWO-VI
V.A. Korkiakoski	guest	J. Zhen	EU-ERC
A. Lesage	NWO-VI	J.E. van Zwieten	guest (Science & Technology, ASTRON)
M. De Lima Leal Ferreira	CNPq Fellowship Brasil		

Promovendi

Name	*Funding source*	*Name*	*Funding source*
A.S. Abdullah	EU-ERC	A.L.M. Lamberts	NWO-Astrochemie
H.E. Andrews Mancilla	EU-ERC	X. Li	NWO-Astrochemie
X. Bacalla	guest, VU	N.F.W. Ligterink	EU-ERC
C.R. Barber	EU-ERC	N. Lopez Gonzaga	NWO-VC
J.E. Bast	guest	K.M. Maaskant	NOVA
J. Bedorf	NWO-M	J.C. Mackie	NWO-SPINOZA

T.C.N. Boekholt	NWO-VI	J. Mao	guest, SRON
J. de Boer	NWO-VI / ESO fellow	N. v.d. Marel	NOVA
E.G. Bogelund	NWO-TOP	C.A. Martinez Barbosa	EU-ITN-GREAT / UL
C.A. Bonnerot	NOVA	F. Maschietto	guest
S. v.d. Broek	NOVA	J.J.A. Matthee	UL Huygens fellow
M. Brogi	NOVA	F.D.M. Mernier	NWO-SPINOZA
M.M. Brouwer	NOVA	T.R. Meshkat	UL / EU-IG
R.F.J. v.d. Burg	NWO-VI	A. Miotello	EU-ERC
G.E. Calistro Rivera	EU-ERC	L.K. Morabito	NWO-TOP
D.P. Caputo	NWO-VI	A.B. Nielsen	NWO-VI
M.T. Carney	NWO-TOP	B.B. Ochsendorf	EU-ERC
D.J. Carton	NWO-VC	G.P.P.L. Otten	NWO-ESFRI-ELT
P. Castellanos Nash	UL Huygens Fellow	D.M. Paardekooper	NWO-VI
K. Chuang	EU-ERC	B. Pila Diez	NOVA
B.J.F. Clauwens	NWO-De Sitter	E.F. Retana Montenegro	NWO-TOP
N. Clementel	NWO-VC	A.J. Richings	EU-ITN-COSMOCOMP
V. Cordeiro de Sousa Santos	guest, external fellow	A.R. Ridden Harper	NWO-VC
S.H. Cuylle	EU-ITN-LASSIE / UL	A.J. Rimoldi	NWO-VI
M.P. van Daalen	UL Huygens Fellow	M.J. Rosenberg	NOVA
M. De Juan Ovelar	NWO-ESFRI-ELT	M.I. Saladino Rosas	guest
E. Di Gloria	NWO-VI	P.A. Salas Munoz	NOW-TOP1
D. Donevski	UL / ASTRON	F.J. Salgado Cambiazo	EU-ERC
K.D. Doney	NWO-VI	V.N. Salinas Poblete	NOVA
M.N. Drozdovskaya	UL Huygens Fellow	I. San Jose Garcia	EU-ITN-LASSIE / UL
C. Eistrup	EU-ERC	J. v.d. Sande	NOVA
G. Fedoseev	NWO-VI	A. Saxena	EU-ERC
J. Franse	NWO de Sitter	H. Schwarz	NWO-VI
M. Fumagalli	EU-ERC	M.C. Segers	EU-ERC
C.C. Giese	NWO-SPINOZA	C. Shneider	NWO-VI

G. Goncalves Ferrari	guest	C.J. Sifon Andalaft	EU-ERC
A.S. Hamers	NWO-VI	D.M. Smit	gast
D.S. Harsono	NOVA-SRON-UL	R. Smit	NWO-VC
G. van Harten	UL / UU	C.M.S. Straatman	NWO-SPINOZA
S. Heikamp	NWO-ESFRI-ELT	A.H. Streefland	FOM/UL
E. v.d. Helm	NOVA	A. Stroe	NWO-TOP
R.T.L. Herbonnet	EU-ERC	G.J.J. Talens	NOVA
A.R. Hill	NOVA	M.L. Turner	NWO-ITN-COSMOCOMP / UL
N.D. Hoang	EU-ERC	I. Urdampilleta Aldama	guest SRON
H.J. Hoeijmakers	UL Huygens Fellow	M. Velliscig	EU-ITN-COSMOCOMP / UL
M. Iacobelli	NWO / ASTRON / UL	S. Verdolini	UL
M. Kazandjian	UL	Y.M. Welling	NWO de Sitter
V. Kofman	NWO-PEPSCI	T.I.M. van Werkhoven	guest
F. Khlinger	NWO-De Sitter	M.J. Wilby	NOVA
S. Krijt	UL	W.L. Williams	UL-ASTRON
		S.T. Zeegers	guest SRON

Support Staff

E. Gerstel	Institute Manager
P. Heijsman	Project Support
D.J. Klaassen	Secretary
A.N.G. Pen-Oosthoek	Programme Coordinator BSc and MSc
A. Schouten-Voskamp	Management Assistant
G.A. v.d. Tang	Secretary
L. v.d. Veld	Secretary
J Visser	Coordinator PR & Education

Computer Staff

E.R. Deul	Manager Computer group
D.J. Jansen	Scientific Programmer
E.J. van der Kraan	ICT support
N. Verbeek	Programmer
A. Vos	Programmer

NOVA office

W.H.W.M. Boland	Managing Director
E.F. van Dishoeck	Scientific Director
C.W.M. Groen	Financial Controller
J.T. Quist	Management Assistant

Appendix II

Committee membership

Committee membership

Appendix II

II.1 Observatory Committees

Directorate

H.J.A. Röttgering (director of research)
P.P. van der Werf (director of education)
E. Gerstel (institute manager)

Observatory management teams

H.J.A. Röttgering (General managment)
E.R. Deul (ICT/Housing)
J. Drost (minutes)
I.A.G. Snellen (outreach)
Alexandra Schouten-Voskamp (Secretariat)
E. Gerstel (HR, Projects/Finances)
C. Keller (Instrumentation)
P.P. van der Werf (Education)
C.U. Keller (Instrumentation)

Supervisory council

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

Research institute scientific council

R. Bouwens
B. Brandl
J. Brinchmann
A.G.A. Brown
E.R. Deul
D. van Delft
E.F. van Dishoeck
N. Doelman
M. Franx (chair)
M. Garret
M. Haverkorn
H. Hoekstra
M. Hogerheijde
V. Icke
F.P. Israel
W. Jaffe
C.U. Keller
K.H. Kuijken
M. Kenworthy
H.J. van Langevelde
R.S. Le Poole
H.V.J. Linnartz
J. Lub
F. van Lunteren
G.K. Miley
S. Portegies Zwart
E. Rossi
H.J.A. Röttgering
J. Schaye
I. Snellen
R. Stuik
A.G.G.M. Tielens
P.T. de Zeeuw

Institute council

E. Deul (chair)
I. Aleman
M. Segers
K. Doney
L. van der Veld
H. Hoekstra
I. Labb
J. Spronck
E. van der Helm
C. Lemmens
A. Vos

Astronomy education committee

H.V.J. Linnartz (chair)
M. Hogerheijde
M. Segers
A. Jakobs
G. de Wit
C. Keller
M. Kenworthy
P. Ortiz Otalvaro
M. Sunder
L. Wolters

Astronomy board of examiners

VI.A.G. Snellen(chair)
J. Aarts (Physics)
J. Brinchmann
B. Brandl
H. Hoekstra

Oort Scholarship Committee

S. Portegies Zwart (chair)
M. Kenworthy
J. Schaye

Mayo Greenberg Prize committee

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

PhD admission advisory committee

E. Rossi
I.A.G Snellen

MSc admission advisory committee

S. Portegies Zwart(chair)
M. Kenworthy
J. Schaye

Graduate student review committee

A.G.G.M. Tielens (chair)
C.U. Keller
S. Portegies Zwart
R. Bouwens
M. Kenworthy

Colloquium committee

S. Portegies Zwart
H. Linnartz
M. Kenworthy

Computer committee

R. Bouwens (chair)
R. Crain
M. Schmalzel
R. Stuik
S. Portegies Zwart

Library committee

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

Public outreach committee

I. Snellen (chair)
M. Segers
J. Hoeijmakers
R. Herbonnet

Social committee

D. Klassen
H. Schwarz
R. Meijerink
F. Mernier
K. Doney
I. Snellen
M. Brouwer
T. van Kempen
C. Barber

II.2 University Committees (non-Observatory)

