Onderzoeksinstituut
Sterrewacht Leiden

Research Institute
Leiden Observatory

Annual Report 1998

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Contents

1 Review of Major Events

1998 was a pivotal year for the future of Leiden Observatory and for Dutch astronomy as a whole. In March an international selection committee appointed by the Netherlands Organization for Research (NWO) rated the national astronomy proposal "Astrophysics: unraveling the history of the universe" first amongst 34 proposals covering all disciplines. The astronomy proposal was made jointly by all university astronomy departments in the Netherlands, in response to an initiative of the Ministry of Education and Science. It was submitted under the umbrella of the Nederlands Onderzoekschool voor Astronomie (NOVA) of which Tim de Zeeuw (Leiden) is Director and Ed van den Heuvel (University of Amsterdam) is Chairman of the Board. On the basis of the proposal, NOVA was awarded Dfl 43M that will augment the normal sources of funding for Dutch astronomy between 1999 until 2005. As well as providing much needed support for normal research activities, this will allow the Netherlands to participate in several programmes to construct astronomical instrumentation. Such projects foreseen in the proposal for which there is heavy Leiden involvement include optical interferometry (VLTI), wide-field imaging, an infrared fiber spectrograph for the VLT and development of mixers for the ALMA millimeter array.

An important component of the NOVA proposal is to build up expertise in optical interferometry. Building on the Leiden tradition of radio interferometry, several of our staff have become heavily involved with instrumentation for ESO's Very Large Telescope Interferometer (VLTI). As part of the NOVA project, NOVA and ESO have concluded an agreement to set up a national VLTI Expertise Center at Leiden, in close proximity to Fokker Space, the industrial firm that in 1998 was awarded the contract by ESO to build three delay lines for the interferometers. Le Poole is project scientist for the NOVA - ESO VLTI Expertise Center (NEVEC) which will be set up in 1999 as a joint venture between NOVA and ESO.

1998 was a happy year for the Leiden Observatory Laboratory. The "LOL" bridges the area between astronomy, chemistry, physics and biology. It was set up by Mayo Greenberg two decades ago as the "Laboratory Astrophysics" in a pioneering joint venture between the astronomy and physics departments. In the early nineties, after the formal retirement of Greenberg, economies caused the physics department to withdraw support and concentrate instead on their core activities. The laboratory continued from within Leiden Observatory under the direction of Ewine van Dishoeck but led a brave "year to year" existence dependent on the availability of soft money. In 1998, two friends and benefactors of Leiden Observatory, Dr. Raymond and Mrs. Beverly Sackler provided an endowment of Dfl 500,000 for the LOL and the Leiden University Funds contributed an additional Dfl 200,000 of matching funding. These generous gifts, together with the success of the NOVA proposal have guaranteed the survival of this unique laboratory for the coming decade.

During 1998 the research of the department continued to cover a broad range of astronomical and astrophysical topics and to exploit large international astronomical facilities as diverse as the ISO satellite, the Keck Telescope, the James Clerk Maxwell Telescope and the Westerbork telescope.

Our 1998 Oort Professor, Jeremy Mould, spent several weeks among us during April and May. Besides delivering the Oort Lecture on "How fast is the Universe expanding?" and giving a series of lectures to our postgraduate students, he organized workshops on the value of the Hubble Constant and on the AUSTRALIS/ANDES infrared fiber spectrograph planned for the VLT.

During 1998 Leiden was also host to several other symposia and workshops and conferences. One of these was a small symposium on 2nd December to formally celebrate Henk van de Hulst's 80th birthday. Another joyous occasion was the inauguration on October 19th of the Joint Institute for VLBI in Europe. Although this international institute is located in Dwingeloo, its director, Schilizzi, is an adjunct professor at Leiden Observatory.

Leiden Observatory has been a member of the European Association of Research in Astronomy (EARA) since its inception. EARA was conceived as a vehicle for stimulating collaboration between 3 excellent astronomical institutes, which initially consisted of Cambridge University, the Institut d'Astrophysique (Paris) as well as Leiden Observatory. Subsequently EARA was expanded to include the Max Planck Institut für Astrophysik in Garching. In 1998 EARA welcomed a new partner into the Association, the Instituto de Astrofysica de Canarias.

Since April 1997 most of Leiden Observatory has been housed in the J. H. Oort Building, a new wing adjoining the Huygens Laboratory on the outskirts of Leiden. On 27th November an official opening of this building was organized jointly by the physics and astronomy departments of Leiden University.

Finally, I mention mutations in scientific personnel. The future health of a research institute depends on the ability to renew its scientific staff. I am happy to report that in 1998 we recruited four outstanding young scientists to our tenure-track staff, Marijn Franx, Jane Luu, Huub Röttgering and Willem Schutte.

George Miley
Scientific Director, Leiden Observatory

2 Research

2.1 Surveys, Databases and Instrumentation

Asteroids

In 1998, the Minor Planet Center in Cambridge, USA gave 196 asteroids found by C.J. van Houten and I. van Houten-Groeneveld in the 4 surveys of 1960, 1971, 1973, and 1977 definitive numbers. Included are 7 Trojans of libration point L4 and 1 Trojan of libration point L5.

Twenty of these are now named by the IAU commission Small Bodies Names Committee.

In the 'Discoverers Ranking List' of the 'Dictionary of Minor Planet Names' the van Houtens are since 8th Dec 1998 the first with 526 resp. 522 numbered objects. The third is Bowell from Lowell Observatory with 481.

Westerbork Survey in the Southern Hemisphere (WISH)

The Westerbork Survey in the Southern Hemisphere (WISH) is a survey at 350 MHz which will ultimately cover the declination range between -10 to -30 deg, a region which will be accessible to the VLT. Production of the maps is taking place at Dwingeloo by Tang (Dwingeloo) and the catalogue of the of order hundred thousand sources is being produced by Zhang (Leiden). The catalogue at the end of 1998 contained 90,000 sources.

DENIS

DENIS is a survey in the near-infrared photometric bands (I, J, K) of the Southern sky with limiting magnitudes 18, 16, 14 made with the 1m telescope of ESO. The project started in late 1995 and is about halfway completion. Leiden participates as one of the two data centers, the other being in Paris at the I.A.P.. In Leiden point sources are extracted and the ultimate point source catalogue is prepared. The data reduction is in its routine phase since the middle of 1997.

Point source data are also input for the thesis research of M.R. Cioni, who will prepare the catalogue of point sources in both Magellanic Clouds and will discuss the luminosities and the distribution of AGB stars in these dwarf galaxies. Cioni started in May 1997 and her work is progressing satisfactorily.

GAIA

ESA is studying a possible follow-up mission to Hipparcos, called GAIA, which will deliver parallaxes and proper motions of microarcsecond accuracy for all one billion stars brighter than $V \sim 20$. The Science Advisory Group contains two Leiden staff members: Perryman (chair) and de Zeeuw. Perryman leads the entire effort, and de Zeeuw coordinates the scientific case, together with Gilmore (Cambridge).

In preparation for GAIA, Robichon simulated fields of globular clusters, and showed that half of the globular clusters will not pose problems in terms of crowding and that tens to hundreds of thousands stars will be observed in any cluster. Images of dense cluster cores have also been simulated taking into account the CCD parameters and PSF of GAIA. They will be used to help define the detection algorithms of the satellite.

Robichon also began to work on the scientific impact of GAIA on the study of open clusters. This will lead to a contribution to the "red report" to ESA. The vast majority of the 3000 or so open clusters closer than 5 kpc contain members which GAIA will be able to separate from field stars. In the open clusters closer than 500 pc, the 3-dimensional structure will be seen, and the internal accuracy of the tangential velocities of the members will be smaller than the cluster internal velocity dispersions. The kinematics and dynamics of these clusters (general rotation, expansion or contraction, mass segregation, equipartition of energy ...) will then be studied in great detail. The depths of more distant clusters will not be resolved, but the projected mass segregations will be visible as well as tidal streams made of stars escaped from the cluster. The IMF of open clusters will also be reconstructed down to a mass limit ranging from the brown dwarf limit for the Hyades to less than 1 $M_\odot$ at 3 kpc. Open cluster sequences in the HR diagram will allow unprecedented high precision comparisons with theoretical tracks of several ages and chemical composition.

SAURON

De Zeeuw, Carollo (JHU), Bacon, Copin, and Emsellem (Lyon), Monnet (ESO), Davies and Allington–Smith (both Durham) are building a wide-field successor to the TIGER integral-field spectrograph, to be mounted on the 4.2m William Herschel Telescope on La Palma. The new instrument is called SAURON (Spectroscopic Areal Unit for Research on Optical Nebulae), and records over 1600 spectra simultaneously, with full sky coverage in a field of 34 by 44$''$, additional coverage of a small 'sky' field 2.2$'$ away, spatial sampling of 1.0$''$, and an instrumental dispersion of 65 km/s. It is funded in part by a grant from ASTRON to de Zeeuw, and is being built at the Observatoire de Lyon. Miller and Bureau have joined the SAURON team. The instrument was completed in late 1998, and tested in Lyon. It was delivered to La Palma in early 1999, and first light was set for February 1, 1999. SAURON will be used to study the full two-dimensional kinematics and line-strength distributions of a sample of elliptical galaxies.

Very Large Telescope

Delay Line; Interferometer

The Very large Telescope Interferometer at Cerro Paranal in Chili is being built by ESO. The maximum difference of the optical paths of two VLT telescopes is 120 m, which calls for a delay line with a length of 60 m. The delay lines for the Very Large Telescope Interferometer are being built by Fokker Space and TNO-TPD. During 1998 a detailed design of the VLTI delay line was made. Arno Wielders is a PhD student funded jointly by Leiden Observatory and Fokker Space. In 1998 he has been actively involved in various aspects of the delay line, including defining a plan how to test the performance of the delay lines.

MID-Infrared Interferometer

Together with many Dutch, French and German collaborators Jaffe and Le Poole are assisting in the design and planning of the MIDI (MID-Infrared) interferometer to be commissioned at ESO/Paranal around Spring 2001.

A New Sample of Powerful Radio Galaxies

Best, Röttgering and Lehnert have used the Molonglo Survey to define a new large sample of the most powerful equatorial radio galaxies, complementary to the northern 3CR sample. Observations taken on the ESO 3.6m telescope have led to all 178 objects being optically identified and spectroscopic redshifts being obtained for 173 of them (97%). This new sample is the first essentially complete sample of the most powerful radio galaxies visible to new large southern telescopes such as the VLT, and is the target of many follow-up projects.

