Research Institute Leiden Observatory

(Onderzoekinstituut Sterrewacht Leiden)

Annual Report 2003

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Front cover: True-colour JHK_s image of Centaurus A, obtained with SOFI on the ESO NTT by Van der Werf and Menéndez-Delmestre (see section 2.6.4).

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Production Annual Report 2003:
F. P. Israel, J. Lub, L. Snijders, D. Schnitzeler, L. van der Veld

Sterrewacht Leiden

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Sterrewacht Leiden

Review of major events

Chapter 1

The year 2003 saw an important change: four new staff members arrived. Bernhard Brandl from Cornell joined the optical/infrared instrumentation effort, Michiel Hogerheijde from Steward Observatory brought much expertise in millimeter wave astronomy and starformation, and Stephan Schlemmer from Chemnitz succeeded Willem Schutte in leading the Raymond and Beverly Sackler Laboratory for Astrophysics. Furthermore, Thijs de Graauw from SRON Groningen was appointed as Extraordinary Adjunct Professor of Space Astrophysics. This significant strengthening of the Observatory was, however, also accompanied by a loss: Pascale Ehrenfreund accepted a full professorship at the University of Amsterdam and left to start a group in Astrobiology.

After an extended period in which Jeanne Drost and Kirsten Kol provided nearly all of the support, the secretariat was expanded with Mirjam Driessen and Liesbeth van der Veld.

The research carried out in Leiden remains diverse, and includes observating programs with a large arsenal of telescopes on the ground and in orbit, laboratory astrophysics, data analysis and interpretation, as well as purely theoretical work. Scientific highlights can be found elsewhere in this Annual Report, and on the Sterrewacht webpages. Particularly noteworthy was the first detection of extragalactic fringes with MIDI attached to the VLT Interferometer. This allowed the team led by Walter Jaffe to resolve the dusty torus that was long postulated to exist in the nucleus of the nearby Seyfert galaxy NGC 1068. This marvellous step forward was selected as one of the annual highlights of the entire Faculty of Mathematics and Physical Sciences.

Leiden astronomers are involved in the development of instrumentation for the ESO-VLT and the associated VLTI effort. This includes SINFONI and second generation instruments MUSE, CHEOPS, and PRIMA. They also play a leading role in the development of OmegaCAM for the VST. There is also major involvement in the HIFI instrument for ESA's Herschel Observatory, in the construction of CHAMP$^+$

and the ALMA Band 9 receivers, and in the preparation for LOFAR. The latter received the green light for construction in late 2003, accompanied by a large grant from the government, so that there will be a state-of-the-art long-wavelength radio observatory in the Netherlands in the near future. Several Leiden astronomers, notably Bernhard Brandl and Ewine van Dishoeck, are also deeply involved in the Spitzer Space Telescope, the last in NASA's series of 'Great Observatories'.

The award of funding for the second phase of NOVA, together with strong support from NWO, made it possible to continue a strong PhD and postdoctoral program, and to continue the build-up of instrumentation expertise at the Observatory. More than half of the Observatory activities are now funded externally by NOVA, NWO or the EU.

Our education program entered a new phase with the introduction of the three-plus-two-year Bachelor/Master structure, which has the main effect of exposing the students to research earlier in their university stay. Four PhD theses were completed.

The annual Oort Lecture was presented by Professor Alexander Dalgarno from Harvard University, entitled *Molecular Synthesis in the Universe*. He also led a fascinating workshop on X-rays in the Solar system. Professor Roland Bacon from Observatoire de Lyon visited for a week in November, and presented the 2003 Sackler lecture, entitled *Integral-field spectroscopy of stars and galaxies*. Nearly a dozen other astronomical workshops were held in Leiden, many in the Lorentz Center.

On 'national science day', the old Sterrewacht was crewed by students, professionals, and amateurs. It attracted record public interest, as did the special day celebrating the closest approach by the planet Mars in recorded history.

Observatory staff continues to carry out high-level international science advisory functions for ESO, ESA, ALMA, AURA, and the Hubble Space Telescope. A noteworthy event was the scientific symposium on AGB stars to celebrate the official retirement of Harm Habing, which was followed by his farewell lecture. At this occasion, Harm also received a royal distinction. It was a special privilege for me to receive a doctorate honoris causa from the Université Claude Bernard in Lyon. George Miley was awarded a most prestigious Royal Academy professorhip, which frees him from all managerial duties, and allows him to concentrate fully on his research using the Hubble Space Telescope and ESO's Very Large Telescope, and to prepare for LOFAR. This allowed him to step down as Director in late October. George led the Observatory for seven years, which constituted a particularly exciting period, with many new staff appointments, and much activity in research and instrumentation. Thank you George!

Finally, I must end on a sad note. March we received the sad news that Jan Coremans had died. Trained as a physicist, Jan had been executive manager for astronomy (as well as for physics and later also for mathematics and computer science) for a quarter of a century. Although it took the Sterrewacht and Jan Coremans some time to get used to one another, through the years he became a staunch supporter of the Observatory and provided invaluable support in the world of university bureaucracy. He was a competent manager with a strong character and a passionate view of science. We owe him much.

Tim de Zeeuw Director

Chapter 2

Research Sterrewacht Leiden

Research

Chapter 2

2.1 Solar System

2.1.1 Minor Planets

Many new asteroids were discovered, numbered or named by I. van Houten, continuing the work by herself and her late husband C. J. van Houten (see Annual Report 2002). In 2003, the Minor Planet Center in Cambridge (USA) gave definitive numbers to 414 asteroids found by the van Houtens in their four surveys of 1960, 1971, 1973, and 1977. They included 406 regular asteroids and 8 Trojans, 4 in L4 and 4 in L5 .

Definitively numbered asteroids found by the van Houtens

year of observation	1960	1971	1973	1977
survey	P-L	T-1	T-2	T-3
region	L4	L5	L4	L5
regular asteroids found	149	30	114	113
Trojans found	2	0	2	4

As of 2003 November 6, the top ten discoverers of numbered minor planets, arranged in decreasing order of number of discoveries, were:

Rank	Discoveries	Co-	Between	Name(s)
1	33866		1997-2003	LINEAR
2	3341		1985-2003	Spacewatch
3	3254		1998-2003	LONEOS
4	3042		1960-1977	C.J. van Houten
				I. van Houten-Groeneveld
				T. Gehrels
5	2801	68	1986-1999	E. W. Elst
6	2226		1995-2003	NEAT
7	2020	2	1991-2002	T. Kobayashi
8	1262		1998-2003	CSS
9	1097	279	1975-1989	S.J. Bus
10	833		1992-1993	UESAC

Note the fourth place held by Leiden emeriti Van Houten and Van Houten-Groeneveld together with Arizona astronomer Gehrels. This is, in fact the first place held by individual astronomers because the ranks 1 through 3 are occupied by automatic surveys!
The 'Small Bodies Names Committee' of the IAU named 38 regular minor planets and 24 Trojans (10 in L4 and 14 in L5) following proposals by the van Houtens. Of special interest to Leiden Observatory were the names (10256) Vredevoogd, after the former president of Leiden University, as well as (18236) Bernardburke and (18239) Ekers honoring well-known astronomers who have both filled the J.H. Oort Chair at Leiden (see Minor Planet Circulars MPC 33919, 48155/48391, 41347, 50251 and 50252). Other names of note included the founder of Dutch meteorology (10961) Buysballot, the Utrecht Observatory (10962) Sonnenborgh, the Dutch 17th century explorers and discoverers of the Cape Horn route (11772) Jacoblemaire and (11773) Schouten, and the 1953 physics Nobel Prize winner (11779). Of the remainder 24 were named after mountains and mountain ranges, mostly in Germany, while the 24 Trojans received, of course, names from ancient Greek mythology.

2.1.2 Kuiper Belt Objects

Kuiper Belt objects (KBOs) are icy aggregates orbiting the Sun beyond Neptune. Thought to be relics of early stages of planetary formation, they are expected to bear signatures of their origin and evolution. One of the many unknown features of KBOs is their shape distribution. Lacerda has been studying the shapes of KBOs through their lightcurves, which exhibit periodic brightness variations caused primarily by the varying reflecting cross-section of the KBOs aspherical shapes as they rotate. The period of the lightcurve is the rotation period of the KBO, and the lightcurve amplitude has information on the KBO axial ratios.

In contradiction to the initial assumption that larger objects would be more spherical due to self-gravitation, Lacerda discovered that some of the largest known KBOs (~ 1000 km) have lightcurves of substantial amplitude (~ 0.4 mag). The fact that such large objects apparently are able to retain a distinctly elongated shape suggested that KBOs are loosely bound aggregates of smaller icy 'chunks' where centripetal acceleration due to rotation causes deformation into equilibrium ellipsoids. Lacerda therefore derived an expression to determine the probability of detecting a lightcurve for an observed KBO. This expression takes as free parameter an assumed *a priori* shape distribution for these objects. The validity of the assumed shape distribution was tested by comparing the calculated probability to the actual fraction of observed KBOs that yield a detectable lightcurve. Luu and Lacerda applied this method to the current database of lightcurves to constrain the shapes of Kuiper Belt objects. By fitting gaussian and power law functions to the shape distribution, they determined that most KBOs ($\sim 85\%$) have shapes that are close to spherical (ratio of longest to shortest axis, $a/b \leq 1.5$) but that there is a small but significant fraction ($\sim 12\%$) possessing highly aspherical shapes ($a/b \geq 1.7$). This long tail of elongated objects implies that the distribution cannot be well fitted by a gaussian and is much better approximated by a power law.

2.1.3 Comets

Together with a group of 14 collaborators, Hogerheijde finished his work on the detection of HCN 1–0 emission from comet C/1999 S4 (LINEAR) obtained in simultaneous measurements at the Owens Valley (OVRO) and Hat Creek interferometers (BIMA). The comet attained brief fame when it disintegrated on closest approach to the Sun in July 2000. The data showed HCN emission over the days leading up to breakup. Analysis of the observations indicated that the HCN originated from evaporating ices at or near the surface of the nucleus and placed a limit of $<$50% on any contribution from, e.g., larger fragments broken off the nucleus.

2.2 Stars

2.2.1 CO in the Chromosphere of the Sun

Kamp, Wedemeyer, Steiner (both Freiburg, Germany) and Freytag (Uppsala, Sweden) developed a small time-dependent CO chemical network in order to calculate the non-equilibrium chemistry of CO in the chromosphere of the Sun. This chemical routine will be fitted in a 3D hydrodynamics code to examine the influence of CO cooling on the structure of the chromosphere and the possibility of thermal bifurcations.

2.2.2 Exoplanets

Frink and Quirrenbach, in a collaboration with Mitchell (UCSD, USA), Fischer (SFSU, USA), Marcy (UCB, USA) and Butler (Carnegie Washington, USA) identified four new substellar companions, two of which are likely planets, in a sample of 177 K giants that had been monitored with precise radial velocities since 1999. Planet-hunting around K giants complemented the ongoing Doppler-surveys for planets around late-type dwarf stars. Because K giants are somewhat more massive than late-type main-sequence stars, they allow to study the influence of the mass of the primary on the properties of the extrasolar planet secondary.

2.2.3 η Carinae, LMC Supergiants

Van Genderen, Sterken (Brussels, Belgium), Allen (Blenheim, New Zealand) and Liller (Vina del Mar, Chile) published their results on the optical features (UBV and BVR) of η Carinae during the 2003.5 spectroscopic event, the supposed periastron passage of a binary companion. The light and colour curves showed a number of features, which were also seen at previous periastron passages: a light maximum of long duration with a superimposed flare-like event, which is temporarily interrupted by an eclipse-like dip, and a steep decline in the $U - B$ colour index. The R brightness reached a minimum at the time of mid X-ray totality, probably implying that the Hα emission line reached a minimum. The source of the optical flare-like event is probably not the same as the one causing the X-ray radiation. It is tempting to consider the epoch of the R minimum and the mid X-ray totality - which roughly coincides with the UBV minimum - as the central moment of the 2003.5 spectroscopic event.

Van Genderen, Sterken (Brussels, Belgium) and Jones (Stoke, New Zealand) finished the analysis and discussion of $VBLUW$ photometry (Walraven system) of five supergiants in the LMC. For one well-known variable, the hypergiant R 59 = HDE 268757 (G7 Ia^{+}) also Hipparcos photometry and numerous visual observations were available. The cycle length is about 550 d. The second variable is HDE 269612 (F0 Ia), cycle length possibly of the order of months, and a third one is HDE 268822 (F6 Ia), cycle length about 180 d. Two F6 Ia supergiants turned out to be constant: HDE 269355 and HDE 270025. Apart from R 59, all reside close to the blue side of the Cepheid strip. The condition which makes an evolved star (non-Cepheid) stable or unstable, likely depends on the evolutionary state e.g. with respect to the number of crossings they have finished.

2.2.4 Galactic OB Associations

As part of Kouwenhoven's (Amsterdam) Ph.D. project on the primordial binary population in young star clusters, he, Brown, and Kaper (Amsterdam) reduced and analysed the data from their adaptive optics multiplicity survey of 200 A and B-type stars in the Sco OB2 association. They found 151 stellar components other than the target stars. A brightness criterion was used to separate the components into 73 background stars and 78 candidate companion stars. A comparison of the findings with existing literature data showed that out of the 78 candidate physical companions, 42 are new. This represents a significant increase in the knowledge of the binary population of Sco OB2. The mass distribution of the companions shows that at separations below about 4 arcsec (~ 500 AU) there is either a deficit of companions below 0.1 $M_\odot$ or a gap in the companion mass distribution between ~ 0.03–0.1 $M_\odot$. This deficit of brown dwarf companions has been noted before and could point to a dynamical ejection scenario for the formation of isolated brown dwarfs.

2.3 Protostars and Circumstellar Disks

2.3.1 Low-Mass Protostars

Physical and Chemical Structure

Jørgensen, Schöier and van Dishoeck, together with Tielens (Groningen), Maret, Caux (CESR, Toulouse, France) and Ceccarelli (Grenoble, France), completed their large JCMT submillimeter line survey of a sample of ~ 20 low-mass (class 0 and I) protostars. Using the physical structure established from dust continuum observations, accurate abundances for a large number of molecules have been determined. The large sample allowed empirical correlations between species to be derived and basic chemical networks to be tested. For example, the HCO^+ and CO abundances are linearly correlated, both increasing with decreasing envelope mass, whereas N_2H^+ and CO are anti-correlated (see Fig. 2.1). Species such as CS, SO and HCN show no trend with envelope mass. In particular no relation is seen between "evolutionary stage" of the objects and the abundances of the main sulfur- or nitrogen-containing species. Among the nitrogen-bearing species, abundances of CN, HNC and HC_3N are closely related. The CS/SO abundance ratio correlates with the abundance of CN, which may reflect a dependence on the atomic carbon abundance. An anti-correlation is found between the DCO^+/HCO^+ and DCN/HCN, due to different temperature dependencies of the gas-phase deuteration mechanisms. The abundances in the cold outer envelope of the previously

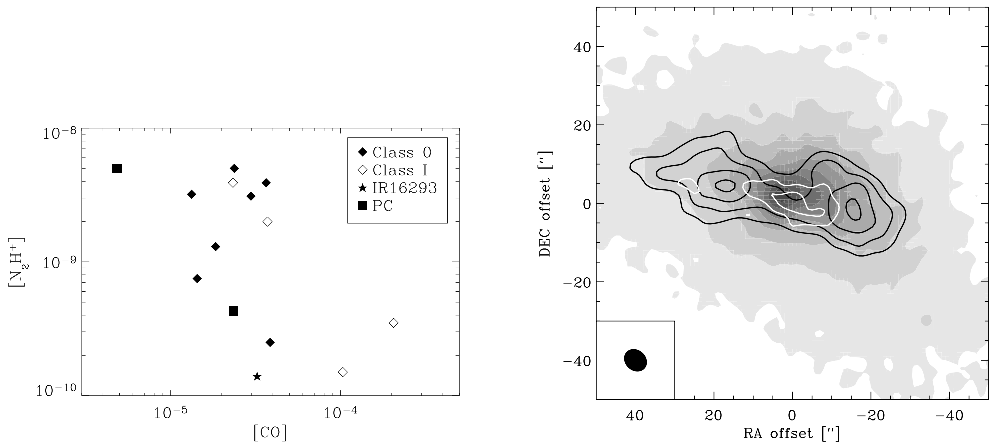


Figure 2.1: Left: Anti-correlation of N_2H^+ and CO abundances found in the JCMT single dish survey of protostellar envelopes, caused by freeze-out of CO in the coldest parts. Right: OVRO interferometer maps of the protostar L483, revealing a spatial anti-correlation between emission from N_2H^+ (thick black line) and from $C^{18}O$ (thick white line). The grey-scale map represents 800μm emission from cold dust measured with SCUBA (From: Jørgensen et al.).

studied class 0 protostar IRAS16293-2422 are in good agreement with the average abundances for the presented sample of class 0 objects.

Some of these chemical characteristics have been further explored in collaboration with Hogerheijde and Blake (Pasadena, USA) through imaging of the molecular emission at $\sim$500 AU resolution using millimeter interferometry with OVRO and BIMA (see Fig.2.1). The envelope model derived from single-dish data is used as a starting point for the analysis of the continuum visibilities seen by the interferometer. A point source is revealed by the interferometer, presumably a cold disk with a mass of 0.3 $M_{\odot}$. The same envelope model also reproduces aperture-synthesis line observations of the optically thin isotopic species $C^{34}S$ and $H^{13}CO^+$. N_2H+ is seen to be closely correlated with dust concentrations where CO is frozen out.

VLT-ISAAC Survey of Gases and Ices toward Embedded Low-Mass YSOs

Pontoppidan and van Dishoeck, in collaboration with Dartois and d'Hendecourt (IAS, Paris, France) and Tielens (Groningen), finished their ESO VLT-ISAAC program to observe ices and gases around a large sample of low-mass young stellar objects (YSOs) in nearby star-forming regions at unprecedented S/N and spectral

resolution. They obtained spectra of about 50 sources covering the $3-5\ \mu\mathrm{m}$ atmospheric windows with resolving powers up to $\lambda/\Delta\lambda \approx 10000$. As part of this program, Pontoppidan carried out a preliminary analysis of the gas-phase emission lines from the fundamental ro-vibrational band of CO. In many cases, he found that the line profiles resemble those observed from T Tauri and Herbig Ae disks. Some sources show broad double-peaked profiles while others have narrow, unresolved lines. In the case of T Tauri stars, profile shapes have succesfully been related to disk inclination. Ro-vibrational line profiles may thus be a unique probe of the inclinations of disks around embedded YSOs.
Pontoppidan and Dartois also carried out VLT-ISAAC spectroscopic observations toward a number of closely-spaced infrared sources, mapping water and methanol ice absorption in a small $(40\times30'')$ section of the Serpens molecular cloud core. Previously detected abundant methanol ice was shown to be extended over a larger area. The outer part of the envelope of the class 0 protostar SMM4, included in the map, betrayed itself by a sharp increase in the abundance of water ice, as expected from protostellar models which have very cold outer envelopes. This result demonstrated that the sensitivity of infrared instrumentation has become sufficiently good to map ices in small and well-defined regions with angular resolutions similar to those of rotational gas-phase line maps.

First Spitzer Spectroscopy Results

Pontoppidan and van Dishoeck, in a collaboration with Noriega-Crespo, Blake, Boogert (all Caltech, Pasadena, USA) and Lahuis, analyzed the first mid-infrared spectroscopic data to be obtained with the Spitzer Space Telescope, launched on August 25, 2003. The southern low-mass protostar HH 46 was targeted and revealed very strong ice absorptions, including clear features by solid CO_2 and CH_4. Using also ground-based ESO VLT-ISAAC data at shorter wavelengths, they made an initial ice inventory of this low-mass protostar and compared this to that found in high-mass YSOs. These results were featured in a NASA Spitzer 'First Results' press conference on December 18. Van Dishoeck and co-workers are part of the Spitzer Legacy program 'From molecular cores to protoplanetary disks' led by N. Evans (Texas).

2.3.2 Protostellar Envelopes

Chemical Models of Low-Mass Protostellar Envelopes

Doty (Denison University; visitor Leiden), van Dishoeck and Schöier (Stockholm, Sweden) continued their studies of the time- and space-dependent chemistry in protostellar envelopes. This year, the efforts focussed on the low-mass protostar IRAS 16293 –2422 for which an accurate physical structure was derived by Schöier last year. A new feature was the use of a detailed, self-consistent radiative transfer model to translate model abundances into line strengths and compare them directly to observations of a total of 76 transitions for 15 chemical species and their isotopes. The model reproduced many of the observed line strengths within 50%. The best fit was for times in the range of $3 \times 10^3 - 3 \times 10^4$ yr and required only minor modifications to the model for the high-mass YSO AFGL 2591. In that source, the ionization rate may be higher than previously thought, which might be due either to an enhanced cosmic-ray ionization rate or, more probably, to the presence of X-ray induced ionization from the protostars. Doty and co-workers also predicted abundances and spatial distributions of other species which can be tested with future facilities such as Herschel-HIFI, SOFIA, or the various millimeter arrays.

High-Energy Radiation Probes

Together with Stauber and Benz (ETH, Zürich, Switzerland), van Dishoeck, Doty and Jørgensen started an observational and modeling program to search for molecular probes of high-energy ultraviolet radiation and/or X-rays in the inner envelopes of deeply-embedded YSOs. Because of the high extinction in protostellar regions, radiation at ultraviolet and X-ray wavelengths cannot be detected directly, although it can selectively enhance molecules in photodissociation and ionization processes. The team started an observing program with the JCMT to search for CN, CO^+ and NO, and could already report the first detection of CO^+ toward W 3 IRS5. In parallel, time- and depth-dependent chemical models containing ultraviolet and X-ray chemistry are being developed by extending the models of Doty et al. described above.

2.3.3 ATCA and SMA Observations of Molecules in Southern Disks

In a collaboration with Wright (ADFA, Canberra), Wong (ATCA, Australia), Wilner and Bourke (Boston, USA), Jørgensen and van Dishoeck started an observational program of southern protostars and disks using the new 3 mm facility of the Australia Telescope Compact Array with $\sim 2''$ resolution. The initial set of observations has revealed compact thermal dust continuum emission from disks surrounding the stars TW Hya and HD 100546. The latter source also showed hints of extended emission, presumably due to a residual protostellar envelope which is also visible in scattered light at optical wavelengths. HCO^+ $J = 1 - 0$ line emission from the disk around TW Hya was detected and spatially resolved. The observed size and intensity turned out to be in good agreement with model calculations by van

Zadelhoff et al. for an irradiated disk with substantial depletions based on earlier single-dish JCMT observations of higher J HCO^+ transitions.

Hogerheijde was also involved in resolved observations of CO line emission from the disk around the young star TW Hya, obtained with the newly completed Smithsonian Submillimeter Array. These data provided strong constraints on the orientation and structure of the flared circumstellar disk.

2.3.4 Circumstellar Disks

Evolution of Planetesimal Disks

Augereau and Papaloizou (QMW, London, UK) reproduced the spiral structure and the main asymmetries of the optically thin dust disk observed with HST/ACS around HD 141569 A – a young 5 Myr main-sequence star with two companions (Fig.2.2). The project was carried out within the context of the PLANETS EU-network to study the evolution of (proto-)planetary systems. They used an N-body 2D dynamical model of about 10^6 solid particles gravitationally perturbed by an external object on an eccentric orbit. They found that the observed surface density resembles that expected from a circum-primary disk within a highly eccentric binary system, leading them to assume that at least one of the two M star companions is bound to HD 141569 A. Their numerical results were reasonably well reproduced by an analytical approach explaining the formation of spiral structure by secular perturbation of a circum-primary disk by an external bound companion. The redness of the disk in scattered light is explained if short-lived grains with sizes one order of magnitude smaller than the blow-out size limit are abundant in the disk.

Using a particle-in-a-box method, Thébault (Meudon, France), Augereau and Beust (Grenoble, France) addressed the problem of conflicting solid mass estimates in the inner disk of β Pictoris. The dust observed in this disk results from a collisional cascade requiring the presence of km-sized bodies (planetesimals). They found that collisional activity very rapidly erodes the more massive planetesimal disk. They estimated an upper limit of 0.1 Earth-mass for the whole disk in the inner 10 AU after $\sim$10 Myr. This was consistent with the lower mass estimates derived from models of the spectral energy distribution. Their conclusions cast doubt on the mechanism proposed to excite extrasolar comets which might be responsible for transient spectroscopic events when they graze the star. The simulations also showed that the differential grain size distribution in collisional disks departs significantly from a simple $a^{-3.5}$ power-law as soon as a lower cut-off is introduced, for instance by the radiation pressure imposed by a central bright star.

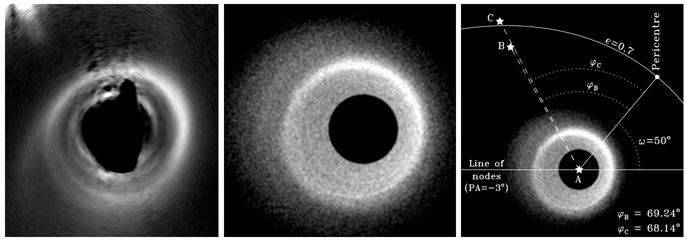


Figure 2.2: Left: the surface density of the dust disk around HD 141569A as derived from HST/ACS coronagraphic observations. One of the two stellar companions is visible (upper left corner). Middle and right: the effect of the companions on an initially axisymmetric disk of solid particles. The simulations were compared to observations after about ten orbital periods (i.e a few Myr) of the perturber under the assumption that it is in a highly eccentric orbit. The size of the disk is truncated by the companions. The overdensity of particles close to the outer edge of the disk is caused by transient spiral structure (From: Augereau & Papaloizou).

Extended PAH Emission in Disks

Geers, Augereau, Pontoppidan, van Dishoeck and Lagrange (Grenoble, France) detected extended emission from Polycyclic Aromatic Hydrocarbons (PAHs) in the circumstellar disk around the pre-main sequence Herbig Ae star HD 100546. They observed the star with VLT-ISAAC in long-slit spectroscopic mode, the slit oriented along the major axis of the disk. They found an extent of about 30 AU for the 3.3μm emission feature which is usually attributed to PAHs. This is much larger than the typical extent of crystalline silicate emission, indicating that ultraviolet excitation of these molecules can continue out to large distances.
Geers, Augereau, Lagrange (Grenoble) and Kaufl (ESO), carried out a mid-infrared N- and Q-band spectroscopic survey of 36 stars using TIMMI2 on the ESO 3.6m. Their aim was to investigate the evolution of grain properties in circumstellar disks around Herbig Ae, T Tauri and Vega-like stars. Some of the objects have recently been identified as members of nearby ($<$ 100 pc) stellar associations. Initial reduction of the N-band spectra shows that several objects have silicate and PAH emission features.

Gas Temperature of (Flaring) Disks

Jonkheid, working with van Zadelhoff and van Dishoeck, continued his studies of the gas temperature in the outer layers of flaring circumstellar disks. The gas temperature was calculated explicitly by balancing the various gas heating and cooling processes. Previous models took the gas temperature to be equal to the dust temperature, an assumption which is only valid at the midplane. Jonkheid paid special attention to effects on the intensities of important emission lines arising at the disk surface, such as the [C II] intensity. He also examined the effects of dust particles settling towards the disk midplane on gas temperature and chemistry. He found that dust settling gives higher temperatures deeper in the disk and results in a more extended layer of ultraviolet radiation-dominated chemistry.