Brinchmann
Member, Leids Kerkhoven-Bosscha Fonds
Member, Leids Sterrewacht Fonds
Member, Jan Hendrik Oort Fonds

Brown
Member, Faculteitsraad

Holwerda
Leiden-ESA Astronomy Program for Summerstudents (LEAPS)

Kenworthy
Organiser, Lorentz Workshop, ”Combining Coronagraphs and Focal Plane Wavefront Sensing”

Linnartz
Member FMD/ELD committee
Member WN committee OC chairmen

van Lunteren
Chair Board Stichting Historische Commissie voor de Leidse Universiteit
Member Gastschrijvercommissie Universiteit Leiden
Member Studium Generale-commissie Universiteit Leiden
Member Advisory Board Foundation for Lorentz & Einstein Media Research
Member Board Octavie Siegenbeek van Heukelom Stichting
Member Wetenschappelijke Raad Scaliger Instituut
Member Wetenschappelijke Raad Museum Boerhaave
Member Board Stichting Vrienden van de Leidse Universiteitsbibliotheken
Member Benoemingsadviescommissie Clusius-leerstoel Leiden

Petrignani
Member, Reading & PhD committee, VU Amsterdam

Portegies Zwart
Lorentz Center, Computational Science board member
Lorentz Center, Advisory board national platform computational science

Röttgering
Member, Curatorium of the professorship at Leiden University "Experimental Astroparticle Physics"
Schaye
Member, WeCo (Permanent Committee for Academic Practice)

Snellen
member, LUF International Study Fund (LISF) committee

van der Werf
Organist of the Academy Auditorium

Appendix III

Science policy functions

Sterrewacht Leiden

Science policy functions

Appendix III

Brandl
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, review board, BMBF Verbundforschung
Member, review board, DLR
Member, Evaluation Board, Leibniz Gesellschaft
Member, NOVA Instrument Steering Committee (ISC)
Member, DAG (Turkish 4m telescope) advisory board
Associate, ESFRI board

Brinchmann
Legacy Science Coordinator, Euclid mission
Galaxy and AGN evolution science working group coordinator, Euclid mission
Member, MUSE Science team
Coordinator, MUSE data management

Brown
Chair, Gaia Data Processing and Analysis Consortium
Member, Gaia Science Team
PI Gaia/Netherlands
Vice President, IAU Commission 8
Member, Steering Committee IAU Division A
Member, IAU Commission 37
Member, EU Marie-Curie ITN Gaia Research for European Astronomy Training (GREAT)
Member, Executive Board GENIUS FP7-Space Collaborative Project

Member, Steering Committee ESF-RNP Gaia Research for European Astronomy Training (GREAT)

Candian
Chair Scientific Organizing Committee, “The Interaction of Stars with the Interstellar medium of Galaxies”
Member Editorial board of AstroPAH Newsletter

Van Delft
Member, National UNESCO committee
Member, History of Science committee KNAW
Member, Board, Avond van Wetenschap en Maatschappij
Member, Nederlandse Maatschappij der Letterkunde
Member, (directeur) Hollandsche Maatschappij der Wetenschappen
Member, Interdisciplinary Program Board Lorentz Center / NIAS
Ambassador Platform btatechniek
Chairman, Caecilia Foundation (Friends of Museum Boerhaave)
Chairman, Bestuur Nederlandsch Natuur- en Geneeskundig Congres
Chairman, Board Stichting Technolab, Leiden
Member, Raad van Toezicht Stichting RINO, Leiden
Member, Ondernemersfonds Leiden
Member, Govering Board Stichting Historie der Techniek
Member, Examencommissie SBB/SCS Leiden Faculty of Science
Member, Committee Paradiso Lectures, Amsterdam

van Dishoeck
Scientific Director, Netherlands Research School for Astronomy (NOVA)
Co-Editor, Annual Reviews of Astronomy & Astrophysics
Member, ESA Space Sciences Advisory Committee (SSAC)
Member, Gebiedsbestuur Exacte Wetenschappen (GB-E)
Member, National Committee on Astronomy (NCA)
Chair, Harvard astronomy department visiting committee
Member, MPIA-Heidelberg Fachbeirat
Co-PI, European JWST-MIRI consortium
President, IAU Division H Interstellar Matter and the Local Universe
Coordinator, Fundamentals of Science profile area Leiden University

Member, Herschel-HIFI Science team
Coordinator, Herschel-HIFI WISH Key Program

Ginski
Member, SPHERE consortium

Guerra Aleman
Executive Editor, AstroPAH Newsletter

Haverkorn
Member, focusgroup valorisation, Rathenau Institute
Member, jury Lorentz Medal KNAW
Member, core team Cosmic Magnetism Working group Square Kilometre Array
Chair, LOFAR Magnetism Key Science Project - Galactic Science Working group
Member, LOFAR Surveys Key Science Project - Galactic Science Working group

Hoekstra
Member, ESO OPC
Member, Science Advisory Committee, Isaac Newton Group
Member Lorentz Center Astronomy Advisory Board
Euclid, Cosmology Coordinator
Euclid, Weak Lensing Science Working Group Lead
Member, Euclid Consortium Coordination Group

Hogerheijde
Member, ALMA European Regional Center Coordinating Committee
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

Holwerda
SOC member, PHISCC 2014 organization

Kaastra
Principal Investigator, XMM-Newton Reflection Grating Spectrometer
Principal Investigator, Chandra Low Energy Transmission Grating Spectrometer

Member, Astro-H Science Advisory Committee
Member, XMM-Newton User's group
Member, Athena Science Working Group
Member, Astronomy Board Lorentz Center
Member, LOFAR Program Committee
Member, NWO Rubicon Committee

Keller
Chair of the Board, Isaac Newton Group of Telescopes
Chair of the Board, Olga Koningfonds, The Netherlands
Co-Chair, Planetary and Exoplanetary Science Network, The Netherlands
Member, E-ELT Project Science Team, ESO
Member, EPA Network
Member, Scientific Committee of the Istituto Ricerche Solari Locarno (IRSOL) Locarno, Switzerland
Member, editorial board of the journal Astronomische Nachrichten

Kenworthy
Chairperson, ELT Adaptive Optic Modelling Consortium
Member, ESO Users Committee
METIS High Contrast Imaging Group Leader
ERIS Coronagraphic Design Leader
Member, ING Time Allocation Committee

Kuijken
Scientific Delegate from the Netherlands, ESO Council
Chair, ESO contact committee
Member and Vice-chair, Netherlands Committee for Astronomy
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)
Member, European Research Council Starting Grants Panel

Labbé
co-chair, Science Organizing Committee EWASS/JWST conference
WP-lead, Euclid Consortium, OU-NIR
Member, SPICA/SAFARI, Science Team, Extragalactic Universe
Member, Euclid Consortium, Science Working Group, Primeval Universe
Member, Euclid Consortium, Science Working Group, galaxy and AGN evolution
PI ZFOURGE survey
PI GREATS survey

Linnartz
Board member, European Task Force for Laboratory Astrophysics
Vice chair, division XII / IAU commission 14 / working group solids and their surfaces
Research coordinator, FP7 ITN 'LASSIE' (Laboratory Astrochemical Surface Science In Europe)
Solid state theme coordinator NWO-EW/CW 'DAN' (Dutch Astrochemistry Network)
Biomarker theme coordinator NWO-PEPSCI (Planetary and Exo-planetary Science)
Editor, CAMOP (Comments on Atomic, Molecular and Optical Physics / Physica Scripta)
Member, SOC biannual Molecular High Resolution Spectroscopy Symposium
Member, SOC IR Plasma Spectroscopy Meetings
Member, SOC Laboratory Astrophysics Session, IAU GA Honolulu 2015
External advisor, RSC/RAS Astrophysical Chemistry Group
Workgroup leader, FOM group FOM-L-027
Member, NWO-CW 'Spectroscopy and Theory'
Member, HRSMC research school

Lub
Treasurer, Dutch Astronomical Society (NAC)
Chairman, Astronomy & Astrophysics Board

van Langevelde
Member, consortium board of directors European VLBI Network
Member, RadioNet Board and Executive Board

Member, 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
Member, SKA klankbordgroep NL
Member, ALMA Scientific Advisory Committee (ASAC)
Member, ALMA European Scientific Advisory Committee (ESAC)
Member, SKA Science Working Group Cradle of Life

Mottram
Member, SKA Focus Group on Galactic Science

Petrignani
Participant, Focus Group Valorisation in chemical and physical research, Rathenau
Editor, AstroPAH news letter