SETI

An improved system for formulating cosmic messages, based on LINCOS as defined by the mathematician Freudenthal about forty years ago, was developed by Ollongren and presented at the 49th International Astronautical Congress in Melbourne in September 1998, during a SETI session. The new system, called LCI, is based on the typed lambda calculus from logic. Pictograms (pixellised bitmaps) are admissible data in LCI and subdata selected from them can be provided with types - aspects of terrestrial life. Static hierarchical relations provide an example. Types correspond to classes in object oriented programming languages but have a more fundamental character. Using LCI an avenue is available for including text written in a natural language in messages for ETI.

2.2 Solar System

The Outer Solar System

J. Luu joined the Sterrewacht staff in October 1998. As was the case for the last few years, most of her work in 1998 was devoted to the outer solar system, in particular the region beyond Neptune. The trans-Neptunian region is the home of the "Kuiper Belt", a population of primordial icy bodies. Much of the attraction of the Kuiper Belt lies in the fact that it is the direct remnant of the solar nebula itself. This year saw the completion of several observational and theoretical projects about the Kuiper Belt, including

- The publication of the results of the Large Kuiper Belt Objects Survey using the 8K CCD and the University of Hawaii 2.2m telescope on Mauna Kea. The survey covered 51.5 deg^2 to a 50% detection threshold red magnitude m_R = 22.5 and found 13 new Kuiper Belt objects

(KBOs). From the survey, it is ascertained that the size distribution of KBOs with radius $r \geq 50$ km follows the inverse power law r^{-4}. Interestingly, Monte Carlo models of the survey indicate that, compared with simulations of power-law Kuiper Belt disks, the observed radial distribution of KBOs is deficient in objects beyond about 50 AU. There is no firm explanation for this, although the deficiency may be due to some combination of the following: (1) the Kuiper Belt might be truncated at about this distance, and (2) the maximum size of KBOs might drop steeply at larger heliocentric distances.

- The publication of the results of the Medium-Deep and Ultra-Deep Kuiper Belt Surveys with the Keck 10-m telescope. The Keck telescope was used to push the survey limit to $m_R = 26.1$ for the Medium-Deep Survey and $m_R = 26.6$ for the Ultra-Deep Survey. These results again confirm a Kuiper Belt differential size distribution of r^{-4}.

- The publication of the first optical (0.4 – 0.8 μm) and near-IR (1.0 – 2.5 μm) spectrum of the scattered Kuiper Belt object 1996 TL_{66}. The spectra show no evidence for absorption features and are neutral across the full wavelength range. The spectra bear no resemblance to the only other KBO spectrum available, that of 1993 SC. Neither do they resemble the spectrum of Pluto. The number of KBO spectra is still too sparse to convey any information about the composition.

- The publication of the first version of an accretion model of KBOs that takes into account velocity evolution (but no fragmentation). Simulations show that the time scale to produce Pluto-size objects (1000+ km in radius) in the Kuiper Belt is comparable to the estimated formation time scale for Neptune. The results indicate that an outer solar nebula, comparable in mass to that predicted by the Minimum Mass Solar Nebula, could produce the observed Kuiper Belt in the time scale $\sim 10^8$ yr, provided that it started out with low-eccentricity bodies with radius in the range $\sim$ 100 m – 1 km.

Luu and collaborators in Hawaii are continuing their surveys to increase the known KBO sample. Part of their effort is now focused on finding large (bright) KBOs which would would be suitable for detailed photometric and spectroscopic studies. The difficulty in finding such large objects lies in their low surface density, and a large-format CCD array is a must. Such an instrument (the 8K CCD array) exists at the Kitt Peak National Observatory (Kitt Peak, Arizona, USA), and an observing program using the 8K CCD to identify large KBOs was awarded time on the Kitt Peak 0.9m telescope in the fall. A successful observing run was carried out in September, and more observations will follow.

The numerical accretion model of the Kuiper Belt is being improved (by S. Kenyon at the Smithsonian Astrophysical Observatory in Cambridge, Massachusetts, USA) to take into account fragmentation as well as velocity evolution. The work is nearly finished, and results from this improved model are expected to be submitted early 1999.

2.3 Stars and Circumstellar Matter

OB Associations

De Bruijne finished refurbishing the classical convergent point method. This method uses the convergence of proper motions of stars on the sky to detect moving groups and select their members simultaneously in a maximum likelihood scheme. The method does not require parallax information and can in principle be applied to any proper motion catalogue, e.g., the ACT and TRC catalogues.

In collaboration with Aguilar, Hoogerwerf completed a new method, the Spaghetti method, which identifies moving groups in the Hipparcos database. This method uses all five astrometric parameters listed in this catalogue, position, proper motion, and parallax. The method addresses the significance of structures in velocity space and selects stars associated with these moving groups. The method has been applied to the Hyades and IC2602 open clusters as clear cut test cases.

In collaboration with Brown and Blaauw, de Zeeuw, Hoogerwerf, and de Bruijne finished their investigation of the membership of the nearby OB associations. The associations were identified based on a common space motion of the member stars, and resulted in new membership lists for nine known nearby OB associations (three subgroups of Sco OB2, Vel OB2, Per OB2, Per OB3/α Persei, Cas–Tau, Lac OB1, Cep OB2, Ori OB1), one new association (Cep OB6) and two associations which were previously known as open clusters (Tr 10 and Col 121). The detection and selection scheme is based on a combination of de Bruijne's convergent point method and the Spaghetti method of Hoogerwerf & Aguilar. The new astrometric members of the nearest associations now go down to spectral type F, cf. spectral type B5 in the pre-Hipparcos era. Several pre-main sequence and T Tauri stars as well as some evolved stars, e.g., the Wolf-Rayet stars γ^2 Vel and EZ CMa, and δ Cep as member of the new group Cep OB6, are identified as association members.

De Bruijne started the determination of secular parallaxes for the members of the nearest associations to improve on the individual trigonometric parallaxes. Secular parallaxes are determined using the "known" space motion of a moving group and the observed proper motions of its members. The relative accuracy of the secular parallaxes is of the same order as that of the proper motions.

Reuland continued his research into the recovery of the initial configurations of high-mass star formation and the determination of kinematic ages of OB associations using synthetic micro-arcsecond-quality astrometric data from the future GAIA satellite. N-body simulations show that kinematic ages can be determined accurate to 0.5 Myr for groups closer than 2 kpc; the initial configurations can be recovered for groups out to 1 kpc.

Den Hollander continued his research on massive runaway stars. By tracing back both stars and associations in the Galactic potential, the origin of runaway stars can be established. The results can be tested against predictions of the two ejection mechanism theories: binary-supernova and dynamical ejection.

Steenbrugge started the reduction of spectra of O- and B-stars in the association Perseus OB2. The resulting radial velocities will complement the five astrometric parameters measured by Hipparcos, and will allow an investigation into the six-dimensional structure of the association.

Robichon's research mainly concentrated on two topics: the continuation of his open cluster studies with Hipparcos data and preparation for the GAIA space astrometry mission under study by ESA. In collaboration with the DASGAL, Observatoire de Paris, and the Institut d'Astronomie de Lausanne, Robichon computed new memberships, mean parallaxes and proper motions for all 9 open clusters closer than 300 pc (except the Hyades) and for 9 rich clusters between 300 and 500 pc, using Hipparcos data. Precisions range from 0.2 to 0.5 mas for parallaxes and 0.1 to 0.5 mas/yr for proper motions, and are of great interest for calibrating photometric parallaxes as well as for kinematical studies. Careful investigation of possible biases revealed no significant systematic errors in the mean cluster parallaxes. Distances and proper motions were also derived for 32 more distant clusters, for use in statistical studies.

Van Houten worked on the text of the publication of his observations of OB stars at the former Leiden Southern Station in South Africa.

High Luminosity Variable Stars

Van Genderen, Sterken (VUB, Brussels), de Groot (Armagh) and Burki (Geneva) analyzed a quarter century multi-colour photometry of η Carinae (1974–1998) among which new Geneva photometry made between 1994 and 1998. Various conclusions from our previous photometric studies are confirmed. The core hides a normal S Dor variable (or LBV): it shows light variations on a time scale of 1–4 y, with superimposed micro-oscillations whose quasi-period indicates a temperature in the order of 22 000 K. Therefore, a more complicated model for η Car is necessary to explain its extraordinary appearance and phenomena exhibited in the past and at present.

An analysis of the brightness of η Car in the ultraviolet (UV) passbands of three photometric systems (Walraven, Strömgren and Geneva) reveals the presence of an important variable UV source, which appears to be modulated with the 5.52 yr period of the spectroscopic events (Fig. 2.1), related to the possible revolution of an eccentric binary of the type proposed by Damineli, Conti & Lopez (1997). These new data support the luminous disk model suggested by van Genderen et al. (1994, 1995). A very hot companion of the LBV would be responsible for the excitation of the disk.

Van Genderen et al. suspect that the flare-like event in the X-ray flux and in the optical and near-infrared light around 1998.0 was the result of the encounter of the interface of the colliding winds of the binary with an arm-shaped density enhancement in a disk around the LBV (not necessarily "the" luminous disk). We suppose that this encounter created an intense X-ray/hot spot region. The subsequent steep decline of the flare is ascribed to an eclipse of the X-ray/hot spot by the wind interface.

The radio flux variation of the gas torus in the equatorial plane at a distance of 2" from the core, could be the result of the luminous disk becoming optically thin. This would, obviously, start abruptly near the time of periastron passage and would last for a few years thereafter, so that a hot star, normally enshrouded by the disk, is able to excite the outer gas torus. The creation of the X-ray/hot spot, with a life-time of at most a few months, could also be the cause of the instantaneous

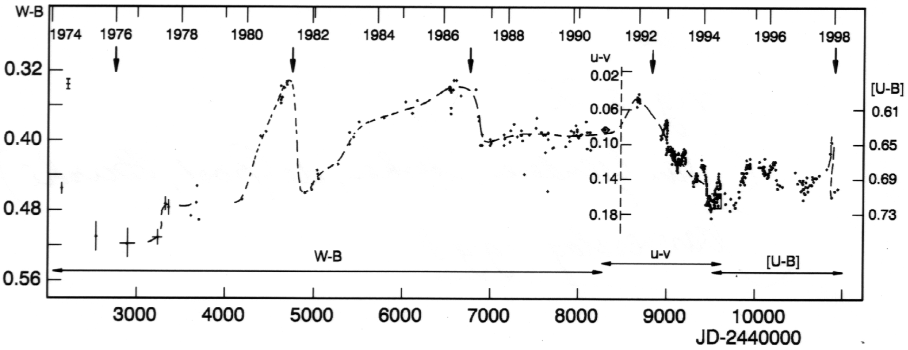

Figure 2.1: The UV curve of η Carinae, mainly reflecting the variation in the Balmer continuum radiated by the luminous disk, based on Walraven, Strömgren and Geneva photometry made between 1974 and 1998 (color indices $W-B$, $u-v$ and $[U-B]$, respectively). Blue is up. The fat arrows at the top mark the expected times of the spectroscopic low-excitation events. The near-coincidence of four out of five of these events with four maxima in the UV curve (luminous disk optically thick) suggests that a causal connection exists between the two phenomena. Thus, obviously the physics of the luminous disk is modulated by the binary revolution in an eccentric orbit.