Kamp, working with Dullemond (MPA Garching, Germany) also extended her chemical and heating/cooling network developed earlier for optically thin disks. She applied her new model to flaring optically thick disk models, in particular to the disk around the T Tauri star HD 143006. The resulting temperature structure showed a hot atmosphere above the disk surface ($\tau_{\rm dust} = 1$) and good coupling between gas and dust below the surface. Those results justified *a posteriori* the calculation of the disk structure from the dust temperature.

As part of the work on gas temperature in disks just mentioned, Jonkheid, Kamp and van Dishoeck have made extensive tests to compare the results of different codes for photon-dominated regions (PDRs). After several iterations and modifications of the gas heating and cooling processes, the codes yielded PDR temperature structures in good agreement with one another. However, they found that the codes give slightly different solutions for the chemistry, especially for the C^+/C/CO transition. The remaining differences in the temperature are therefore mainly due to the different chemical structure of the C^+/C/CO transition as resulting from the various codes.

Chemical and Excitation Models of Disks

Chen (JPL, Pasadena, USA) and Kamp applied chemical disk models to the STIS and FUSE ultraviolet spectra of HR 4796A (age 8 ± 2 Myr). From the absence of circumstellar absorption lines of C II, O I, Zn II, H_2, and CO, she concluded that there is very little gas left in this system, $< 1 M_\oplus$, certainly not enough to allow ongoing formation of Jupiter-like planets.

In a collaboration with Liseau, Brandeker and Olofsson (Stockholm, Sweden), Kamp has compiled a large Fe I model atom and calculated the statistical equilibrium excitation of neutral iron in the disk around β Pictoris. The oberved line ratios could only be fitted if collisions play an important role. This provides indirect evidence of a high density gas component in the disk around this star, previously inferred from ISO H_2 data and the apparent stability of the disk against blow-out. Due to the lack of collisonal data for Fe I-H or Fe I-H_2 collisions, it was however not yet possible to derive a good estimate of the density of the collision partner.

More Circumstellar Dust Disks

Jourdain de Muizon and Laureijs (ESA-ESTEC) have extended the work begun by Habing and coworkers on debris disks around stars observed with ISO (in which they had been long involved). In particular, they have exploited the ISOPHOT chopped data at 60μm and 90μm that was originally left aside because of the complexities of a reliable reduction of data taken in this mode. They detected several new candidate-disks in the original Habing et al. sample. They were also able to add a 90μm data-point to the Spectral Energy Distributions (SEDs) of the infrared excesses thereby putting further constraints on the properties of the disk. The conclusion of Habing et al. that debris disks around A stars are rather young (less than 400 Myr) was confirmed, although it appears that some debris disks around F and G stars could have much greater ages of the order of a few Gyr.

2.4 Interstellar Medium

2.4.1 Interstellar Polarization Screens

Schnitzeler, Katgert, Haverkorn (now at Harvard U., USA) and de Bruyn (ASTRON/Groningen) further investigated the large-scale structure of the Galactic magnetic field by studying polarization data from the WENSS survey. They produced the 'supermosaic' presented in Fig.2.3 constructed from six adjacent WENSS mosaics. It shows the angle of lineair polarization (carefully corrected for differences in ionospheric Faraday rotation) coded from black (-90°) to white (+90°). Although there is structure on many different angular scales, this part of the second Galactic quadrant exhibits a clear stratification of polarization angle with Galactic latitude. In addition, they found several circular and elliptical features superimposed on larger-scale structure such as the ring-like feature at (l, b)=(138°, 8°) (thought to be a 'tunnel' of magnetic field lines seen into) and the V-shaped feature at (l, b)=(161°, 16°).

A significant effort was devoted to the 'reconstruction' of the real distribution of the polarization angle (i.e. by unfolding the -90° to +90° range). This reconstruction, which is quite robust, allowed gradients of polarization angle to be determined on large angular scales, which is important because such gradients can be translated into Rotation Measure (RM) gradients. As these are determined by thermal electron density gradients and by the large-scale magnetic field structure, information on the structure and strength of the Galactic magnetic field may be extracted. A particular interesting feature of the map in Fig.2.3 is the unusually steep gradient of -2.5 radians/degree in polarization angle in the region $137° < l < 165°$, $0° < b < 22°$. Another remarkable feature is the rather abrupt change in the structure of the

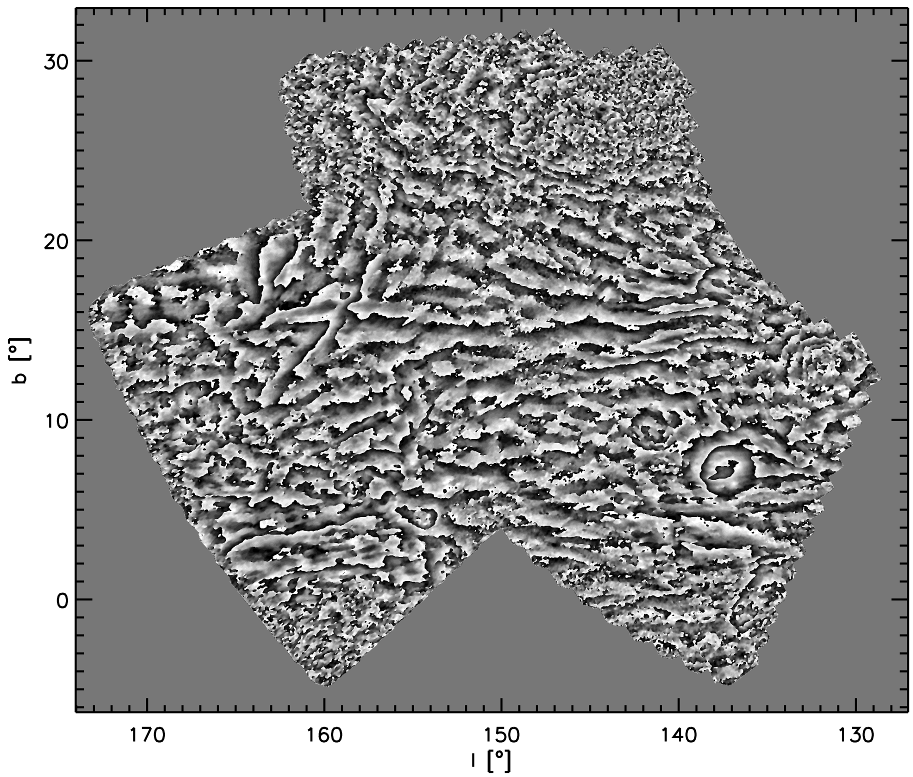


Figure 2.3: Distribution of polarization angle in six neighbouring mosaics from the WENSS survey. The data were taken at a frequency of 325 MHz with an 8 MHz bandwidth. The resolution of the map is about 6.7' $\times$ 6.7'csc(δ) and the polarization angle ranges from -90° (black) to +90° (white).

distribution of polarization angle around $b \approx 20°$.

Power Structures in the RM Sky

Using an interpolated all-sky rotation measure map generated for over 800 reliable published rotation measures (RMs), Johnston-Hollitt, Hollitt (Adelaide, Australia) and Ekers (ATNF, Australia) investigated structures in the RM sky via Fourier decomposition. They found excess RM power to exist on scales of 30-50 degrees within the Galactic plane, consistent with other results in the literature. They also noted that the new dataset did not reproduce the alternating positive-negative-positive-negative RM signal required in each of the Galactic quadrants to support a bisymmetric Galactic magnetic field.

2.5 Galactic Structure

2.5.1 Structure and Kinematics of the Inner Galaxy

Thermally pulsing AGB stars, surrounded by dense envelopes of dust and molecular gas are bright at infrared wavelengths and can be detected even when highly obscured. The OH and SiO maser emission from their envelopes can also be detected throughout the Galaxy, providing stellar line-of-sight velocities to within a few km s^{-1}. AGB stars are thus excellent tools to probe Galactic kinematics, structure and mass-distribution.

Messineo, Habing, Menten (MPIfR, Germany), Omont (IAP, France) and Sjouwerman (NRAO, USA) compiled a catalogue of 1–25μm photometry by DENIS, 2MASS, ISOGAL, MSX and IRAS for a sample of 441 late-type stars that were previously searched for 86 GHz SiO maser emission. The comparison of the DENIS and 2MASS J and K_S magnitudes showed that most of the sources are variable stars. Since variable AGB stars and, in particular the sub-class of Mira variables, obey a period-luminosity relation, the variability is a key ingredient to measure the distance to the stars. The MSX colours and the IRAS $[12] - [25]$ colours of the SiO maser stars were found to be consistent with those of Mira-type stars with a dust silicate feature at 9.7 μm in emission, indicating only a moderate mass-loss rate. Stellar bolometric magnitudes were computed by direct integration of the observed energy distribution. The luminosity distribution was found to peak at $M_{bol} = -5.0$ mag, which coincides with the peak also shown by OH/IR stars in the Galactic Centre, suggesting similar initial masses for the two samples.

In addition, Messineo and Habing together with their collaborators at the MPIfR and IAP carried out the analysis of 2MASS CMDs of several fields in the Galactic plane at longitudes l between 0° and 30° in order to obtain extinction estimates for all SiO maser stars in their sample. With this analysis, they were also able to place new constraints on the near-infrared power law extinction law.

Kuijken and Rich (UCLA, USA) measured the proper motion distribution of some 30,000 bulge stars near the minor axis from archival and new HST/WFPC2 images. A first model of the kinematics showed that the vertical potential gradient on the Galactic minor axis is remarkably shallow, implying either implausibly) a rather prolate axisymmetric mass distribution in the central kpc of the Galaxy or (more likely) a significantly barred triaxial one.

2.5.2 Internal Dynamics of Globular Clusters

Verolme, van den Bosch, van de Ven and de Zeeuw continued work on dynamical models of the globular cluster ω Centauri. They could obtain a dynamical estimate of the distance to this cluster by combining the proper motions and radial velocity observations of individual stars. An extension of the existing axisymmetric Schwarzschild software was used to construct realistic flattened and anisotropic dynamical models, which fitted the observed surface brightness as well as all the (averaged) kinematical measurements. Tests with analytical models showed that it was possible to obtain accurate estimates of the mass-to-light ratio, inclination and distance. The use of the averaged properties of the observations of individual stars, required a careful analysis of the data. The analysis and subsequent modeling of the observations of ω Centauri are nearly completed.
Van den Bosch and Gebhardt (University of Texas, Austin) analysed WFPC2 images of two nearby globular clusters, taken at different epochs, and measured internal proper motions, with as aim to use these for the determination of the dynamical distance of the clusters. Together with Noyola (University of Texas, Austin) and de Zeeuw, they are also analysing the published proper motions and unpublished radial velocities for the globular cluster M15.

2.6 Gas and Dust in Nearby Galaxies

2.6.1 The Molecular ISM in the Magellanic Clouds

Molecular Inventory of the Giant N 11 Complex

In the period 1988 to 1995, an ESO-Swedish Key Programme mapping CO in the Magellanic Clouds was carried out on the Swedish-ESO Submillimeter Telescope (SEST) in Chile under the co-chairmanship of Israel and Johansson (Onsala, Sweden). In 2003, Israel, Johansson, Rubio, Garay (both U. Chile) and other members of the international collaboration finished the analysis of the last parts of the survey.
The second-brightest star formation complex in the Large Magellanic Cloud (after 30 Doradus with its retinue of HII regions, supernova remnants and dark clouds) N 11 is prominent at optical, infrared and radio wavelengths. The southern part is a filamentary shell of diameter 200 pc enclosing the OB association LH 9 (NGC 1760) and in turn surrounded by the OB associations LH 10 (NGC 1763, IC 2115, IC 2116), LH 13 (NGC 1769), LH 14 (NGC 1773) exciting the bright HII regions N 11A through N 11E. These OB associations power the complex by the radiative output of about a hundred O stars. The N 11 complex has an overall linear diameter of 700 pc. From the main body of the complex, a loop of HII regions and more diffuse Hα

emission extends to the northeast, delineating the eastern half of LMC supergiant shell SGS-1 which has a diameter of about a kiloparsec.

N 11 was surveyed extensively in the J=1–0 transition of ^{12}CO. Israel and collaborators presented maps and a catalogue containing the parameters of 29 individual molecular clouds in the complex. They found the distribution of molecular gas in the N 11 complex to be highly structured. In the southwestern part of N 11, several molecular clouds were found to form a ring or shell surrounding the major OB star association LH 9. In the northeastern part, a chain of molecular clouds was seen to delineate the rim of supergiant shell SGS-1. Most of the individual clouds have dimensions only little larger than those of the survey beam, i.e diameters of 25 pc or less. A subset of the clouds mapped in J=1–0 ^{12}CO was also observed in the J=2–1 ^{12}CO transition, and in the corresponding transitions of ^{13}CO. Clouds mapped in the J=2-1 transition with a twice higher angular resolution showed further, clear substructure. The elements of this substructure once again had dimensions comparable to those of the mapping beam. For a few clouds, sufficient information was available to model their physical parameters. These clouds contain fairly warm ($T_{\rm kin} = 60 - 150$ K) and moderately dense ($n_{H2} = 3000$ cm^{-3}) gas. The northeastern chain of CO clouds, although lacking in diffuse intercloud emission, appeared to be characteristic of the more quiescent regions of the LMC, and to have been subject to relatively little photo-processing. The clouds forming part of the southwestern shell or ring, however, are almost devoid of diffuse intercloud emission, and also exhibit other characteristics of an extreme photon-dominated region (PDR).

Molecular Gas near Star-forming Regions in LMC and SMC

Israel and collaborators also analyzed several other star-forming regions in both the Large and the Small Magellanic Cloud, including clouds associated with another supergiant shell in the LMC, SGS-4. Cloud morphologies suggested that their structure is dominated by their interaction with the expannding shell. Most of the molecular clouds were found to be relatively isolated and quite small with dimensions of typically 20 pc. Although some form larger complexes, the extent of all CO clouds was much less than that of the ionized gas clouds. As in N 11, diffuse CO in-between or surrounding the detected molecular clouds was either very weak or absent. Analysis of the large number of LMC lines of sight sampled in both ^{12}CO and ^{13}CO revealed characteristic isotopic emission ratios ^{12}CO/^{13}CO of about 10, twice higher than the ratios commonly found in Galactic star-forming complexes. Israel et al. also noted that the spread of isotopic emission ratios rapidly increased at the lowest CO intensities; they surmised that the low ratios represented relatively dense and cold molecular gas in cloud centers, whereas the high ratios marked CO photo-dissociation zones at the cloud edges.

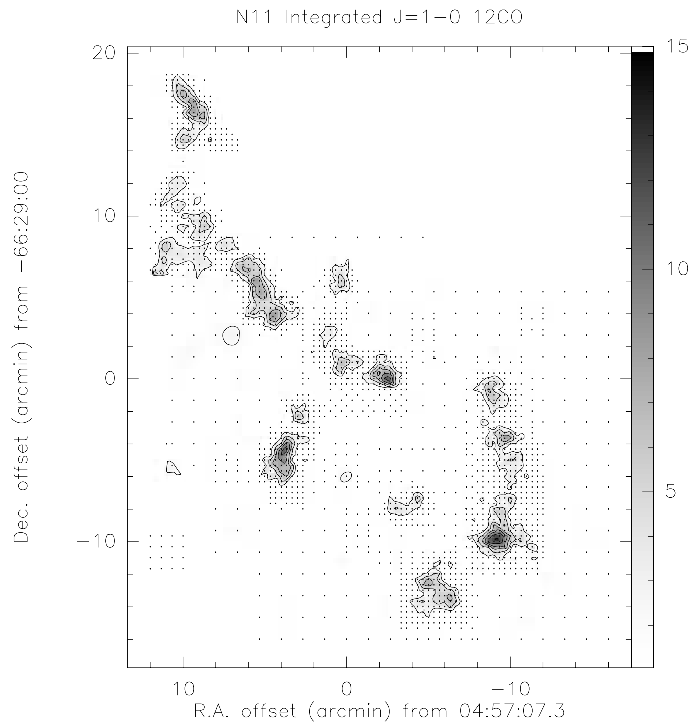


Figure 2.4: Integrated J=1–0 ^{12}CO emission from the N 11 complex in the LMC. Dots indicate positions sampled; first contour and contour interval correspond to 3 K km s^{-1} in main-beam brightness temperature.

The Remarkable N 83/N 84 Complex in the SMC Wing

Finally, Israel also took part in the analysis of CO observations of N 83/N 84, a major molecular cloud complex in the south-east Wing of the Small Magellanic Cloud (SMC) together with Bolatto, Leroy (both Berkeley, USA) and Jackson (Boston, USA). They noted that the J2–1/J1–0 line brightness ratio was uniformly 0.9 throughout most of the complex, but were surprised to find two distinct regions with unusually high ratios larger than 2. Both these regions were associated with the nebula N 84D, and with the inside of the expanding shell N 83. This 50-pc-sized shell is spatially coincident with stellar association NGC 456 and the radio continuum/X-ray source HFPK2000-448 suspected to be a supernova remnant. Bolatto, Israel, Leroy and Jackson explored various possible causes for these high ratios and concluded that in those regions, the CO emission probably arises from ensembles of small (R 0.1 pc), warm (T 40 K) clumps. Their analysis of the CO shell parameters suggested that it is wind-driven and that it is slightly more than 2 million years old. They also used their dataset to determine the CO-to-H_2 conversion factor in the SMC, an especially interesting measurement because of the low ambient metallicity (1/9 solar). Comparison of the CO luminosities of clouds in N 83/N 84 with their virial masses suggested local values for the CO-to-H_2 conversion factor $X_{\rm CO}$ only twice larger than that obtained in a similar way from solar metallicity clouds in the Milky Way and M 33. However, comparison of CO, neutral hydrogen and far-infrared measurements yielded a global factor fifty times higher than found in the Milky Way! They noted that this result fitted into the pattern that CO observations with high linear resolution invariably suggest nearly Galactic values of $X_{\rm CO}$ (nearly) independent of environment.

2.6.2 Planetary Nebula Population in M 31 and Others

Kuijken and collaborators Douglas, Napolitano (both Groningen), Merrifield, Romanowsky, Merrett (all Nottingham, UK), Arnaboldi (Turin, Italy) and Freeman (ANU, Australia) joined forces with a team led by Dave Carter (JMU) to map the stellar kinematics of M31 by means of the planetary nebula population. Using the Planetary Nebulae Spectrograph (PNS) the team discovered and measured the radial velocities for almost 3000 planetaries. They augmented the sample of halo planetary nebulae with narrow-band imaging obtained at the INT. Their analysis of the kinematics of the sample yielded a number of objects that are plausibly associated with the stream in the halo of M31 discovered by Ibata and co-workers. They then developed a model in which these stars are tidal remnants of M32. A dispersion orbit for this model was calculated by undergraduate student Franssen. The PNS team also continued their investigation of the dark halos of nearby ellipticals. A first set of results yielded the surprising conclusion that low-luminosity ellipticals tend to show little or no evidence for dark matter halos out to as far as five effective radii. The survey continues.

2.6.3 Microlensing of the M 31 Disk

De Jong (Groningen), Kuijken, Sackett (ANU, Australia), Crotts (Columbia U., USA) and Sutherland (RoE, UK) analysed and published data from the first two years of a monitoring campaign of microlensing in M 31 using the INT wide-field camera. They obtained a total of 14 plausible microlensing candidate events,. Intruigingly, these are distributed asymmetrically over the face of M 31, as predicted for a roughly round halo of microlenses around the galaxy. Analysis of the remaining two years of data, and a measurement of the microlensing optical depth, is underway.

Figure 2.5: K_s-band image of Centaurus A after subtraction of the underlying galaxy. Dark patches mark residual extinctions, while bright regions indicate emission from a young stellar population inside the dust lane.

2.6.4 Star Formation in the Cen A Dust Lane and in the Antennae

Kriek, Menéndez-Delmestre and van der Werf carried out a near-infrared study of the dust lane of the nearby active radio galaxy Centaurus A. K_s-band imaging showed significant stellar emission in the dust lane (Fig.2.5), whereas JHK_s imaging (front cover) combined with ISO $6.7\,\mu$m data revealed the internal structure of the dust lane. By analyzing the dust lane colours in combination with a model for the underlying elliptical galaxy, they could show that the stellar light from the dust lane (corrected for extinction) is significantly bluer than that of the elliptical host galaxy, characteristic of a young population. From near-infrared spectroscopy they also found that the inner dusty disk contains a significant population of red supergiants, which supports the notion of a young stellar population generated by a recent merger. Because near-infrared emission is hardly contaminated by non-stellar continuum sources (e.g. the AGN), stellar synthesis models could succesfully be used to derive star formation parameters.

Snijders and van der Werf analysed JHK_s imaging data of the Antennae (NGC 4038 and NGC 4039 – Fig 2.6). The near-infrared data were combined with HST data to

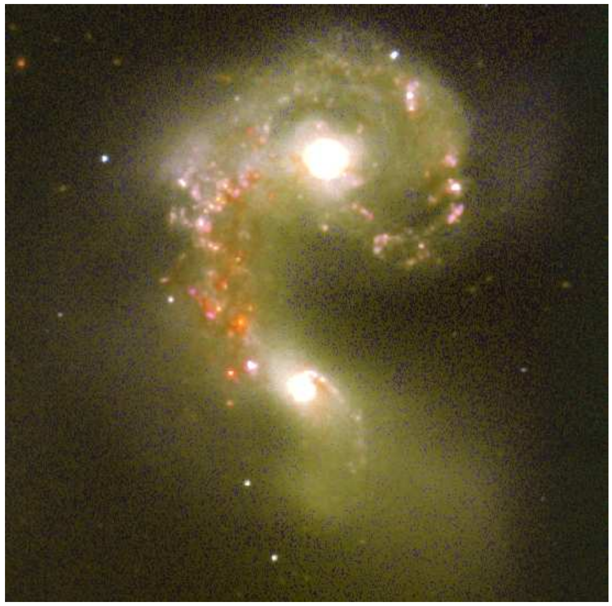


Figure 2.6: JHK_s colour image of the Antennae showing large concentrations of red, very obscured star clusters.

yield extinction values ranging from $A_V = 2.3$ to $A_V = 9.5$, as well as estimates of the relative ages of the clusters.

2.6.5 A Disk of Cold Dust in M 51

Meijerink, Israel, van der Werf, Tilanus (JAC, Hawaii) and Dullemond (MPA, Garching) analyzed a SCUBA map at 850 μm of the interacting spiral galaxy M 51 (see Fig 2.7). The map showed a well-defined spiral structure, very similar to that seen in maps of CO and HI emission. However, most of the intensity measured at 850 μm emission does not come from the arms but originates in an underlying exponential disk, marking the first time that such a disk was unequivocably detected at submillimeter wavelengths. The disk was found to have a scale-length of 5.45 kpc, somewhat exceeding the scale-length of the stellar disk. In turn, the disk scalength is also somewhat shorter than that of atomic hydrogen. The disk radial intensity profile could not be explained solely by a temperature gradient but required the radiating dust to have an exponential radial distribution as well. Meijerink et al. considered this to be supporting the view that submillmeter emission from spiral galaxy disks

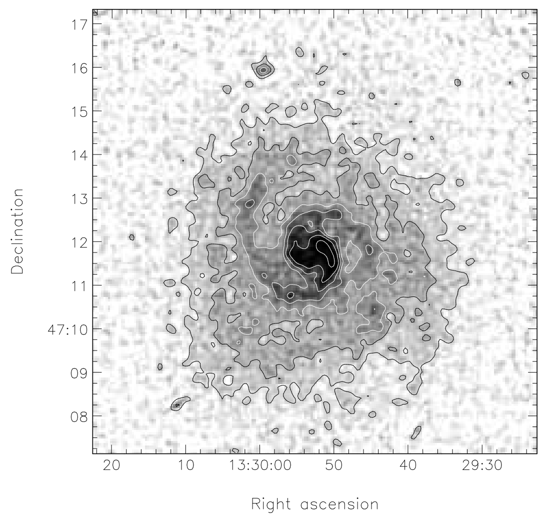


Figure 2.7: SCUBA 850 μm image of M 51. Contour levels are at 13.5, 27, 40.5, 58.5, 72, 90 and 117 mJy/beam. A surface brightness of 13.5 mJy/beam corresponds to 2.6 MJy sr^{-1} or 1.5 σ. The image clearly shows the extended 850 μm disk; the small source to the north is the nucleus of NGC 5195.

traces total hydrogen column density n_H i.e. the sum of H_2 and H I. They suggested M 51 to have a gas-to-dust ratio of $65 \times \kappa_{850}$ (κ_{850} being the dust opacity at 850 μm) based on dust surface densities estimated from the observed emission.

2.6.6 Molecular Gas in the Starburst Centers of IC 342 and Maffei 2

Israel and Baas finished their analysis of CO and [CI] measurements of dense interstellar gas in the inner kiloparsec of the very nearby Sc galaxies IC 342 and Maffei 2. Both galaxies have centers harbouring modest starbursts, and both are major members of the galaxy group which, at a distance of about 2 Mpc, appears to be close to the Local Group of Galaxies. Unfortunately, it is located in the sky very close to the Galactic plane, so that its members suffer high foreground extinction rendering several of them, including Maffei 2, practically invisible at optical wavelengths.

Israel and Baas used their extensive sets of data obtained with the JCMT in ^{12}CO (J=2–1, J=3–2, J=4–3 transitions), [CI] (492 GHz) and ^{13}CO (J=2–1, J=3–2 transitions). They found that both galaxies have strong molecular gas concentrations towards their nucleus, with nearly identical ^{12}CO transitional ratios. At the same time, however, they exhibit large differences in the relative intensities of their ^{13}CO and [CI] emission lines. The observed line intensities require the existence of at least two gas components in either galaxy. A dense component must be present ($n(H_2) \approx 10^4 - 10^5$ cm^{-3}) with kinetic temperatures T_{kin} = 10–20 K (IC 342) or 20–60 K (Maffei 2), as well as a less dense (IC 342: a few hundred cm^{-3} at most; Maffei 2: $\approx 3 \times 10^3$ cm^{-3}) and hotter (T_{kin} = 100–150 K) component. In both galaxies, neutral and ionized atomic carbon amounts were found to exceed those of CO by factors of 1.5 and 2.5. In both starburst centers about half to two thirds of the molecular gas mass is associated with the hot PDR phase. The center of IC 342 contains within R = 0.25 kpc an (atomic and molecular) gas mass of 1 $\times 10^7$ M$_\odot$ and a peak face-on gas mass density of about 70 M$_\odot$ pc^{-2}. For Maffei 2 these numbers were less clearly defined, mainly because of uncertainties in its distance and carbon abundance. Israel and Baas found a gass mass $M_{\rm gas} \geq 0.5 \times 10^7$ M$_\odot$, and a peak face-on gas mass density of about 35 M$_\odot$ pc^{-2}.

2.7 Structure and Kinematics of Elliptical Galaxies

2.7.1 Stellar Disks in Nearby E and S0 Galaxies

The central regions of early-type galaxies show many interesting features such as nuclear stellar disks. These suggest complex formation scenarios and are nice probes of the evolution history of the galaxies. Krajnovic and Jaffe used the Hubble Space Telescope to acquire high resolution images (WFPC2) in B, V and I band to investigate the morphology of the nuclear regions, and multiple long-slit spectra (STIS) to derive the stellar kinematics from different components (nuclear disk and bulge). They also used line-strengths to investigate the stellar populations of each component and discovered color/metallicity anomalies. Many of the galaxies showed signs of recent dynamical ”events” which have not yet damped out. In particular, kinematically separated components show signatures of different chemical composition, which may evidence for bar driven evolution.