Portegies Zwart
Quatar NSF, Quatar national science foundation, external advisor
Editor in Chief Spinger open access journal "Computational Astrophysics and Cosmology"
Visiting professor RIKEN/Tokyo University (Particle Simulation Team)
Member of the Scientific Steering Committee, PRACE
Beta Ambassador for the Netherlands
Colloquim organizer at the Sterrewacht
GAIA, member of the science advisory board
Chair of the Oort fellowship, Selection committee
NOVA ISC, AMUSE progress representative
IAU Member of Division VII Galactic System
IAU Member of Division VII Commission 37 Star Clusters & Associations
Sterrewacht, computer group advisory team

Rigby
Work Package Leader, Herschel Extragalactic Legacy Programme project management board
Member, Square Kilometre Array: Low Frequency tiger team

Rossi
Member, Committee of Astroparticle Physics in the Netherlands (CAN)
Member, eLISA consortium, “Supermassive Black Hole Formation” working group.
Chair, “tidal disruption evensts” working group of Large Observatory X-ray Timing (LOFT) consortium
Chair, “tidal disruption evensts” working group of the Square Kilometer Array (SKA) consortium

Röttgering
Member, XMM Large Scale Structure Survey Consortium
PI, LOFAR surveys: Opening up a new window on the Universe
Member, Science Advisory Committee ASTRON
Member, Euclid consortium board 2010
Member, LOFAR’s NL-LAC, national LOFAR steering committee
Member, Herschel H-ATLAS survey
Member, Extra-galactic science team SPICA/SAFARI
Member, Board LOFAR International Telescope
Member, Board of the Netherlands Research School for Astronomy (NOVA)
Member, SKA Science working group on radio continuum surveys
Member, NL-SKA contact committee
Member, Board Holland Space Cluster

Schaye
Member, steering committee, Virgo Consortium for cosmological supercomputer simulations
Co-Investigator, MUSE (Multi Unit Spectroscopic Explorer)
Member, MUSE science team
Member, LOFAR Epoch of Reionization science team
Member, Athena X-IFU science team
Member, EUCLID cosmological simulations working group
Scientific Editor, Monthly Notices of the Royal Astronomical Society
Scientific Editor, Scientific Reports
Member, Scientific Organizing Committee, ”The challenges of upcoming HI surveys”, Dwingeloo
Chair, Local Organizing Committee, Virgo consortium meeting, Leiden
Chair, Local Organizing Committee, MUSE consortium meeting, Haarlem
PI, OWLS collaboration (OverWhelmingly Large Simulations)

PI, EAGLE collaboration (Evolution and Assembly of GaLaxies and their Environments)

Snellen
Member, PLATO consortium
Member ESA ARIEL Consortium
Member, METIS consortium
Board Member, Nederlandse Astronomen Club
Reviewer, OPTICON Telescope Applications
Panel chair, ESO Observation Programme Committee (OPC)
EU FP7 Network progress reviewer
Co-I of HARPS3@INT project
Editor, Zenit

Sobral
Member, ESO OPC referee P95 (ESO)
Member, ESO Users Committee (ESO)
Board Member, Portuguese Astronomical Society (SPA)
Member, PhD Selection Committee for PhD:SPACE (U. Lisbon)

van der Werf
Principal Investigator, SCUBA-2 Cosmology Legacy Survey
Principal Investigator, Herschel Comprehensive ULIRG Emission Survey
Co-investigator, HIFI
Co-investigator, MIRI
Member, METIS Science Team
Member, STFC Herschel Oversight Committee
Member, TAMASIS Network
Project Scientist, AMKID submillimeter camera

Appendix IV

Workshops, colloquia, and lectures

Workshops, colloquia, and lectures

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 2013 the Leiden astronomers contributed to the following workshops:

Date
Title
Organisers

January 27 - 31
Computational Astrostatistics
Jarle Brinchmann, Eric Cator, Tom Heskes, Gijs Nelemans, Rien van de Weygaert

May 6 - 9
The Passage of Light within Spiral Galaxies
Maarten Baes, Simone Bianchi, Benne W. Holwerda

May 19 - 23
Galactic Science with the SKA & Its Pathfinders
Huib Jan van Langevelde, Mark Thompson

July 28 - August 1
Grain-Surface Networks and Data for Astrochemistry
Robin Garrod, Herma Cuppen, Dmitry Semenov, Valentine Wakelam, Catherine

Walsh

December 8 - 12
ESA/GTTP Teacher Training Workshop 2014
Rebecca Barnes, Rosa Doran

IV.2 Endowed Lectures

May 15, 2014
Oort Lecture: Our home in the universe
Lecturer: Neal J. Evans of the University of Texas at Austin

IV.3 Scientific Colloquia

Date	Speaker (affiliation)	Title
1/1/14	Michael Shull (University of Colorado)	Recent Results from the Cosmic Origins Spectrograp
1/9/14	Jesse van de Sande (Leiden Observatory)	Galaxies inside-out: A kinematic study of massive high-redshift galaxies [PhD colloquium]
1/16/14	Silvia Verdolini (Leiden Observatory)	Modeling interstellar bubbles: near and far [PhD Colloquium]
1/23/14	Stefan Dreizler (University of Goettingen)	Planets in post-common envelope binaries - a second phase of planet formation?
1/30/14	Norbert Werner (Stanford University)	"From supermassive black holes to the large-scale structure of the Universe "
2/6/14	Marco Iacobelli (Leiden Observatory)	Exploring the magnetic, turbulent Milky Way through radio waves
2/13/14	Bryan Gaensler (University of Sydney)	Radio Polarimetry and the Magnetic Universe [NOVA Colloquium]
2/20/14	Remco van der Burg (Leiden Observatory)	The assembly of stellar mass in galaxy clusters since z 1 [PhD colloquium]
2/27/14	Ian Smail (Durham University)	ALMA studies of submm galaxies
3/6/14	Beth Biller (Royal Observatory Edinburgh)	Direct Imaging of Exoplanets: Prospects for Comparative Exoplanetology

3/13/14	Jorge Penarrubia (Royal Observatory Edinburgh)	Testing Dark Matter particle models with dwarf spheroidals
3/27/14	Eva Schinnerer (MPIA)	Gas, Dust and Star Formation in M51
4/3/14	Matteo Brogi (Leiden Observatory)	Atmospheres of hot exoplanets [PhD colloquium]
4/10/14	Martin Harwit (Cornell University)	The Instability of Astrophysics Witnessed in the Twentieth Century
4/17/14	Jeroen Bdorf (Leiden Observatory)	The Gravitational Billion Body Problem
4/24/14	Mher Kazandijan (Leiden Observatory)	Diagnostics of Mechanical Heating in the Molecular ISM of Galaxies [PhD colloquium]
5/1/14	Michael Shull (University of Colorado)	Recent Results from the Cosmic Origins Spectrograph: Missing Baryons, AGN, and Reionization
5/8/14	Nuria Calvet (University of Michigan)	Protoplanetary Disks: aiming to understand their structure and evolution [NOVA Speaker]
5/15/14	Marissa Rosenberg (Leiden Observatory)	Excitation of Molecular Gas in Nearby Star Forming Galaxies [PhD Colloquium]
5/22/14	Marcel van Daalen (Leiden Observatory)	Clustering and the formation of galaxies [PhD Colloquium]
6/5/14	Koen Maaskant (Leiden Observatory)	Tracing the Evolution of Protoplanetary Disks [PhD Colloquium]
6/12/14	Akira Endo (Technical University Delft)	The Dawn of Superconducting Astrophotonics
6/19/14	Mordecai-Mark Mac Low (AMNH)	Decretion and Intermittent Heating Leading to Mineral Formation in Magnetized Disks
6/26/14	Steve McMillan (Drexel university)	Dynamical evolution and spatial mixing of multiple population globular clusters