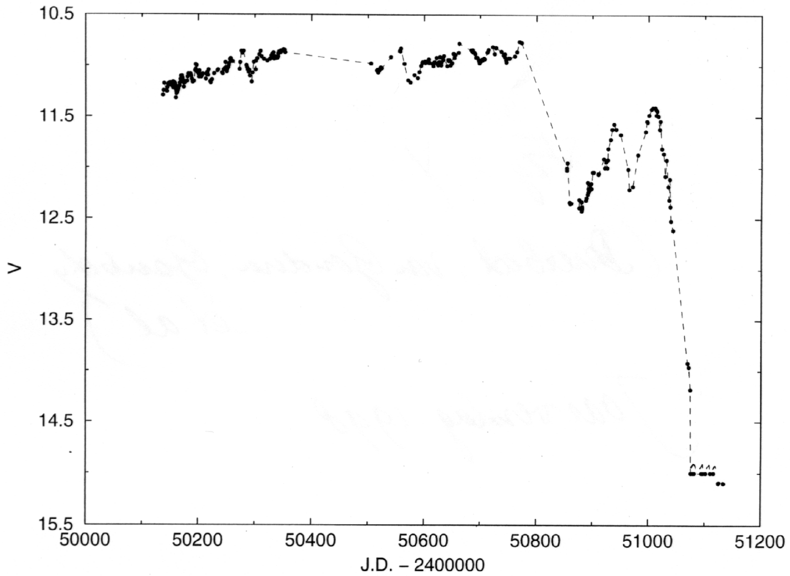

Figure 2.2: The light curve of the final He-flash object (V4334 Sgr) in 1996–1998. Near maximum, the light curve is superimposed by low-amplitude quasi-periodic pulsations, followed by a drop of 4 mag, likely caused by dust formation.

physical change of the luminous disk mentioned above (and its 5.52 yr modulation) visible in the UV, since both happen at the same time (Fig. 2.1).

Apart from the 5.52 yr period in the UV, van Genderen et al. found a striking 200 d-oscillation, also in the UV, during the last orbital cycle between 1992.5 and 1998.0. Its possible explanation depends on whether it is cyclic or truly periodic (in the latter case η Car could hide a triple star).

Van Genderen and Sterken (VUB, Brussels) started to analyze the photometric data of 5 α Cyg variables in the LMC, based on monitoring programs. They are R 74 (an LBV), R 78, HD 34664 = BE 381 = S 22 (a suspected LBV), R 84 an R 116. With their variability characteristics it is possible to separate LBVs from non-LBVs. The role of LBVs in the evolution of massive stars is important since they form the presumably short transition high-mass loss stage from post-main sequence stars to the Wolf-Rayet stage. All these objects, LBVs as well as non-LBVs, show micro-pulsations on time scales of days or weeks (Ofpe/WN9 and B spectral types) to months (spectral type A). There are strong indications that most evolved massive stars are subject to multi-cyclic/periodic pulsations combined with stochastic processes in their atmospheres and photospheres.

Final, or Late He-Flash Objects

Duerbeck (Muenster), van Genderen, Gautschy (Basel), Liller (Vina del Mar, Chile), Pavlenko (Kyev), Sterken (Brussels), Brogt and Janson (Groningen), Kemper, Kurk, Thomas, Voskes and van der Meer kept the Final He-flash object Sakurai's Object (V4334 Sgr) under photometric ($UBVRiz$) surveillance since early 1996. The object was recognized as such by Duerbeck (Muenster) and Benetti (ESO). It has been a 21 mag central star of a planetary nebula and underwent a rare observable stellar explosion: a final He-flash, presumably in late 1994. The light and color curves 1996–1997 showed that the star was continuously cooling while it slowly expanded and slightly increased its luminosity. Its apparent V magnitude reached 10.9. The star cooled from 8000 K in early 1996 to 5000 K at the end of 1997. The distance is estimated to be 8 kpc and $E(B-V) = 0.53$.

With the assumption of a slightly accelerated photospheric expansion and using pre-discovery brightness measurements, a realistic description of the outburst light curve is achieved. Obviously, the final He-flash accelerates the outer layers radially symmetric in a much more gentle way ($\sim 1\,\mathrm{km\,s^{-1}}$) than e.g. nova explosions, while radiating at a more or less constant luminosity. This is supported by spectral observations which show that the object evolved from a late A- to an early K-type star with moderate to strong H-deficiency.

Superimposed on the gradual brightness change are variations due to pulsations with amplitudes of up to 0.1 mag and cycle lengths of a few weeks to two months. In spite of the fact that no persistent periodicities could be detected, pulsational studies show that such cyclic lengths can be used to constrain stellar parameters, such as mass ($\sim 0.7\,M_\odot$) and luminosity ($\sim 10\,000\,L_\odot$). The time scales are comparable with linearly overstable radial pulsation modes, but complex light/velocity curves are expected in view of the many simultaneously excited overstable modes and rapid evolution of Sakurai's Object across the HR-diagram.

Up to the end of 1997 no indication of noticeable dust formation has been found, which should result in steep R CrB-type fading events. Because of the rapid cooling and the carbon-rich photosphere such drops were expected in the near future. Indeed, early 1998, the brightness dropped dramatically, which, after a few small recoveries, led to a minimum 4 mag deep at the end of 1998 (Fig. 2.2). The fading was followed by a reddening in all colours. The colour evolution and the way of fading strongly suggests that we are witnessing a dust formation episode. It will be very useful to follow this process intensively in order to see if the pulsations continue.

Variable "Dusty" Wolf-Rayet Stars

In the framework of the IR monitoring program by Williams (Royal Observatory, Edinburgh) and Van der Hucht (SRON, Utrecht), Veen observed a second dust episode of the Wolf-Rayet system WR 19 during the final run of infrared imaging using IRAC-1 mounted on 2.2m telescope, ESO. The prototype periodic dust producer WR 140 (WC7 + O4-5, $P = 7.94$yr) forms heated amorphous carbon dust grains during periastron passage in the colliding wind region. Since the first episode of WR 19 occured in 1988 and the object was also shown to have an O9 spectral companion, it was concluded that this object is another long-period eccentric colliding-wind binary with an orbital period of 10 years.

Veen and collaborators finished their work on the occasional "eclipses" of "dusty" WR stars. Using the five-colour simultaneous photometer of Walraven, an eclipse of WR 121, which has an IR excess due to a distant optically thin dust shell, could be attributed to a temporary obscuring dust cloud. Since all other occasional eclipses of Wolf-Rayet stars (WR 103, WR 113), also happen to have an IR dust shell, Veen suggests that these were caused by similar events. A simple geometric model could be fitted to all available lightcurves, indicating that the dust cloud condensation appears to occur at radii ranging from 100 to 1000 $R_\odot$.

Vega–Like Stars

Dominik, Habing, Jourdain de Muizon (LAEFF, Vilspa, Spain), Laureijs (ESA, Vilspa, Spain) and the HJHVEGA consortium continued their work with data from the ISO satellite to search for dust disks around nearby stars. A sample of about 90 stars in the solar neighborhood is being studied. The reduction of a large fraction of the data is now finalized. The most important result from this study is that we find a clear age trend: Young main–sequence stars have a much higher chance to possess a detectable debris disk than old stars (70% versus 20%). The timescale for removal of the disk is of order 400 Myr (see Fig. 2.3), comparable to the era of heavy bombardment in the solar system and to the collisional evolution timescale of the inner Kuiper Belt. These results indicate strongly that the evolution of the dust debris disk is linked to the ejection of planetesimals out of the stellar system and to the life–time of the cometary cloud. However, the existence of old stars with a

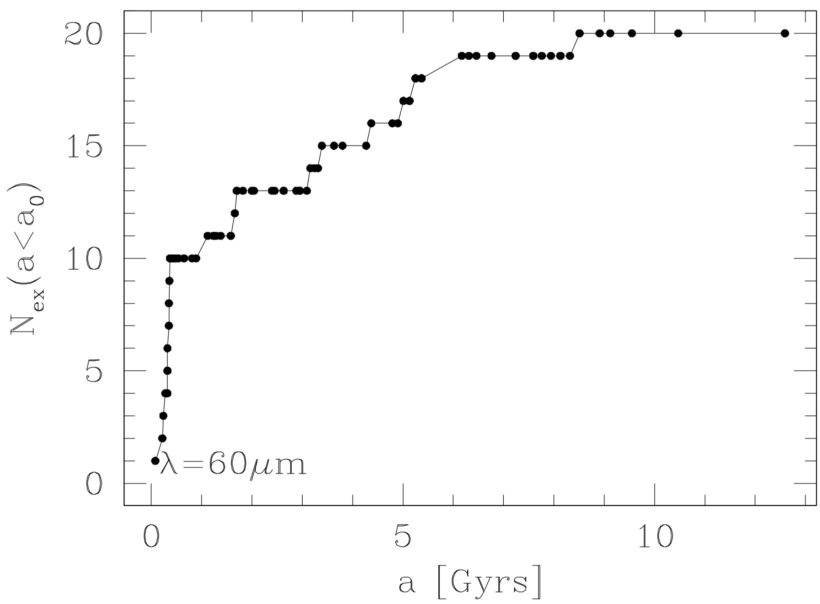

Figure 2.3: Cumulative distribution of stars with disks in the volume–limited sample studied by ISO. The curve denotes the number of stars with disk below a given age. The dots indicate the individual stars. Note the steep rise of the distribution and the flat saturation towards high ages.

prominent disk is still a puzzle. The best example for this is the star HD 207129, which as an age of 4.4 Gyr has one of the infrared–brightest disks we have detected.

OH/IR Stars in the Galactic Bulge

Ortiz, Habing and Omont (Obs. Paris) looked for ISO counterparts of type II OH sources (OH/IR stars) in the galactic bulge. About 200 infrared sources were found. Their location in the colour-magnitude diagram permits one to distinguish them of non-stellar objects, such as star forming regions or HII regions.