Comparing kinematics derived from the near-infrared Calcium triplet and Balmer lines, McDermid found that disky elliptical galaxies with young global stellar populations do not show significant evidence for young stars concentrated in dynamically cold disk-like components, as had been suggested by other authors. Small mass fractions of young stars are still permitted, but they alone cannot explain the disky nature of these objects. This supports the hypothesis that disky ellipticals are not formed via collisionless merger events, but instead require dissipational processes which form stars over a longer period, forming a disky structure with a build up of young stars.

2.7.2 SAURON results

Galaxy Center Kinematics

Cappellari and Emsellem (Lyon) investigated the accuracy of the parameteric recovery of the line-of-sight velocity distribution (LOSVD) of the stars in a galaxy, while working in pixel space. Problems appear when the data have a low signal-to-noise ratio, or the observed LOSVD is not well sampled. They proposed a simple solution based on maximum penalized likelihood and applied it to the common situation in which the LOSVD is described by a Gauss-Hermite series. This penalized pixel fitting (pPXF) method was used for the extraction of the kinematics of the 48 early-type galaxies of the SAURON sample.
The resulting kinematic maps displayed a rich structure and provided a wealth of information about the dynamical structure of galaxies. To exploit them efficiently, Krajnovic continued his work on the extension of the technique of kinemetry, which is a method to describe and quantify the features on these maps. It is based on Fourier analysis, analogous to the method used to describe HI velocity fields. Although the epicyclic framework developed for HI velocity fields is not applicable here, it is possible to give a clear meaning to the dominant terms in the Fourier expansion of the kinematic maps, considering parity of the line-of-sight velocity distribution moments (velocity is odd, dispersion even...) and the symmetry conditions that follow from them. Using this information, the method becomes a powerful tool for filtering the maps and parameterising the inputs for comparison with other properties of the galaxies as well as for statistical studies of the distribution of intrinsic shapes.
McDermid and Shapiro obtained the first results of the SAURON follow-up survey obtained with the OASIS integral-field spectrograph during its period at the CFHT, Hawaii. High spatial resolution data were obtained for the central regions of 31 of the 48 SAURON E/S0 galaxies, revealing several previously unknown central kinematically decoupled components (see Fig. 2.8) and young galaxy cores.

NGC 7332

Falcón-Barroso, together with Peletier (Groningen), Emsellem (CRAL, Lyon), Cappellari and de Zeeuw continued the study of the formation and evolution of S0 galaxies using SAURON integral-field observations. As a particular case the S0 galaxy NGC7332 was studied. The unique data set provided by SAURON provided revealed in NGC7332 a wealth of different structures not found in previous work. The presence of a large-scale bar can explain most of those structures, but the fact that there is a significant amount of unsettled gas, together with additional peculiar features, suggests that this galaxy is still evolving. The study showed that interactions as well

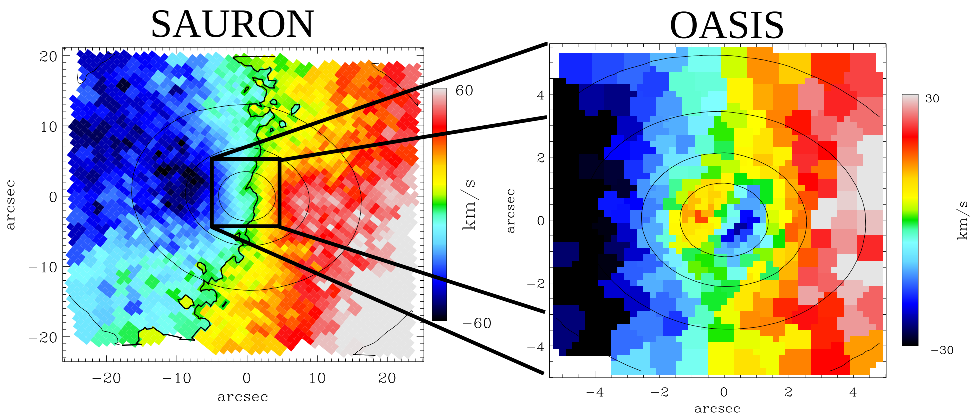


Figure 2.8: Illustrating the improvement in spatial resolution produced by OASIS as compared to SAURON

as bar-driven processes must have played an important role in the formation and evolution of NGC7332. The study of more S0 galaxies in the SAURON sample is required to assess whether similar conclusions apply to S0 galaxies in general, and is ongoing.

2.7.3 Dynamical Models

Krajnovic used the SAURON observations of NGC2974 to construct an axisymmetric stellar dynamical model of the galaxy. The best fitting model gave M/L=3.5 and inclination of 60 degrees. The gas is distributed in a disk structure defined by the potential from the best fitting stellar model. The difference between the streaming velocity and circular velocity is due to the asymmetric drift (given by Jeans equations). The gas model was in a good agreement with the observations outside 3″.

Cappellari, assisted by McDermid and Krajnovic, worked on the systematic dynamical modeling of SAURON early-type galaxies using the axisymmetric Schwarzschild numerical orbit-superposition technique. A new major counterrotating disk was discovered in NGC 4473. For most of the other modeled galaxies, at least two kinematically-decoupled components, a bulge-like one and a flatter faster-rotating one, were required to explain the integral-field kinematics. Interestingly the more disk-like components also showed up clearly in two-dimensional maps of the metallicity of the stellar population, indicating that gas was involved in the formation of the objects.

Verolme, van de Ven, Cappellari, Emsellem (CRAL, Lyon) and de Zeeuw further developed the Schwarzschild software for triaxial galaxies. It enables the construction of realistic triaxial dynamical models, which fit the observed surface brightness as well as two-dimensional kinematical measurements of elliptical galaxies. Initial application to observations of NGC4365, taken with the integral-field spectrographs SAURON and OASIS, showed that the method was able to reproduce the kinematically decoupled core and other observational features within the errors. Currently the method is being refined, such that besides the best-fitting parameters (the mass-to-light ratio and the black hole mass), it also provides the internal orbital structure of elliptical galaxies. The method is tested against theoretical Abel models, for which the distribution function is known analytically, but allows enough freedom to incorporate many of the observed triaxial features. Once all this is done, this extended Schwarzschild method will allow the detailed study of many of the large elliptical galaxies in the SAURON sample that show significant signatures of non-axisymmetry.

2.7.4 Analytic Methods

Van de Ven continued work on theoretical triaxial galaxy models with a gravitational potential of separable Stäckel form. For these models the continuity equation and the three Jeans equations have been solved analytically. The resulting first and second velocity moments can be used to construct velocity and velocity dispersion fields. Stäckel models only harbour regular motion and all have cores rather then central density cusps. Even so, they capture much of the rich internal dynamics of elliptical galaxies. For these galaxies, this should reproduce many of the two-dimensional kinematical features observed with integral-field spectrographs such as SAURON, and to constrain their intrinsic structure and orientation. Moreover, the latter reduction of parameter space in combination with the computationally expensive but more general Schwarzschild software, allows the construction of detailed realistic dynamical models of elliptical galaxies.

Weijmans and de Zeeuw continued their project on the probability distributions of ellipticity and misalignment of elliptical galaxies. As part of this, Weijmans developed a Maximum Likelihood code to find the best fitting distribution of intrinsic misalignment in elliptical galaxies, given the observed joint distribution of ellipticity and misalignment between the rotation axis and the minor axis of the surface brightness distribution. The formalism is also useful for the analysis of the relative orientation of radio jets and central dust distributions, which is under study together with Verdoes Kleijn (ESO).

2.8 Active Galaxies and Quasars

2.8.1 Mid-infrared Interferometry of AGNs with VLTI-MIDI

Jaffe and members of the MIDI team accomplished the first successful detection of an active galactic nucleus (AGN –NGC 1068) with an interferometer in the mid-infrared wavelength range. Their scientific aim was to determine the structure of the 'obscuring torus' which was postulated for decades as the cause of the observational differences between AGNs of the Seyfert 1 and Seyfert 2 types. The former show an intense nonthermal central source and broad emission lines. These are lacking in the latter and assumed to be extinguished by a thick dust structure. The MIDI measurements spatially and spectrally resolved emission at 10μm from a structure about 4×2 parsec across in NGC 1068. Jaffe and collaborators found the overall size and temperature to be consistent with existing model predictions for a torus, but the detailed temperature distribution did not fit any existing model. The 10μm band is dominated by absorption from silicate minerals in the dust. However, the profile from the central regions of the galaxy differed from that normally seen in Galactic stars, suggesting that the higher temperature in the former has changed the minerals in the dust.

2.9 Clusters and Cluster Galaxies

2.9.1 Nearby Clusters

Structure of Nearby Galaxy Clusters

Biviano (Trieste, I) and Katgert reanalyzed the evidence on the orbits of the different types of galaxies in an ensemble of 59 nearby ($z < 0.1$) and rich clusters from the ENACS sample. The method by which they could derive the (anisotropy of the) velocity distribution was conceptually clear but its application to real data was not easy. The velocity distribution and its anisotropy profile follow from a mass model, the observed projected distribution and the line-of-sight kinematics (in the form of velocity-dispersion profiles). The latter required sensible extrapolation to large distances. Finally, all integrals involved had to be evaluated numerically.

The robustness and reliability of the results were checked by going round the circle: i.e. all derived functions such as the number space density, the dispersion of the radial component of the velocities and the velocity anisotropy were projected back into the domain of the observables for a direct comparison to the observations from which they were originally derived. This has led to quite robust and self-consistent solutions for which the uncertainty can be estimated reliably.

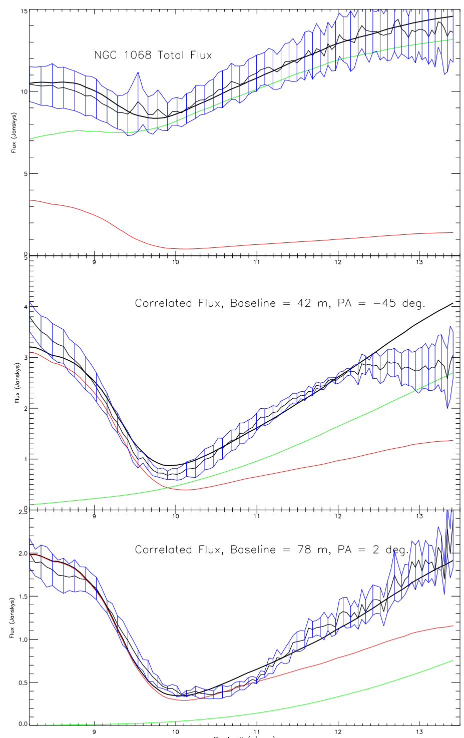


Figure 2.9: Observed MIDI spectra from the nucleus of NGC 1068 compared with model predictions. Thin jagged lines show observed flux versus wavelength, hatched areas show r.m.s. scatter, and thick smooth lines show model predictions. The absorption dip near 10 μm is caused primarily by silicate dust.

Biviano and Katgert found that the orbits of the early-type galaxies (all but the brightest ellipticals and the S0 galaxies) are consistent with being isotropic. The orbits of the early spirals showed an apparent tangential anisotropy near about half the virial radius, which may be connected to the process by which the early spirals are thought to be transformed into S0 galaxies. Finally, the late spirals were found t have orbits which, beyond about half the virial radius, are clearly radially elongated.

Cooling Flows

Jaffe maintained his long-standing interest in the subject of molecular gas in cluster cooling flows. Together with Bremer and Baker (both Bristol, UK) he showed that molecular gas is present over wide areas of cooling flows. He concluded that wherever ionized hydrogen is seen, molecular hydrogen is, in fact, also always found. Jaffe, Bremer and Baker obtained IR and optical spectra in order to investigate the excitation mechanism of the warm gas. They considered EUV photons from the cooling flow to be the most likely candidate.

Diffuse Radio Emission from Clusters

Johnston-Hollitt, Ekers (ATNF, Australia) and Hunstead (Sydney, Australia) observed the central region of the unique southern cluster A3667 at 1.4 GHz with the ATCA in an attempt to confirm the existence of a central low surface brightness radio halo the existence of which had been proposed in Johnston-Hollitt's Ph.D. thesis. As the new data were inconclusive, the possibility remains that A3667 contains both a pair of Mpc-scale radio "relics" and a central radio halo.
Johnston-Hollitt, Vogt (MPA, Germany) and Hunstead (Sydney, Australia) analysed low resolution archival 1.4 GHz ATCA and 0.8 GHz MOST data for the double relic cluster A3376, the second double relic cluster seen after A3667. They confirmed the existence of the double relic structure and obtained additional high resolution ATCA imaging. The diffuse emission exhibited similar radio and X-ray characteristics to A3667 and is possibly also the result of cluster-cluster merging.
Moreover, Johnston-Hollitt and Clarke (Virginia, USA) completed their analysis of a deep VLA 4.8 GHz image of the Mpc-scale diffuse radio emission in the Rood 27 cluster group. They found the structure to be polarised at the 40% level and to contain an embedded point source associated with an optical galaxy at the same redshift as the clusters that comprise the Rood 27 group. The diffuse emission has none of the other hallmarks for 'relic' radio emission, such as associated thermal X-ray emission or close proximity to a known cluster. However, Johnston-Hollitt and Clarke did find evidence for a radio and X-ray point source overdensity in the region suggesting it might be a weak cluster group. This would account for the lack of thermal X-rays and would then be the first relic source associated with a weak, rather than rich, galaxy group.

2.9.2 Horologium-Reticulum Supercluster

Johnston-Hollitt, Fleenor, Rose, Christiansen (the latter three North Carolina, USA) and Hunstead (Sydney, Australia) continued their investigation of the Horologium-

Reticulum supercluster. The group significantly expanded its optical data on the supercluster adding some 1700 unpublished high-quality optical spectra to the existing data making a total of about 3000 spectra for the region. They also obtained fully processed 1.4 GHz ATCA mosaiced observations of the central region of the supercluster. Their examination of the optical data showed a rich velocity structure and supported the previously suggested hierarchical merging model for this supercluster. The radio data uncovered a compact group of three head-tailed galaxies associated with a known in-falling component to the central supercluster region. Using newly obtained ATCA 4.8 GHz and archive MOST 0.8 GHz data, Johnston-Hollitt and collaborators could determine that two of the galaxies are members of the in-falling group while the third is simply a change alignment with a background source. Both in-falling head-tailed galaxies are strongly polarised at 4.8 GHz and show significant twisting and bending of their radio jets probably due to bulk gas flow in the ICM as the group is attracted to the centre of the Supercluster.

2.10 Distant Objects and Large-Scale Structure

2.10.1 Galaxies at Medium-Redshift

Van der Wel and Franx measured the evolution of the mass-to-light ratio of early-type galaxies in the field at redshift one. To this end, they obtained the offset from the local Fundamental Plane from deep optical spectroscopy and HST imaging. The results for the first four galaxies yielded an average evolution of 1.8 magnitudes at z=1. The two galaxies more massive than 3×10^{11} solar masses had luminosity-weighted ages of about 3 Gyr, implying that their stellar populations were formed at redshift 3. The less massive galaxies had younger stellar populations. Van der Wel and Franx also found the rest-frame UV color to correlate well with the mass-to-light ratio, as expected from stellar population synthesis models for 1-3 Gyr old stellar populations.

Van Starkenburg started her Ph.D. research with van der Werf by analyzing high resolution VLT ISAAC near-infrared spectroscopy of nine Hα emitting galaxies at redshifts $\sim\ 0.8-1.8$ from the NICMOS grism survey. In one case, a rotation curve with a peak velocity of $\sim\ 100\,\mathrm{km\,s^{-1}}$ could be extracted. Because the [N II] lines appear to be absent, the emission line in this case is probably not Hα but [O III]5007 which put the galaxy at a redshift of 2.47.

Best (Edinburgh), Röttgering, Miley and Lehnert (MPE, Munich) studied the environments of a complete subsample of six of the most powerful radio-loud active galactic nuclei (AGN) at redshifts $z\ \approx\ 1.6$ using deep RJK imaging. An excess of galaxy counts in the K-band was seen in these fields. The surplus galaxy-counts were predominantly associated with red galaxies (R-K $\geq$ 4) of magnitudes 17.5 $\leq$ K $\leq$ 20.5 found within radial distances of $\approx$1 Mpc of the AGN host. Such a combination of magnitude, colours and location would be expected of old passive elliptical galaxies in cluster environments at medium-redshifts. By using both an Abell-style classification scheme and investigations of the angular and spatial cross-correlation functions of the galaxies, Best and company found the average environment of the fields around these AGN to be consistent with Abell cluster richness classes 0 and 1.

2.10.2 Star Formation History of Infrared-Luminous Galaxies

A team led by Franceschini (U. Padova, It) including van der Werf completed and published follow-up spectroscopy of galaxies in the Hubble Deep Field South, detected with the Infrared Space Observatory (ISO) at 7μm, $15\,\mu$m or both. This ISO dataset constitutes the deepest survey to date at mid-infrared wavelengths. A follow-up in the form of near-infrared spectroscopy of redshifted Hα of 18 galaxies at $z = 0.2 - 1.5$ revealed that in the large majority of objects, star formation is responsible for the observed luminosity. Evidence for an active nucleus was found in only two cases. Star formation rates range from 10 to $300\,M_{\odot}$ yr^{-1}, and the galaxies were found to be remarkably massive. A comparison of inferred stellar masses with measured star formation rates indicated a wide range of formation timescales, from 0.1 to more than 10 Gyr. Only a fraction of the stars could have been formed in any single starburst event, while several of such episodes during a protracted star formation history are required for building up the total stellar population.

2.10.3 SCUBA Surveys of High-Redshift Galaxies

Lensed Dusty Starburst Galaxies

Knudsen and van der Werf succesfully completed the Leiden-SCUBA Lens Survey. This survey used clusters as gravitational lenses to probe the fainter part of the submillimetre background galaxy population. In collaboration with Kneib (Caltech, Pasadena, USA) they constructed mass models for the whole sample mapping the gravitational potential of the intervening galaxy clusters. This allowed them to correct the intensities and positions of the individual submillimetre galaxies for gravitational lensing. Because of the larger number of sources, the resulting number counts at $850\,\mathrm{mJy}$ are much more reliable than those obtained previously. It should be noted that the Leiden-SCUBA Lens Survey establishes number counts down to flux-densities of 0.25 mJy which is twice as deep as previous results, and a factor of eight fainter than the blank field confusion limit.

They also started a multiwavelength follow-up of the survey, by obtaining optical spectroscopy for a fraction of the galaxies. Noteworthy in this follow-up was

the identification of a SCUBA galaxy with a (previously unknown) quasar at redshift $z = 2.837$, which was subsequently detected at all wavelengths from the radio through X-rays, including CO line emission detected at the Owens Vally Radio Observatory. Analysis of the spectral energy distribution suggested that the SCUBA-selected quasar is located in a host galaxy with a high star-formation rate.
Reuland, Röttgering and van Breugel (Livermore, USA) observed the dust continuum emission from a sample of $z > 3$ radio galaxies with the SCUBA bolometer array. They confirmed and strengthened an earlier result that high-z radio galaxies (HzRGs) are massive star-forming systems and that the submillimeter detection rate appears to be a strong function of redshift. They also observed HzRG candidates that had eluded earlier attempts at spectroscopic redshift determination. Four candiadates were measured and provided evidence that these are extremely obscured radio galaxies, possibly in an early stage of their evolution.

Blank-Field Survey (CUDSS) of High-Redshift Galaxies

Webb and collaborators at Cardiff U. (UK), U. of Toronto (Canada) and ETH Zurich (Switzerland) completed and published the Canada-UK Deep Submillimetre Survey (CUDSS). CUDSS is a very deep, blank-field imaging survey at 850μm which was carried out with the SCUBA imaging instrument on the James Clerk Maxwell Telescope in Hawaii. Six years after the commissioning of SCUBA, CUDSS remained the deepest survey to be carried out over large contiguous areas of sky. It has produced a catalogue of 50 high-redshift submillimetre-selected galaxies.
Among these systems are some of the most luminous objects in the early universe, forming stars at unprecedented rates of 100-1000 $M_\odot$ yr^{-1}. Given such high rates of star formation, these objects may represent an important phase in the formation of today's massive elliptical galaxies. The submillimeter data indicated that, down to a 3 mJy flux-density, these galaxies produce $\sim$13% of the total far-infrared background light at 850 μm. That is, they are responsible for roughly 13% of all the energy emitted at 850 μm by objects in the universe, integrated over all time. The large field sizes covered by the survey made a clustering analysis possible. Although final numbers were too small to be conclusive, the statistics were consistent with substantial spatial clustering within this population as seen in other high-redshift star-forming populations and also in measurements of the clustering strength by other groups.
Substantial progress was made in follow-up observations, necessary to understand these systems and place them into a cosmological context. Observations at radio, near-infrared and optical wavelengths revealed many of these systems to have extremely red colours ($(I - K) > 4$) which may, in fact, be used to identify source counterparts in the absence of radio data. Deep HST imaging revealed disturbed morphologies and often multiple components, supporting the idea of merger-driven

activity in these systems. Although the redshift distribution was found to be generally very similar to those determined by different surveys, the CUDSS sample has an excess of low-redshift ($z < 1$) galaxies. This may be explained through a submillimeter-luminosity-redshift relation, such that the submillimeter luminosity of galaxies was higher at higher redshifts. Because CUDSS is the deepest survey for its area it would be sensitive to more lower-redshift systems than other shallower surveys.

Webb also carried out a statistical study of the submillimetre properties of Extremely Red Objects (ERO) within the CUDSS fields with the broad goals of determining the fraction of the far-infrared background produced by EROs and the average submillimeter intensity of the ERO population. Her results indicated that EROs produce $< 10\%$ of the background and, in fact, this fraction was already accounted for through submillimeter-selected galaxies. However, an unexpected result was that EROs, showing signs of substantial star-formation through their strong submillimeter emission, often are found in pairs or small groups. This also suggested that galaxy-galaxy interactions may be important drivers for intense bursts of star formation.

2.10.4 Properties of Galaxies at High-Redshift

Labbé and Franx discovered six large disk-like galaxies at redshifts ranging from $z = 1.4$ to $z = 3.0$, using deep near-infrared VLT/ISAAC imaging of the Hubble Deep Field South. The galaxies, selected in the K_s band ($2.2\mu m$), are regular in shape and surprisingly large in the near-infrared (rest-frame optical), with face-on effective radii comparable to the size of the Milky Way galaxy. Their structural and spectral characteristics appeared to be similar to those of nearby disk galaxies: they exhibit exponential profiles with large scale-lengths, morphologies more regular and centrally concentrated in the rest-frame optical than in the rest-frame UV and, as a result, red nuclei. Nevertheless, kinematic studies are still necessary to confirm that the material is in a rotating disk. The discovery of these galaxies was unexpected from previously studied samples. In particular, the Hubble Deep Field North is deficient in large galaxies with the morphologies and profiles described here.

Reuland, Röttgering and a group at ROE Edinburgh (Stevens, Ivison, Dunlop, Smail, Percival) carried out deep submillimeter mapping of seven high-redshift radio galaxies and their environments. These data confirm not only the presence of spatially extended massive star-formation activity in the radio galaxies themselves, but also in companion objects previously undetected at any wavelength. The prevalence, orientation, and inferred masses of these submillimeter companion galaxies suggest that we are witnessing the synchronous formation of the most luminous elliptical galaxies found today at the centres of rich galaxy clusters.

Daddi, Röttgering and members of the FIRES survey team (PI Franx) measured the clustering properties of faint galaxies in ultradeep J, H, and K near-IR images of the Hubble Deep Field-South (HDF-S) obtained with ISAAC at the Very Large Telescope. As a function of the K magnitude, a relatively large clustering amplitude was found. At the highest redshifts ($2 < z < 4$), galaxies selected in the rest-frame optical (K band) appeared significantly more clustered than galaxy populations selected in the rest-frame over a similar redshift range and with similar number densities. Although semi-analytical hierarchical models predicted the existence of strongly clustered populations at $z \approx 3$, they did so with number densities at least a factor of ten lower than the one measured. The properties of this strongly clustered population suggest that it is the progenitor or major building block of local massive early-type galaxies.
Solorzana-Inarrea, Best (Edinburgh), Röttgering and Cimatti (Arcetri) carried out deep VLT spectropolarimetric observations of two powerful radio galaxies, 0850-206 and 1303+091 in the rest-frame UV wavelength range. In both galaxies, total flux and polarized flux spectra revealed the $2200\mathring{A}$ dust absorption feature. Comparison with dust-scattering models suggested that the composition of the dust in these galaxies is similar to that in the Milky Way. In 0850-206, scattered quasar radiation dominated the UV continuum emission, with the nebular continuum accounting for no more than a fifth and no requirement for any additional emission component such as emission from young stars. However, in 1303+091 unpolarized radiation could be a major constituent of the UV continuum emission, with starlight accounting for up to half and the nebular continuum accounting for about a tenth of the emission.
Wilman (Durham), Jarvis (Oxford) and Röttgering obtained VLT-UVES echelle spectra of the Lyman-α emission and absorption in five radio galaxies at redshifts ranging from $z = 2.5$ to $z = 4.1$. They identified two groups of HI absorbers: strong absorbers with $N_{\rm HI} = 10^{18} - 10^{20}$ cm^{-2} and weak absorbers $N_{\rm HI} = 10^{13} - 10^{15}$ cm^{-2}; they found none with intermediate values of $N_{\rm HI}$. The strong absorbers migh be a by-product of massive galaxy formation or could instead represent material cooling behind the expanding bow-shock of the radio jet. Wilman, Jarvis and Röttgering argued that the weak absorbers are part of the Lyman-α forest, as their rate of incidence is within a factor of two to four of that in the IGM at large. Such column densities are consistent with models of a multi-phase proto-intracluster medium at $z > 2$.

2.10.5 Searching for Protoclusters

Luminous radio galaxies are the IR-brightest and presumably most massive galaxies at $z > 2$, very probably marking the centres of forming clusters. Miley, Röttgering, Venemans, Kurk and collaborators used ESO's Very Large Telescope to find overdensities of Lyman-α emitters around radio galaxies at redshifts of $z > 2$. They identified objects with a probable excess of Lyman-α emission, and carried out spectroscopy of the brightest of these candidates to establish that they were at the same distance as the radio galaxy by confirming that they had similar redshifts. The seven radio galaxies (at $z = 2.2, 2.9, 2.9, 3.1, 3.2, 4.1$ and 5.2 respectively) that they studied with sufficient sensitivity all turned out to be surrounded by an overdensity of Lyman-α emitters (by factors of 5 – 15) having velocity dispersions of 300 – 1000 km s^{-1}. The scale of these structure was larger than 3 Mpc, exceeding the 7' $\times$ 7' FORS field imaged. Structure masses were estimated at $> 10^{14} - 10^{15}$ M$_{\odot}$, comparable to the mass of present-day rich clusters of galaxies.

Overzier & Miley obtained deep Advanced Camera for Surveys (ACS) imaging observations of protocluster targets from their VLT Large Program. One such protocluster, associated with the radio galaxy TN J1338–1942 at $z = 4.11$, showed that the overdensity of Lyman-α emitters surrounding the radio galaxy is accompanied by a similar overdensity of g,r,i-selected Lyman-break galaxies. The existence of such a population of Lyman-break galaxies was anticipated for some time. However, the object in question appeared to be very rich: Overzier & Miley identified approximately 90 (candidate) cluster members surrounding TN J1338–1942 (both Lyman-α and Lyman-break galaxies) and quantification of their HST morphological properties and spectral energy distributions is underway. ACS observations of other protoclusters between $z \sim 5$ and $z \sim 2$ as well as $z \sim 1$ clusters from the Intermediate Redshift Cluster Program of the ACS GTO Science Team will be used to trace the evolution of the largest building blocks of the Universe, that began forming when the Universe was only 10% of its present age.