9/4/14	John Kormendy (The University of Texas)	Coevolution (or not) of supermassive black holes and host galaxies [NOVA Colloquium]
9/5/14	John Kormendy (The University of Texas)	Structure and Formation of Elliptical, Spheroidal, and S0 Galaxies [NOVA speaker]
9/16/14	Daniel Harsono (Leiden Observatory)	Protostellar disk formation around low-mass stars [PhD colloquium]
9/17/14	Jean-Chistophe Hamilton (CNRS, Paris)	QUBIC, the QU Bolometric Interferometer for Cosmology
9/19/14	Renske Smit (Leiden Observatory)	Star-forming galaxies at the Cosmic Dawn
9/25/14	Sean Raymon (U. Bordeaux)	Formation of terrestrial exoplanets
10/2/14	Gleb Fedoseev (Leiden Observatory)	Atom addition reactions in interstellar ice analogues; new pathways towards molecular complexity in space.
10/9/14	Gary Ferland (University of Kentucky, USA)	Molecular hydrogen in Crab Nebula filaments
10/16/14	Mitch Begelman (University of Colorado, Boulder)	What Can Tidal Disruption Events Teach Us About Black Hole Accretion?
10/23/14	Dan Caputo (Leiden Observatory)	The symbiosis between black holes and stars in clusters
10/30/14	Kevin Heng (University of Bern, Switzerland)	Exoplanetary Atmospheres: Theory and Simulation
11/6/14	Gerard van Harten (Leiden Observatory)	Spectropolarimetry for planetary exploration
11/10/14	Agata Karska (Obserwatorium Astronomiczne)	”Feedback from deeply embedded protostars probed by Herschel PACS”
11/13/14	Scott Ransom (NRAO Charlottesville, USA)	But wait! There’s more! A Wealth of Science from Millisecond Pulsars

11/20/14	James Dunlop (Institute for Astronomy, University of Edinburgh)	The cosmic history of star formation
11/27/14	Nicola Clementel (Leiden Observatory)	Radiative transfer in Eta Car [PhD Colloquium]
12/4/14	Mattia Fumagalli (Leiden Observatory)	Spectral properties of galaxies from z=2 to z=0 [PhD Colloquium]
12/11/14	Jane R. Rigby (NASA Goddard Space Flight Center)	Galaxy Evolution in High Definition, Via Gravitational Lensing

IV.4 Student Colloquia

Date	**Speaker**	**Title**
01/27/14	Arisa Hatagaya	Searching for exoplanets in the Beta Pictoris System
02/03/14	James Hunter	Galactic Centre Black Hole Effects on Supernovae Evolution
05/12/14	Shannon Vlaar	High redshift quasar candidate selection in RIZ and IZY
05/19/14	Kirstin Doney	Near-Infrared Observational Study of PAH features in the Milky Way and Magellanic Clouds
05/28/14	Steven Duivenvoorden	The Growth of massive black holes in the early universe
06/16/14	Pawel Biernacki	PSF Gaussianization in Kilo-Degree Survey and its application to flexion of galaxies
06/18/14	Geert Talens	A Comparison of Galaxy Morphology Estimators in the EAGLE Simulations
06/23/14	Geoffry Peeters	Constraining particle acceleration in high redshift radio galaxies with LOFAR
06/25/14	Chaoli Zhang	The large scale structures around HzRGs with GMRT and Herschel

06/27/14	Leandra Swiers	Searching for lensed quiescent massive galaxies at redshift 2 using the Deep Extragalactic Survey
09/17/14	Merel van 't Hoff	Tracing the CO snow line in protoplanetary disks with N2H+
10/21/14	Luuk Visser	Design, modelling and performance validation of TreePol: remote detection of homochirality as a signature of life through sensitive spectropolarimetry
11/05/14	Niek Wisse	Tidal Disruptions by a Super-Massive Black Hole: a Numerical Study

IV.5 Colloquia given outside Leiden

Aleman

First Detection of OH+ in Planetary Nebulae, Annual Meeting of the Brazilian Astronomical Society, Armao dos Bzios, Brazil, September 3

Bouwens

Observing the First Galaxies, Oberguergl, Austria; April 28

What current HST observations teach us about galaxy build-up, Dubrovnik, Croatia; May 16

Combining our MUSE redshifts with deep IRAC data to derive the strength of the nebular emission lines in z 4-7 galaxies, Aussois, France; June 3

What current HST observations teach us about galaxy build-up, Dubrovnik, Croatia; June 6

What current HST observations teach us about galaxy build-up, with a prelude to JWST, Geneva, Switzerland; July 1

What current HST observations teach us about galaxy build-up,, Geneva, Switzerland; July 4

Galaxy Build-up and Evolution in the First 2 Billion Years of the Universe, University of California, Santa Cruz, California, USA; August 11

What current samples of z=9-10 candidates from CANDELS, the HUDF, and the Frontier Fields tell us about future science with WISH; September 24

Observing the Build-up of Galaxies in the Early Universe with Hubble and Spitzer, Anton Pannekoek institute for Astronomy; October 1
UV Luminosity Evolution z=4 to z=10, Past Results and Future Results Including the Frontier Fields, Yale University, New Haven, Connecticut, USA; November 12
First Light WFIRST-AFTA Which Requirements would allow us to do the Best Science?, IPAC, Pasadena, California, USA; November 18

Brandl
Brandl Introduction to Astronomy, invited lecture course, TU Delft, January
Exoplanet Science with METIS, ESO, Garching, Germany, February 5
IFU Spectroscopy with METIS, Milton Keynes, UK, March 10
The Mid-Infrared E-ELT Imager and Spectrograph, SPIE, Montreal, Canada, June 26
METIS Overview, CEA Saclay, France, October 2nd
Star Formation in W49A, ESTEC, Noordwijk, the Netherlands, November 12
The Mid-Infrared E-ELT Imager and Spectrograph, Stewart Observatory, Tucson, USA, December 5

Brinchmann
A decade of stellar masses in the SDSS, Groningen, the Netherlands; November 25
The HDFS overall sample properties & lessons learned, MUSE consortium meeting, Haarlem, the Netherlands; November 3-7.
Galaxy formation, lectures at NOVA autumn school, Dwingeloo, the Netherlands; October 6-10
The M-Z-something relation, invited talk at IAP, Paris, France; June 26
MUSEWISE - An update, MUSE consortium meeting, Aussois, France; Jun 3
The Galaxy & AGN Evolution Science Working Group, Euclid consortium meeting, Marseille, France; May 14

Brown
Gaia and Gould's Belt, Star Formation and Galactic Structure: A centennial cruise honoring Adriaan Blaauw as cartographer of the heavens, Groningen, April 7
Gaia Data Processing — for real now, EWASS, Geneva, Switzerland, June 30
Gaia data processing, Fifth Gaia Science Alerts Workshop, Warsaw, Poland, September 9

DPAC status, Gaia Operations Workshop, Tenerife, Spain, November 19
Thoughts on Future Space Astrometry Missions, The Milky Way Unravelled by Gaia: GREAT Science from the Gaia Data Releases, Barcelona, Spain, December 5

Candian
Armchair PAHs and the 12.7 micron band,3rd NASA-DAN-PEPsci bilateral meeting, Mountain View, US; May 2014
idem, International Conference on Interstellar Dust, Molecules and Chemistry, Tezpur, India; December 2014

van der Marel
Planet formation in action; a major asymmetric dust trap in a protoplanetary disk, Fysica 2014 Young Speaker Contest Finals, Leiden, Netherlands, April 1
Idem, Herzberg Astrophysics institute, Victoria, Canada, April 17

Van Delft
Philips Research. Honderd jaar uitvindingen die ertoe doen. Philips Museum Eindhoven, January 26
Leve het vrijdagmiddagonderzoek! What?s New? De Nieuwe Zakelijkheid, Panningen, March 13
Museum Boerhaave, Society and the Real Thing, Micheletti Award, Glasgow, April 25
Philips Research. 100 Jaar uitvindingen die ertoe doen. KIVI Eindhoven, August 26
The oldest Dutch telescope, ImPhys Science Day, TU Delft, October 7

van Dishoeck
Zooming into planet-forming zones of disks: sweet results from ALMA ANU Mt. Stromlo, Canberra, Australia; May 1
Disks in the embedded phase of star formation: observations vs theory Universidad de Chile, Santiago, Chile, August 21
Building stars, planets and the ingredients for life between the stars Chalmers University, Gothenburg, Sweden, September 19 (Lise Meitner award lecture)
Water in space: from interstellar clouds to planets Queens University, Belfast, UK, November 11

Drozdovskaya

Methanol along the Path from Envelope to Protoplanetary Disk, LYDAN, Leiden, The Netherlands; January 14

Idem, University of Bern, Bern, Switzerland; May 2

Idem, 40th COSPAR Scientific Assembly, Moscow, Russian Federation; August 6

Franse

An Unidentified Line in X-ray Spectra of the Andromeda Galaxy and Perseus Galaxy Cluster, 19th APP in NL Symposium, Beekbergen, Netherlands; March 28

Idem, National Astronomy Conference, Noordwijkerhout, Netherlands; May 21

Idem, SUSY 2014, Univ. of Manchester, United Kingdom; July 21

An Unidentified Line in X-ray Spectra of the Andromeda Galaxy and Perseus Galaxy Cluster and the Galactic Center, COSMO 2014, KICP, Chicago, USA; August 26