VLBI Parallax Measurements of Nearby AGB Stars

Vlemmings, van Langevelde (JIVE, Dwingeloo), Habing and Schilizzi use VLBA observations of masers around AGB stars to study several fundamental properties of these stars. The parallax and proper motions are determined by using multi-epoch observations of OH-maser spots. This will allow them to accurately measure the distances to stars with a thick obscuring circumstellar shell. They have started a pilot project on the star U Her and have obtained proper motion results that are in good agreement with Hipparcos results ($\mu_{\rm Hip} = -16.84 \pm 0.82, -9.83 \pm 0.92$ mas/yr vs. $\mu_{\rm VLBA} - 17.05 \pm 0.85, -9.48 \pm 0.73$ mas/yr). Furthermore, a parallax has been measured of 4.2 ± 1.2 mas. Because the star is quite faint Hipparcos could not detect a parallax.

Shock Focusing in Bipolar Nebulae

Icke completed his study of shock focusing with cooling. Extending his 1987 work on the hydrodynamics of aspherical interacting winds, he computed the way in which the inner ('reverse') shock deflects the initially spherical stellar wind. This was done for elliptical shocks (as in the original 1987 article), for figure-8 shocks expected for mature bipolars, and 'apple-core' shaped shocks which are expected to occur when the confining density field is sharply disk-shaped. In all cases the result was the same (albeit with differing details): the equatorial and polar flows pass through perpendicular shocks, are strongly heated, and compressed with the usual factor $(\gamma+1)/(\gamma-1)$. At intermediate latitudes, the flow is deflected in the direction of the symmetry axis. This flow is less heated and less compressed than the flow along the axis and in the plane. Cooling of the shocked material is relevant for central stars with low temperatures, i.e. below 3000 K or thereabouts. Remarkably, it turns out that the cooling in the polar and equatorial flows is *more* efficient than at intermediate latitudes. This is due to the fact that the density jumps there are so high, that the n^2-increase of the cooling is more important than the decrease of the cooling due to the higher temperatures. Thus, the generic situation expected is: strongly cooling, slow flows near the equator and along the axis, and weakly cooling, faster flow in two cones on opposite sides of the equator (Fig. 2.4).

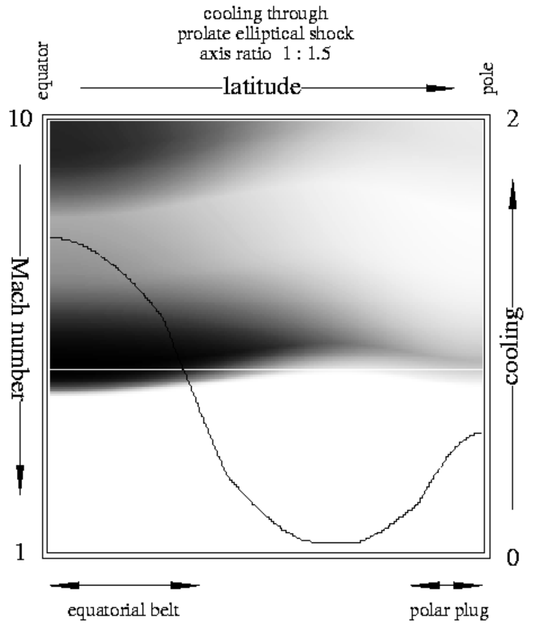

Figure 2.4: Cooling rate as a function of latitude and Mach number for gas flow passing through a prolate elliptical shock. Dark zones indicate strong cooling. For a given Mach number of the central outflow, strong cooling zones occur near the equator and near the poles. As an example, the horizontal white line indicates the cooling near Mach 5. The black line shows the cooling rate (axis to the right of the figure). The cooling is largest near the equatorial belt, with another (lower) maximum near the poles.

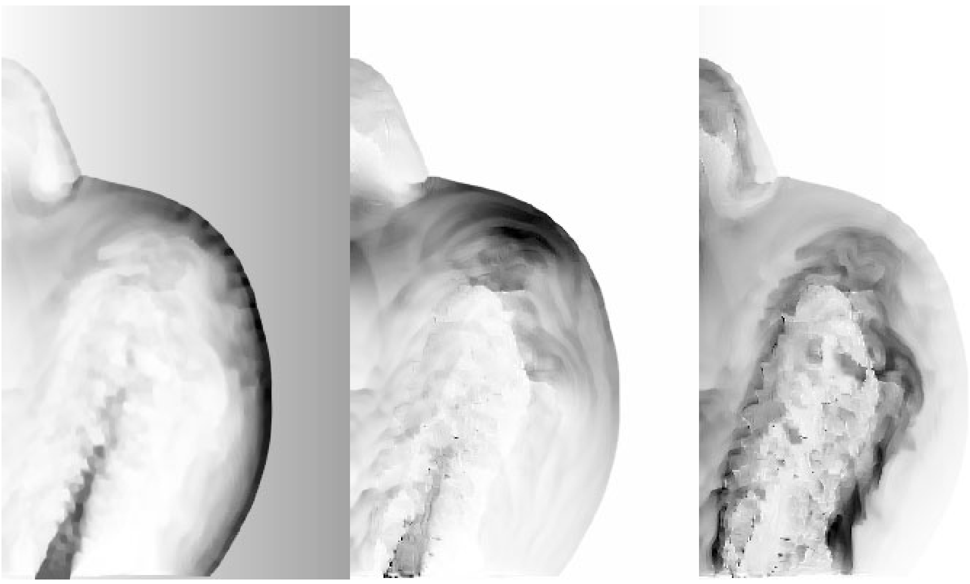

Figure 2.5: The image shows some flow variables in a model for biconical nebulae, such as the Red Rectangle. The equatorial plane is horizontal, the symmetry axis vertical. From left to right: gas density, pressure, temperature. Notice the peculiar lobes, and the formation of precursor 'ansae' on the symmetry axis.

Biconical flow in the Red Rectangle

Inspired by the recent HST results of Van Winckel (Leuven, Belgium), Icke resurrected his 1981 computations on biconical hydrodynamics. Van Winckel's excellent observations confirm in detail the flow patterns predicted 18 years ago. With current computational equipment, the study of such patterns is much easier. The basic situation is, that the central region of the nebula produces an opposing pair of outflow cones. These inject toroidal condensations which produce a series of enveloping bow shocks with a characteristic pattern (Fig. 2.5). These are indeed seen in the HST observations. Contrary to the 1981 article, however, it is no longer believed that the biconical outflow is driven by a radiative ring in the accretion disk around the central star of the Red Rectangle: instead, shock focusing by a prolate inner ('reverse') shock suffices. It is predicted that the intersection of the bow shocks near the axis should produce interesting observable effects.

Numerical Hydrodynamics of Dust Driven Stellar Winds

In collaboration with Icke, Simis continued her PhD research on dust driven winds from evolved late–type stars. The numerical code written for this purpose is a self–consistent hydrodynamics code for two–fluid time dependent calculations in spherical symmetry. The numerical method is a predictor–corrector method, using centered differencing, flux corrected transport and local curvature diminishing. Included physics involve equilibrium chemisty and dust formation and growth according to the moment method (in collaboration with Dominik), semi–analytical radiative transfer and a semi–implicit implementation of the frictional drag force of dust onto gas. The computed profiles run from the stellar photoshere to the outer layers of the extended envelope and hence are transsonic. The region in which the wind becomes supersonic is most interesting because there interaction between gas and dust becomes important.

A New 2-D Radiative Transfer Algorithm

Dullemond has developed a new 2-D radiative transfer algorithm for axi–symmetric circumstellar nebulae. The algorithm can treat problems of low, medium and high optical depth. It is an Accelerated Lambda Iteration algorithm, based on the method of Short Characteristics. In collaboration with A. de Koter (UvA) the algorithm is currently being tailored for radiative transfer in axi–symmetric dust nebulae around Post AGB stars, and Young Stellar Objects. The goal of this work is to make models of the spectral energy distribution of very non–spherical nebulae such as the Red Rectangle.

2.4 Interstellar Matter

Dynamical Evolution and Fragmentation in Molecular Clouds: The Early Phase of Star Formation

Using smoothed particle hydrodynamics in combination with the special-purpose hardware device GRAPE, R. Klessen numerically investigated the initial phases of the star-formation process. In this investigation the dynamical evolution and fragmentation of large regions within molecular clouds is followed until a cluster of protostellar cores has formed. Adopting an isothermal description of self-gravitating gas, it can be shown that even this simple model is able to explain many of the observed features of star-forming regions and identify the processes that dominate the formation and evolution of protostellar cores. The number of protostellar cores that form during the evolution is roughly proportional to the number of Jeans masses contained in the system initially. The overall dynamical behavior of the system is insensitive to the adopted initial conditions, since it evolves through a sequence of highly probabilistic events.

The interplay between self-gravity and gas pressure creates a complex network of clumps, sheets and filaments, and the subsequent evolution leads to the formation of a bound cluster of protostellar cores. This evolutionary sequence is illustrated in Fig. 2.6. Dense cores grow in mass via accretion from the available gas reservoir and are subject to highly unpredictable N-body interactions. It is found that the angular momenta of protostellar cores are correlated with their location. The mass spectrum of gas clumps can be well approximated by a power-law distribution $dN/dM \propto M^{-1.5}$, comparable to observed molecular clouds. In contrast, the mass spectrum of protostellar cores is best described by a log-normal distribution which peaks roughly at the overall Jeans mass of the system. With the appropriate scaling, this is in excellent agreement with the IMF for multiple stellar systems and suggests a star-formation efficiency which ranges from 5 – 15 %.

Small Scale Magnetic Field in the Galactic ISM

Haverkorn, Katgert and De Bruyn (ASTRON/Groningen) have been using Westerbork radio continuum data at 341–375 MHz to investigate properties of the small scale galactic magnetic field. In the polarized component of the radio background radiation, abundant small scale structure with largely varying topologies is found. This is an indication that Faraday rotation by a foreground Faraday screen is an important process in the nearby ISM. Multi-band observations are being analyzed to estimate rotation measures, which give information on the local electron density and the parallel component of the interstellar magnetic field.