Kurk (Leiden/Arcetri), Röttgering, Miley and Pentericci (Heidelberg) conducted a detailed study of the environment of the powerful radio galaxy PKS 1138-262 (z=2.2) at optical, NIR, radio and X-ray wavelengths. They carried out deep narrow-band imaging, yielding 70 candidate Lyman-α emitters with an overdensity by at least a factor of two compared to the field. Their spectroscopic follow-up so far confirmed 14 galaxies to have redshifts similar to that of the radio galaxy. Deep narrow-band imaging and spectroscopy in the infrared resulted in the detection of 7 confirmed Hα-emitting galaxies. Interestingly, the distribution of Hα-galaxies seems much more concentrated than that of the Lyα emitting galaxies. Furthermore, the population of Hα emitters appeared to have a brighter average K-band magnitude and a lower velocity dispersion. Kurk and coworkers surmised that the population of Hα-emitting galaxies is older and dustier and is closer to having it orbits virialized in the “proto-cluster” potential, implying that seeds of the morphology-density relation are already in place at $z = 2.2$. As before, they estimated the mass associated with the ‘overdensity’ to be in the range $10^{14} - 10^{15} M_{\odot}$, as expected for a progenitor of nearby massive clusters.

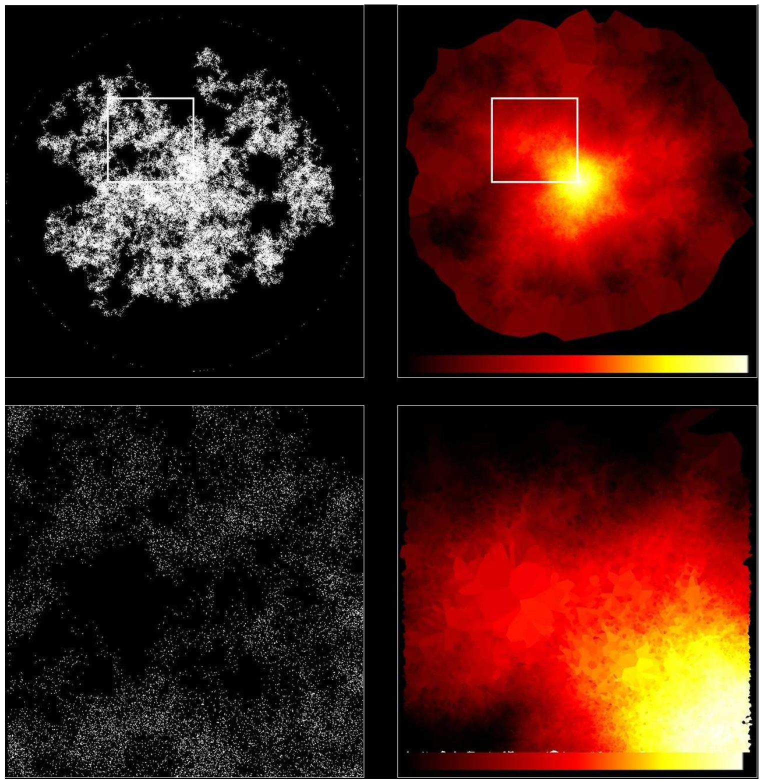


Figure 2.10: Top: Inhomogeneous point distribution representing a spiral galaxy and a logarithmic plot of the resulting radiation field from a central source. Bottom: Magnified view (16X) of the region within the white square.

2.11 Models and Theory

2.11.1 Numerically Solving Radiative Transfer Equations

Ritzerveld, Icke and Rijkhorst developed a new numerical method for solving the equations of radiative transfer. It makes use of unstructured grids in which the grid-points are placed coincident with most of the optically active material, thus putting the accuracy where it is needed most.

This approach led them to several interesting and advantageous properties of the method. First of all, this method reduces the ordinary 7-dimensional set of equa-

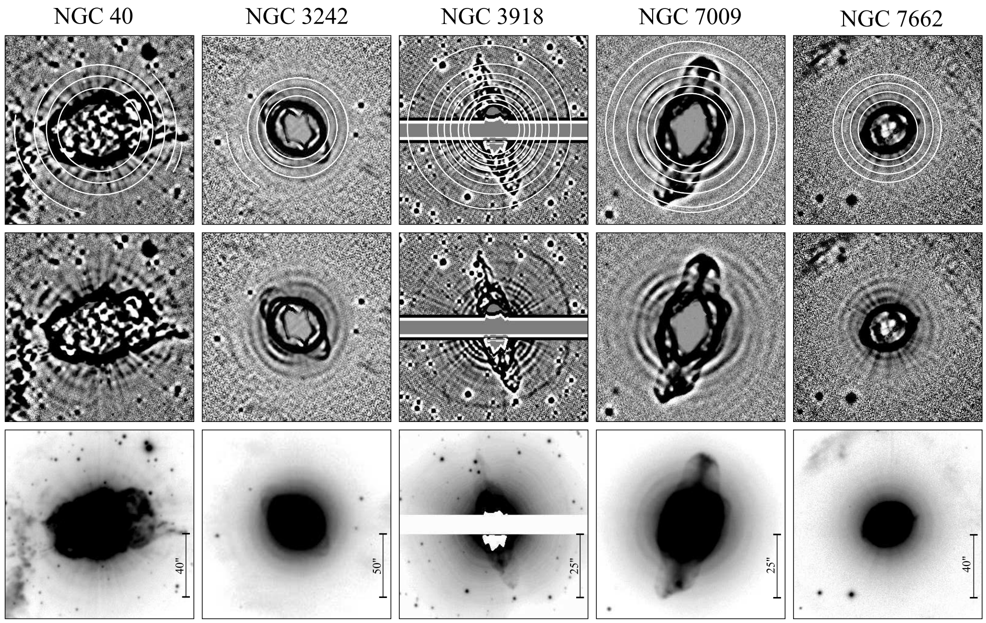


Figure 2.11: Images of the newly detected ring systems in the halos of planetary nebulae. All images are in *negative* greyscale. The bottom row of images shows the original image in a logarithmic display, the middle row shows the processed images in a linear display, and the top row the processed images with circular fits of the rings.

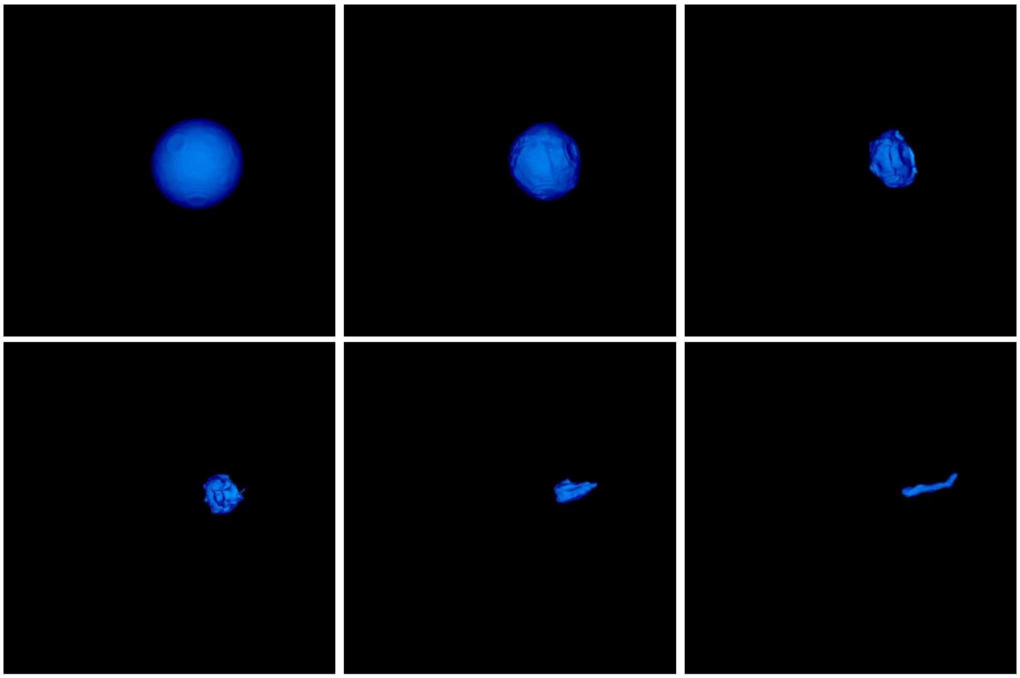
tions to a 1-dimensional one, thus reducing the computational costs by enormous factors making it possible, for the first time, to do complicated multi-dimensional radiative transfer on a simple stand-alone computer and to couple it to existing hydodynamical schemes. Secondly, their use of unstructured, Lagrangian grids circumvents limitations commonly found in current transfer codes. For instance, these may be optimised only for axi-symmetric problems with a single central source, or while they may yield reliable solutions in one opacity regime, fail in others. Ritzerveld and coworkers could show that their method is as fast in every dimension, even when the number of sources increases and when the sources are not centrally distributed. They also showed that their method implicitly guarantees a correct treatment even when a photon propagates from an optically thick to an optically thin region, and the time-dependent transfer equations are solved implicitly not requiring extra computational effort.

Subsequently, they used their SimpleX-code, a two- and three-dimensional implementation of their new method, to verify the method by testing several time-(in)dependent test-cases such as the creation of Strömgren spheres, the tracking of non-spherical ionisation fronts and various intrinsic three-dimensional inhomogeneous problems. An example is given in Fig. 2.10 which shows a highly inhomogeneous matter distribution represented by an inhomogeneous grid-point distribution (top-left), and the result of the method for a central point source (top-right). The advantages of an unstructured, Lagrangian grid are highlighted by exemplifying the amount of detail with a zoom-in on the region within the white squares. The results are plotted in the bottom half of Fig. 2.10

2.11.2 Planetary Nebula Modelling

Individual Planetary Nebula (PN) distances are frequently determined by comparing their angular expansion in the sky to the spectroscopically measured radial velocity of the gas. However, even in the case of a perfectly spherical nebula, these velocities are different since the first is a pattern velocity and the second a material velocity. Mellema derived analytical expressions to estimate the magnitude of the difference between the two velocities and found that for the typical PN velocities measured, the pattern velocity is 20–30% higher than the material velocity. PN distances estimated from the expansion parallax may therefore be 20–30% larger than previously thought.

Mellema, Corradi (ING-UK), Schwarz (CTIO-USA), Sanchez-Blazquez (Madrid, Sp) and Gianmanco (IAC, Sp) searched for ring-like structures in the faint halos of Planetary Nebulae. Eight new nebulae with such rings were found, increasing the total sample to ten! This allowed them to apply (small number) statistics to the sample. Given the biases in the original sample, they estimated that rings may be present in a third of all PNs. They suspected that the spacing increases with the age of the system, especially after comparison with the proto-Planetary and Planetary Nebula samples. Such properties would be roughly consistent with the models of Meijerink, Mellema and Simis, but do not rule out other models.



Isosurface representation of the squashing of an intergalactic cloud by the passage of a strong shock. The top left shows the initial cloud with a size of 100 pc, the rest of the sequence shows the evolution in steps of 300,000 years, from the initial flattening to the squashing into a long thin cloud, which would be subject to gravitationial collapse.

2.11.3 Three-Dimensional Models of Intergalactic Clouds

Mellema and Rijkhorst numerically investigated the three-dimensional structure of intergalactic clouds being hit by the bow shock of a radio jet. This process had only been studied in two dimensions before. The calculations were done with the locally developed Capreole code, using a fixed grid with a size of 256x128x128 and were run on the national supercomputer Teras. Their simulation showed the cloud first being squashed and flattened and subsequently being compressed and drawn out in a long thin structure. Their analysis showed that quite early in the evolution of the system, substantial parts of the cloud become Jeans-unstable. They considered this to be strong support for the hypothesis of jet-induced star formation, although higher resolution adaptive mesh simulations would be needed to confirm this.

2.11.4 Hydrodynamics of Gravitational Collapse

Intema and Mellema performed simulations of the gravitational collapse of a spherically symmetric, high-density gas cloud in a low-density environment, using the special metrical approach of the Roe-Eulderink-Mellema solver to implement self-gravity and a general non-linearly spaced grid. Although some problems still needed to be resolved, the method allowed succesgful simulation of the isothermal collapse of a one-solar-mass cloud until after the moment of core formation, with enhanced spatial resolution in the centre of the collapsing cloud.

2.12 Raymond & Beverly Sackler Lab. for Astrophysics

2.12.1 Instrumentation

LIRTRAP

In May 2003, Schlemmer joined the Leiden staff as leader of the Sackler laboratory. Together with his appointment, a low-temperature 22-pole ion trap (LIRTRAP) was transferred from Chemnitz (Germany) to Leiden. This ion trap is capable of determining rate coefficients for gas phase ion-molecule reactions at conditions prevailing in the interstellar medium. In particular, deuteration reactions have been investigated in order to identify the primary sources for isotopic fractionation in gas phase processes. A new data acquisition system was installed on the apparatus by Asvany.

After conducting the first low-temperature trapping experiments in Leiden, the apparatus was brought to FOM Rijnhuizen to intersect the cloud of cold trapped ions with the bright IR light source of the free electron laser FELIX. FELIX offers the unique possibility of a very wide scanning range to obtain (far-)infrared spectra of mass selected, cold ions. In these experiments, the laser induced formation of product ions ($C_2H_3^+$ in this case) is used as a monitor for the excitation of the parent ion ($C_2H_2^+$ in this case). This new method serves as a new tool for both spectroscopy and for the measurement of state-to-state rate coefficients for astrophysically relevant reactions.

SURFRESIDE

Fraser and Schlemmer, together with Bradley from the commercial supplier Oxford Scientific, completed the design of the Atomic Line system for the Surface Reaction Simulation Device (SURFRESIDE): an experiment that looks at atom-molecule, radical-molecule and molecule-molecule surface chemical reactions under interstellar conditions. The atomic line will provide low-flux atoms and radicals for future experiments that are included in the SURFRESIDE research programme. The system was delivered in early November. Fraser, Bisschop and Schlemmer started installation and tests of the system. Prior to installation of the atomic beam, first results using temperature programmed desorption to study the desorption kinetics of CO trapped in CH_3OH have been conducted and published.

CRYOPAD: Assembly and First Results

Van Broekhuizen, Schlemmer and Fraser, together with de Kuiper, Benning (both FMD-Leiden) and van As (LIS-Leiden), continued work on the construction and testing of, as well as 'first light' experiments on the CRYOgenic Photo-product Analysis Device (CRYOPAD) designed to study solid-state processes in hot-core chemistry. Major developments during 2003 included heat-treatment of all the steel parts to prevent outgassing of contaminant gases and re-assembly of the entire system to operational ultra-high vacuum (UHV; $< 5 \times 10^{-10}$ mBar) pressures for the first time, simulating the interstellar environment and providing a 'clean' vacuum for surface science studies. Also, calibration of temperature, pressure and mass spectrometer readings have been completed. Additional progress included setting up the temperature programmed desorption technology, and mounting/testing of the UV photon source, an H_2 discharge lamp.
A set of initial experiments was conducted on the CO - CO_2 ice system. CO_2 ice is found to be ubiquitous in all lines of sight in interstellar regions and is thought to be produced through a combination of atom-molecule surface reactions and UV photon-induced processes. Sub-monolayer to multi-layer coverages of each ice were deposited and then slowed warmed, to study their desorption characteristics. First, only CO or CO_2 were studied as control experiments, both without and with UV irradiation. These preliminary data suggested that CO_2 cannot be made from irradiation of pure CO ices and that photodesorption of both CO_2 and CO readily occurs when a pure CO_2 ice is exposed to UV doses characteristic of interstellar regions. Following UV exposure, some CO produced from photodissocation of CO_2 remains trapped in the ice, forming an ice mixture which desorbs when CO_2 itself desorbs. The next step is a more detailed and quantitative study of this system.

2.12.2 Investigating CO

CO Desorption Behaviour of Astrochemically Relevant Ices

Fraser, Bisschop and Alsindi (visiting student, Nottingham), UK, studied in detail the spectroscopy and desorption behavior of CO in a variety of ice systems, i.e.

HCOOH, CO_2, CH_3OH, and CH_4, all of which are found in roughly equal abundances in a variety of high and low mass young stellar objects. Recent VLT-ISAAC observations by Pontoppidan et al. suggested that more than 60% of CO ice is present in its pure form, probably in a layer segregated from other ice species. In a series of experiments, 1:1 ice mixtures, CO over-layers and CO-underlayers were investigated (Fig. 2.12). A more general comparison of the results showed that CO desorption from layers and mixed ices is significantly different as the temperature of the ice increases. In a similar way, the spectroscopy of mixed ices is rather complex whereas that of layered ices appears identical to that of pure ices. Small amounts of CO trapping were observed in all the systems studied. Fraser and coworkers concluded that for CO ices at least, layers more closely resemble the interstellar observations and reproduce the evolutionary behavior. Moreover, trapping of CO means that a fraction of interstellar CO may remain in the solid state beyond its expected desorption temperature thereby being available for subsequent chemistry on or in the ice, especially in regions where the ices are already warming or evaporating.
Alsindi and Fraser observed the formation of a low temperature CO–CH_4 complex. Together with Gardner (Chemistry, Leiden) and van Dishoeck they showed that the complex is hydrogen-bound. Using ab initio quantum chemistry methods, they also calculated its binding energy.

CO-Surface Adsorption

Fraser and Bisschop applied the results of their spectroscopic study of CO on grain analogs in the lab to understanding an unidentified solid-state band at 2175 cm^{-1} in the VLT-ISAAC data obtained by Pontoppidan et al. They fitted laboratory spectra of CO chemisorbed to a zeolite surface including a component for OCN^- to the observed spectra and obtained excellent agreement for all 30 objects in which the band was detected. The correlation found between the optical depths of the 2175 cm^{-1} band and the more commonly known CO feature at 2136 cm^{-1} is likely to be related to grain temperature, which itself could be linked to the fraction of bare grain surface area exposed to the interstellar gas. This result constituted the first direct evidence for grain-gas interactions in interstellar and protostellar regions.
Aiming to understand the processes governing the growth and destruction of icy mantles on interstellar grains, Al-Halabi, together with Fraser, van Dishoeck and Kroes (Chemistry-Leiden), performed classical trajectory calculations on the adsorption of thermal CO to the surfaces of amorphous and crystalline water ice for a range of energies. They found the sticking probability of hyperthermal CO to decrease with incident energy and with angle of incidence. They also found the energy transfer from the impinging molecule to the surface to be efficient and fast: for normal incidence most of the transfer occurs within 0.5–1.0 ps. No surface pene-

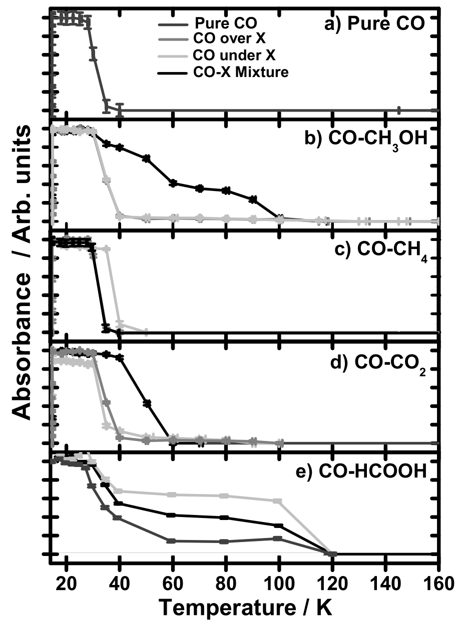


Figure 2.12: Desorption behavior of CO as a function of temperature for layers and mixtures of CO with various species (From: Fraser et al.)

tration was found to occur even at high energies, but the impinging molecule may damage the surface significantly when it hits in the center of a hexagonal ring of crystalline ice.

At the low temperatures relevant to interstellar conditions, the calculations predicted a high adsorption probability (~ 1), with the adsorbed CO having an average potential energy of –0.094 eV, but with a large range corresponding to various geometries. In all the adsorbing trajectories, CO sits on top of the surface. Geometry minimizations suggested that the maximum potential energy of adsorbed CO occurs when CO interacts with a “dangling OH” group, attributed to the secondary (weaker) CO band seen in solid-state infrared laboratory spectra, at 2152 cm^{-1}. This number of “dangling OH” at the amorphous ice surface is quite small, potentially explaining the absence of this feature in astronomical spectra. CO also interacts with “bonded OH” groups, which the team attributed to the primary (stronger) band of solid CO at 2139/2136 cm^{-1}. Finally, the adsorption lifetimes of CO at surface temperatures predominant in the interstellar medium have been calculated.

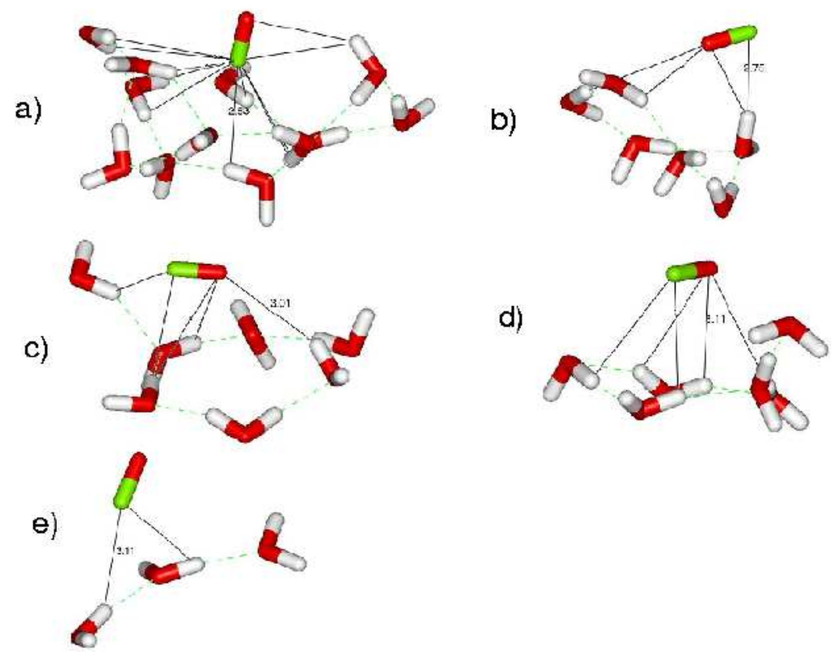


Figure 2.13: Examples of CO-amorphous ice interactions, obtained from geometry optimizations at five different values of the binding energy. Dotted lines show the hydrogen-bonding network between the water molecules; full lines connect CO with the H-atoms. The 2152 cm^{-1} CO infrared band is associated with the configurations seen in (a) and (b); the 2139 cm^{-1} with those in (c), (d) and (e) (From: Al-Halabi et al.)

2.12.3 Testing the Accuracy of DFT for Reactions with Hydrogen

Andersson, after discussions with Kroes (Chemistry-Leiden) and van Dishoeck, evaluated the quality of a large number of different density functionals (DFT) for describing astrophysically relevant chemical reactions, all involving hydrogen. The main application was in studies of the kinetics of reactions thought to occur on interstellar grains. These include the H + CO, H + H_2O, C + H_2 and N + H_2 reactions. After consideration of general trends in the performance of the density functionals for reactions involving H atoms, the best overall performance for H_2 and OH was found for the hybrid density functionals. In contrast, the OH + CO reaction was found to be a very problematic case for DFT.

2.13 Astrobiology

Cox and Ehrenfreund studied the diffuse interstellar bands (DIBs) in a variety of environments, observed in a heavily reddened galactic line of sight towards a high mass X-ray binary and in extragalactic lines of sight. These include the Large Magellanic Cloud and the galaxy NGC 1448 which hosted two supernovae over the past three years. Ruiterkamp and Cox developed a model for the polycyclic aromatic hydrocarbon (PAH) ionization in diffuse/translucent clouds and the suspected link between DIBs and PAHs.

ten Kate and Garry operated the Mars simulation chamber, located at ESTEC (Noordwijk, NL) in an attempt to characterize the effects of the martian near-surface environment on organic matter. This simulation chamber passed its qualification tests, with only some minor refinements still needed. At the same time, another vacuum system was built at the Leiden Institute of Chemistry for the production of experimental samples of organic material. The first experiments, using these systems, were performed. Analytical tools have been applied to the processed samples and the first measurements of the effect of the martian environment on the stability of the amino acid glycine were obtained.

Peeters, Botta and Ehrenfreund investigated a particular group of prebiotic molecules, the nucleobases, in different regions in the interstellar medium and the difficulties in observing this group. They found these molecules to be relatively stable against UV radiation. Martins and Botta analyzed the content of nucleobases in carbonaceous meteorites. Their search for nucleobases in the well-known Murchison and Orgueil meteorites was performed using state-of art high-performance liquid-chromatography (HPLC) equipment using a diode array detector. They could not confirm the presence of nucleobases in these meteorites.

Ehrenfreund and collaborators observed comet C/2002 C1 (Ikeya-Zhang) and determined its HNC/HCN ratio at two heliocentric positions. Their observations appear to confirm that the dominant source of HNC in cometary comae is the degradation of complex organic material. The search for submillimetre emission from the nucleic acid building block pyrimidine yielded only upper limits towards Sgr B2(N), Orion KL and W51.

Ehrenfreund and Fraser investigated the physics and chemistry of interstellar icy particles. Within the framework of an ESA Topical Team, they studied ground-based experiments on ice and dust, models as well as related space experiments performed under microgravity conditions.

2.13.1 SETI

In collaboration with colleagues from the SETI Institute Mountain View, CA, USA) Ollongren continued his research on the application of the theory of types (originated by Per Martin-Lf, Stockholm) in further developing LINCOS (a Lingua Cosmica). Altruistic aspects of communication with unknown cultures were described using this theory enriched with induction. He elaborated self-interpretation in inductive LINCOS for a contribution to the International Astronautical Congress in Bremen.

2.14 Instrumentation

2.14.1 Optical Projects

SAURON

De Zeeuw, Cappellari, Falcón-Barroso, Krajnović, McDermid, van de Ven and Verolme are members of the SAURON team that has built a panoramic integral-field spectrograph for the 4.2m William Herschel Telescope on La Palma, in a collaboration which involves groups in Lyon (Bacon) and Oxford (Davies). SAURON (Spectroscopic Areal Unit for Research on Optical Nebulae) records 1577 spectra simultaneously, with full sky coverage in a field of 33 by 44″, additional coverage of a small 'sky' field $1.9'$ away, spatial sampling of $0.94'' \times 0.94''$, and an instrumental dispersion of 105 km/s. SAURON was funded in part by a grant from NWO to de Zeeuw, and was built at Observatoire de Lyon. First light was obtained on February 1, 1999.
SAURON is used for a multi-year program to measure the kinematics and linestrength distributions for a representative sample of 72 nearby early-type galaxies (ellipticals, lenticulars, and Sa bulges, in clusters and in the field). The entire survey was completed in 2003. In parallel with the data taking, the team is developing a number of tools that are key to analyse all the resulting maps.
De Jong largely completed the SAURON pipeline data reduction software. This software package provides an automatic way of organizing and consistently reducing the SAURON survey data. Unlike other pipelines all information of the intermediate reduction steps is maintained in a database which can be viewed by a webbased user interface. The astronomer can alter parameters and remove bad data to optimize the reduction, after which the pipeline only repeats the affected steps.

2.14.2 OASIS and NAOMI

As part of the OASIS instrument team, McDermid assisted in the commissioning and science verification of the OASIS integral-field spectrograph coupled with the NAOMI adaptive optics system at the William Herschel Telescope, La Palma, in July and October 2003. Correction of natural seeing by more than a factor of two was obtained at visible wavelengths, giving an effective seeing of less than 0.3 arcsec in the V-band, compared with an uncorrected value of 0.65 arcsec.