Idem, nuMSM and Structure Formation Workshop, GRAPPA, Amsterdam, Netherlands; July 7

Idem, 4th APS meeting, GRAPPA, Amsterdam, Netherlands; September 30

Furuya

Water dueteration in protoplanetary disks: effect of mixing, Chalmers University of Technology, Sweden; June 10

Ginski

Astrometric monitoring of the GQ Lup system, ESO, Garching, Germany, November 26th

Haverkorn

The Galactic Magnetic Field, Stellenbosch Institute for Advanced Study, Stellenbosch, South-Africa, Feb 20

The moiling and magnetized Milky Way, Max-Planck-Institute for Radio Astronomy, Bonn, Germany, Mar 31

Galactic Mahgnetism, Lorentz Center, Leiden, May 20

Interstellar Turbulence, Kapteyn Institute, Groningen, June 30

Cosmic Magnetic Fields: current knowledge and future ideas, Jagiellonian University, Krakow, Poland; Oct 21

The Galactic Magnetic Field, International Space Science Institute, Bern, Switzerland, Dec 8

Hoekstra
Cosmology and more with Euclid, NAC, Noordwijkerhout, May 19-21
Weak lensing overview, Euclid Consortium Meeting, Marseille, France, May 5-9
Accurate cluster masses, CIfAR meeting, Quebec City, Canada, May 23-26
Dark matter in clusters from gravitational lensing, EWASS, Geneva, June 3-4
Weak lensing overview, Euclid Consortium Meeting, Marseille, FR, 5-9 May 2014
Presentation at CIfAR meeting, Quebec City, Canada, 23-26 May 2014
Weak lensing by large-scale structure, ESTEC, Noordwijk, January 18
idem, Birmingam, UK, February 6
Cluster masses and profiles, Madonna di Campiglio, Italy, March 18-22
Dark energy workshop, Clermont-Ferrand, France, April 13
CosmoLens, Marseille, France, Mary 27-30
Ripples in the Cosmos, conference, Durham, UK, July 22-26

Hogerheijde
ALMA probes the formation and evolution of stars and planetary systems, NAC, Noordwijkerhout; May 20
MMtron and searching for water in planet-forming disks, Science with a 10-m cooled FIR space telescope, Paris; May 17
From protoplanetary to debris disks: formation and evolution, EWASS/(sub)mm astronomy in the ALMA era, Geneva; June 4

Holwerda
What can the Occult do for you? - Observations of Dust in Nearby Galaxies, 2-3, December, Tucson, USA
What can the Occult do for you? - GAMA team meeting, Cape Town, South Africa,

Kaastra
Anatomy of the AGN in NGC 5548: discovery of a fast and massive outflow, The X-ray Universe 2014, Dublin, Ireland; June 18
Photoionised plasma analysis, Tokyo Metropolitan University, Tokyo, Japan; September 6

Absorption features and edges, Tokyo Metropolitan University, Tokyo, Japan; September 7

Kama

DISCO: carbon and oxygen, from disks to planets, PEPSci meeting, University of Amsterdam, the Netherlands; October 31
Depletion of chlorine into HCl ice in a protostar, Leiden Observatory Astrochemistry Seminar, the Netherlands; October 7
Gaseous carbon from disks to planets, Planet Formation and Evolution conference, Kiel University, Germany; September 8
The cosmic journey of some elements, Anton Pannekoek Institute for Astronomy, Amsterdam, the Netherlands; May 13
Astrochemical studies of protostars and disks, Research Institute in Astrophysics and Planetology, Toulouse, France; February 6
Dutch Galactic science with APEX, Science with APEX workshop, Ringberg, Germany; January 21

Keller

Polarimetry with the E-ELT, ESO, Garching, Germany; January 24
Fun with Photons, Biopartners, Leiden, The Netherlands, February 6
idem, TNO, Delft, The Netherlands, June 19
Fun with Photons Exoplanets, Aerosols and Microscopes, NOAO, Tucson, USA; March 14
Towards Polarimetric Exoplanet Imaging with ELTs, Exoplanets, Biosignatures & Instruments 2014, Tucson, USA; 20 March
High-Contrast Polarimetry: Lessons Learned, Lorentz Center, Leiden, The Netherlands; 25 March
Some Thoughts on Focal-Plane Wavefront Sensing, TU Delft, The Netherlands; April 17
Characterizing Exoplanets and the PEPSci Rocky Exoplanets Theme, NASA AMES, Moffet Field, USA; May 28
All-In-One: A Combined Coronagraph and Focal-Plane Wavefront Sensor for Exoplanet Characterization, Lorentz Center, Leiden, The Netherlands; October 7

Kenworthy

The giant ring system seen in eclipse around J1407b, University College London,

Britain; October 27
idem, Royal Observatory Edinburgh, Britain; October 15
idem, University of Rochester, USA; June 19
idem, 69th Dutch Astronomy Conference, Leiden, the Netherlands; May 19
Successes and Challenges in Directly Imaging Planets around Nearby Stars, LUMC Imaging Group, Leiden, Netherlands; April 07
Focal-Plane Wavefront Sensing with Coronagraphs for High-Contrast Imaging, Gordon Research Conference, USA; June 11
Characterization of the large multiple ring system seen in transit around the young substellar companion J1407b, Arizona State University, USA; March 28

de Kok

The surprising composition of Titan's southern polar cloud, DPS, Tucson, USA, November 10

Krijt

How to overcome obstacles in planetesimal formation, University of California, Berkeley, United States; September 3
Idem, Southwest Research Institute, Boulder, United States; September 9
Compaction and erosion of rapidly growing icy planetesimals, Massachusetts Institute of Technology, Cambridge, United States; September 16
Idem, Harvard University, Cambridge, United States; September 17

Kuijken

Status of the KiDS Survey, Capodimonte Observatory, Naples; March 18
Status of the KiDS Survey, ATLAS science conference, Durham University, UK; April 15
Evolution of galaxies and large-scale structure, symposium George Lemaitre's Big Bang, Leuven, Belgium; May 7
KiDS and GAMA, GAMA workshop, University of Cape Town, South Africa; Sept 10
First results from the KiDS survey, colloquium, Arizona State University, Phoenix, USA; Oct 20

Labbe

A hidden phase of massive galaxies, Aspen, USA, Feb 6

Discovery of massive quiescent galaxies in the early universe with ZFOURGE, Swinburne, Mar 19
The first billion years of Galaxy formation, Swinburne, AU, Apr 8
idem, Sydney, AU, Apr 14
idem, Canberra, AU, Apr 24
The earliest massive galaxies, Zion, USA, Sep 11

van Langevelde
Molecular masers in the Milky Way, Colloquium, Nijmegen, 4 March
From the DRT to VLBI, zooming in on circumstellar masers, Mini symposium dedication of the Dwingeloo radio telescope, Dwingeloo, 4 April
Masers as tools for star formation and probes of Galactic structure, Blaauw workshop on Star formation and Galactic structure, Groningen, 8 April
The EVN (and AVN) for Galactic science as a SKA pathfinder, Lorentz workshop on Galactic Science with the SKA and its pathfinders, Leiden, 23 May
VLBI with ALMA, EWASS 2014, Geneva Switzerland
Conference summary, EVN Symposium, Cagliari Italy, 10 October

Linnartz
DAN Midterm, Amsterdam, December
DIB meeting, Leiden, December
EUCMOS2014, Duesseldorf, September
NASA-ARC/DAN workshop, SETI, Sunnyvale, May
Marie Curie Colloquium, Radboud University Nijmegen, May
Colloquium DIFFER, FOM Institute, Nieuwegein, April
PAC symposium, Utrecht, March

Van Lunteren
Concluding Commentary, Conference The Second Scientific Revolution, Museum Boerhaave, Leiden, May 24
Frederik Kaiser and the co-creation of popular and professional science, 26th Baltic Conference in History of Science: 'Science as Profession', Helsinki, Finland, August 22
The conservation of energy in The Netherlands, 1850-1875, Meeting of the European Society for the History of Science, Lissabon, Portugal, September, 6

De academische vrijheid en het universitaire grootbedrijf in de 20ste eeuw, Symposium Academische Vrijheid, Groningen, September 12
The rise and decline of the 'laws of nature', Science Faculty Colloquium, VU Amsterdam, September 25
The conservation of energy in The Netherlands, Annual Meeting of the History of Science Society, Chicago, USA, November 10