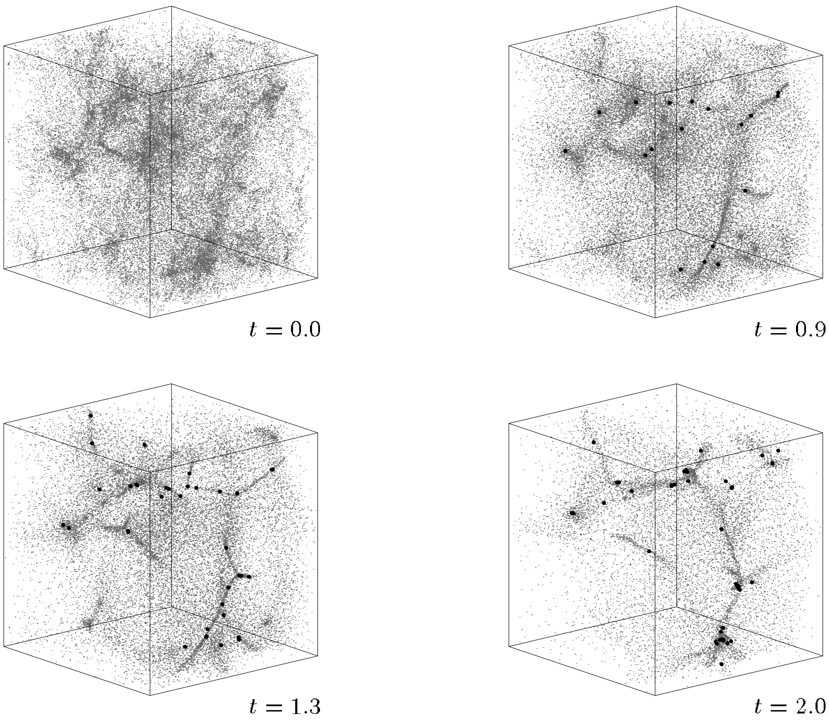

Figure 2.6: Time evolution of a region of 222 Jeans masses in the interior of a molecular cloud with initial Gaussian density fluctuations. Overdense regions collapse and form a cluster of highly condensed cores, which continue to accrete from the surrounding gas reservoir. At $t = 0.9$ about 10% of all the gas mass is converted into "protostellar" cores (denoted by black points). At $t = 1.3$ and $t = 2.0$ these values are 30% and 60%, respectively. Time is given in dimensionless units with the free-fall time being $\tau_{\rm ff} = 1.4$.

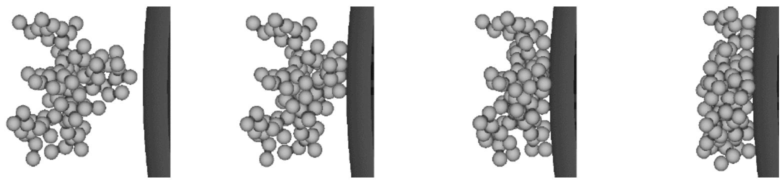

Figure 2.7: Impact of a dust aggregate on a curved surface. The dust aggregate is highly compacted and sticks to the surface.

3D models of Dust Aggregates

Dominik and van de Kamp developed a code to model dust aggregates and the interactions between the individual components in three dimensions. This work is an extension of the 2D computations carried out earlier. A new visualization tool was also developed in order to simplify the study of these structures. The first application (see Fig. 2.7) was a model of the accretion of dust grains on the surface of chondrules in the early solar nebula, in collaboration with J.N. Cuzzi (NASA Ames). The accreted dust form a rim of fine grained material which can be identified in primitive meteorites. We could show that only the accretion of dust aggregates can lead to compact rims. The accretion of single particles produces porous structures.

Gamma Rays

Van der Meulen, in collaboration with Bloemen (SRON Utrecht) and other members of the COMPTEL team, continued his studies of the galactic MeV gamma-ray emission. This work is aimed at disentangling the gamma-ray radiation from the Milky Way, with main emphasis on the study of gamma-ray lines which result from nuclear transitions. Such lines are formed either following the decay of long lived radio nuclei produced in processes of nucleosynthesis, or following energetic nuclear interactions. They provide direct information on many important problems in high-energy astrophysics, including nucleosynthesis, particle acceleration, and the physics of compact objects. The study of these lines has become very diverse. A variety of detections of nuclear decay lines has been made, including e.g. emission from ^{44}Ti associated with a previously unknown Galactic supernova. The study of nuclear-interaction gamma-ray lines, previously only seen in solar flares, has been booming since the detection of 3–7 MeV emission from the Orion complex, tentatively attributed to nuclear-deexcitation lines from C and O. More indications have been seen in the emission from the inner-Galaxy, although conclusive line identifications are still lacking. Using maps of the galactic plane emission in narrow energy bands, a search for localized excesses of 3–7 MeV emission was conducted. At the same time, however, the Orion detection was unfortunately found to be a spurious result. Nevertheless the search did result in the discovery of an extended source in the Vela/Carina region in the 3–7 MeV range that does not suffer from the same problems as Orion. Its emission remains unexplained by standard large-scale models of the galactic diffuse continuum radiation and cannot be attributed to a single point source. Its projected location is inside the Gum nebula, about 10° from the Vela pulsar/SNR, and adjacent to the Vela OB2 association and the so-called IRAS Vela shell. The production site of the gamma-rays cannot be identified, but a diffuse origin related to this very nearby ($\sim$ 400 pc) region of star-forming activity and supernova remnants seems plausible.

2.5 Molecular Astrophysics

As in previous years, the research with data from the *Infrared Space Observatory* (ISO), in particular the *Short Wavelength Spectrometer* (SWS) (PI: de Graauw, SRON Groningen), formed the bulk of the effort in the Molecular Astrophysics group.

The Complete ISO-SWS Spectrum Toward Orion IRc2/BN

One of the recent highlights of the ISO-SWS is the complete infrared spectrum from 2.4 to 45.2 μm toward the massive star-forming region Orion IRc2/BN observed by van Dishoeck and Wright, in collaboration with González-Alfonso and Cernicharo (both CSIC, Spain), de Graauw (SRON, Groningen) and others. Due to its proximity and extraordinary brightness, this object plays a pivotal role in our understanding of the formation of massive stars. It also serves as a template for more distant star-forming regions in external galaxies. Much of the complexity of these regions results from the interaction of the young stars with their surroundings through winds, shocks and ultraviolet photons. A wealth of emission and absorption features is found, including H_2 vibration–rotation lines, the full set of H_2 pure rotational lines (0,0) S(1) – S(17), H recombination lines, ionic fine-structure lines, PAH emission features, and absorption and emission bands by interstellar ices and gas-phase molecules, including CO_2, CH_4 and SO_2 (see Fig. 2.8). Particularly interesting is the detection of strong emission and absorption lines in the H_2O ν_2 bending mode at 6.2 μm (Fig. 2.9), and the observation of highly–excited pure rotational lines of H_2O in absorption at 25–45 μm. Analysis of the lines provides detailed information on each of the physical components included in the ISO–SWS beam, i.e., the H II region, PDR, quiescent ridge, and the shocked low-velocity plateau.

The H_2O lines in the ν_2 bending mode at 6 μm show a pattern in which the shorter-wavelength R-branch lines are observed in absorption and the longer-wavelength P-branch lines in emission. This effect has been explained by a resonant scattering process in which absorption of 6 μm continuum photons is followed by spontaneous emission to the ground state. The models provide constraints on the physical parameters of the absorbing shell around BN.

Boonman, in collaboration with Wright and van Dishoeck, has analyzed the HCN, C_2H_2 and CO_2 gas-phase absorption toward Orion-IRc2 and other massive YSOs in Orion/Monoceros. In contrast with sources such as AFGL 2136, the bands toward IRc2 are much narrower, indicating low excitation temperatures of at most 200 K. Even though gas-phase CO_2 is clearly seen toward IRc2, its abundance is low, only a few $\times 10^{-7}$.

Detection of the HD J=1$\rightarrow$0 112 μm Line in the Orion Bar

Wright and van Dishoeck, in collaboration with Cox (IAS, Paris), Sidher (RAL, UK) and Kessler (ESA, Vilspa), have obtained the first detection outside of the solar system of the lowest pure rotational J=1$\rightarrow$0 transition of the HD molecule at 112 μm using the ISO-LWS. This line is important to trace the deuterium abundance [D]/[H] and its evolution in the interstellar medium. Because all deuterium was produced in the Big Bang and destroyed in stellar interiors, the observed [D]/[H] ratios can be used as a measure of galactic chemical evolution. Because HD is the major reservoir of deuterium in dense clouds, it does not suffer from the chemical fractionation effects that plague the analysis of other molecules such as DCN. The detection was made toward the warm Orion Bar PDR, and the line is observed to be in emission (Fig. 2.10). Together with ISO-SWS observations of the

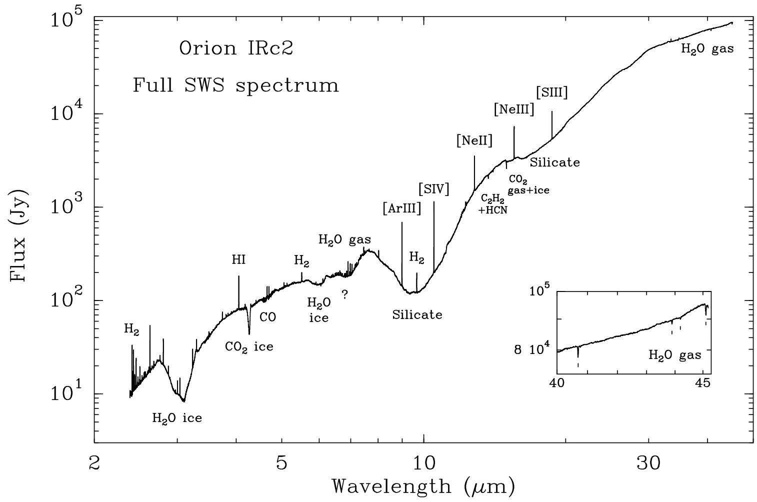

Figure 2.8: Complete ISO–SWS grating spectrum centered at Orion IRc2/BN. The principal absorption and emission features are indicated. The inset shows a blow-up of the 40–45 μm region, in which several gas-phase H_2O absorption lines can be seen.

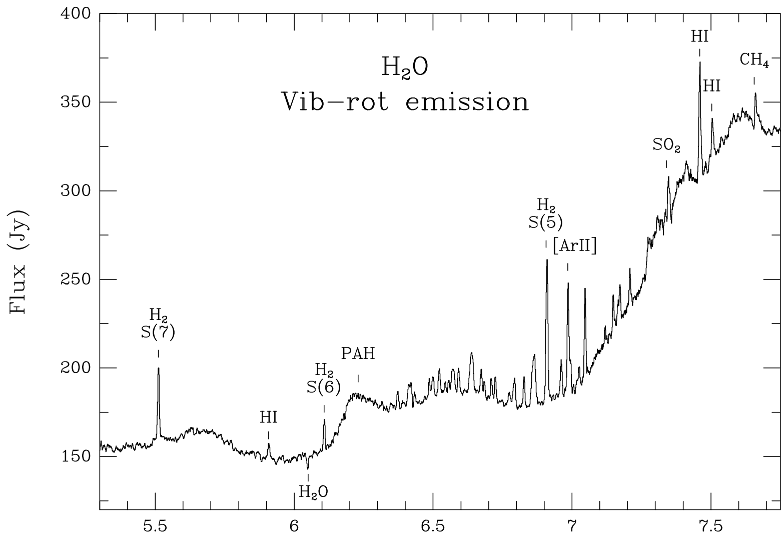

Figure 2.9: Enlargement of the ISO–SWS spectrum toward IRc2 in the 5.3–7.8 μm range, showing the H_2O ν_2 vibration-rotation lines, as well as the CH_4 ν_2/ν_4 and the SO_2 ν_3 bands in emission.