NEVEC

The NOVA-ESO VLTI Expertise Centre (NEVEC) is a national centre partially funded by NOVA as a joint venture with ESO – for more detail see the Sterrewacht Leiden Annual Reports 2001 and 2002. In Leiden, NEVEC involves Bakker, Gori, Jaffe (Project scientist), de Jong, le Poole, Meisner, Miley, Quirrenbach (Principal Investigator) and Röttgering.

Two observing runs with the newly commissioned interferometric instrument VLTI/MIDI (a two-way beam combiner for the VLTI operating at a wavelength of 10 μm) have been devoted to thermal background radiation measurements. Sets of different observational conditions were chosen in order to determine the various contributions to the background radiation. A presentation on this topic was given at the Schloss Ringberg (D) Conference on 'Long-Baseline Interferometry in the Mid-Infrared'.

The NEVEC team analyzed data obtained on the post-AGB binary HR 4049 through the shared-risk science program with VINCI, a 2.2μm interferometric instrument for the VLTI. The results of this analysis are inconsistent with the current disk model of the system. Several solutions are possible: the disk may be seen at a higher inclination angle, or the star may be highly obscured by large circumstellar dust grains. Further insight is expected from MIDI observations of HR 4049 in 2004 through the NOVA guaranteed science program.

A detailed study concerned the feasibility of measuring main sequence stellar radii with currently available optical interferometers. Notwithstanding a clear scientific interest to determine these radii, the accuracy of measurement that can be reached today, is insufficient to verify current theoretical predictions. More progress awaits the availability of interferometers operating in the optical range at wavelengths of 400 nm to 800 nm.

Astrometric measurements with a relative error of 10 micro-arcseconds are expected to be possible with the VLTI Phase-Reference Imaging and Micro-arcsecond Astrometry (PRIMA) facility. This would allow detection of Jupiter-size planets around nearby main-sequence stars. A detailed study was conducted on the best way to reduce PRIMA astrometric data into a self-consistent, globally calibrated data set. As a result, a proposal was written that could form the basis for a PRIMA astrometric data reduction center at Leiden.

A full-scale science program to integrate optical interferometry into mainstream astronomy was conceived by parties from 14 countries, as well as ESO and ESA. This has resulted in a proposal to the European Union within the Framework 6 Program as part of a larger OPTICON proposal. This proposal was successful and the project will run from 2004 up to 2009.

SINFONI

SINFONI (SINgle Faint Object Near-infrared Investigation) is a collaboration between the European Southern Observatory (ESO), the Max-Planck-Institut für extraterrestrische Physik (MPE) and the Nederlandse Onderzoekschool Voor Astronomie (NOVA). SINFONI combines a cryogenic near-infrared (J,H and K-bands) integral field (image slicer) spectrograph ($R \sim 3000$) with an adaptive optics unit and will be installed at the VLT in 2004. A laser guide star facility will enable nearly diffraction-limited imaging over the whole sky. A seeing-limited mode is also available. Leiden astronomers involved in SINFONI include van der Werf (NOVA Principal Investigator), Franx, de Zeeuw and Katgert. The NOVA contribution consists of a combination of work on adaptive optics (carried out partly by Brown in Leiden) and development of the camera required for enhancing SINFONI with a 2048^2 detector (done at ASTRON). A principal milestone in 2003 was the successful Final Design Review of the camera in April after which lens procurement and production of the housing started. A particular challenge to successful camera construction was the difference in thermal expansion coefficient of the lenses and the aluminum housing, which required a special design for the lens mountings. The lenses were produced, coated, tested and accepted in the second half of 2003. A final milestone was the succesful interface verification, where a copy of the camera housing was installed in the SINFONI spectrograph (Fig. 2.14).
Brown extended the laser guide star simulations for SINFONI by including the possibility to vary the height and thickness of the sodium layer, the distance between the laser beacon and the natural tip-tilt star, and the zenith distance of the science target. In addition numerous simulations for the SINFONI adaptive optics system in natural guide star mode were carried out. These are aimed at predicting the optimum settings of the parameters of the adaptive optics system as a function of observing conditions.

Adaptive Optics Instrumentation Development

A begin was made with the establishment of a High Resolution Astronomy Laboratory (HRAL) at Leiden Observatory, an optical lab intended to provide hands-on experience with different aspects of interferometry and Adaptive Optics and to enable participation in the hardware development which is part of larger (European) projects. Several experiments in the area of Adaptive Optics were planned or initiated.
Stuik completed the major part of the study phase for MUSE, a visible light integral field spectrograph, currently under study as a second generation instrument for the VLT. In collaboration with ESO, the specifications for the Adaptive Optics sys-

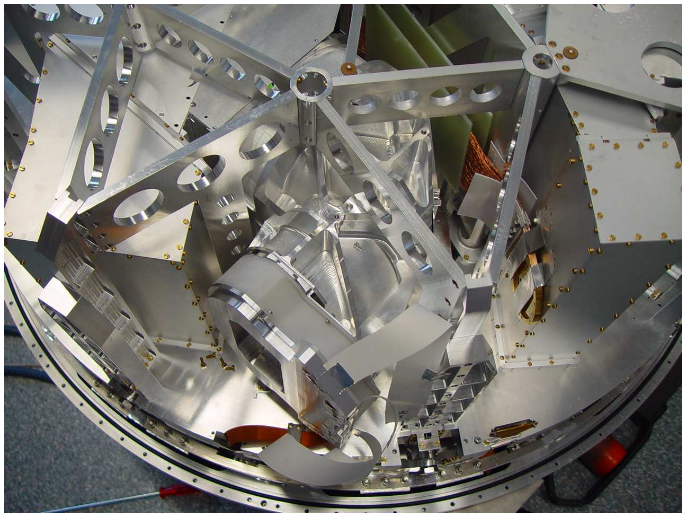


Figure 2.14: Engineering model of the 2K camera housing (without lenses or detector) installed in the SINFONI spectrograph at the interface verification test in Garching.

tem – such as required correction and correction homogeneity, sky coverage and allowable light pollution – have been translated in two opto-mechanical designs. If an Adaptive Secondary is going to be built, MUSE will most likely be one of the instruments to use it; if not, an internal AO system will have to be used.

CHEOPS, another VLT second generation instrument under study, is a planetfinder-type instrument, based on Adaptive Optics-assisted polarimetry and integral-field spectroscopy. The properties of the Adaptive Optics system are currently being modeled, based on accurate measurements done on Deformable Mirrors in collaboration with the MPIA, Heidelberg and ASTRON.

OmegaCAM

The hardware for the OmegaCAM instrument, for which Kuijken is PI, was virtually completed in 2003. Most of this work took place at Göttingen and Munich Observatories. In parallel with the instrument work, planning for the first years of observations continued with a number of meetings in the Netherlands and elsewhere. Start of operations is foreseen for the second half of 2005.

2.14.3 Radio Projects

LOFAR

On November 2003, the Dutch Government issued a grant of 52 million Euros to the LOFAR project, following years of planning and lobbying. LOFAR, the Low Frequency Array, is meant to be a large radio telescope that will open up the virgin territory of observations at low radio frequencies for a broad range of astrophysical studies. Its high sensitivity and resolution will dramatically improve results obtained from previous facilities operating at these wavelengths. The astronomical science case has four major themes: (i) the epoch of reionisation; (ii) the origin of cosmic rays; (iii) transient sources and high energy objects; (iv) formation and evolution of galaxies and quasars. The telescope itself will consists of a hundred stations, each consisting of a few hundred dipoles, in the Netherlands and Northern Germany. First operations with a central core of stations are planned for 2005. The ASTRON foundation is leading the overall management and technical work on the project, while Röttgering and Miley are involved in the detailed scientific definition of the instrument.
During 2003, overall system design efforts intensified and work packages were defined including low-band antenna, receiver and clock unit, central processing, calibration and wide area networking. The small town of Exloo in the municipality of Borger-Odoorn was chosen as the center of the LOFAR array. A detailed 'ruimtelijke ordening plan' (environmental plan) was developed and presented to the community, followed by detailed negotiations related to land-use which are still continuing. The first LOFAR test station became operational during mid 2003. It consisted of ten prototype antenna's, a digitizing system and a simple software reduction system. It succesfully detected the Sun and mapped the Galactic plane.

2.14.4 Space Projects

GAIA Preparation

As a member of the Gaia photometry, classification, and simulation working groups, Brown was involved in the preparations for the photometric aspects of the mission. He made a plan for the division of the photometric data analysis study for Gaia into distinct work-packages, at the same time recruiting people who will carry out the specific tasks. He also worked on the further optimisation of the photometric filter systems for Gaia. Different proposals for the photometric filters were tested through a blind testing process where participants were given two sets of simulated Gaia photometric data. One set was used to train classification and parametrisation algorithms, which were then applied to the other data set. Brown collected and

analysed the results for all the participants in the two rounds of blind testing that were organised. He also analysed the photometric filter systems independent from any parametrisation methods by considering their intrinsic sensitivity to changes in stellar parameters (taking degeneracies between parameters into account). He used a method that employs gradients of the filter fluxes with respect to changes in the stellar parameters to calculate the expected parametrisation errors. The filter system is then optimised against specified error targets (which are a function of stellar type and Galactic population).
Furthermore, Brown contributed to the Gaia data processing prototype through writing test software for photometric calibration algorithms and providing simple simulations of the spatial and temporal variations of the response of the detectors in the focal plane arrays.

Darwin

ESA's proposed infrared space interferometry mission Darwin presently has two main aims: (i) to detect and characterize exo-planets similar to the Earth, and (ii) to carry out astrophysical imaging in the wavelength range 6 - 20 micron at a sensitivity similar to JWST, but at an angular resolution up to a hundred times higher. Röttgering, den Herder and d'Arcio worked on the the imaging performance of the Darwin mission and elaborated how Darwin can contribute in a very significant way to our understanding of the formation and evolution of planets, stars, galaxies, and supermassive black-holes located at the centers of galaxies.

ISO Infrared Astronomical Spectroscopic Database (IASD)

Jourdain de Muizon worked, together with Castets, Brouillet, Billebaud (all Bordeaux, France) and Ceccarelli (Grenoble, France) and with support from the ISO team (Vilspa), on the constitution of a database of all published ISO spectroscopic results. The output product is basically a big table in which each ISO observed and published spectral line or feature is described in a line of the table giving most of its possible observation and spectroscopic parameters. It will eventually be either a side product of the ISO Archive or included in it, in any case available on Internet and also connected to Simbad. Given that Spitzer does not have any spectroscopic instrument with a resolution that can compete with ISO short and long wavelength spectrographs (SWS and LWS) the team's ambition is to have the IASD ready in time to help in the preparation of observations with Herschel.

Chapter 3

Education, popularization and social events

Education, popularization and social events

Chapter 3

3.1 Educational matters

3.1.1 Organization

The education of students is a top priority of the Leiden Observatory. Fortunately, we can welcome a high number of new students every year. In the academic year 2003/2004, 24 freshman students registered for the new Bachelors program. In their first year, some of these change over to other studies, as the astronomy program is challenging. In each of the five years of the program, students are presented with astronomy courses. However, in the first two years the emphasis lies on physics and mathematics as a foundation for the more advanced astronomy courses in the last three years.

Astronomy student performance is monitored by three members of our faculty: Van der Werf and Kuijken for the students in the first three years of the program, and le Poole for the senior undergraduates. These advisers have regular contacts with the students and can be consulted at any time.

Moreover, for the duration of their first year, students are assigned to any of three groups which meet at regular intervals with a stafmember acting as mentor, assisted by two senior students acting as ”student mentors”. Students may exchange views and experiences in these mentor groups. The university requires that each freshman to collect a minimum number of credit points. The mentor groups play an important role in helping the students to achieve this goal. In the academic year 2003/2004, mentors were Hogerheijde, Kuijken and Röttgering.

The “Opleidings-Commissie” (Education Committee) consists of both faculty members and students. It meets regularly to discuss student performance reports, and to advise the director of Education, Franx. The committee consisted of faculty members Katgert (chair), le Poole, Kuijken, van der Werf, van de Ven and student members van der Berg, van de Voort and Lukkezen.

The astronomy curriculum is formally defined by the “Examen Commissie” (Examining Committee). In September 2003, its members were Franx (chair), Israel, Nienhuis (Physics), van der Werf and de Zeeuw.

3.2 Degrees awarded in 2003

3.2.1 Ph.D. degrees

A total of 4 graduate students defended their thesis successfully in 2003. They all obtained their Ph.D. degree. They are:

G.M. Muñoz-Caro	February 5
Title Thesis:	*From photoprocessing of interstellar ice to amino acids and other organics*
Thesis advisor:	Van Dishoeck / Copromotor: Schutte

A.M.S. Gloudemans-Boonman	March 5
Title Thesis:	*Spectroscopy of gases around massive young stars*
Thesis advisor:	Van Dishoeck / Copromotor: Doty (Denison University, Ohio)

E.K. Verolme	May 21
Title thesis:	*Dynamical models of axisymmetric and triaxial stellar systems*
Thesis advisor:	De Zeeuw

J.D. Kurk	May 22
Title Thesis:	*The cluster environments and gaseous halos of distant radio galaxies*
Thesis advisor:	Miley / Copromotor: Röttgering

3.2.2 Master's degrees ("doctoraal diploma's")

The following 4 students obtained their Master's degrees in 2003:

Name	**Date**
N.G.H. Ritzerveld	February 25
D.H.F.M. Schnitzeler	June 24
M.T.Kriek	August 26
L. Snijders	September 30

3.3 Courses and teaching activities

3.3.1 Courses taught by Sterrewacht staff in 2003

Elementary courses

Semester	Course title	Teacher
1	Introduction Astrophysics	van der Werf
2	Astronomy Lab 1	Katgert
3	Elementary Astronomy/Milky Way Galaxy	Israel
4	Presentation 1	Israel
4	Astronomy Lab 2	Franx
5	Stars	le Poole
5	Presentation 2	le Poole
5	Observational Techniques 1	Quirrenbach
5	Radiative Processes	Katgert
5	Astronomy Lab 3	Schitte/Franx
6	Observational Techniques 2	Röttgering
6	Galaxies	Lub
6	Presentation 3	Lub
6	Introduction Observatory	Deul
7-10	Student Colloquium	Miley

Advanced courses

Semester	Course title	Teacher
8,10	Active galaxies	de Zeeuw
7,9	Starformation	van Dishoeck
7,9	Cosmology	Icke
7,9	Space-based Astronomy	de Graauw
8,10	Stellar Dynamics	Jaffe

Other courses

As in the years before, Israel gave a lecture course on Astronomy at Delft Technical University (TUD) to 4th year students in Aerospace Engineering and 1st year students in Applied Physics.

Icke and van Ruitenbeek (Physics) organized an interdisciplinary course 'The Living Universe' for first-year students concerning life in the universe. Several Sterrewacht staff (van Dishoeck, Icke, Israel) lectured in this series.

Van de Weijgaert (Groningen) coordinated an interuniversity course, 'The early universe'. Katgert and van der Werf lectured on cosmology and the high-z universe.

Ollongren gave lectures on the 'Mathematical Aspects of Relativity Theory' as part of the course 'Physics of Relativity' for seniors (organized by De Bruyn Ouboter).

3.4 Popularization and media contacts

3.4.1 Organization

Astronomy has a strong appeal to the general public, and is well represented in the media. Our staff, Ph.D. students and undergraduate students spend considerable time and effort to explain the exciting results of astronomy to the general public, in the form of lectures, press releases and newspaper articles, courses, public days at the old observatory complex, and input to television and radio programs. Every year, these efforts are very successful; they play an important role in creating enthousiasm in young high school students for science in general, and astronomy in particular. They are also very important in maintaining the present high level of student inflow, and in keeping Leiden Observatory known throughout the country.

3.4.2 Public Lectures and Media Interviews

Van Dishoeck
"Astrochemie: van exotische ionen tot 'geladen' vragen'" (PAC Sym Utrecht, Mar 6)
"Van moleculen tot planeten" (Astronomisch Gezelschap, Leuven, België, Apr 26)

Fraser
"Through the Looking Glass: a different view of the stars" (Lecture, Mar, July, Oct)

Van der Heijden
"Frederik Kaiser, zijn sterrewacht en zijn bijdrage aan de Nederlandse sterrenkunde" (presentation Kaiser familybook. Old Observatory, Leiden, Sept 27)

Israel
"Leven in het Zonnestelsel?" (SSR, Leiden, Mar 24)
"Jury International Space Camp" (Noordwijk, May 10)
"De Leidse Sterrewacht" (Nat. Rest. Fonds, Leiden, June 6)
"Naamgeving Planetoïde Vredevoogd" (Leiden, June 18)
"Future ESA Manned Space, Brainstorm Session" (Dutch Space, Leiden, Aug 28)

"Interview, Plus Magazine" (Leiden, Dec 9)

Ehrenfreund
"Astrobiology"(HEA Summerschool; Aug 20)
"Astrobiologie: das Leben im Universum" (Science Museum Bonn; Oct 22)
"Life in the Universe" (FANTOM school, Nov 5)

Jaffe
"How Big is the Universe" (Lecture; Mar 11 & Oct 11)

Johnston-Hollitt
"Science Stars on Radio" (Interview Adelaide Radio, 5UV; Australia, Aug 4)
"Morning Show with Matthews & Abraham" (Interview Adelaide Radio; Aug 5)
"Radio Telescopes of The Future" (AIP & ASSA; Australia, Aug 6)

De Jong
"MIDI: Het MIR interferometrisch instrument voor de VLTI" (LWSK; Oct 20)
Idem (Publiekssterrewacht Vesta, Oostzaan; Sept 25)

Katgert
"Clusters van melkwegstelsels" (Almere; Mar 5 & Heerhugowaard; May 15)

Knudsen
"Paa rejse i universet – om stjerner og fjerne galakser" (MEDIUM; Nov 1)

Kriek
"Botsende melkwegstelsels" (Rotary Club Duivenvoorde; Nov 12)

Kuijken
"Cosmologie, Donkere Materie, Donkere Energie en het Ontstaan van Melkwegstelsels" (Public Lecture at Woudschoten Conference; Dec 12)

Mellema
"Planeten: vinden, vormen, vullen" (KNVWS Delft; Jan 21)
Idem (KNVWS Friesland, Leeuwarden; Mar 29)
Idem (HWSK, Haarlem; Apr 17)
Idem (WSK Zaanstreek, Oostzaan; May 15)
"Computersimulaties in de Sterrenkunde" (LWSK, Leiden; Feb 25)
Idem (KNVWS Twente, Enschede; Oct 28)
"Het ontraadselen van Planetaire Nevels" (VSML, Roermond, Sept 21)

Miley
"LOFAR" (VPRO Radio; Oct 13)
Idem (Avro Network Television; Oct 23)

Ollongren
"Communicatie met buitenaardse intelligentie" (NG & SK Minnaert Utrecht, Jan 7)
Idem (Sterrenkundige vereniging ZENIT, Den Helder, Jan 17)

Paardekooper
"Exoplaneten" (NVWS Venlo; Sep 26)
Idem (NVWS Eindhoven; Oct 23)

Quirrenbach
"Zoek de schommelster" (Volkskrant; Jan 17)

3.5 The "Leidsch Astronomisch Dispuut 'F. Kaiser' "

The association L.A.D. 'F.Kaiser' is named after the founder of Leiden Observatory, Frederik Kaiser. Every five years, the days of his birth and death are commemorated. Since the association was founded in 1993, 2003 was such a lustrum year.

The major goal of the L.A.D. is to improve the social contacts between undergraduate students and Observatory personnel. The board of the association consisted in 2003 of Van Kempen (praeses), Holl (vice-praeses), Van Vugt (quaestor), Helmsing (ab-actis) and Helder (assessor). The year's main activities included several student lectures and weekly drinks in the Kaiser Lounge at the Oort building. The first gathering for drinks was organised especially to welcome first year undergraduate students. Furthermore, instruction courses were given for student use of the telescopes at the Old Observatory. The traditional June barbecue at the Old Observatory was a big success this year with a record 115 participants!

3.5.1 Mars symposium

On the day of Mars' closest approach to Earth, August 27, a Mars symposium was organized by the L.A.D. In cooperation with the Mars Society several speakers on Marsrelated topics were invited (Brown, ten Kate and Garry from Leiden, Atzay from ESA and Westenberg from the Mars Society). With 80 visitors and interest from the media the symposium was a huge success.

3.5.2 Old Observatory tours

The L.A.D. contributes to the popularization of astronomy by providing guided tours for the public at the Old Observatory, located in the historical center of Leiden. Last year nearly 250 people took part in these tours. Special tours were given in honor of the birthday of F. Kaiser to his kin. Other tours and lectures were given by Nuyten, van Kempen, van Vugt, Holl, van Boven, Wuyts, Meijerink and ter Haar.

Appendix I

Observatory staff December 31, 2003

Sterrewacht Leiden

Observatory staff December 31, 2003

Appendix I

The Sterrewacht website

`http://www.strw.LeidenUniv.nl/org/people_byname.php`

provides names, e-mail adresses, room numbers and telephone extensions of all personnel currently at the institute. Telephone extensions should always be preceded by (071) 527 .... (from inside The Netherlands) or by ++31-71-527 .... (from abroad).

Full Professors

E.F. van Dishoeck
M. Franx
V. Icke
K.H. Kuijken
G.K. Miley (KNAW)
H.A. Quirrenbach
P.T. de Zeeuw

Full Professors by Special Appointment

M. A. Th. M. de Graauw (SRON Groningen, for J.H.Oort Fund)
M.A.C. Perryman (ESTEC, for Leiden University Fund)
R.T. Schilizzi (JIVE, Faculty W&N)
R.P.W. Visser (UU(0.5)/UL(0.5), Teyler's Professor)

Associate Professors and Assistant Professors

B.R. Brandl
M. Hogerheijde
F.P. Israel
W.J. Jaffe
P. Katgert
J. Lub
R.S. le Poole
H.J.A. Röttgering
S. Schlemmer
P.P. van der Werf

Visiting Staff

M.J. Betlem
C. Helling
A. Dalgarno (J.H. Oort Fund)
P. Ehrenfreund (UVA)
M. Kessler-de Muizon
G. Mellema (ASTRON)
P. Papadopoulos
J. Roland (CNRS)
R. Stark(NWO)
J.A. Stuwe

Computer staff

T. Bot	programmer
E.R. Deul	manager computer group
D. J. Jansen	scientific programmer
A. Vos	programmer

Management Assistants and Secretaries

J.C. Drost
M.P.E.J. Driessen
B. de Kanter (voluntary)
K. Kol
L. van der Veld

Astronomy & Astrophysics office

H.J. Habing	emeritus editor
J.K. Katgert-Merkelijn	language editor
B.A. Smit	secretary

NOVA office

P.T. de Zeeuw	director
W.H.W.M. Boland	adjunct director (UL/FWN)
R.T.A. Witmer	financial controller (0.2) (UL/FWN)
K. Kol	management assistant

Emeriti

W.B. Burton
A. Blaauw (also: Groningen)
A.M. van Genderen
H.J. Habing
L.J.F. Hermans (Physics)
I. van Houten-Groeneveld
K.K. Kwee
K.R. Libbenga
A. Ollongren
C. van Schooneveld
J. Tinbergen

Postdocs and Project Personnel

S.J.S. Andersson	Spinoza, LIC	M. Johnson-Hollitt	LOFAR/ASTRON
O.I.L. Asvany	NWO, Spinoza	J.A. de Jong	S/W, NEVEC
J.-C. Augereau	EU	I. Kamp	Spinoza, NOVA
E.J. Bakker	+NEVEC Manager	F. Lahuis	NWO, Spinoza, SRON
O. Botta	ESA fellow	R. McDermid	NWO
A.G.A. Brown	NOVA,Sinfoni	J.A. Meisner	NEVEC, NOVA
M. Cappellari	NWO, VENI	R. Rengelink	S/W NOVA, Omegacam
J. Falcon Barroso	EU	R. Stuik	NOVA
H.J. Fraser	NWO, Spinoza	R.N. Tubbs	NOVA, NEVEC
S. Frink	NWO, VICI	T.M.A. Webb	NOVA
V. Joergens	NWO, VICI	A.W. Zirm	NWO

Ph.D. Students

S. Albrecht *	1	R.A. Overzier	4
S.E. Bisschop *	1,2	S.-J. Paardekoper	1
F.A. van Broekhuizen	2	F.I. Pelupessy	4
V.C. Geers *	7	K.M. Pontoppidan	2
P.M.B.J.C. Gori	13	M.A. Reuland	1,9
J.M.T. van der Heijden	1,5	N.G.H. Ritzerveld *	4
S. Hekker *	14	R. Ruiterkamp	10
J.K. Jörgensen	2	E.J. Rijkhorst	4
B.J. Jonkheid	7	D.H.F.M. Schnitzeler *	4
I.L. ten Kate	1	L. Snijders *	1
K. Kraiberg-Knudsen	4	L. van Starkenburg	1,2
D. Krajnović	2	K. Steenbrugge (UU, SRON)	10
M.T. Kriek *	4	C. Tasse *	1
I.F.L. Labbé	4	B.P. Venemans	2
P. Lacerda	4	P.M. van de Ven	1,2
R. Meijerink	1	A. van der Wel	1,2
M. Messineo	2	S.E.R. Wuijts	4

Funding notes:
1. Leiden University; **2.** NOVA program; **3.** NWO direct; **4.** NWO via Leiden University; **5.** 50% funding by Schuurman Schimmel-van Outeren Foundation; **6.** 50% funding by Fokker Space; **7.** funding by Spinoza award; **8.** funding by Max Planck Gesellschaft; **9.** funding in part by L. Livermore Laboratory; **10.** funded by SRON; **11.** funded by World Lab; **12.** partly funded by Space Tel. Sc. Inst.; **13.** funded by TPD Delft; **14.** funded by VICI Quirrenbach.
***** denotes employment for only part of the year – see section staff changes

Senior students

M.E. Ameling	T.A. van Kempen
A. von Benda Beckman	J.-P. Keulen
R.C.E. van den Bosch	G.M. Kosters
S.C. van Boven	F. Maschietto
C. van Breukelen	J.H.M. Nuijten
F. Christen	D.M. Salter (MSc student)
M.C. Damen	K. Shapiro (Univ.Texas)
M. van Duijn	D.M. Smit
R.S.A. Ensing	M. Valdes (EU, Florence)
M.J. Fransen	P. Verburg
P. Groot	S.R.G. Veijgen
N. ter Haar	N. de Vries
P. Herfst	J.M. van Vugt
H.T. Intema	A. Weijmans
O. Janssen	

Staff changes and visitors in 2003

Name (Funded by)	start	end
L. d'Arcio (SRON)		31-12-03
S.H. Albrecht (UL)	15-11-03	
O.I.L. Asvany (NWO, Spinoza)	01-07-03	
S.E. Bisschop (Ul, NOVA)	01-11-03	
B.R. Brandl (UL, NOVA)	01-07-03	
M. Cappellari (NWO, VENI)	01-03-03	
A. Dalgarno (JHOF)	20-04-02	01-06-02
M.P.E.J. Driessen (UL)	01-11-03	
P. Ehrenfreund (NWO, Vern. Impuls)		30-11-03
J. Falcon Barroso (EU)	01-07-03	
N.M. Foerster-Schreiber (NWO)		30-11-03
S. Frink (NWO, VICI)	01-06-03	
V.C. Geers (NWO, Spinoza)	01-02-03	
S. Hekker (NWO, VICI)	15-09-03	
M.R. Hogerheijde (UL, Spinoza)	01-09-03	
V. Joergens (NWO, VICI)	01-11-03	
M.T. Kriek (AandA)		30-09-03
M.T. Kriek (NWO)	01-10-03	
M.E. Lindhout (AandA)		31-12-03
G. Mellema (KNAW)		01-11-03
M. Messineo UL, NOVA)		31-12-03
I. Percheron (UL, NOVA/NEVEC)		28-02-03
A.S.A. al Rimawi (NWO, Spinoza)		31-07-03
N.G.H. Ritzerveld (NWO)	01-04-03	
S. Schlemmer (UL, NOVA/Sackler)	01-05-03	
D.H.F.M. Schnitzeler (NWO)	01-09-03	
J.F. Schöier Larsen (NWO)		31-03-03
W. Schutte (UL, NOVA/Sackler)		01-08-03
L. Snijders (UL)	01-10-03	
C. Tasse (UL)	01-09-03	
R.N. Tubbs (NOVA/NEVEC)	01-05-03	
L. van der Veld (UL)	01-11-03	
E. Verolme (UL)	01-04-03	
R.J. Wilman (EU, Marie Curie)		31-03-03
P. Woitke (NWO)	01-12-03	
M. Zaal (UL, NOVA)	01-09-03	
A.W. Zirm (NWO)	17-03-03	