Mottram
Waterfalls, fountains and water bombs: infall, outflows and shocks in solar-mass protostars traced by rotational lines of water, ASTRON/JIVE, The Netherlands; April 3
Infall rates from observations, Oort Workshop 2014: Episodic Accretion, Lorentz Centre, Leiden, May 14
Tracing protostellar environments with H2O and CO: from low to high mass with Herschel, Star Formation Across Space and Time conference, ESTEC, The Netherlands, November 11

Otten
Vector Apodizing Phase Plate coronagraph, NAC, Noordwijk, May 21
idem, SPIE Astronomical Telescopes and Instrumentation Conference, Montreal, Canada, June 26

Persson
Herschel observations of cold H2O and its OPR in planet-forming disks, Nuclear Spin Effects in Astrochemistry, Chalmers University, Gothenburg, Sweden, June 10
The water D/H ratio in solar system analogs, NAC meeting, Noordwijkerhout, The Netherlands, May 20
The water D/H ratio toward young solar-system analogs, Astronomdagarna, Lund Observatory, Lund, Sweden, October 10

Petrignani
LEAPS: Gas Phase Spectroscopy of Astronomical PAHs ? Ion Flight Simulation, FELIX Facility, Nijmegen, The Netherlands; September 16
Spectroscopy of PAHs using the FELICE intra-cavity FTICR MS, Radboud University Nijmegen, Nijmegen, The Netherlands, May 16

Spectroscopy of Astronomical PAHs Up Close, NASA ARC ? NWO PEPSci/DAN, SETI Institute, Mountain View, California, USA, May 28

Portegies Zwart

Precision reconstruction of HU Aqr, Anglander Institute, Bonn, Germany; March 5
Superrekenen in de sterren, SARA, Amsterdam, NL, March 13
The curious case of HLX-1, Lorentz Center, Leiden, NL, April 1
The Astronomical Multipurpose Software Environment, Technion, Israel, April 7
Reconstrcuting the history of post common-envelope binaries , Haifa, Israel, April 8
The solar siblings, MPE, Bonn, May 14
Supercomping in the Netherlands, Athens, Greece, June 2
The evolution of open star clusters, Bad Honneff, Germany, June 5
N-body dynamics on accelerator hardware, Chefalu, Italy, September 9
HPC astro simulations on GPUs, PEZY, Japan, Japan, October 27
Simulating the galaxy on Titan, RIKEN, Kobe, Japan, October 28
The Galaxy in Silico, LNeSC Lelystad, NL, November 6
Simulating the galaxy on 20000GPUs, New Orleans, US, November 18
AMUSE for star cluster simulations, RIKEN, Kobe, Japan, December 9
Long term weather simulations using AMUSE, Utrecht, NL, December 17

Rigby

Searching for protoclusters in the far-infrared with Herschel/SPIRE, ASTRON, Netherlands, February 6

Rosdahl

Stellar radiation feedback in a galactic disk with radiation-hydrodynamics Virgo Consortium meeting, Leiden, Netherlands, Jan 23rd.
Stellar feedback in a galactic disk with HD and RHD KITP conference, 'Fire Down Below', Santa Barbara, USA, April 14th.
Galaxies That Shine: stellar radiation feedback on a galactic scale National Astronomy meeting, Portsmouth, UK, June 26th.
RAMSES-RT developments and results on radiation feedback RAMSES users meeting, Saclay, France, June 27th.

Galaxy-scale RHD with Ramses-RT Virgo Consortium meeting, Garching, Germany, Dec 19th

Rossi
Hypervelocity stars, conference on Galactic Centre, Alajar, Spain, September, 25
Jets from Tidal Disruption Events, RU, Nijmegen, October, 22
Idem, Monte Porzio Observatory, Rome, July, 17
Observing Jets from Tidal Disruption Events with LOFT, INAF/IAPS ROME, November, 12
Hypervelocity stars in the Gaia Era, University of Barcelona, Spain, December, 4
Formation of Supermassive black holes: a review, Bicocca University, Milan, December, 10
Tidal Disruption events, Universita' Statale, Milano, December, 18

Röttgering
LOFAR Science week 2014, Amsterdam, April 7-11
Euclid Consortium Meeting 2014, Marseille, France, May 5-9
Galaxies in 3D across the Universe, Vienna, Austria, July 7-11
The formation and evolution of galaxy clusters and proto-clusters: Recent results from optical, IR, X-ray and LOFAR radio studies, colloquium, Cambridge, UK, Oct 14
LOFAR observation of radio relics in clusters of galaxies, 8th Korean Astrophysics Workshop on Astrophysics of High-Beta Plasma in the Universe, Jeju Island, South-Korea, Nov 10-13
The Synergy of Combining the Radio and WFIRST, Wide-field InfraRed Surveys: Science and Techniques, Pasadena, Nov 17-20
Synergie with Euclid, Wide-field InfraRed Surveys: Science and Techniques, Pasadena, Nov 17-20

Schaye
Galactic superwinds: beyond phenomenology, Puerto Rico, March 24
The impact of feedback on star and galaxy formation, Santa Barbara, USA, April 18
The formation and growth of galaxies in the young universe, Obergurgl, Austria, April 27
Quenching and quiescence, MPiA, Heidelberg, Germany, July 18

Gas in and around galaxies, Ringberg, Germany, May 13
The EAGLE project, Nationale Astronomen Conferentie, Noordwijk, May 20
Cosmological simulations of the formation of galaxies, Stockholm University, Stockholm, Sweden, September 26
Idem, University of Leicester, UK, October 15
Idem, CITA, Toronto, Canada, November 25

Snellen
Finding Extraterrestrial Life using ground-based high-dispersion spectroscopy, Cambridge, UK, 27 February
Characterizing the atmospheres of transiting planets from the ground, Searchign for lief beyond the solar system, Tucson Az, USA, 19 March
Exoplanet Atmosphere Spectroscopy, Quy Non, Vietnam, 23 April
Future of groundbased characterization of exoplanet atmospheres, NASA Aimes, 28 May
Exoplanet atmosphere spectroscopy, Towards Other Earths, Porto, Portugal, 16 September

Sobral
H-alpha surveys at z=2-7, WISH workshop, LAM, Marseille, Sep 24
2014 ENAA (Prize for Best ESO talk), Porto, PT, 18 July
IAU S309: ?Galaxies in 3D across the Universe?, Vienna, Austria, 10 July
Subaru Seminar, NAOJ, Hilo, Hawaii, 27 May
Galaxy Formation and Evolution from the Early Universe to Today, Croatia, 12 May
Exploring the Universe in 3D with MUSE, KMOS and ALMA, Garching, 13 Mar

Straatman
Discovery of massive compact quiescent galaxies at redshift four with ZFOURGE, ASA Annual Scientific meeting, Maquarie University, Sydney, Australia, July 22nd
High Redshift Galaxies and Early Retirement, Center for Astrophysics and Supercomputing, Swinburne University, Melbourne, Australia, September 11th

Tobin
The Formation of Protostellar Disks and Multiple Star Systems, Yale University,

New Haven, USA; Oct 9
Evidence for Disks in the Embedded Class 0 Phase, University of Michigan, Ann Arbor, USA; Oct 12
A Complete Census of Dense Cores in Chamaeleon I: Results from an ALMA Cycle 1 Survey, ESTEC, Noordwijk, The Netherlands; Nov 11

Toonen
Binary Population Synthesis: Implications for Common Envelope Evolution", Lake Louise, Canada
Stellar tango at the rockies '14, March 26th

van der Werf
Radiative and Mechanical feedback in (Ultra)luminous infrared galaxies, Ringberg, Germany; January 21
idem, Sesto, Italy; July 17

Appendix V

Grants

Grants

Appendix V

Only major grants above €12,000,-

Kenworthy
NWO-NRF, 'Development of an Economical Adaptive Optics System', €12.000

Kuijken
NWO-EW TOP grant, "Testing Gravity on the Largest Scales with KiDS and Friends", €645,000

Keller
EU H2020 - ICT 2014, "The International Year of Light in Europe 2105" , €260.000
Avantes, "HAWKEYE", €30.000
ESA, Education for Earth Observation capitalizing on a Citizen Science Approach, €17.000

Labbe
NWO-TOP2 The Earliest Red Galaxies in the Universe, EU, €151,000

Miley, Brinchman and Russo
EU H2020 - COMPET, "EU - Space Awareness" €680.000
NWO KIEM, "Astronomy Training Videos for Elementary School Teachers", €15.000
SpaceScoop - astroEDU, "Universe Awareness" €28.000