H_2 S(0) and S(1) pure-rotational lines and ground-based submillimeter data on CO, the implied HD abundance, HD/H_2, ranges from 0.7×10^{-5} to 2.6×10^{-5}, with a preferred value of $(2.0\pm0.6)\times10^{-5}$. The corresponding deuterium abundance of [D]/[H]=$(1.0\pm0.3)\times10^{-5}$ is somewhat lower than the average [D]/[H] ratio of 1.6×10^{-5} in the solar neighborhood derived from ultraviolet absorption line observations of atomic H I and D I, but comparable to recent results from ultraviolet observations toward the star δ Orionis and from the ISO-SWS detection of the HD $R(5)$ line in the Orion shock by others. The low [D]/[H] abundance in Orion compared with the local interstellar medium is not yet fully understood.

Searches for H_2 Emission from Diffuse and Translucent Clouds

Thi, van Dishoeck, Jansen, Black (Onsala Space Observatory), Evans and Jaffe (both Texas) have performed deep integrations on the lowest pure rotational lines of H_2 with the ISO-SWS to determine the physical conditions in various interstellar clouds, including the well-known diffuse cloud toward ζ Oph, some translucent clouds, and the photo-dissociation region IC 63. The lines are generally not detected in clouds with densities less than 5000 cm^{-3} and exposed to radiation fields less than 30

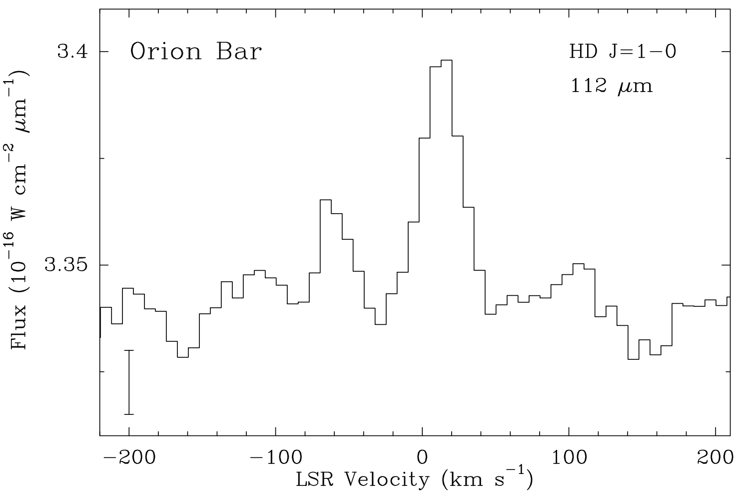

Figure 2.10: The ISO–LWS Fabry–Pérot spectrum toward the Orion Bar of the HD 0–0 J=1→0 R(0) 112.0725 μm line. The error bar represents the typical standard deviation in individual data points.

times the average interstellar field. The detected lines are generally stronger than can be explained by standard models of photon-dominated regions.

Infrared Absorption Bands of the Diffuse Interstellar Medium: the 6.2 μm Feature of Aromatic Compounds

Schutte, van Dishoeck and Greenberg, in collaboration with Tielens and Boogert (both Groningen), van der Hucht (SRON, Utrecht) and Whittet (Rensselaer, USA), concluded their research of the 6.2 μm absorption band which is observed by the ISO-SWS spectrometer in the diffuse interstellar medium. While this band was originally thought to be caused by solid state aromatic material, a re-reduction of the data gave a considerable smaller bandwidth (see Fig. 2.11). The width and position of the feature is quite close to that of the well-known Galactic 6.2 μm emission feature, such as observed towards NGC 7027, indicating a common origin. Thus, like the emission feature, the absorption probably arises in large Polycyclic Aromatic Hydrocarbons (PAHs) or clusters of such molecules. The abundance constraints obtained from the absorption band are consistent with the abundances that have previously been estimated from the emission feature. Comparison of the intensity of the absorption feature towards Galactic Center sources with more local objects shows no strong gradient throughout the Galaxy. This argues against an origin of the PAHs in the outflow of carbon stars, since it is known that the distribution of such objects experiences a strong gradient with distance to the Galactic Center.

Besides the 6.2 μm band and the 3.4 μm aliphatic CH stretching mode, which was already known from ground-based observations, other infrared features of diffuse medium material are either very weak or absent. This shows that the carbonaceous dust material in the diffuse medium is remarkably devoid in infrared active groups. Therefore the material should be quite poor in oxygen and hydrogen. It must originate either from carbon-rich stellar outflows, or it was originally created inside dense clouds from energetic processing of an oxygen-rich ice layer, and subsequently carbonized by heavy diffuse medium processing.

Laboratory Simulation of the Destruction of Organic CH Groups in the Interstellar Medium

Ruiterkamp, Schutte, Greenberg and Ehrenfreund investigated the destruction of CH groups in various hydrocarbon materials under simulated conditions analogous to the dense and diffuse interstellar medium. The rationale of this research is the observation that the interstellar 3.4 μm feature, which is ascribed to the CH stretching mode of solid hydrocarbons, is weaker per unit dust mass in dense clouds compared to diffuse clouds. This is a somewhat puzzling situation, since it is thought that the interstellar medium is regularly cycled between the dense and diffuse phase. If the carrier of the 3.4 μm feature is destroyed inside dense clouds, its presence in the diffuse medium would require highly efficient local formation of organic solids by a hitherto unknown mechanism.

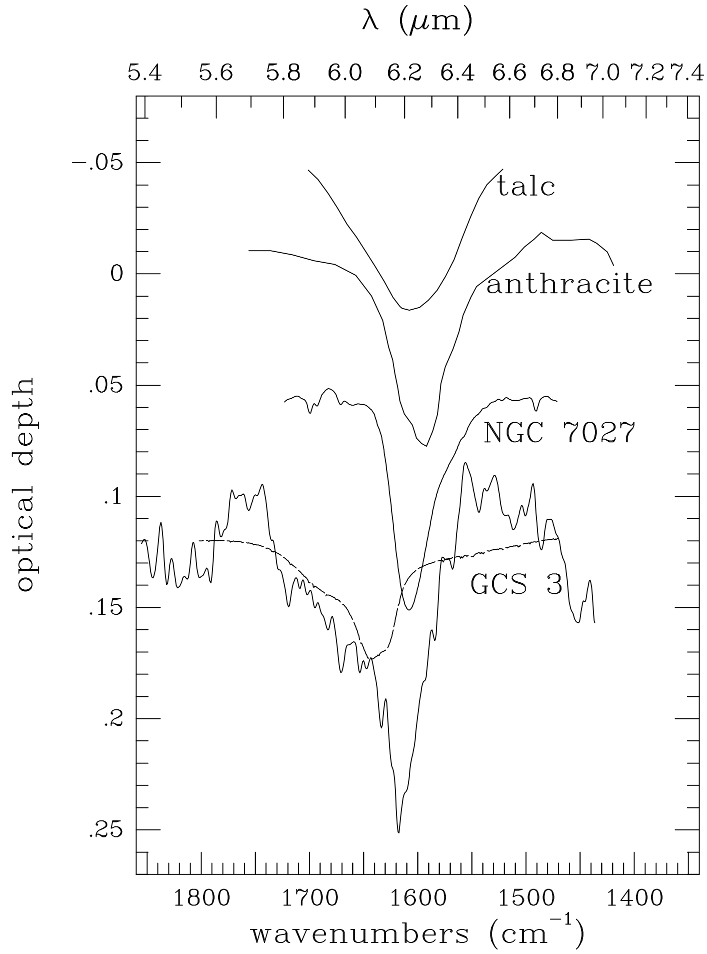

Figure 2.11: The 6.2 μm absorption feature towards the Galactic Center source GCS 3 as observed by ISO-SWS, compared with the (inverted) 6.2 μm emission feature towards the planetary nebula NGC 7027, the laboratory spectrum of the coal anthracite (as a representative of solid aromatic carbon) and water of hydration in talc. The dashed line superimposed on the GCS 3 spectrum indicates the profile of a band of H_2O ice which underlies the 6.2 μm band.

Ultraviolet irradiation of various hydrocarbons in the laboratory at temperatures representative of interstellar dust (12 K) show that CH stretching bonds are quickly destroyed under diffuse medium circumstances on timescales of $\sim 10^3 - 10^5$ years. The presence of CH groups in diffuse ISM dust can therefore only be explained if the CH bonds are efficiently replenished by the abundant atomic H in the diffuse medium.

To simulate the circumstance of dense interstellar clouds, a layer of H_2O ice was deposited on top of the hydrocarbon prior to the UV irradiation. It was found that an H_2O layer of 0.01 μm, representative of dense cloud dust, had little influence on the modification of the hydrocarbon material, which was still efficiently depleted in hydrogen. This shows that dehydrogenation may proceed on timescales of the order of $\sim 10^6$ years in dense clouds. On the other hand, the rehydrogenation process will be stopped once an ice mantle has accreted on the carbonaceous grains. It is therefore expected that the carbonaceous dust will contain considerably less hydrogen in dense cloud compared to the diffuse medium, consistent with the observations. An important implication of the laboratory result is that the dearth of CH bonds in dense clouds may not point to a lower abundance of carbonaceous dust, but should rather be attributed to a lower hydrogen content. Such a scenario offers a way out of the dilemma of requiring an unknown highly efficient production mechanism of organic solids under diffuse medium circumstances.