Appendix II

Committee membership

Committee membership

Appendix II

II.1 Observatory Commitees

(As of December 31, 2003)

Directorate
(Directie onderzoekinstituut)
P.T. de Zeeuw (director of research)
M. Franx (director of education)
J.Lub (secretary)

Observatory management team
P.T. de Zeeuw (chair)
E.R. Deul
M. Franx
F.P. Israel
K. Kol (minutes)
K.H. Kuijken
J. Lub

Research committee
(Onderzoek-commissie OZ)
K.H. Kuijken (chair)
A.G.A. Brown
M.R. Hogerheijde
W.J. Jaffe
P. Katgert
R.T. Schilizzi
T.M.A. Webb
P.P. van der Werf

Astronomy education committee
(Opleidingscommissie OC)
P.Katgert (chair)
J.C. Drost (minutes)
K.H. Kuijken
R.S. Le Poole
P.M. van de Ven
P.P. van der Werf

M. van den Berg
J.H.J. Lukkezen
F. van de Voort

Astronomy examination committee
(Examen-commissie)

M. Franx (chair)
F.P. Israel
G. Nienhuis (Physics)
P.P. van der Werf
P.T. de Zeeuw

Library committee

W.J. Jaffe (chair)
J. Lub
A.M. van Genderen
F.P. Israel

Computer committee

P.P. van der Werf (chair)
F.A. van Broekhuizen
A.G.A. Brown
G. Mellema
B.P. Venemans
K. Kol

Computer group

W.J. Jaffe (head)
E.R. Deul
D.J. Jansen
T. Bot
A. Vos

Research institute scientific council
(Wetenschappelijke raad onderzoekinstituut)

F.P. Israel (chair)
B.R. Brandl
E.R. Deul
E.F. van Dishoeck
M. Franx
M.A.Th.M. de Graauw
M.R. Hogerheijde
V. Icke
W.J. Jaffe
P. Katgert
K.H. Kuijken
G.K. Miley
J. Lub
R.S. Le Poole
M.A.C. Perryman
H.J.A. Röttgering
H.A. Quirrenbach
R.T. Schilizzi
S. Schlemmer
P.P. van der Werf

Institute council
(Instituutsraad)

E. Deul (chair)
J. Drost
F.P. Israel
W.J. Jaffe
A. van der Wel
J.H.M. Nuijten

Public outreach committee

V. Icke
F.P. Israel
M.T. Kriek
F.I. Pelupessy
P.M. van de Ven
A. van de Wel

Graduate student review committee

J. Lub (chair)
W.H.W.M. Boland (NOVA)
G.K. Miley
K.H. Kuijken

Social committee

A.G.A. Brown
T.A. van Kempen
K. Kol
M.T. Kriek
R.S. Le Poole

II.2 University Committees

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

Franx
Director, Leids Kerkhoven–Bosscha Foundation
Director, Leids Sterrewacht Foundation
Director, Jan Hendrik Oort Foundation

Habing
Member, special advisory board of Dean

Israel
Member, Education Committee Physics and Astronomy
Member, Department Council (Faculteitsraad)

Katgert
Member, Education Committee Physics and Astronomy
Secretary/Treasurer, Leids Sterrewachtfonds
Secretary/Treasurer, Jan Hendrik Oort Fonds
Secretary/Treasurer, Leids Kerkhoven-Bosscha Fonds

Kuijken
Member, Faculty Research Committee (WECO)
Chair, Astronomy Programme Board, Lorentz Center

Lub
Member, Public Relations Committee Department W & N
Member, Department Student Recruitment Committee
Director, Leids Sterrewacht Fonds
Director, Leids Kerkhoven–Bosscha Fonds

Director, Jan Hendrik Oort Foundation

Ollongren
Member, Committee University Level Courses for Seniors

Röttgering
Chair, Panel of LUF Internationaal Studie Fonds (LISF)

Schlemmer
Member, Mayo Greenberg Scholarship Prize Committee

Van de Ven
Member, National Education Committee Astronomy (LOCNOC)

Van der Werf
Member, Education Committee Physics and Astronomy

De Zeeuw
Member, Advisory Committee Lorentz Professor
Member, Advisory Committee Kloosterman Professor
Member, Board of Directors, Leids Kerkhoven Bosscha Fonds
Member, Board of Directors, Leids Sterrewacht Fonds
Member, Board of Directors, Oort Foundation
Member, Steering Committee Lorentz Center

Appendix III

Science policy functions

Sterrewacht Leiden

Science policy functions

Appendix III

Augereau
Member, VLT/PLANET FINDER Science Team
Member, VLTI/APreS-MIDI Science Team

Bakker
Member, Dutch Joint Aperture Synthesis Team (DJAST)
Member. NOVA-ESO VLTI Expertise Centre (NEVEC) Management Team

Brown
Member, IAU Commission 37
Member, NOVA-SINFONI management team
Member, Gaia photometry, Classification and Simulation Working Groups

Van Dishoeck
Member, SRON Board
Member, MPIA-Heidelberg Fachbeirat
Member, Visiting Committee Astronomy Department of Harvard University
Member, FOM-AMO Werkgemeenschapscommissie
Interim ALMA European Project Scientist
Member, ALMA Science Advisory Committee
Chair, ALMA European Science Advisory Committee
Co-PI, European JWST-MIRI consortium
Member, ESA–JWST Science Study Team
Member, ESO-CRIRES Science Team
Chair, IAU Working Group on Astrochemistry
Chair, Working Group 5 on Molecular Data, IAU Commission 14
Member, Herschel–HIFI Science team
Member, VLT–VISIR Science team
Member of the Board, J.C. Kapteyn and Pastoor Schmeits Foundations
Member, SOC, Zermatt meeting on ‘The Dense Interstellar Medium in Galaxies’
Coordinator, NOVA network II on ‘Birth and Death of Stars and Planets’
Member, Royal Netherlands Academy of Arts and Sciences (KNAW)

Ehrenfreund
Vice President, EANA European Astrobiology Network Association
Member, ESSC European Space Science Committee, Life Science Panel (Chair)
Member, LSWG Life Science Working Group, European Space Agency
Member, US Space Studies Board Committee COEL, European representative
Chair, International Space Science Institute, WG: Prebiotic matter in space
Member, IMEWG, International Mars Exploration Working Group
Member, ESA-XPG, Cross-disciplinary Perspective Group: Life in the Universe
Member, Scientific Advisory Board: SRON
Member, IAU Working Group on Astrochemistry
Member, IAU Working Group on Bioastronomy
Member, Topical Team ESA: Physico-chemistry of ices in space
Member, COSPAR, EGS, IAU, ISSOL
Discipline Editor: Planetary and Space Science
Discipline Editor: International Journal of Astrobiology
Discipline Editor: Astrobiology

Franx
Member, ESO Science and Technology Committee
Member, ESO contact committee
Member, Advanced Camera for Surveys Science Team
Member, NOVA Board (from October 28) Member, Nova Fellowship Committee
Member, Nova Instrument Steering Committee
Member, Sinfoni Science Team
Member, ESO-Omegacam science team
Member, MUSE science team
Member, NWO astronomy committee
Organizer, FIRES workshop

Fraser
Team Member, ESA ICAPS Experiment for International Space Station
Team Leader, ESA Topical Team on Physico-Chemistry of Ices in Space
Ordinary Committee Member, Astrochemistry Group of the RSC and RAS, UK

Frink
Member, RAVE Science Team

Habing
Editor-in-Chief, “Astronomy and Astrophysics”
Chair, Netherlands Committee for Astronomy
Chair, “Kamer Sterrenkunde” of the VSNU
Chair, Nederlandse Astronomen Club
Member, Royal Netherlands Academy of Sciences (KNAW)
Member, KNAW Subcommittee for the Recognition of Research Schools in Physics, Mathe-

matics and Astronomy

Van der Heijden
Member, Board Leidse Weer- en Sterrenkundige Kring
Member, Board and PR Committee Gewina

Hogerheijde
Member, Ad-hoc Panel for Review of JCMT-SMA Linked Interferometry
Member, ALMA Science Integrated Product Team
Member, Netherlands Programme Committee

Icke
Member, National Committee on Astronomy Education
Member, Minnaert Committee (NOVA Outreach)
Member, Netherlands Astronomical Society Education Committee
Member, Editorial Council “Natuur & Techniek”
Member, Board of Directors, National Science Museum NEMO
Member, Advisory Council, “Technika10”
Member, Board of Editors, Nederlands Tijdschrift voor Natuurkunde
Member, Advisory Committee, Computational Science (NWO)
Representative for the Netherlands, ESO Observing Programme Committee
Member, Advisory Council, Faculty of Creative and Performing Arts

Israel
Member, IAU Commissions 28, 40 and 51
Member, Editorial Board Euro Physics News, European Physical Society
Member, Noordwijk Space Expo Foundation (NSE) Exposition Committee
Member, NL Jury International Space Camp
Member, HIFI Science Team
Member, MIRI NL Science Team
Member, NWO VENI Research Grant Allocation Panel

Jaffe
Member, IAU FITS working group

Kuijken
NL Representative, Science and Technical Committee, ESO
Member, Instrument Steering Committee, NOVA
Principal Investigator, OmegaCAM project
Co-Investigator, Planetary Nebulae Spectrograph project
Member, SOC, Winterschool on gravitional lensing, Aussois
Chair, SOC, workshop ”OmegaCAM’s first Surveys”, Lorentz Center, Leiden
Member, NWP VIDI Reserach Grant Allocation Panel
Member, NWP VICI Reserach Grant Allocation Panel

Local Coordinator, EU-FP5 netwwork SISCO

Lub
Member at Large, ESO Observing Programs Committee
Member, ESO Contact Committee
Secretary, Netherlands Committee for Astronomy
Secretary, Kamer Sterrenkunde van de VSNU

Mellema
Treasurer, Association of Academy-Fellows (VvAO)
Deputy, European Association for Research in Astronomy (EARA)

Miley
Member, National Radio Astronomy Observatory Visiting Committee
Member, Max Planck Institut fur Radioastronomie Fachbeirat
Chair, Netherlands LOFAR Steering Committee
Member, NASA Advisory Committee on Future of HST
Member, Board of Stichting ASTRON
Member, Board of NOVA (until 27 October)
Member, Board of EU Opticon Network
Member, Royal Netherlands Academy of Arts and Sciences (KNAW)
Member, Scientific Organizing Commmittee, Joint Discussion No. 10, IAU Sydney
Founding Member, European Astronomical Society

Ollongren
Member, Permanent SETI Study Group
International Astronautical Academy (IAA)
Member, IAU Commissions 7, 33 and 51
Founding member, European Astronomical Society

Perryman
Chair, GAIA Science Advisory Group
Member, HIFI Science Team

Quirrenbach
Data Scientist, NASA Space Interferometry Mission
Member, IAU Working Group on Interferometry
Member, IAU Working Group on Extrasolar Planets
Principal Investigator, Netherlands-ESO VLTI Expertise Center (NEVEC)
Member, NOVA Instrument Steering Committee
Member, ESO VLT Interferometer Implementation Committee
Member, ESA Terrestrial Exoplanets Science Advisory Team

Röttgering
Leiden PI, European Research and Training Network “The Physics of the Intergalactic Medium”

Member, Dutch Joint Aperture Synthesis Team (DJAST)
Member, VLTI Science Demonstration Team (SDT)
Member, Mid-Infrared Interferometric Instrument for VLTI (MIDI) Science Team
Member, NASA's Terrestrial Planet Finder Science Team
Member, Science Advisory Group on ESA's InfraRed Space Interferometer DARWIN
Member, LOFAR, Dutch steering group
Member. LOFAR, Science consortium board
Member, VISIR Science team
Member, OmegaCam Science team
Member, XMM Large Scale Structure Consortium
Chair, ASTRON Time Allocation Committtte (PC)
Member, NWO selection committee for VENI postdocs
Member, JCMT international time allocation committee

Schilizzi
Editor, Experimental Astronomy
Member-at-large RadioNet Board
Vice-President, URSI Commission J on Radio Astronomy
Member Scientific Council, Foundation for Space Research in the Netherlands (SRON) Member, KNAW Netherlands Geodetic Commission

Van der Werf
Principal Investigator, NOVA-SINFONI
Member, ESO Contact Committee
Team Leader, EC - RT Network "Probing the origin of the extragalactic background" (POE)
Member, EC - RT Network "Promoting 3D spectroscopy in Europe" (Euro3D)
Member, JWST near-IR spectrograph study team
Member, MIRI Science Team (NL)
Member, NOVA wide-field imaging science team
Member, NOVA millimeter interferometry team
Member, SINFONI Science team
Member, VISIR Science team
Co-investigator, HIFI
Member, JCMT Board
Member, Final Design Review board, SINFONI-2K camera
Co-investigator, Multi-Unit Spectroscopic Explorer (MUSE)
Member, NOVA instrumentation advisory committee
Member, NWO VIDI research grant allocation panel
Member, PPARC Astronomy Advisory Panel

De Zeeuw
Member, Scientific Advisory Board of " New Astronomy"
Member, Publications Committee, Astronomical Society of the Pacific
Member, IAU Commission 28
Member, SOC, IAU Symposium 221 "Dark Matter in Galaxies"

Member, SOC, 2nd Potsdam Workshop " The structure of the Milky Way and the Local Group"
Member, MUSE Executive Board
Member, SINFONI Science Team (MPE&ESO)
Member, OPTICON Board
Member, ESO/OPTICON Science Working Group for Extremely Large Telescopes
Member, National Committee Astronomy
Member, Scientific Advisory Committee, SRON
Chair, Advisory Committee for Astronomy, NWO
Member, ESO Contact Committee
Member, ESO Council
Leiden University Member Representative to AURA
Chair, Space Telescope Institute Council
Member, AURA Board of Directors
Chair, Cycle 12 Hubble Space Telescope Time Allocation Committee
Director, Netherlands Research School for Astronomy, NOVA

Appendix IV

Visiting scientists

Sterrewacht Leiden

Visiting scientists

Appendix IV

Name	Dates	Institute
C. Eiroa	Sept ('02) – Sept ('03)	Instituto de Astronoma y Fsica del Espacio, Buenos Aires, Argentina
M. Bremer	Jan 26 – Jan 30	H H Wills Physics Laboratory, Bristol, UK
J. Gerssen	Feb 3 – Feb 4	STScI, Baltimore, USA
L. d' Hendecourt	Feb 5 – Feb 6	CNRS, Orsay, France
W. Thiemann	Feb 5 – Feb 6	University Bremen, Germany
S. Schlemmer	Feb 10 – Feb 15	Technical University Chemnitz, Germany
G. Helou	Feb 12 – Feb 14	Caltech, Pasadena, USA
P. Woitke	Feb 17 – Feb 17	Zentrum für Astronomie und Astrophysik,Technisch Universität Berlin, Germany
M. Hogerheijde	Feb 17 – Feb 24	Steward Observatory, University of Arizona, USA
D. Folini	Feb	ETH Zürich, Switzerland
S. Doty	Mar 4 – Mar 9	Denison University, Ohio, USA
M. Groenewegen	Mar 5 – Mar 6	Institute d'Astrophysique de Paris, France
A. Dalgarno	Apr 1 – Apr 25	Cambridge, USA
K.-V. Tran	Apr 15 –Apr 19	UC Santa Cruz, USA
G. Sarazin	Apr 23 – Apr 25	University of Virginia, USA
F. Larsen Schoier	Apr 26 – Apr 29	Stockholm Observatory, Stockholm, Sweden
A. Dariush	Apr 27 – May 15	University of Shiraz, Iran
C. Vogt	May 1 – July 31	UC Santa Cruz, USA
M. Brookes	May 6 – Aug 4	Marie Curie student
D. Johnstone	May 6 – June 26	Herzberg Institute of Astrophysics, Victoria, Canada
A. Romanowsky	May 15 – May 16	School of Physics and Astronomy, University of Nottingham, UK
N. Douglas	May 15 – May 16	Kaptyen Institute, Groningen
N. Napolitano	May 15 – May 16	Kaptyen Institute, Groningen
S. Kilston	May 16 – May 16	Ball Aerospace Corp., USA

Name	Dates	Institute
K. Gebhardt	May 19 – May 23	University of Texas, USA
R. Bacon	May 20 – May 22	Lyon Observatory, France
R. Davies	May 20 – May 22	University of Durham, UK
S. Doty	May 25 – June 16	Denison University, Ohio, USA
P. Stäuber	May 26 – July 12	ETH Zürich, Switzerland
R. Metzler	May 27 – June 16	Ohio State Denison University, Granvill, USA
G. Bono	June	INAF-Osservatorio Astronomico di Roma, Italy
M. Dopita	June 1 – June 22	Mount Stromlo, Australia
H. Hoekstra	June 19– June 19	University of Toronto, Canada
R. Windhorst	June 20 – July 18	Arizona State University, USA
K.-V. Tran	June 24 – June 27	ETH Zürich, Switzerland
M. Haverkorn	June 30 – July 11	Harvard-Smithsonian Center for Astrophysics, UK
H.-W. Rix	July 7 – July 9	MPIA, Heidelberg, Germany
O. Shalabiea	Aug 18 – Aug 22	Cairo University, Egypt
K. Shapiro	Sept 9 – May 5	University of Texas, USA
P. Serra	Sep 11 – Sep 12	Kaptyen Institute, Groningen
R. Rutten	Sep 27 – Sep 30	Astronomical Institute, Utrecht Unversity
E. Tolstoy	Sep 28 – Sep 29	ESO, Garching bei München, Germany
T. Wilson	Oct 14 – Oct 15	Max Planck, Bonn, Germany
H. Buttery	Nov 1 – May 1	Marie Curie student
W. van Breugel	Nov 17 – Nov 21	Laurence Livermore National Laboratory, USA
I. Ferreras	Nov 24 – Nov 28	Physics Department Denys Wilkinson Building, Oxford, UK
A. Pasquali	Nov 24 – Nov 28	ESO/ST-ECF, Garching, Germany
K. Ganda	Nov 28 – Nov 28	Kapteyn Institute, Groningen
D. Mitchell	Dec 1 – Dec 8	UCSD, USA
N. Haering	Dec 1 – Dec 22	MPIA, Heidelberg, Germany
D. Mitchell	Dec 1 – Dec 5	UC, San Diego, USA
G. Rudnick	Dec 2 – Dec 6	MPA, Garching, Germany
B. Balick	Dec 8 – Dec 12	University of Washington, USA
K.-V. Tran	Dec 9 – Dec 12	ETH Zürich, Switzerland
P. van Dokkum	Dec 18 – Dec 24	Caltech, USA
W. Alsindi	Dec 7 – Dec 13	

Appendix V

Workshops, colloquia and lectures

Sterrewacht Leiden

Workshops, colloquia and lectures

Appendix V

V.1 Workshops and Meetings

Dutch Astrophysics Days III
For the third year in a row, Mellema organised the Dutch Astrophysics Days on March 13 and 14, bringing together Dutch astronomers with a specific interest in theoretical work, emphasizing mechanisms and processes over objects, general methods over incidental application, physical and mathematical tools over observational methods. Leiden-based speakers were Paardekoper, Ritzerveld, Cappellari and Rijkhorst. Speakers from other institutes included Casse, Dominik, Gualandris, Kuijpers, Pols, Spaans, Spinnato, Stegeman, Van de Weijgaert and Wijers. The special guest lecture was delivered by H. Dijkstra from the Institute for Marine and Atmospheric research Utrecht on *The Physics of El Nino*.
Programme and list of attendents can be found on the website:
`http://www.lc.leidenuniv.nl/lc/web/2003/20030313/info.php3?wsid=87`

JWST-MIRI Science Team Meeting
On March 17, a meeting of the joint European-US science team for the mid-infrared camera and spectrometer (MIRI) on the James Webb Space Telescope took place in Leiden, organized by van Dishoeck. About 20 scientists gathered to discuss science drivers and instrument trade-offs for this revolutionary instrument.

J.H. Oort Workshop: X-rays in the Solar System
About 30 scientists participated in the workshop held April 7 – 9 "X-Rays in the Solar System", organized by van Dishoeck and the 2003 J.H. Oort professor, A. Dalgarno from Harvard University. Discovery of X-ray emission from comets was one of the big surprises of recent X-ray satellites, given that these objects are very cold. Astrophysicists and atomic physicists discussed this highly interdisciplinary topic for three days at the Lorentz Center. Programme and list of attendents can be found on the website:
`http://www.lc.leidenuniv.nl/lc/web/2003/20030407/info.php3?wsid=83`

Future Directions in AGB Research
On the occasion of the retirement of H. J. Habing as Professor of Astrophysics from Leiden University, a group of (ex)-Leiden Colleagues led by Israel and van Dishoeck organized an International Workshop on April 10 and 11. The subject of this workshop was an area of research that over the years had become particularly close to Habings: the Asymptotic Giant

Branch (AGB) Stars. The Workshop focused on the physical aspects of the dying stars: their nature, their composition, their evolution. Programme and list of attendents can be found on the website:
http://www.strw.leidenuniv.nl/~agbworkshop/

Solid State Chemistry in Star Forming Regions

Fraser and several colleagues from the UK organized a workshop on April 14 – 17 on molecular species, including some of the simplest molecules in space, that form through surface-catalysed processes. In thes workshop two broad research communities whose research specialties can both be applied in enhancing understanding of gas-grain processes in star forming regions were brought together, namely the astronomers working on observations and theoretical modelling of star forming regions, and the experimental and theoretical physical scientists working on surface reactions and processes.

First Observations of Clusters with the Advanced Camera for Surveys of the Hubble Space Telescope

The Advanced Camera for Surveys is a new powerful camera that was fitted to the Hubble Space Telescope in March 2002. Franx and Miley, members of the ACS Science Team (AST), organised a workshop discussing results of the first year of observations on May 27 – 29. The major scientific goal of the AST in using their guaranteed time (300 orbits) was to use the superior sensitivity, wide field and angular resolution of the ACS to study clusters of galaxies over a huge range of distance, ranging from the nearby Universe to the most distant galaxy structures known.

For further information on the programme and the participants, see:
http://www.lc.leidenuniv.nl/lc/web/2003/20030526/info.php3?wsid=84

Deep InfraRed Studies and the Distant Universe: FIRES Project

The FIRE Survey is a deep NIR survey of two fields of the sky, supplemented with optical imaging, both from groundbased telescopes and HST. The goal is to improve our understanding of the high redshift universe, and to measure the evolution and formation of galaxies. Franx organized a meeting from June 2 – 7 intended for those who were directly involved in the FIRE survey. During the weeklong meeting, new results were presented, new observing sessions and the work for the coming year were planned.

More details can be found at the web-site:
http://www.lc.leidenuniv.nl/lc/web/2003/20030602/description.php3?wsid=88

Herschel HIFI Science Team Meeting

On June 13, a meeting of the Herschel-HIFI science team took place in Leiden, organized by van Dishoeck and Kol, in collaboration with SRON. About 25 scientists from many different nationalities (including several from Leiden) gathered to discuss the plans for the HIFI guaranteed time and key programs.

OmegaCAMs First Surveys

OmegaCAM is a new wide-field imaging camera for astronomical surveys, currently being built with NOVA funding and destined for the VLT Survey Telescope (VST) on ESO's Paranal observatory. Over the years it will build up a huge survey of large parts of the Southern sky. The data rate from the instrument will be phenomenal: every exposure translates into 1 Gbyte of pixel data, and every night the instrument will typically make 50-100 exposures. The instrument will start operations towards the end of 2004, and NOVA has guaranteed access to almost 10% of the observing time. In a workshop, organized from June 30 to July 4 by K.H. Kuijken, the people who contributed survey plans were brought together. Also present were representatives from German and Italian partner institutes in OmegaCAM and VST (who also have access to observing time)and from the similar projects MEGACAM and VISTA. Main topic of discussion was the strategy for making as much of the survey plans happen as possible.
More information can be found on:
`http://www.lc.leidenuniv.nl/lc/web/2003/20030630/info.php3?wsid=80`

Technologies for Extremely Large Telescopes, Information Workshop for Dutch Industry

This workshop was organized on August 14 by Quirrenbach with the aim of informing Dutch technical institutes and industry on the plans for a 50–100m optical/infrared telescope, and the possibilities to participate in design and development.

LOFAR and the Epoch of Reionisation

One of the most exciting goals of the low-frequency array under construction, LOFAR, will be to chart the end of the Dark Ages when the first stars and AGNs started to ionize the neutral baryonic gas pervading the Universe. A one-day workshop was held at the Sterrewacht on October 30 to discuss this epoch of reionisation. Both theoretical simulations as well as details of planned LOFAR observations were discussed. Outside participants included Spergel, Ferrara, Theuns, di Matteo, Minniati, Shaver, and Haehnelt.

Astronomy with the Square Kilometre Array

The Square Kilometre Array (SKA) will be a revolutionary new instrument at centimetre and metre radio wavelengths, with an effective collecting area more than 30 times greater than Arecibo and 100 times greater than the current VLA. Intended to be built by 2020, it will be a discovery instrument with exquisite sensitivity. In the internatinal workshop organized by Schillizzi, Carilli (USA) and Rawlings (UK) on November 10 – 14, astronomers engaged in revising the science case for the Square Kilometre Array were brought together to discuss science goals, first results of simulations of the deep radio sky, and plans for further work. Primary areas of the science case include cosmology and large-scale structure; galaxy formation; life-cycle of stars; super-massive black holes and AGNs; transients; SETI; galaxy structure; astrometry, geodesy and spacecraft navigation; and solar system science.
List of participants and programme can be found on the www site:
`http://www.lc.leidenuniv.nl/lc/web/2003/20031110/description.php3?wsid=92`

V.2 Scientific colloquia

The Leiden Observatory Colloquia are generally held weekly on Thursday afternoons at 16:00 hours, preceded by an Astronomers' Tea at 15:50 hours. In 2003 the colloquium series was organized by Huub Röttgering.