Portegies Zwart
ORCL TITAN, Gordon Bell Preparation, 10 Million node hours
CSCS Piz Daint, Fine structure of the Galaxy, 27 Million node hours

Netherlands eScience Center, 'ABCMUSE: The Generalization and the Optimization of the Multi-purpose Software Environment', €250,000

Rossi

Astroparticle Physics Program, NWO, "Compact Objects as Gravitational Wave Sources", €215.000
TOP2, NWO, "Discovery More Hypervelocity Stars to Shed Light on the Galaxy", €221.000

Röttgering

NWO Big Bang Big Data, "The Computer Science Challenge of Calibrating the Ionosphere over the SKA Sky", €216.000
Nationale roadmap grootschalige onderzoeksfaciliteiten 2014: Square Kilometer Array, 600Keuro

Snellen

NWO, "Observing the Atmospheres of Super-Earths and Rocky Exoplanets", €25.000

Tobin

VENI, NWO, 'Revealing the Origins of Solar Systems: Examining the Formation of Proto-Planetary Disks and Binary Stars', €250.000

Appendix VI

Scientific publications

Scientific publications

Appendix VI

VI.1 Ph.D. Theses

A total of 16 graduate students successfully defended their Ph.D. thesis in 2014 and were awarded their Ph.D. degree. They are in order of date:

N. Clementel	Casting the light on the Carinae puzzle
G. Fedoseev	Atom Addition Reactions in Interstellar Ice - new pathways towards molecular complexity in space
M.P. Daalen, van	Galaxy formation and the structure of the Universe
G. Harten, van	Spectropolarimetry for planetary exploration
T. J. C. Hengel, van	The Diving Dutchman
J. Sande, van de	Dawn of the Red and Dead: Stellar Kinematics of Massive Quiescent Galaxies out to z = 2
D.S. Harsono	Unveiling Protostellar Disk Formation around Low-Mass Stars
A. Karska	Feedback from deeply embedded low- and high-mass protostars
M.J. Rosenberg	Causing a stir: radiative and mechanical feedback in starburst galaxies
J. Bedorf	The Gravitational Billion Body Problem
T.I.M. Werkhoven, van	Lasers, lenses and light curves: adaptive optics microscopy and peculiar transiting exoplanets
K.M. Maaskant	Tracing the evolution of protoplanetary disks
M. Brogi	Atmosheres of hot alien Worlds
R.F.J. Burg, van der	The distribution of stellar mass in galaxy clusters over cosmic time
M. Iacobelli	Exploring the magnetic, turbulent Milky Way through radio waves
S. Verdolini	Modeling interstellar bubbles: near and far

VI.2 Publications in refereed journals

Alatalo, K, and 30 co-authors, including **Zeeuw de, P**, NGC 1266 as a Local Candidate for Rapid Cessation of Star Formation, *ApJ*, 2014, **780**, 186

Albrecht, S, and 10 co-authors, including **Snellen, I**, The BANANA Project. V. Misaligned and Precessing Stellar Rotation Axes in CV Velorum, *ApJ*, 2014, **785**, 83

Aleman, I, and 17 co-authors, including **Tielens, A**, Herschel Planetary Nebula Survey (HerPlaNS). First detection of OH^+ in planetary nebulae, *A&A*, 2014, **566**, A79

André, P, and 141 co-authors, including **Chluba, J**, **Haverkorn, M**, **Schillaci, A**, **Van, TentB**, PRISM (Polarized Radiation Imaging and Spectroscopy Mission): an extended white paper, *Journal of Cosmology and Astroparticle Physics*, 2014, **2**, 6

Anglés-Alcázar, D, and 3 co-authors, including **Oppenheimer, B**, Cosmological Zoom Simulations of z = 2 Galaxies: The Impact of Galactic Outflows, *ApJ*, 2014, **782**, 84

Antonello, J, and 5 co-authors, including **Werkhoven van, T**, Optimization-based wavefront sensorless adaptive optics for multiphoton microscopy, *Journal of the Optical Society of America A*, 2014, **31**, 1337

Aresu, G, and 10 co-authors, including **Meijerink, R**, [O I] disk emission in the Taurus star-forming region, *A&A*, 2014, **566**, A14

Ashby, M, and 20 co-authors, including **Muzzin, A**, Erratum: ''The Spitzer South Pole Telescope Deep Field: Survey Design and Infrared Array Camera Catalogs'' (2013, ApJS, 209, 22), *ApJ*, 2014, **212**, 16

Aykutalp, A, and 3 co-authors, including **Meijerink, R**, Songlines from Direct Collapse Seed Black Holes: Effects of X-Rays on Black Hole Growth and Stellar Populations, *ApJ*, 2014, **797**, 139

Bagnoli, T., and 3 co-authors, including **Patruno, A.**, Double-peaked thermonuclear bursts at the soft-hard state transition in the Rapid Burster, *MNRAS*, 2014, **437**, 2790

Bailey, V, and 16 co-authors, including **Meshkat, T**, **Kenworthy, M**, HD 106906b: A Planetary-mass Companion Outside a Massive Debris Disk, *ApJ*, 2014, **780**, L4

Baldry, I, and 19 co-authors, including **Holwerda, B**, Galaxy And Mass Assembly (GAMA): AUTOZ spectral redshift measurements, confidence and errors, *MNRAS*, 2014, **441**, 2440

Balogh, M, and 8 co-authors, including **McGee, S**, The GEEC2 spectroscopic survey of Galaxy groups at $0.8 < z < 1$, *MNRAS*, 2014, **443**, 2679

Barone-Nugent, R, and 10 co-authors, including **Bouwens, R**, **Labbe, I**, Measurement of Galaxy Clustering at $z \sim 7.2$ and the Evolution of Galaxy Bias from $3.8 < z < 8$ in the XDF, GOODS-S, and GOODS-N, *ApJ*, 2014, **793**, 17

Bartkiewicz, A, and 2 co-authors, including **Langevelde van, H**, European VLBI Network observations of 6.7 GHz methanol masers in clusters of massive young stellar objects, *A&A*, 2014, **564**, A110

Bassa, C, and 12 co-authors, including **Patruno, A**, A state change in the low-mass X-ray binary XSS J12270-4859, *MNRAS*, 2014, **441**, 1825

Best, P, and 4 co-authors, including **Rigby, E**, The cosmic evolution of radio-AGN feedback to $z = 1$, *MNRAS*, 2014, **445**, 955

Biller, B, and 15 co-authors, including **Juhász, A**, An Enigmatic Point-like Feature within the HD 169142 Transitional Disk, *ApJ*, 2014, **792**, L22

Birkby, J, and 37 co-authors, including **Kenworthy, M**, **Nefs, S**, **Snellen, I**, WTS-2 b: a hot Jupiter orbiting near its tidal destruction radius around a K dwarf, *MNRAS*, 2014, **440**, 1470

Bogdanov, S, and 6 co-authors, including **Patruno, A**, X-Ray Observations of XSS J12270-4859 in a New Low State: A Transformation to a Disk-free Rotation-powered Pulsar Binary, *ApJ*, 2014, **789**, 40

Bonafede, A, and 10 co-authors, including **Röttgering, H**, A giant radio halo in the cool core cluster CL1821+643, *MNRAS*, 2014, **444**, L44

Bonafede, A, and 7 co-authors, including **Röttgering, H**, Evidence for Particle Re-acceleration in the Radio Relic in the Galaxy Cluster PLCKG287.0+32.9, *ApJ*, 2014, **785**, 1

Bordoloi, R, and 14 co-authors, including **Oppenheimer, B**, The COS-Dwarfs Survey: The Carbon Reservoir around Sub-L* Galaxies, *ApJ*, 2014, **796**, 136

Bossa, J, and 8 co-authors, including **Paardekooper, D**, **Tielens, A**, **Linnartz,**

H, Porosity measurements of interstellar ice mixtures using optical laser interference and extended effective medium approximations, *A&A*, 2014, **561**, A136

Bossa, J, and 4 co-authors, Laboratory spectroscopy of 1, 2-propanediol at millimeter and submillimeter wavelengths, *A&A*, 2014, **570**, A12

Bouwens, R, and 36 co-authors, including **Franx, M**, **Smit, R**, **Labbé, I**, A Census of Star-forming Galaxies in the Z ~ 9-10 Universe based on HST+Spitzer Observations over 19 Clash Clusters: Three Candidate Z ~ 9-10 Galaxies and Improved Constraints on the Star Formation Rate Density at Z ~ 9.2, *ApJ*, 2014, **795**, 126