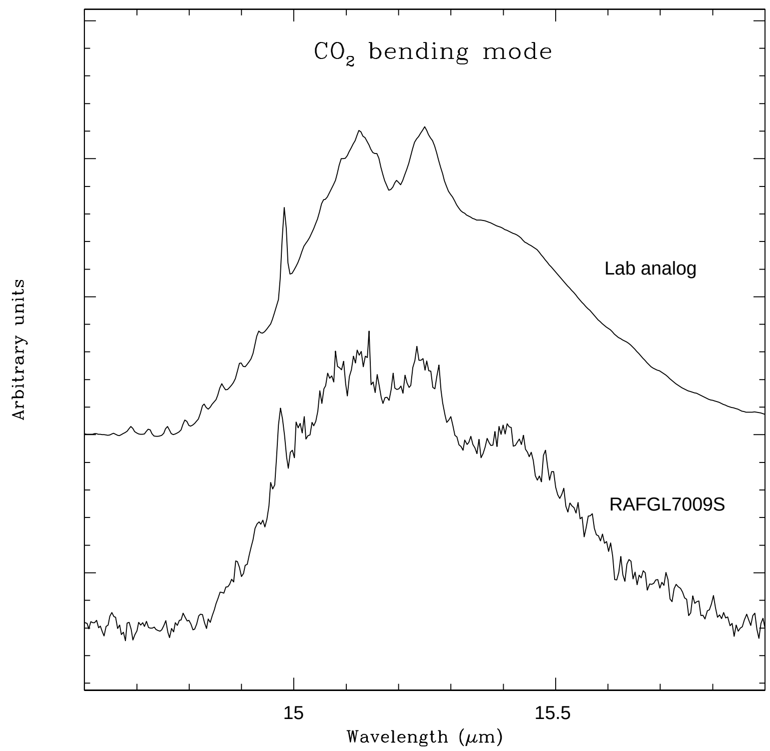

Figure 2.12: The observed bending mode of solid CO_2 toward RAFGL 7009S compared with laboratory data of a CO_2:H_2O:CH_3OH=1:1:1 mixture at 105 K obtained in the Leiden Observatory Laboratory. The spectra show evidence for ice heating and segregation.

The Evolution of CO_2-Ice in Space

ISO observations by Boogert (Groningen), Gerakines (RPI) and collaborators show that CO_2 resides predominantly in water-rich ices. The remarkable triple structure observed in the CO_2 bending mode in a variety of objects can be well reproduced in laboratory experiments by Ehrenfreund et al. The best fits are currently obtained with ice mixtures containing H_2O, CH_3OH and CO_2, which are thermally processed through slow warm-up to temperatures above 100 K. This particular triple structure is presumably formed when the matrix is rearranged and molecules start to be mobile within the ice matrix. The CO_2 bending mode feature in dense clouds was identified in the laboratory with molecular complexes formed between CO_2 and CH_3OH ice, which become spectroscopically discernible during the ice segregation process. The comparison of laboratory data and the ISO spectra of protostars indicates the presence of an ice layer with a composition of CO_2, CH_3OH and H_2O in equal proportions (Fig. 2.12). These results provide important evidence for extensive ice segregation and thermal processing in the line-of-sight toward massive protostars.

Detection of Anomously Abundant Methanol Ice Towards the High-Mass Protostar RAFGL 7009S

Schutte and Ehrenfreund, in collaboration with Dartois, Demyk and d'Hendecourt (IAS, Orsay, France) and Geballe (JAC, Hawaii, USA), observed 3 absorption bands of solid methanol at 3.54, 3.84 and 3.94 μm toward the embedded high-mass young stellar object RAFGL 7009S. The derived abundance of methanol amounts to 30 % of that of H_2O ice, by far the highest abundance observed toward any object. Comparison with abundances toward other YSOs indicates that solid methanol is considerably more efficiently produced in the environment of high-mass protostars than near low-mass protostars or in the general dense cloud medium. This result can give important insight into the differences between the chemical conditions associated with low- and high-mass star formation. The high methanol abundance of RAFGL 7009S poses severe constraints on the formation mechanism. Previously proposed mechanisms like UV radiation and grain surface hydrogenation of CO are not able to produce such high quantities. Further theoretical and laboratory studies are necessary to understand its origin.

Band Strengths of CH_4, CH_3OH and NH_3 in Astrophysical Ice Analogs

Kerkhof, Schutte and Ehrenfreund measured the intrinsic band strengths of the infrared features of CH_4, CH_3OH and NH_3 when diluted in astrophysically relevant ice mixtures (H_2O, CO_2, CH_3OH). Such measurements are essential for a quantitative interpretation of observations of interstellar ices. Contrary to earlier reports in the literature, which were based on less accurate methods, the band strengths differed only little from those in the pure ices of these molecules (i.e., differences < 25 %).

Weak Ice Absorption Features at 7.24 and 7.41 μm

Schutte et al. concluded their analysis of the weak 7.24 and 7.41 μm features seen in the ISO-SWS spectra of the highly obscured YSO W 33A. These features have been compared with laboratory-produced interstellar ice analogs containing various mixtures of compounds to select plausible candidates. The 7.24 μm band can be well matched by the CH deformation mode of formic acid (HCOOH) in an ice dominated by H_2O. Good matches of the 7.41 μm band can either be obtained with the formate ion ($HCOO^-$) or acetaldehyde (CH_3HCO) in H_2O dominated ices. The former species is created in the laboratory ice sample by acid-base reactions. The laboratory spectra show strong additional features of all these species which should make a more definite identification straightforward once the entire mid-infrared ISO spectrum becomes available. In any case, the earlier tentative detection of the strong CO stretching mode of HCOOH near 5.85 μm towards the embedded YSO NGC7538:IRS9 suggests that formic acid may be a general component of the ice in the environment of massive protostars.

Laboratory Studies of Apolar Ices

Ehrenfreund and collaborators continued their study of the nature of apolar ices in the laboratory. These ices are likely dominated by molecules such as CO and the infrared inactive molecules O_2 and N_2. Recent ISO results show the ubiquitous presence of abundant CO_2 ice. The position and widths of the bands indicate not only the polar and apolar character of the ice, but can also give an indication of the temperature and radiation history of ices. Ehrenfreund et al. have produced laboratory infrared spectra of apolar ice mixtures of pure, binary and multicomponent type in order to study the formation and evolution of apolar ices in the interstellar medium. A database on solid CO/CO_2 prepared for the ISO community has been installed on the WWW (`http://www.strw.leidenuniv.nl/~lab`).

The Search for Solid O_2

Using recent ISO and ground-based observations, Vandenbussche (Leuven), Ehrenfreund, van Dishoeck, Schutte and others have reassessed the interstellar oxygen budget in interstellar gas and dust. Theoretical models for the composition of icy grain mantles predict that O_2 can be an important grain mantle constituent in apolar ices. O_2 is an infrared inactive molecule and also does not have strong millimeter transitions. Only interactions in the solid state allow observations of the weak fundamental vibrations. Solid O_2 has been searched for directly at 6.45 μm with the ISO-SWS, and indirectly through high-quality ground based observations of the solid CO profile. These data give an upper limit of 50 % of solid O_2 relative to solid CO toward the protostellar targets RCrA IRS2 and NGC 7538 IRS9. This indicates that the abundance of solid O_2 in dense clouds is less than 5 % of the total oxygen budget. The low abundances of solid and gaseous O_2 leave atomic oxygen as the main candidate for the dominant form of oxygen in cold clouds.

From Interstellar to Cometary Ices: an ISO View

A large number of dust grains may have survived unmodified in the outer solar nebula before incorporation into comets. To trace interstellar ices and heterogeneous organic matter (formed during the evolution of interstellar dust) in comets is one of the future goals of the STARDUST and ROSETTA comet rendezvous missions. The interstellar ices are released as cometary volatiles and probe the origin and history of comets. ISO has allowed to study for the first time both the composition of interstellar dust as well as targets of opportunity, such as comet Hale-Bopp and Hyakutake. The comparison of interstellar ices and cometary measurements has been discussed in a series of reviews by Ehrenfreund and Schutte. Whereas a general correspondence in the composition of cometary and interstellar ices can be observed, some evidence for more processed material is found as well.

The Molecular Environment of Low-Mass Protostars

In collaboration with van Dishoeck, van der Tak, Salverda, Blake (Caltech), van Langevelde (JIVE, Dwingeloo), and Mundy (Maryland), Hogerheijde completed an investigation into the molecular envelopes surrounding a sample of low-mass, embedded young stellar objects (YSOs) in Taurus and Serpens. Submillimeter observations of molecular-line and dust-continuum emission were obtained with single-dish telescopes (JCMT, CSO, IRAM 30m) and the Owens Valley Millimeter Array. The main conclusions of this study are that high-density tracers like HCO^+ J=3–2 and 4–3 are reliable probes of the envelopes throughout the embedded phase (class 0 and class I). The density structure of deeply embedded class 0 envelopes is also revealed by interferometric continuum observations, but HCO^+ lines are more sensitive to the low column densities in the later class I stages. These lines are better probes than, e.g., the 1 mm continuum flux in a single-dish beam or the IRAS colors, because unresolved circumstellar disks ($\sim$ 100 AU radius), or – in the case of the dense class 0 envelopes – the warm inner regions of the envelopes ($<$ 300 AU), contribute significantly to the continuum flux.

Model fits to the continuum emission and integrated HCO^+ 3–2 emission show that the density in the envelopes of the class 0 and I sources follows a radial power-law dependency, with an index in the range of -1 to -2. This agrees well with theoretical expectations for collapsing cloud cores, but only molecular line profile modeling can provide a more rigorous test of such models. To this end, Hogerheijde and van der Tak developed a Monte-Carlo formalism to solve the radiative transfer and molecular excitation in an axisymmetric geometry. First results show that the simple inside-out collapse model of Shu can explain many features of the observed single-dish line profiles, spanning a wide range in physical regimes. The smaller scales of $<$ 1000 AU imaged by the interferometer reveal deviations from this simple picture, with rotation and ordered magnetic fields giving rise to flattening, and the outflow interacting with the envelope. A simple mixing-layer description for the entrainment of molecular material into the flow successfully reproduces the observed bright HCO^+ and HCN 1–0 emission lining the outflow cavities of several deeply embedded sources.

Physical Structure of the Envelopes Around High-Mass YSOs

Van der Tak, in collaboration with van Dishoeck, Evans (Texas) and Blake (Caltech), continued their study of the physical structure of regions of massive star formation. The aim is to compare the results with similar studies of low-mass YSOs, and investigate whether the higher luminosity and hard ultraviolet spectrum have significant effects. An accurate physical model of the envelope is also a prerequisite for any chemical studies.

A large amount of observational data on lines and continuum has been obtained at the JCMT, OVRO and with the Phoenix infrared spectrometer at Kitt Peak for up to 14 massive YSOs. These have been selected according to luminosity ($> 10^3$ $L_\odot$), distance ($<$ 4 kpc), infrared brightness and isolated location. The first goal was to constrain the physical structure of YSOs on scales ranging from $\sim$ 0.01 pc, using the infrared absorption lines, to $\sim$ 1 pc, from the JCMT maps. Intermediate scales are covered by the interferometric images. While the continuum emission gives information about the dust temperature structure and total mass, the density structure can only be obtained from molecular lines, such as the range of transitions provided by CS 2-1 up to 10-9.