Date	**Speaker (affiliation)**	**Title**
Jan 16	Richard McDermid (Leiden, NL)	*The Nature and Origin of Disky Elliptical Galaxies*
Jan 23	Marco Spaans (Groningen, NL)	*Star Formation in the Early Universe*
Jan 30	Melanie Johnston-Hollit (Leiden, NL)	*Detecting Magnetic Fields in Galaxy Clusters*
Feb 6	Karel van der Hucht (Utrecht, NL)	*Dust Formation by Wolf-Rayet WC Stars, Imaging, Spectroscopy and Photometry*
Feb 13	George Helou (Pasadena, USA)	*Infrared Surveys: Planned Serendipity*
Feb 20	Martin Krause (Heidelberg, DE)	*Very Light Jets in Powerful radio Galaxies*
Feb 27	Ger de Bruyn (Groningen, NL)	*The Quasar J1819+3845: Microarcsecond Resolution with the Interstellar Telescope (ISS)*
Mar 6	Peter Papadopoulos (Noordwijk, NL)	*Measuring H2 Gas Mass in Galaxies, an Overview*
Mar 13	Henk Dijkstra (Utrecht, NL)	*The Physics of El Nino*
Mar 20	Russell Schweickart (USA)	*Cosmic Intersection*
Mar 21	Tom Abel (Pittsburgh, USA)	*The First Stars in the Universe*
Mar 27	Bob Sanders (Groningen, NL)	*Astronomical Constraints on the Accelerating Universe and Modifications of Newtonian Gravity*
Apr 03	Jan Kuijpers (Nijmegen, NL)	*Radio Pulsars and Gamma ray Bursts: Energizing the Particles*
Apr 17	Premana Premadi (Bandung, ID)	*Numerical Study of Lensing by Large Scale Structure*
Apr 25	Craig Sarazin (Charlottesville, USA)	*Chandra Observations of Low Mass X-Ray Binaries, Globular Clusters, and Hot Gas in Elliptical Galaxies*
May 8	Tracy Webb (Leiden, NL)	*Exploring the High-Redshift Universe with SCUBA: the Canada-UK Deep Submm Survey*
May 15	Ignas Snellen (Edinburgh, UK)	*The Lifecycles and Cosmological Evolution of Radio-Loud AGN*
May 19	Jim Rose (Chapel Hill, USA)	*The Ages and Chemical Compositions of Early-Type Galaxies*

Date	Speaker (affiliation)	Title
June 5	Ortwin Gerhard (Basel,CH)	*The Large-Scale Structure of the Milky Way*
June 12	Michael Dopita (Weston, AU)	*Measuring Star Formation Rates in Galaxies: H-Apha, what is it good for?*
June 16	Ellen Verolme (Delft, NL)	*Dynamical Models of Axisymmetric and Triaxial Stellar Systems*
June 19	Giuseppe Bono (Rome, IT)	*Cepheid and RR Lyrae Stars: Observations, Theory and Distance Scales*
July 3	Therese Encrenaz (Paris, FR)	*Water in the Solar System*
July 10	Rogier Windhorst (Tempe, USA)	*An HST mid-UV Survey of Nearby Galaxies: Quantitative Tools to Understand High-Redshift Galaxy Structure*
Sept 11	Natasha Förster Schreiber (Leiden, NL)	*New Views of the High-Redshift Universe from the Deep Near-Infrared FIRES survey*
Sept 18	Jaron Kurk (Arcetri, IT)	*The Cluster Environment and Gaseous Halo of PKS 1138-262*
Sept 25	Robert Braun (Dwingeloo, NL)	*Tidal Streams and Low Mass Companions of Messier 31*
Oct 2	Piotr Popowski (Garching, DE)	*Non-Microlensing Applications of Microlensing Surveys: Galactic Extinction*
Oct 9	Frank Verbunt (Utrecht, NL)	*X-Ray Sources in Globular Clusters: a New Era with Chandra and HST*
Oct 16	Bob Tubbs (Leiden, NL)	*Lucky Exposures: High Resolution Imaging without Adaptive Optics*
Oct 23	Willem Drees (Leiden, NL)	*God, the Universe and the University*
Oct 30	David Spergel (Princeton, USA)	*First Year Results from WMAP: Implications for Cosmology & Inflation*
Nov 6	Scott Trager (Groningen, NL)	*Directly Detecting Galaxy Evolution: the Ages and Abundances of Early-Type Galaxies from z=0.8 to the Present*
Nov 13	Steve Rawlings (Oxford, UK)	*Tracing LSS with Present and Future Radiosource Redshift Surveys*
Nov 20	Jesus Falcon (Leiden, NL)	*Kinematics & Stellar Populations of Nearby Bulges*
Nov 27	Roland Bacon (Lyon, FR)	*Sackler Lecture: Integral-field Spectroscopy of Stars and Galaxies: from Infancy to Maturity*
Dec 4	Andy Fabian (Cambridge, UK)	*Heating and Cooling in the Cores of Clusters of Galaxies*
Dec 11	Sabine Frink (Leiden, NL)	*Upper Mass Limits for Known Extrasolar Planets from Hipparcos Intermediate Astrometric Data*
Dec 18	Jacques Bos (Leiden, NL)	*Describing the Word or "Saving the Appearances"? Realist and Antirealist Views on the Nature of Scientific Theories*

V.3 Student colloquia

Date	Speaker	Title
Feb 18	N.G.H. Ritzerveld	*Triangulating Radiation*
Mar 18	F. Sammar	*Gas reservoir in circumstellar disks of G-type stars*
Jun 18	D.H.F.M. Schnitzeler	*A WENSS view of the Galactic ISM*
Aug 21	M.T. Kriek	*Star formation in the dusty disk of Centaurus A*
Sep 16	L. Snijders	*Obscured star formation in The Antennae*
Oct 15	J.-P. Keulen	*De CE-afstudeervariant, richting wetenschapsjournalistiek*

V.4 Endowed lectures

Date	Speaker (affiliation)	Title
Apr 24	A. Dalgarno (Harvard University, USA)	**Oort lecture** *Molecular synthesis in the Universe*
Nov 27	R. Bacon (Lyon Observatory, France)	**Sackler lecture** *Integral-field spectroscopy of stars and galaxies*

Appendix VI

Participation in scientific meetings

Sterrewacht Leiden

Participation in scientific meetings

Appendix VI

Andersson

Bijeenkomst van de CW-Studiegroep Spectroscopie en Theorie (Lunteren; January 27–28)
"Computational Studies on the Kinetics of the C+NO and O+CN Reactions"

Solid State Chemistry in Star Forming Regions (Leiden, The Netherlands; April 14–17)
"Using Density Functional Theory to Probe the Energetics of the H+CO Reaction"

Gordon Conference on Dynamics at Surfaces (Proctor Academy, NH, USA; August 10–15)
"Using Density Functional Theory to Study the Kinetics of Chemical Reactions Relevant to Astrophysics"

10th Int Conf on the Applications of Density Functional Theory in Chemistry and Physics (Brussels, Belgium; September 7–12)
"Using Density Functional Theory to Study the Kinetics of Chemical Reactions Relevant to Astrophysics"

Augereau

Journées ALMA (Paris, France; January 13–14)
"Disques Protoplanétaires et Planétaires (invited talk)"

5th ICM Meeting (Amsterdam; March 13)
"The dust and gas disk around HD 141569 A"

CHFT-PUEO/NUI Workshop (Grenoble, France; May 13)
"Debris Disks (invited talk)"

Extrasolar Planets: Today and Tomorrow (IAP Colloquium) (Paris, France; June 30–July 4)
"Structures in Dusty Disks (invited review)"

SIRTF Galactic Science Workshop (CalTech, USA; August 6–8)
"Structuring the HD141569A Circumstellar Dust Disk"

DPS, 35th Annual Meeting (Monterey, USA; September 2–6)
"Collisional Dust Production in Extrasolar Discs: a New Dynamical and Photometric Model (poster)"

PLANETS European Network meeting (Heidelberg, Germany; October 6–8)
"Planetesimal Disks : Secular Perturbation and Dust Production"

High Resolution IR Spectroscopy in Astronomy (ESO, Germany; November 18–21)
"TIMMI2 and VLT-ISAAC Spectroscopy of Circumstellar Dust Disks around PMS and Vega-like Stars (poster)"

Bakker

MIDI Science Meeting (Heidelberg, Germany; Febraury 3–5)

DARWIN Conference (Heidelberg, Germany; April 22–25)
"Interferometric Observations of Main Sequence Stars: Fundamental Stellar Astrophysics and Circumstellar Matter"
Long-baseline Interferometry in the MIR (Heidelberg, Germany; Sept 1–5)
"The Pre-GENIE Experiment"
National MIDI Science Day (UvA; November 13)
"Interferometric Observations of HR 4049"

Bisschop
4th Cologne-Bonn-Zermatt-Symposium (Zermatt, Switzerland; september 22–26)
"CO as a Surface Adsorbate under Interstellar Conditions"

Van Broekhuizen
Solid State Astrochemistry in Starforming Regions (Leiden; April 13–17)
"Hot Core Laboratory"
Gordon Conference on Dynamics at Surfaces (Andover (NH), US; Aug 8–14)
"The Effects of UV Radaition from H_2 Discharge Sources on Astrochemically Relevant Ices"

Brown
Gaia Photometric Working Group Meeting (Heidelberg, Germany; March 10–11)
"Talk: Results of the First Blind Testing Run"
Gaia GDAAS Workshop (Barcelona, Spain; April 8–9)
Nederlandse Astronomen Conferentie (Kleve, Germany; May 21–23)
"Poster: Simulations of Adaptive Optics with a Laser Guide Star for SINFONI"
Gaia Simulation Working Group Meeting (Besancon, France; June 5–6)
ESO workshop: Science with Adaptive Optics (Garching, Germany; September 16–19)
"Poster: Simulations of the SINFONI AO Module: Predicting the Performance for Extended Sources and a Laser Guide Star"
Gaia Photometric Working Group Meeting (Leiden, October 9–10)
"Talk: ICAP Blind Testing Cycle 2: Results"
Gaia Simulation and Radial Velocity Working Groups Meeting (Nice, France; Dec 10–12)

Cappellari
Dutch Astrophysics Days (Leiden; March 13–14)
"Adaptive 2D-Binning Using Voronoi Tessellations"
Galaxy Dynamics and Evolution (Roma, Italy; May 19–21)
"Dynamical modeling of SAURON galaxies"
The Local Group as Cosmological Training Sample (Potsdam, Germany; June 12–15)
"Review: Supermassive Black Holes in the Local Group"
From First Light to the Milky Way (Zurich, Switzerland; August 18–21)
"The Fossil Record of Galaxy Formation Observed with SAURON*"*
SAURON Meeting (Oxford, UK; September 8–11)
"Dynamical Modeling of the SAURON *'Axisymmetric' Sample"*

Van Dishoeck

Herschel-HIFI and Low-Mass Star Formation (Grenoble, France; March 3–4)
"Unbiased Spectral Line Surveys with HIFI"

X-Rays in the Solar System (Leiden; April 7–9)

Future Directions in AGB Research (Leiden; April 10–11)

Solid-state Astrochemistry in Star Forming Regions (Leiden; April 14–17)
"Heterogeneous Chemistry in Astronomy: Data Needs and Requirements (invited lecture)"

ESO Meeting on Large Programmes with the VLT (Garching, Germany; May 19–20)
"Evolution of Ices in Star Forming Regions"

XXVth IAU General Assembly (Sydney, Australia; July 12–25)
"From Molecules to Planets: a Milky Way Dreaming (invited discourse)"

High-Resolution Molecular Spectroscopy Meeting (Dijon, France; September 8–10)
"Molecules in Astrophyiscs: the Need for High Resolution Spectroscopy (invited review)"

Science with Herschel-HIFI (Zermatt, Switzerland; September 19–20)
"Water in Starforming Regions"

IVth Cologne-Bonn-Zermatt Symposium (Zermatt, Switzerland; September 22–25)
"Molecular Astrophysics: an Integral Part of Astronomy (invited lecture)"

EU PLANET Network meeting (Heidelberg, Germany; October 6–8)
"Molecular Astrophysics Research in Leiden"

Ehrenfreund

Centro Astrobiologia, Inauguration (Madrid,Spain; January 14–17)
"Chemical Reactions and Molecules in the Interstellar Medium"

NASA Astrobiology Meeting (Tempe,US; Fabruary 10–12)
"The European Astrobiology Network Association"

ICAPS/IMPF Meeting (Noordwijk; February 19–20)

European Space Science Committee (Kopenhagen, Denmark; March 12–13)

Academy of Science (Vienna, Austria; March 14–15)
"Das Kleine Fach Astrobiologie"

UK Astrobiology Forum, Inauguration (Cambridge, UK; March 27–27)
"Carbon Chemistry in Space: from Dark Clouds to the Early Earth"

Astrobiology: Future Perspectives (Bern,Switzerland; March 31–April 4)

Towards other Earth's (Heidelberg, Germany; April 22–26)
"Origin of Life"

Mars Express Space Science Talks (Frankfurt, Germany; April 29–29)
"Life on Mars: a Mission Objective ?"

Mars Aurora Workshop ESA HQ (Paris, France; May 14–15)

Astrophysics of Dust (Boulder, USA; May 26–31)
"Physics and Chemistry of Interstellar Ices"

Internation Mars Exploration Working Group (Cocoa Beach, USA; May 22–26)
"Dutch Activities in Mars Exploration"

ESA Cross-Disciplinary Perspective Workshop (Gaaderen; June 30–July 1)

GUCS Galileo Ulysses Cassini Stardust Science Meeting (Noordwijk; July 7–8)

"Interstellar Dust: Ice and Carbon Chemistry"
XXVth IAU General Assembly (Sydney, Australia; July 22–26)
"Cometary Chemistry: Constraints from Observations and Laboratory Simulations"
"Detection of Diffuse Interstellar Bands in the Magellanic Cloud"
Next Steps in Deep Space Exploration (Noordwijk; September 22–23)
"Astrobiology and Conditions for Life"
NSF Committee COEL Meeting (Orange County, USA; October 8–10)
"Astrobiology in Europe"
Mars Aurora Meeting (Cologne, Germany; November 13–14)
3rd European Astrobiology Conference (Madrid, Spain; November 18–20)
"The Fate of Organic Molecules on the Martian Surface"
European Space Science Committee (Strasbourg, France; December 1–2)

Falcón Barroso
SAURON **Meeting** (Oxford, United Kingdom; September 8–11)
Stellar Populations 2003 (Garching, Germany; October 6–10)
"The CaT-σ Relation for Bulges of Spiral Galaxies"

Franx
Van Albada workshop (Groningen; March 15 & 19)
"Very Deep Infrared Imaging with the VLT"
"Evolution of Galaxies from the Fundamental Plane"

Fraser
ICAPS-IMPF Joint Facility Workshop (ESTEC, Noordwijk; Feb 2–8)
"The Roadmap to ICAPS Science (invited lecture)"
"Physico-Chemistry of Ices under Microgravity (invited lecture)"
"CO'ded' messages? Just what can we learn about the ISM with Surface Chemistry (invited lecture)"
Solid State Chemistry in Star Forming Regions (Lorentz centre, Leiden; April 7–13)
"Surface Chemistry in Star Forming Regions (invited lecture)"
EU Photochemistry Network Meeting (FOM Rijnhuizen; May 8)
"Surface Chemistry in Star Forming Regions (invited lecture)"
NEVAC, Dutch National Vacuum Society Meeting (Leiden; May 16)
" CO'ded' messages? Just what can we learn about the ISM with Surface Chemistry (invited lecture)"
Gordon Research Conference - Dynamics at Surfaces (Andover, USA; August 8–15)
"Surface Chemistry in Protostellar Regions (invited lecture)"
IVth Cologne-Bonn-Zermatt Symposium (Zermatt, Switzerland; September 22–26)
"Ices and Dust (invited lecture)"

Geers
5th ICM meeting (Amsterdam; March 13)
AGB Workshop: "Future Directions in AGB Research" (Leiden; April 10–11)

Workshop on Solid State Astrochemistry of Star Forming Regions (Leiden; April 13–17)
4th Cologne-Bonn-Zermatt Conference (Zermatt, Switzerland; September 21–27)
PLANETS European Network meeting (Heidelberg, Germany; October 6–8)
High Resolution IR Spectroscopy in Astronomy (Garching, Germany; November 18–21)
"TIMMI2 and VLT-ISAAC spectroscopy of Circumstellar Dust Disks around PMS and Vega-like Stars"
6th ICM Meeting (Leiden; December 11)
"PAHs and Silicates in Young Circumstellar Dust Disks"

Hogerheijde
IVth Köln-Bonn-Zermatt Symposium (Zermatt, Switzerland; September 22–26)
"Modeling Molecular-line Emission from Circumstellar Disks"
PLANETS RTN Joint Network Meeting and School (Heidelberg, Germany; October 5–8)
"Millimeter-wavelength Observations of Planet Forming Disks"

Israel
Workshop Masers & **Molecules** (Särohús, Sweden; September 18–19)
"Molecules in the Magellanic Clouds"
The Dense Interstellar Medium in Galaxies (Zermatt, Switzerland; September 22–26)
"CO and CI in Galaxy Centers"

Jaffe
Lessons Learned in Instrument Building (Garching, Germany; April 8–9)
"MIDI software"
The age of big interferometers (Ringberg, Germany; September 1–5)
"Coherent Integration Techniques"

Johnston-Hollitt
X-rays in the Solar System (Leiden; April 7–9)
The Riddle of Cooling Flow Clusters (Charlottesville, USA; May 30–June 4)
"The Magnetic Field of A3667"
XXVth IAU General Assembly (Sydney, Australia; July 14–26)
"Detailed Radio and Optical Analysis of A3667"
International SKA Conference 2003 (Geraldton, Australia; July 27–August 2)
The Magnetized Intersellar Medium (Antalya, Turkey; September 8–12)
"An Interpolated Image of the RM Sky and what this tells us about Galactic Magnetic Fields"
LOFAR and the Epoch of Reionisation (Leiden; October 30)
Bonn-Dwingeloo Symposium (Dwingeloo; November 5)
SKA Science Retreat (Leiden; November 10–14)
Mini workshop on Diffuse Constituents of Galaxy Clusters (Dwingeloo; December 3)
"Radio and Optical Properties of A3667"

De Jong
SAURON **Team Meeting** (Oxford, UK; September 10–11)
"Demonstration of the SAURON *Pipeline Software"*

Jonkheid
4th Cologne-Bonn-Zermatt Symposium (Zermatt, Switzerland; September 22–26)
"The Gas Temperature in Gaseous Circumstellar Disks"
PLANETS Network Meeting (Heidelberg, Germany; October 6–8)
"Gas Temperature in Disks"

Jørgensen
Annual Meeting of the Danish Physical Society (Nyborg, Denmark; June 12–13)
"High-resolution Studies of Low-mass Protostars"
XXVth IAU General Assembly (Sydney, Australia; July 14–25)
"Envelope, Outflow, Disk and Chemistry in NGC1333-IRAS2; Linking Single Dish and Interferometer Data"

Kamp
Workshop Planet Formation (Weimar, Germany; February 19–21)
"Protoplanetary Disks Around Solar-Type Stars"
ICM Meeting (Amsterdam; March 12–12)
XXVth IAU General Assembly (Sydney, Australia; July 13–25)
"Tenuous Disks Around Young G-Stars: Temperature and Chemistry"
AG Meeting (Freiburg, Germany; September 15–19)
"Protoplanetary Disks around Solar-Type stars"
Planet Network Meeting (Heidelberg, Germany; September 6–8)
"Chemical Models of Protoplanetary Disks"
ICM Meeting (Leiden; December 11–11)

Ten Kate
LPSC (Houston, USA; March 17–21)
"Simulations of Martian Surface and Subsurface Processes"
3rd European Workshop on Astro/Exobiology (Madrid, Spain; November 18–20)
"Behaviour of Organic Molecules under Simulated Mars Conditions"

Knudsen
FIRES Workshop (Leiden; June 2-7)
"Deep SCUBA Observations of MS1054-03"
Multiwavelength Cosmology (Mykonos, Greece; June 7–20)
"A New Deep SCUBA Survey of Gravitationally Lensing Galaxy Clusters"

Kriek
Jerusalem Winter School on the Origin of Galaxies (Israel; Dec 29 ('03)– Jan 8 ('04))
"Star Formation in Cen A's Dusty Disk"

Kuijken
Winterschool Gravitational Lensing (Aussois, France; January 6–10)
"The Basics of Lensing"
Lessons Learnt on VLT Instrumentation (ESO-Garching, Germany; April 8–9)
"OmegaCAM"
ESO Large Programmes and Surveys (ESO-Garching, Germany; May 19–21)
"OmegaCAM Surveys"
Satellite Galaxies and Tidal Streams (La Palma, Spain; May 26–30)
Milky Way Surveys: the Structure and Evolution of our Galaxy (Boston, USA; Jun 14–18)
"The Stellar Kinematics of the Bulge/Bar"
XXVth IAU General Assembly (Sydney, Australia; July 15–26)
SISCO science meeting (Naples, Italy; September 4–5)
Dark Matter and dark Energy (Bad Honnef, Germany; December 8–11)

Lacerda
XXVth IAU General Assembly (Sydney, Australia; July 13–26)
"Detectability of Lightcurves of KBOs"

Labbé
FIRES Workshop (Leiden; June 2–7)
XXVth IAU General Assembly (Sydney, Australia; July 13–26)
"The Rest-frame Optical Properties of Galaxies"
ESO Workshop (Venice, Italy; October 13–26)
"The Rest-frame Optical Properties of Galaxies"

McDermid
Euro 3D Workshop (Cambridge, UK; May 20–23)
"OASIS High-Resolution Follow-Up of SAURON E/S0 Galaxies"
Stellar Populations 2003 (Garching, Germany; October 13–16)
"Mapping Stellar Populations with Integral Field Spectroscopy"

Meijerink
Dutch Astrophysics Days 3 (Leiden; March 13–14)
Nederlandse Astronomen Conferentie (Kleve, Germany; May 21–23)
"Mass Loss Variations on the AGB and Rings around Planetary Nebulae"

Meisner
Workshop on Future Directions in AGB Research (Leiden; April 10–11)
"Interferometric Measurements of o Ceti using VINCI in the K Band"
XIXth IAP Colloquium (Paris, France; June 30–July 4)
"Direct Detection of Exoplanets using Long-baseline Interferometry and Visibility Phase"
Long Baseline Interferometry in the Mid-IR (Ringberg castle, Germany; September 1–5)
"Data Reduction, Calibration, and Stellar Diameter Results using VINCI"

Mellema

Dutch Astrophysics Days 3 (Leiden; March 13–24)
Future Directions in AGB Research (Leiden; April 10–11)
"AGB Mass Loss Variations and Rings around Planetary Nebulae"
Annual Meeting RTN The Physics of the IGM (Ile d'Oleron, France; September 7–10)
"Three Dimensional Models of the Intergalactic Medium"
Annual Meeting RTN The Origin of Planetary Systems (Heidelberg, Germany, October 6–8)
"Planets in Disks, a New Method for Planet-Disk Interaction"
Computational Science Programme Meeting (Eindhoven; November 28)
"3D AMR Simulations of Point Symmetric Nebulae"

Menéndez-Delmestre

The neutral ISM in Starburst Galaxies (Marstrand, Sweden; June 23–27)
"NIR Imaging of Star Forming Regions in Cen A's Dust Lane"

Messineo

Future Directions in AGB Research (Leiden; April 10–11)
"Maser Surveys of Late-type Stars in the Inner Galaxy"

Miley

ESO Workshop on Large Programmes (Garching, Germany; May 19–21)
"The Most Distant Protoclusters"
ACS Science Team Annual Meeting (Aspen, USA; September 6–16)
"The ACS Distant Radio Galaxy GTO Program"
Symposium for Professor Roy Booth (Onsala, Sweden; September 17–20)

Ollongren

Workshop on Interstellar Message Construction (Paris, France; March 23–24)
"A Characterisation of Altruism in Logic"
Workshop on Extra-terrestrial Altruism (Bremen, Germany; September 28)
"A Characterisation of Altruism in Logic"
54th International Astronautical Congress (Bremen, Germany; September 29 – October 3)
IAA.9 32nd Meeting on SETI (September 30)
"Inductive self-interpretation in LINCOS"

Paardekooper

Dutch Astrophysics Days 3 (Leiden; March 13–14)
Extrasolar Planets: Today and Tomorrow (Paris, France; June 30–July 4)
"Planets in Disks: a New Method for Hydrodynamic Disk Simulations"
Network Meeting: The Origin of Planetary Systems (Heidelberg, Germany; October 6–8)
"Planets in Disks: a New method for Hydrodynamic Disk Simulations"
Computational Science Meeting (Eindhoven; November 28)

Pontoppidan

High Resolution Infrared Spectroscopy (ESO Garching, Germany; November 18–21)
"VLT-ISAAC 3-5 micron Spectroscopy of Low-mass YSOs"
4th Nordic Workshop (Odense, Denmark; September 20)
"The Micro-Structure of Interstellar Ice"
XXVth IAU General Assembly: IAU Joint Discussion 14 (Sydney, Australia; July 19–26)
"Processed and Unprocessed Ices in Circumstellar Disks"
Annual Meeting of the Danish Physical Society (Nyborg, Denmark; June 12–13)
"VLT-ISAAC Spectroscopy of Ice and Gas Around Low-Mass Young Stars"
5th ICM Meeting (Amsterdam; March 13)
"VLT-ISAAC Spectroscopy of Ice and Gas Around Low-Mass Young Stars"

Quirrenbach

AAS Conference (Seattle, USA; Jan 6–9)
"HST/STIS Coronagraphic Imaging of the Disk of DM Tauri"
Eddington Conference (Palermo, Italy; Apr 8–11)
DARWIN & the Search for Extrasolar Terrestrial Planets (Heidelberg, Germany; Apr 21–26)
"Astrometry as a Precursor to DARWIN/TPF"
Michelson Summer School (Pasadena, USA; Jun 6–10)
"Observing through the Turbulent Atmosphere"
XXVth IAU General Assembly (Sydney, Australia; Jun 13–26)
JENAM (Budapest, Hungary; Aug 25–30)
"Astrometry .– a Powerful Tool for Dynamical Studies of Planetary Systems"
Infrared Interferometry Workshop (Ringberg, Germany; Sep 1–3)
"Past and Future Impact of Interferometry"
ELT Workshop (Bäckaskog, Sweden; Sep 9–12)
"Extremely Large Synthesis Array"
ESO Site Testing Workshop (Garching, Germany; Oct 12–13)
"Interferometric Measurements of the Outer Scale"
ELT Science Workshop (Marseille, France; Nov 4–7)
"A strawman Instrument Suite for a European Extremely Large (50- to 100-m) Telescope"
Infrared Spectroscopy Conference (Garching, Germany; Nov 18–21)
"High-Resolution Spectroscopy on the Milliarcsecond Scale"

Reuland

Emission Line Halos: Recent Observations and Modeling (Leiden; June 20)
"Emission Line Nebulae Around High-z Radio Galaxies: Evidence for Feedback in Galaxy Formation"
RTN: Physics of the Intergalactic Medium (Ile d'Oleron, France; September 6 – 12)
"Emission Line Nebulae Around High-z Radio Galaxies: Evidence for Feedback in Massive Galaxy Formation"

Rijkhorst

Dutch Astrophysics Days 3 (Leiden; March 13-14)
"Visualizing 3D Adaptive Mesh Refinement simulations"

Nederlandse Astronomen Conferentie (Kleve, Germany; May 21-23)
"Squashing Interstellar Clouds in 3 Dimensions"

Asymmetric Planetary Nebulae III (Mount Rainier, USA; July 28-August 1)
"3D AMR Simulations of Point-Symmetric Nebulae"

Chicago Workshop on Adaptive Mesh Refinement Methods (Chicago, USA; September 3-5)
"3D AMR Simulations of Point-Symmetric Nebulae"

Aster-workshop for users of the Dutch national supercomputer (Utrecht; November 4)

Computational Science Meeting (Eindhoven; November 28)
"3D AMR Simulations of Point-Symmetric Nebulae"

Ritzerveld

Dutch Astrophysics Days 3 (Leiden; March 13–14)
"Triangulating Radiation, Radiative Transfer on Unstructured Grids (invited talk)"

Nederlandse Astronomen Conferentie (Kleve, Germany; May 21–23)

Chicago Workshop on Adaptive Mesh Refinement (Chicago, USA; September 3–5)