Bouwens, R, and 9 co-authors, including **Labbé, I**, **Franx, M**, **Smit, R**, UV-continuum Slopes of >4000 z ~ 4-8 Galaxies from the HUDF/XDF, HUDF09, ERS, CANDELS-South, and CANDELS-North Fields, *ApJ*, 2014, **793**, 115

Boyarsky, A, and 3 co-authors, including **Franse, J**, Unidentified Line in X-Ray Spectra of the Andromeda Galaxy and Perseus Galaxy Cluster, *Physical Review Letters*, 2014, **113**, 251301

Brogi, M, and 4 co-authors, including **Kok de, R**, **Birkby, J**, **Schwarz, H**, **Snellen, I**, Carbon monoxide and water vapor in the atmosphere of the non-transiting exoplanet HD 179949 b, *A&A*, 2014, **565**, A124

Brown, M, and 8 co-authors, including **Brandl, B**, An Atlas of Galaxy Spectral Energy Distributions from the Ultraviolet to the Mid-infrared, *ApJ, Supplement*, 2014, **212**, 18

Bruderer, S, and 3 co-authors, including **Marel, N**, **Dishoeck van, E**, **Kempen van, T**, Gas structure inside dust cavities of transition disks: Ophiuchus IRS 48 observed by ALMA, *A&A*, 2014, **562**, A26

Burg van der, R, and 5 co-authors, including **Muzzin, A**, **Hoekstra, H**, A census of stellar mass in ten massive haloes at z ~ 1 from the GCLASS Survey, *A&A*, 2014, **561**, A79

Cacciato, M., and 2 co-authors, including **Hoekstra, H.**, Describing galaxy weak lensing measurements from tenths to tens of Mpc and up to z 0.6 with a single model, *MNRAS*, 2014, **437**, 377

Calapa, M, and 12 co-authors, including **Werf van der, P**, **Israel, F**, The Heating of Mid-infrared Dust in the Nearby Galaxy M33: A Testbed for Tracing Galaxy Evolution, *ApJ*, 2014, **784**, 130

Cappetta, M, and 37 co-authors, including **Birkby, J**, **Snellen, I**, Erratum: The first planet detected in the WTS: an inflated hot-Jupiter in a 3.35 d orbit around a late F star, *MNRAS*, 2014, **444**, 3150

Caputo, D, and 2 co-authors, including **Vries de, N**, On the effects of subvirial initial conditions and the birth temperature of R136, *MNRAS*, 2014, **445**, 674

Castellanos-Nash, P, and 4 co-authors, including **Tielens, A**, C_{60} in Photodissociation Regions, *ApJ*, 2014, **794**, 83

Ceccarelli, C, and 6 co-authors, including **Kama, M**, Herschel Finds Evidence for Stellar Wind Particles in a Protostellar Envelope: Is This What Happened to the Young Sun?, *ApJ*, 2014, **790**, L1

Chesneau, O, and 22 co-authors, including **Genderen van, A**, The yellow hypergiant HR 5171 A: Resolving a massive interacting binary in the common envelope phase, *A&A*, 2014, **563**, A71

Clementel, N, and 4 co-authors, including **Icke, V**, 3D radiative transfer in η Carinae: application of the SIMPLEX algorithm to 3D SPH simulations of binary colliding winds, *MNRAS*, 2014, **443**, 2475

Cluver, M, and 24 co-authors, including **Holwerda, B**, Galaxy and Mass Assembly (GAMA): Mid-infrared Properties and Empirical Relations from WISE, *ApJ*, 2014, **782**, 90

Coenen, T, and 89 co-authors, including **Garrett, M**, **Röttgering, H**, The LOFAR pilot surveys for pulsars and fast radio transients, *A&A*, 2014, **570**, A60

Connor, T, and 6 co-authors, including **Hoekstra, H**, Scaling Relations and X-Ray Properties of Moderate-luminosity Galaxy Clusters from $0.3 < z < 0.6$ with XMM-Newton, *ApJ*, 2014, **794**, 48

Cooke, E, and 4 co-authors, including **Rigby, E**, A $z = 2.5$ protocluster associated with the radio galaxy MRC 2104-242: star formation and differing mass functions in dense environments, *MNRAS*, 2014, **440**, 3262

Courteau, S, and 10 co-authors, including **Hoekstra, H**, Galaxy masses, *Reviews of Modern Physics*, 2014, **86**, 47

Coutens, A, and 5 co-authors, including **Persson, M**, **Dishoeck van, E**, High D_2O/HDO Ratio in the Inner Regions of the Low-mass Protostar NGC 1333 IRAS2A, *ApJ*, 2014, **792**, L5

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Cox, N, and 7 co-authors, including **Ochsendorf, B**, VLT/X-Shooter survey of near-infrared diffuse interstellar bands, *A&A*, 2014, **569**, A117

Paardekooper, D M, and 3 co-authors, including **K., Isokoski**, **and, H.Linnartz**, Laser desorption time-of-flight mass spectrometry of ultraviolet photo-processed ices, *Review of Scientific Instruments*, 2014, **85**,

Daalen van, M, and 4 co-authors, including **Schaye, J**, The impact of baryonic processes on the two-point correlation functions of galaxies, subhaloes and matter, *MNRAS*, 2014, **440**, 2997

Dall'Osso, S, and **Rossi, E**, Constraining white dwarf viscosity through tidal heating in detached binary systems, *MNRAS*, 2014, **443**, 1057

Dannerbauer, H, and 18 co-authors, including **Miley, G**, **Röttgering, H**, An excess of dusty starbursts related to the Spiderweb galaxy, *A&A*, 2014, **570**, A55

Davis, T, and 24 co-authors, including **Zeeuw de, P**, The ATLAS^{3D} Project - XXVIII. Dynamically driven star formation suppression in early-type galaxies, *MNRAS*, 2014, **444**, 3427

De Lucia, G, and 2 co-authors, including **Muzzin, A**, **Weinmann, S**, What Regulates Galaxy Evolution? Open questions in our understanding of galaxy formation and evolution, *New Astronomy Review*, 2014, **62**, 1

Defrère, D, and 22 co-authors, including **Kenworthy, M**, L'-band AGPM vector vortex coronagraph's first light on LBTI/LMIRCAM, *Search for Life Beyond the Solar System. Exoplanets, Biosignatures & Instruments*, 2014, 4P

Di Noia, A, and 9 co-authors, including **Harten, G**, **Snik, F**, **Boer, J**, Use of neural networks in ground-based aerosol retrievals from multi-angle spectropolarimetric observations, *Atmospheric Measurement Techniques Discussions*, 2014, **7**, 9047

Donahue, M, and 37 co-authors, including **Bouwens, R**, CLASH-X: A Comparison of Lensing and X-Ray Techniques for Measuring the Mass Profiles of Galaxy Clusters, *ApJ*, 2014, **794**, 136

Drozdovskaya, M, and 4 co-authors, including **Walsh, C**, **Harsono, D**, **Dishoeck van, E**, Methanol along the path from envelope to protoplanetary disc, *MNRAS*, 2014, **445**, 913

Druard, C, and 13 co-authors, including **Werf van der, P**, The IRAM M 33 CO(2-1) survey. A complete census of molecular gas out to 7 kpc, *A&A*, 2014, **567**, A118

Eidelsberg, M, and 9 co-authors, including **Heays, A N**, High-resolution study of oscillator strengths and predissociation rates for 13C16O and 12C18O, *Astron. Astrophys.*, 2014, **566**, A96

Ellerbroek, L, and 23 co-authors, including **Klaassen, P**, Relating jet structure to photometric variability: the Herbig Ae star HD 163296, *A&A*, 2014, **563**, A87

Elteren van, A, and 2 co-authors, including **Pelupessy, I**, Multi-scale and multi-domain computational astrophysics, *Royal Society of London Philosophical Transactions Series A*, 2014, **372**, 30385

Emonts, B, and 21 co-authors, including **Miley, G**, **Röttgering, H**, **Stroe, A**, CO(1-0) survey of high-z radio galaxies: alignment of molecular halo gas with distant radio sources, *MNRAS*, 2014, **438**, 2898

Erfanianfar, G, and 32 co-authors, including **Balogh, M**, The evolution of star formation activity in galaxy groups, *MNRAS*, 2014, **445**, 2725

Fedeli, C, and 5 co-authors, including **Semboloni, E**, **Velliscig, M**, **Daalen van, M**, **Schaye, J**, **Hoekstra, H**, The clustering of baryonic matter. II: halo model and hydrodynamic simulations, *Journal of Cosmology and Astroparticle Physics*, 2014, **8**, 28

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