Computational Science Day (Eindhoven; November 28)
"Triangulating Radiation, Radiative Transfer on Unstructured Grids (poster presentation)"

Röttgering

Meeting Science Demonstration Time for VLTI (ESO Graching, Germany; Jan 25-26)

Darwin & the Search for Extrasolar Terrestrial Planets (Heidelberg, Germany; Apr 22-25)
"Astrophysical Imaging with Darwin"

Star Formation Near and Far: the ALMA Promise (Elba, Italy, May 27-30)
"Radio Galaxies"

Multiwavelength Mapping of Galaxy Formation and Evolution (Venice, Italy, Oct 13-16)
"The Evolution of Cluster Galaxies from z=4 to z=1 "

Long Baseline Interferometry in the mid-infrared (Ringberg castle, germany, Sept 1-5)
"Mid-IR Interferometry from Space"

Annual Meeting of the RTN Network "Physics of the IGM" (Ile d'Oleron, France Sept 6 - 10)

Meeting Science Demonstration Time for VLTI (ESO, Garching, Oct 20 - 21)

Multiwavelength AGN Surveys (Cozumel, Mexico, Dec 8 - 12)

Schlemmer

28th Fall AMO meeting (Lunteren; November 13–14)
"Isotopic Fractionation of Small Hydrocarbon Ions"

4th Zermatt Symposium (Zermatt, Switzerland; September 22–26)
"Isotopic Fractionation of Small Hydrocarbon Ions"

Snijders
Formation and Evolution of Young Massive Stellar Clusters (Cancun, Mexico; Nov 17–21)

EARA Workshop (Paris, France; December 3–5)
"Extreme Star Formation in Starburst and Ultraluminous Infrared Galaxies"

Stuik
NAOMI AO Workshop (Santa Cruz de La Palma, Spain; January 8–11)

RTN Meeting/Mini-school on MCAO for ELTs (Garching, Germany; February 17–21)
"Guide Stars for MUSE"

CfAO Summerschool (Santa Cruz, USA; August 9–15)

Workshop on "Atmosphere knowledge and AO for 8–100 m telescopes" (Garching, Germany; Oct 13)

Light on Planetary Atmospheres (Amsterdam; December 15–16)

Tubbs
MIDI Ringberg Science Meeting (München, Germany; August 1–5)
"MIDI Observations of W Hydrae"

Dutch/Belgium MIDI Science Day (Amsterdam; November 13)
"Differential Phase Observations with MIDI"

Van de Ven
XXVth IAU General Assembly (Sydney, Australia; July 17–28)
"Triaxial Dynamical Models for Elliptical Galaxies"

SAURON **Team Meeting** (Oxford, England; September 9–11)
"Triaxial Dynamical Models for Elliptical Galaxies"

Venemans
Multiwavelength Mapping of Galaxy Formation and Evolution (Venice, Italy; Oct 13–16)
"A Study of Distant Lyα Emitters in Overdense Regions"

Webb
Clusters of Galaxies: Probes of Cosmological Structure and Galaxy Evolution (Carnegie Institution, Pasadena, USA; January 26–31)

Canadian Astronomical Society General Meeting (Waterloo, Canada; June 1–3)
"A Dusty Universe, the hHdden Phases of Galaxy Formation"

Multi-wavelength Cosmology (Mykonos, Greece; June 17–20)
"The Submillimeter Properties of EROs"

Multi-wavelength Mapping of Galaxy Evolution (Venice, Italy; October 13–16)
"The Submillimeter Properties of EROs"

Weijmans
SAURON **Team Meeting** (Oxford, United Kingdom; September 8–11)
"Shape and Kinematic Misalignment in Galaxies"

Van der Werf

Science with VISIR (Kapteyn Laboratorium, Groningen; January 10)
"Starburst Galaxies with VISIR"

Next Generation of Submillimetre Detectors (SRON, Utrecht; February 6)
"Extragalactic Infrared-Submillimetre Astronomy for the Next Decade"

Faint InfraRed Extragalactic Survey workshop (Lorentz Centre, Leiden; June 2–4)

The Neutral ISM in Starburst Galaxies (Marstrand, Sweden; June 23–27)
"H_2 Emission from Starburst Galaxies"

Science with OmegaCAM (Lorentz Centre, Leiden; June 30–July 3)

Science with VISIR (University of Amsterdam; July 2)
"Extragalactic Astronomy with VISIR"

De Zeeuw

IAU Symposium 220: Dark Matter (Sydney, Australia, July 22–25)
"Session Summary: The Shapes of Dark Halos"

Conference: From First Light to the Milky Way (ETH Zürich, Switzerland, August 17–22)
"Session Summary: Scaling Relations"

Conference in Honor of Peter Vandervoort (University of Chicago, USA, October 10)
"The SAURON *Project: Reading the Fossil Record of Galaxy Formation"*

Appendix VII

Observing sessions abroad

Sterrewacht Leiden

Observing sessions abroad

Appendix VII

Augereau	ESO 3.6m Telescope (La Silla, Chile; March 26–30)
Bakker	VLTI (Paranal, Chile; February 9–26) VLTI (Paranal, Chile; October 1–10)
Boland	JCMT (Mauna Kea, Hawaii, November)
Cappellari	WHT (La Palma, Spain; April 25–2)
Falcón Barroso	WHT (La Palma, Spain; August 27–September 1)
Franx	Keck Observatory, (Hawaii, USA; February 13–18) VLT (Paranal;Chile; August 31–September 6)
Frink	TNG (La Palma, Spain; November 1) TNG (La Palma, Spain; December 7)
Förster-Schreiber	WHT (La Palma, Spain; March)
Geers	ESO 3.6m Telescope (La Silla, Chile; March 26–29)
Israel	ESO (La Silla, Chile; February 24–March 5) ESO (La Silla, Chile; March 13–19)
Jaffe	VLTI-MIDI (Cerro Paranal, Chile; February 9–26) VLTI-MIDI (Cerro Paranal, Chile; May 10–26) VLTI-MIDI (Cerro Paranal, Chile; November 30–December 16)
Johnston-Hollitt	ATCA (Narrabri, Australia; July 1–14) ATCA (Narrabri, Australia; August 29–30) ATCA (Narrabri, Australia; December 6–8)

De Jong	VLTI/MIDI commissioning (Paranal, Chile; December 1–14)
Jørgensen	JCMT (Mauna Kea, US; February; 20–26) OVRO (Owens Valley, US; March; 1–7) SEST (La Silla, Chile; April; 3–6) ATCA (Narrabri, Australia; July 9–13)
Kamp	ESO (La Silla, Chile; January 15–21)
Knudsen	JCMT (Mauna Kea, Hawaii, USA; April 22–28)
Krajnovic	MDM 1.3 m (Tucson, USA; March 25 – April 6)
Labbé	WHT (La Palma, Spain; October 20–23)
Larsen-Schoier	JCMT (Mauna Kea, Hawaii, July)
McDermid	WHT (La Palma, Spain; April 28–May 4) WHT (La Palma, Spain; July 10–17) WHT (La Palma, Spain; October 6–10)
Meijerink	JCMT (Mauna Kea, Hawaii; March 24–31)
Messineo	IRAM 30m (Granada, Spain; October 28–November 4)
Miley	VLT (Paranal, Chile, February)
Nuyten	La Palma, Spain, January
Overzier	VLT (Paranal, Chile; March 3–4)
Pontoppidan	VLT (Paranal, Chile; July 8–9)
Quirrenbach	La Palma, Spain, November
Röttgering	KECK (Hawaii, USA, Jan 29–Feb 3)
Tubbs	NOT (La Palma, Spain; June 27–July 5)
Venemans	VLT (Paranal, Chile; March 3–4)
Webb	JCMT (Mauna Kea, Hawaii, USA; October 6–19) JCMT (Mauna Kea, Hawaii, USA; December 11-24)
Van der Wel	VLT (Paranal, Chile; February 28 - March 3) VLT (Paranal, Chile; October 20–24)
Wuyts	Keck Observatory (Hawaii, USA; January 20–February 1)

Appendix VIII

Working visits abroad

Sterrewacht Leiden

Working visits abroad

Appendix VIII

Asvany
TU Chemnitz (Chemnitz, Germany; September 18–20)
TU Chemnitz (Chemnitz, Germany; October 23–24)

Augereau
LAOG (Grenoble, France; March 3–7)
LAOG (Grenoble, France; May 5–19)
Meudon (Paris, France; July 9)
LAOG (Grenoble, France; December 8–10)
Meudon (Paris, France; December 11–12)

Bakker
ESO (Garching, Germany; May 14–15)
ESO (Garching, Germany; June 1–2)
ESO (Garching, Germany; August 18–19)
ESO (Garching, Germany; November 6–7)
ESO (Garching, Germany; November 20–21)
MPIA (Heidelberg, Germany; December 18–19)
Observatory of Geneva (Geneva, Switzerland; July 25)
Observatory of Geneva (Geneva, Switzerland;September 11–12)
LAOG (Grenoble, France; May 26–27)
LAOG (Grenoble, France; August 21–23)

Brandl
Caltech/Spitzer Science Center (Pasadena, USA, September 9–October 10)
Caltech/Spitzer Science Center (Pasadena, USA, November 2–24)

Brown
Royal observatory of Belgium (Brussels, Belgium; May 7)
European Southern Observatory (Garching, Germany; December 15)

Cappellari
Astronomy Department (Padova, Italy; February 10–14)
MPIA (Heidelberg, Germany; November 13–18)

Van Dishoeck
MPIA (Heidelberg, Germany; January 20–21)
ETH (Zurich, Switzerland; January 22–23)

ESO (Garching, Germany; February 20)
ESTEC (Noordwijk, The Netherlands; February 21)
MPIfR (Bonn, Germany; February 24–25)
LAOG (Grenoble, France; March 3–4)
ESTEC (Noordwijk, The Netherlands; March 18–19)
Center for Astrophysics (Cambridge, USA; March 20–21)
IRAM (Grenoble, France; April 2–3)
Steward Observatory (Tucson, USA; May 2)
University of Washington (Seattle, USA; May 15–17)
ESO (Garching, Germany; May 19–20)
UK-ATC (Edinburgh, UK; May 21)
ESO (Garching, Germany; June 12)
University of Porto (Porto, Portugal; June 15–16)
OAN (Madrid, Spain; September 1)
McMaster University (Hamilton, Canada; September 5–6)
ESO (Garching, Germany; September 15–16)
INTA (Madrid, Spain; September 17)
California Institute of Technology (Pasadena, USA; October 22–December 19)

Franx
Paris Observatory (Paris, France; January 22–23)
MPIA (Heidelberg, Germany; January 29–February 1)
Caltech (Pasadena, USA; February 10–13)
Caltech (Pasadena, USA; February 18–20)
Johns Hopkins University (Baltimore, USA; June 23–25)
Center for Astrophysics (Cambridge, USA; June 25–27)
UC Santa Cruz (Santa Cruz, USA; June 28–July 2)
Johns Hopkins University (Baltimore, USA; August 28–30)
University of Lyon (Lyon, France; September 18–20)
Johns Hopkins University (Baltimore, USA; November 13–16)
Caltech (Pasadena, USA; November 17–22)

Fraser
Department of Chemistry, University of Nottingham (Nottingham, UK; January 10–15)
Department of Chemistry, University of Nottingham (Nottingham, UK; April 30–May 6)
Department of Chemistry, University of Nottingham (Nottingham, UK; October 22–28)
Department of Chemistry, University of Nottingham (Nottingham, UK; December 20–24)

Frink
Max Planck Institute for Astronomy/LandesSternwarte (Heidelberg, Germany; Sep 1)

Jaffe
Max Planck Institute for Astronomy (Heidelberg, Germany; February 2–5)
Max Planck Institute for Astronomy (Heidelberg, Germany; May 28–30)
Max Planck Institute for Astronomy (Heidelberg, Germany; July 6–9)

Johnston-Hollitt
University of Virginia (Charlottesville, USA; June 4–12)
University of North Carolina (Chapel Hill, USA; June 12–18)
Australia Telescope National Facility (Sydney, Australia; July 22–25)
University of Adelaide (Adelaide, Australia; August 3–7)

De Jong
Observatoire de Lyon (St. Genis Laval, France; January 27 to February 5)

Jørgensen
Herzberg Institute of Astrophysics (Victoria, Canada; March 10–13)
Radio Astronomy Lab., UC Berkeley (Berkeley, US; November 4–6)
Caltech (Pasadena, US; November 7–10)
University of Texas in Austin (Austin, US; November 11–17)
Harvard-Smithsonian Center for Astrophysics (Cambridge, US; November 18–22)
University of Michigan (Ann Arbor, US; November 23–25)

Jourdain de Muizon
Bordeaux Observatory (Bordeaux, France; July 7–9)

Kamp
Hamburger Sternwarte (Hamburg, Germany; October 23–24)
AIP (Potsdam, Germany; October 15–16)
Stockholm Observatory (Stockholm, Sweden; November 9–28)

Katgert
Osservatorio Astronomico (Trieste, Italy; May 31 – June 6)

Knudsen
Califonia Institute of Techonology (Pasadena, USA; Jan 26–Feb 8)
Cornell University (Ithaca, USA; May 5–16)

Krajnovic
NOAO (Tucson, USA; March 20 – 21)

Kuijken
Osservatorio Astronomico Capodimonte (Naples, Italy; Jan 20–22)
Institut d'Astrophysique Paris (Paris, France; Feb 18)
Bonn Observatory (Bonn, Germany; May 8–9)
Universitätssternwarte München (Munich, Germany; Oct 1–2)
Case Western Reserve University (Cleveland, USA; Oct 9–14)
University of Toronto (Toronto, Canada; Oct 15–18)

Lacerda
Harvard-Smithsonian CfA (Cambridge, USA; Jan–June)

Lub
ESO (Garching, Germany; May 19–21, June 01–06 & November 23–28)

McDermid
Observatoire de Lyon (Lyon, France; February 23–March 1)
Oxford University (Oxford, UK; September 7–11)

Meijerink
Max Planck Institute for Astrophysics (Garching, Germany; February 3–7)

Meisner
ESO (Garching, Germany; September 15–19)

Messineo
Institut d'Astrophysiqe (Paris, France; February 07)

Miley
Instituto de Astrofisica de Canarias (Tenerife, Spain); January 23–26
NASA Johnston space center (Houston, USA); April 5–7
Johns Hopkins University (Baltimore, USA); July 4–10
Univ. California Santa Cruz (Santa Cruz, USA); July 10–18
NRAO (Socorro, USA); November 17–23
NRAO (Charlottesville, USA); November 23–28

Overzier
Harvard-Smithsonian Center for Astrophysics (Cambridge, USA; May 31–June 20)
Aspen Center for Physics (Aspen, USA; September 5–11)

Pontoppidan
California Institute of Technology (Pasadena, USA; December 2 – 12)

Quirrenbach
Vienna University (Vienna, Austria; Jan 10)
IAC (Tenerife, Spain; Jan 24–25)
Padova University (Padova, Italy; Jan 26–28)
MPIA (Heidelberg, Germany; Feb 2–3)
UK ATC (Edinburgh, UK; Feb 20)
EU-Interferometry (Gdansk, Poland; Feb 27–28)
UK ATC (Edinburgh, UK; Mar 10)
ESO (Garching, Germany; Mar 19–20)
UCSD (San Diego, USA; Mar 25–30)
ESO (Garching, Germany; Apr 14)
JPL (Pasadena, USA; Apr 27–May 02)
ESO (Garching, Germany; May 14–15)
STScI (Baltimore, USA; May 19–22)
ESO (Garching, Germany; Jun 3–5)
UCSC (Santa Cruz, USA; Jun 11–15)

ESO (Garching, Germany; Jun 16)
U Durham (Durham, UK; Jun 29–Jun 2)
ESO (Garching, Germany; Aug 18–20)
U Geneva (Geneva, Switzerland; Aug 21–23)
OPTICON (Chania, Greece; Sep 3–6)
NASA (Washington, USA; Sep 14–18
Astrium (Friedrichshafen, Germany; Oct 1–2
ETH (Zürich, Schweiz; Oct 6–7
U Nice (Nice, France; Oct 8–9
ESO (Garching, Germany; Oct 10, Nov 26 & Dec 9)
JPL (Pasadena, USA; Dec 15–20)

Reuland
Landessternwarte (Heidelberg, Germany; December 2–4)

Rengelink
Osservatorio Astronomico di Capodimonte (Naples, Italy; May 7–9)

Röttgering
ROE (Edinburgh, Scotland, Jan 9–11)
PPARC (Swindon, UK, May 13–14)
CEA (Saclay, France, Aug 19–20)
Arcetri (Italy, Nov 25–26)
ROE (Edinburgh, Scotland, Jan 27–29)

Schlemmer
TU Chemnitz (Chemnitz, Germany; October 23–25)
University of Heidelberg (Heidelberg, Germany; November 21–22)

Stuik
Osservatorio Astronomico di Padova (Padova, Italy; January 27–28)
MPIA (Heidelberg, Germany; May 6–7)
Durham University (Durham, United Kingdom; June 30–July 2)
Oxford University (Oxford, United Kingdom; September 26)
ETHZ (Zürich, Switzerland; October 6–7)
ESO (Garching, Germany; December 1–12)

Tubbs
European Southern Observatory (Garching, Germany; June 1–2, November 25–28 & December 15–18)

Van der Werf
European Southern Observatory (Garching, Germany; March 11)
Mullard Space Science Laboratory (Holmbury St. Mary, England; March 20)
Institute of Astronomy (Cambridge, England; May 21–24)
UK Astronomy Technology Centre (Edinburgh, Scotland; June 5–6)

European Southern Observatory (Garching, Germany; December 15)

Wuyts
Yale University (New Haven, USA; March 23–May 4)

De Zeeuw
AURA Headquarters (Washington DC; USA, February 27–28)
European Southern Observatory (Chile; March 10-16)
Space Telescope Science Institute (Baltimore MD, USA; March 24–29)
European Southern Observatory (Garching, Germany; April 8–9)
National Optical Astronomy Observatories (Tucson AZ, USA; May 2)
Astronomisches Recheninstitut and MPIA (Heidelberg, Germany; May 27)
European Southern Observatory (Garching, Germany; June 10–11)
Space Telescope Science Institute (Baltimore MD, USA; June 12–13)
Observatoire de Lyon (Lyon, France; July 7–8)
General Assembly IAU (Sydney, Australia; July 16–26)
AURA Headquarters (Washington DC, USA; July 30–31)
ETH (Zürich, Switzerland; August 17–22)
European Southern Observatory (Garching, Germany; September 2–3)
University of Oxford (Oxford, UK; September 7–10)
Observatoire de Paris (Paris, France; October 6–7)
Astron. Dept. Univ. of Chicago (Chicago IL, USA; October 9–10)
Astron. Dept. Univ. of Texas (Austin TX, USA; November 11–14)
European Southern Observatory (Garching, Germany; October 29)
Space Telescope Science Institute (Baltimore MD, USA; November 13–14)
California Institute of Technology (Pasadena CA, USA; November 15–22)
European Southern Observatory (Garching, Germany; December 9–10)

Appendix IX

Colloquia given outside Leiden

Colloquia given outside Leiden

Appendix IX

Andersson

Using Density Functional Theory to Study the Kinetics of Chemical Reactions Relevant to Astrophysics	Goteborg University, Sweden; Oct 17

Augereau

Vues Nouvelles sur la Formation et l'Évolution des Systèmes Planétaires	IAS, Orsay, France; Apr 30
Idem	LAOG, Grenoble, France; May 7
Idem	LAM, Marseille, France; May 20

Bakker

Very Large Telescope Interferometry: Recent Achievements and Road Ahead	MPIA, Heidelberg, Germany; July 9
Idem	LAOG, Grenoble, France; May 28

Brown

GAIA - Taking the Galactic Census: Current Status and Activities	Kapteyn Institute, Groningen; Nov 11
Simulations of Adaptive Optics with a Laser Guide Star for SINFONI	ESO, Garching, Germany; Dec 15

Cappellari

Dynamics of Galaxies as seen from the SAURON *Survey*	Groningen; Oct 6
The Fossil Record of Galaxy Formation Observed with SAURON	MPIA, Heidelberg, Germany; Nov 14

Van Dishoeck

Gas and Ices in Protoplanetary Disks	MPIA, Heidelberg, Germany; Jan 21
From Molecules to Planets	ETH, Zürich, Switzerland; Jan 22
Gas and Ices in Protoplanetary Disks	ETH, Zürich, Switzerland; Jan 23
The Atacama Large Millimeter Array: Project Status and Science Operations	Sterrenkundig Instituut, Utrecht; Jan 29
Gas and Ices in Protoplanetary Disks	Univ of Washington, Seattle, USA; May 15

The Atacama Large Millimeter Array: Project Status and Science Operations	University of Porto, Porto, Portugal; June 16
Water in Star Forming Regions	Caltech, Pasadena, USA; Nov 18
Gas and Ices in Protoplanetary Disks	UCLA, Los Angeles, USA; Nov 19
Photochemistry in the Outer Regions of Circumstellar Disks	Caltech, Pasadena, USA; Nov 25
From Molecular Cores to Protoplanetary Disks: Evolution of Gas and Dust	Caltech, Pasadena, USA; Dec 3
The Atacama Large Millimeter Array: Project Status and Science Operations	Caltech, Pasadena, USA; Dec 4
Evolution of Gas and Ice in Star Forming Regions: a VLT-ISAAC 3–5 μm Spectroscopic Survey of Low-Mass Protostars	Carnegie Institution, Pasadena, USA; Dec 9

Ehrenfreund

Astrobiology: the Search for Life in the Universe	Univ. Aarhus, Aarhus, Denmark; Mar 11
Astrobiologie	Inst Jacob Monod, Paris, France; Mar 28
Leven in het Heelal	NWA, Utrecht; Apr 16

Fraser

CO'ded' messages? Just what can we learn about the ISM with Surface Chemistry	Department of Astronomy, Jena University, Germany; Jan
Idem	Dept of Physics, Chemnitz, Germany; Jan
Idem	Dept of Astronomy, Helsinki, Finland; Jan
UV-mediated CO Reactions in the Solid State under Interstellar Conditions	Astrobiology Seminar Series,Open University, UK; May
The Solid CO band Towards Young Stellar Objects	Department of Chemistry, University of Cambridge, UK; May
Surface Chemistry in Protostellar Regions	Department of Chemistry, University of Provence, Marseille, France; July

Johnston-Hollitt

Radio Imaging of the Relic 0917+75	ATNF, ATCA, Narrabri, Australia; July 8

Jørgensen

Physical and Chemical Structure of Low-mass Protostars	Herzberg Institute of Astrophysics, Victoria, Canada; Mar 11
Tracing the Physical and Chemical Evolution of Low-mass Protostars	UC Berkeley, Berkeley, US; Nov 5
Idem	Caltech, Pasadena, US; Nov 10
Idem	Univ of Texas, Austin, US; Nov 12
Idem	Harvard-Smithsonian CfA, Cambridge, US; Nov 18

Idem	Unive of Michigan, Ann Arbor, USA; Nov 25

Kamp

From Protoplanetary Disks to Planets	St. Andrews, UK; May 26
Von Protoplanetaren Scheiben zu Planeten	Astrophysical Inst, Jena, Germany; June 13
From Protoplanetary Disks to Planets	Hamburger Sternwarte, Germany; Oct 24
Idem	ITA, Heidelberg, Germany; Nov 5
Idem	Stockholm Observatory, Sweden; Nov 14

Katgert

The Properties of the Faraday Screen of the Galactic ISM, and the Strength and Structure of the Galactic Magnetic Field	Kapteyn Lab, Groningen; Jan 10

Knudsen

A New Deep SCUBA Survey of Gravitationally Lensing Clusters	Joint Astronomy Center Hilo, USA; May 2
Idem	Cornell University, Ithaca, USA; May 14

Kuijken

Bulges Large and Small	Case, Cleveland, USA; Oct 14
Idem	CITA, Toronto, Canada; Oct 17

Mellema

Squashing Clouds in Radio Lobes	KU Nijmegen; Feb 12
The Hydrodynamics of Radiative Feedback	Kapteyn Institute, Groningen; March 31
Idem	ASTRON, Dwingeloo; June 13

Messineo

86 GHz SiO Maser Survey of Late-type Stars in the Inner Galaxy.	ASTRON, Dwingeloo; Feb 21
Idem	MPIfR, Bonn, Germany; Apr 22

Miley

Radio Galaxies: Probes of the Most Distant Protoclusters	NRAO, Charlottesville, USA; November 25
The Most Distant Protoclusters	ESO, Garching, Germany; June 5

Ollongren

Communication with ETI, Interstellar Message Construction	Kernfysisch Versneller Instituut, Groningen; March 13
Communication with ETI: CETI	ASTRON, Dwingeloo; November 14

Pontoppidan

Recent Results from Ground-based Observations of Ice Mantles in Low-mass Star Forming Regions	Caltech, Pasadena, USA; December 8

Quirrenbach

Taking the Measure of the Universe: Interferometric Astrometry	ASTRON, Dwingeloo; Mar 7
Idem	Groningen University; Mar 17
Idem	MPIfR, Bonn, Germany; Apr 4
Optical / Infrared Interferometry	ESTEC, Noordwijk; May 23
Stellar Interferometry: a First Look at the Milliarcsecond Universe	MPI für Gravitationsphysik, Golm, Germany; Sept 8

Reuland

Gas and Dust in Distant Radio Galaxies: Witnessing Massive Galaxy Formation	Landessternwarte, Heidelberg, Germany; Dec 3

Röttgering

The Evolution of Clustering of Galaxies and AGN and the Quest for Proto-clusters	Meudon, Paris, France; June 24
Idem	Oxford, UK; Nov 4

Schlemmer

Electrodynamic trapping - a Tool for Laboratory Astrophysics	University of Freiburg, Germany; July 2
Idem	University Köln, Germany; July 4
Idem	VU, Amsterdam; Nov 3

Webb

Dusty Galaxies at High Redshift and the Cosmic Star Formation History	University of Britisch Columbia, Vancouver, Canada; Sept 23
Idem	NRC-HIA., Victoria, Canada; Sept 25
Idem	McMaster Univ, Hamilton, Canada; Sept 29
Idem	Kapteyn Institute, Groningen; Nov 10
Idem	York Univ, Toronto, Canada; Nov 18

De Zeeuw

Integral Field Spectroscopy of Galaxies: The SAURON *Project*	Astronomisches Recheninstitut and MPIA, Heidelberg, Germany; May 27
Idem	UvA; Dec 12
SAURON, *Black Holes and Cosmic Collisions*	Univ Claude Bernard, Lyon, France; July 8
The SAURON *Project: Reading the Fossil Record of Galaxy Formation*	Caltech, Pasadena, USA; Nov 19

Appendix X

Scientific publications

Sterrewacht Leiden

Scientific publications

Appendix X

X.1 Ph.D. theses and books

A.M.S. Gloudemans-Boonman, Spectroscopy of gases around massive young stars, Ph.D. thesis, Leiden University, March 2003.

H. J. Habing and H. Olofsson, Asymptotic giant branch stars, Astronomy and astrophysics library. Springer New York, Berlin, 2003.

J.D. Kurk, The cluster environments and gaseous halos of distant radio galaxies, Ph.D. thesis, Leiden University, May 2003.

G.M. Muñoz-Caro, From photoprocessing of interstellar ice to amino acids and other organics, Ph.D. thesis, Leiden University, February 2003.

E.K. Verolme, Dynamical models of axisymmetric and triaxial stellar systems, Ph.D. thesis, Leiden University, May 2003.

X.2 Papers in refereed journals

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[1]Written as part of the Communication and Education graduation track for MSc students