In a first ApJ paper, the modeling strategy is developed and applied to one of the objects, AFGL 2591. The strong dust emission provides evidence for grain coagulation and for ice evaporation in the warm inner envelope. The density structure is found to follow a power law with an exponent of -1.25 ± 0.25, suggesting that only part of the envelope is in free fall. The strong near-infrared emission and the emission line profiles suggest a small deviation from spherical symmetry, likely a cavity evacuated by the outflow which is directed nearly along the line of sight (see Fig. 2.13). Compared to this model, OVRO continuum data show excess thermal emission, probably from $\sim$ 1000 K dust within $\approx$ 30 AU from the star. In contrast, OVRO data of HCN do not show such an excess. Hence, the hot, abundant HCN seen in ISO-SWS data is not located in the inner part of the envelope, but in a separate region within 175 AU from the star, where high-temperature gas-phase reactions are affecting the chemistry.

A second paper applies the same modeling technique to a sample of 14 sources. Most of these are bright at mid-infrared wavelengths, but a comparison is also made with "hot core"-type regions and an ultra-compact H II region. The principal question is how these sources differ in physical structure. First results indicate that the bright infrared sources have shallower density gradients (-1 to -1.5) than other sources (up to -2).

Molecules in Disks Around Young Stars

Thi, in collaboration with van Dishoeck, van Zadelhoff, Hogerheijde, Blake (Caltech) and others, has carried out a deep survey of the lowest-lying pure-rotational lines of H_2 towards a set of isolated T Tauri and Herbig Ae stars in Taurus and Ophiuchus. The presence of a circumstellar disk around these objects has been established by millimeter interferometry. The H_2 J=3$\rightarrow$1 S(1) line has been detected in most sources, whereas the $J = 2 \rightarrow 0$ line is seen in at least 2 objects. The inferred

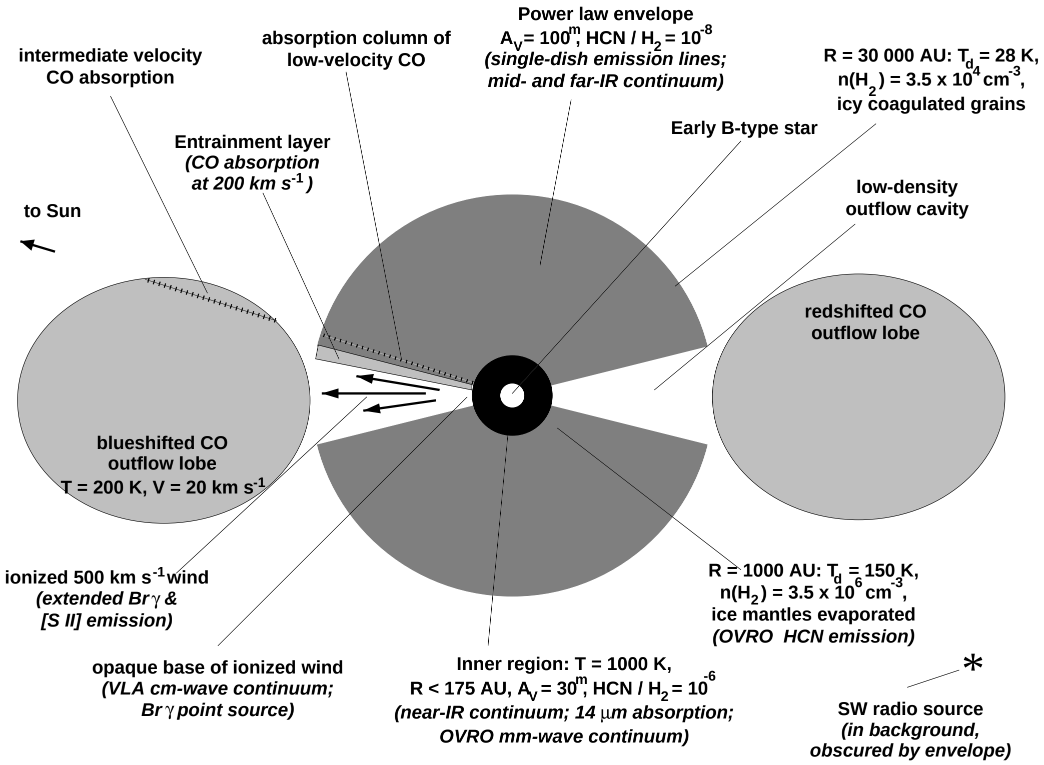

Figure 2.13: Schematic illustration of the various components around the massive YSO AFGL 2591 probed by millimeter and infrared observations.

temperatures are typically 100 K, and the inferred mass of warm gas is a few % of the total amount of gas + dust, derived from the millimeter continuum and assuming a gas to dust ratio of 100. Various models for the heating of such a large fraction of the gas are currently being explored by van Zadelhoff.

The detection of these weak H_2 lines required the development of special data reduction and analysis software by Thi and Valentijn (Groningen) to correct for glitches and other non-standard problems. The software is now fully tested and operational.

Thi, in collaboration with Horn and Becklin (UCLA), also used his special data reduction techniques to search for H_2 line emission around the old pre-main sequence stars 49 Cet and HD 135344.

Van Zadelhoff, Thi and van Dishoeck have started a large program to observe the very weak lines of other molecules in disks using the JCMT and the IRAM-30m telescope. The JCMT observations have been made possible by the new sensitive dual polarization B3 receiver at 345 GHz. High-frequency lines of HCN, HCO^+, H_2CO and other species have been detected toward several objects. Combination with interferometer data on lower-lying transitions by Qi and Blake (both Caltech) allows the excitation to be constrained.

2.6 The Galaxy

Tidal Streams

Helmi and White (MPA, München) studied numerical simulations of satellite galaxy disruption in a potential resembling that of the Milky Way. Their goal is to assess whether a merger origin for the stellar halo would leave observable fossil structure in the phase-space distribution of nearby stars. They showed how mixing of disrupted satellites can be quantified using a coarse-grained entropy. Although after 10 billion years few obvious asymmetries remain in the distribution of particles in configuration space, strong correlations are still present in velocity space. They gave a simple analytic description of these effects, based on a linearized treatment in action-angle variables, which shows how the kinematic and density structure of the debris stream changes with time. By applying this description they found that a single satellite of current luminosity $10^8 L_\odot$ disrupted 10 Gyr ago from an orbit circulating in the inner halo (mean apocentre $\sim$ 12 kpc) would contribute about $\sim$ 30 kinematically cold streams with internal velocity dispersions below 5 km/s to the local stellar halo. If the whole stellar halo were built by disrupted satellites, it should consist locally of 300 - 500 such streams. Clear detection of all these structures would require a sample of a few thousand stars with 3-D velocities accurate to better than 5 km/s. Even with velocity errors several times worse than this, the expected clumpiness should be quite evident. They applied their formalism to a group of stars detected near the NGP, and derive an order of magnitude estimate for the initial properties of the progenitor system.

Search for Tidal Streams

Shimron and Zhao continued their search for tidal streams in the halo of the Galaxy. By integrating over heliocentric great circles in COBE/DIRBE maps from which the zodiacal light has been removed, they looked for remnants of past mergers that are so stretched out that their surface density has been below the limit of other searches. They applied the symmetry of the foreground Galactic emission to remove the effects of the Galactic disk. So far no remnants were found.

Zhao continued his project to reconstruct the dynamical history of satellites in the halo of the Milky Way. Together with Johnston (IAS), Spergel (Princeton), and Hernquist (Harvard) he showed that future astrometric satellites such as SIM and GAIA could resolve the proper motions of these objects. By studying the orbits of these objects they show these proper motions hold the promise of tightly constraining the Galactic potential and its evolution history.

DENIS and Star Counts Towards the Galactic Pole

Ortiz and Habing studied an area of 32 square degrees in a region around the galactic pole, observed by the DENIS survey of the southern sky. The star counts obtained in three infrared bands (I, J and K) were compared with the predictions of a model for the Galaxy proposed by Ortiz & Lepine (Ortiz, R. & Lepine, J.R.D., 1993, *A&A*, 279, 90–106). An excess of stars showing $I - J < 0.3$ was found, which cannot be explained by the model assuming the standard distribution of A, F stars. The stars are at distances of several kiloparsecs from the galactic plane and show a scale height of 0.75 kpc. If they are not evolved objects, like horizontal-branch stars, those A, F stars may have been ejected from the galactic plane by close encounters with disk stars or they are the result of an abnormal event of star formation.

AGB Stars Near the Center

Habing and Wood (Canberra, Australia) discussed a large data set of photometric measurements of more than 100 OH/IR stars and other long-period variables very close to the galactic center as well in projection as in real distance. Periods and luminosities have been determined. Two main conclusions are drawn: the stars seen are AGB stars with ages of up to a few Gyr; (2) the stars do not follow the period-luminosity relation that has been established for Mira variables in the Magellanic Clouds: for a given star the mass loss leads to a longer pulsation period whereas the luminosity increases too slowly to maintain any pre-existing relation between $M_{\rm bol}$ and P. Systematic, large deviations from the existing $M_{\rm bol}$ versus P relation has been shown in a few stars, but this study makes clear that such deviations are quite common.

Microlensing

Zhao and Pronk started to work on a project to find multiple images of stars created by the black hole in the center of the Galaxy. Relating positions, proper motions and magnitudes of pairs of stars near the center might reveal that the light of the two stars actually comes from the same source star, whose light is bent by the black hole. Upon finding such an image-pair it will be possible to set a lower bound on the mass of the central black hole, independent of dynamical determinations.

2.7 Relatively Nearby Galaxies and Globular Clusters

Submillimeter Maps of the Edge-On Galaxy NGC 891

Using the SCUBA submillimeter camera on the JCMT, Israel, van der Werf and Tilanus (NFRA) observed the nearby edge-on spiral galaxy NGC 891 at wavelengths of 850μm and 450μm. They found the submillimeter images to be very similar to those in the CO line and the 1.3 mm continuum. Emission occurs throughout the disk, with peaks at the center and symmetrically at locations in the disk. The central peak corresponds to the compact circumnuclear disk seen in high-resolution CO images; it is embedded in soft X-rays, and the dust has a temperature of at least 40 K. The lesser peaks most likely correspond to the tangential points of spiral arms. Towards the central region, 850

μm emission is relatively strong compared to that of CO and C°, but this situation is reversed in the 'molecular ring' corresponding to the inner spiral arms. Israel et al. assume that the central region is characterized by a low molecular gas content, while the enhanced molecular ring line intensities are due to geometrical factors. The increase of C° emission with respect to 850μm continuum at greater galactic radii probably reflects an increase in the effects of photo-dissociation due to a decreasing space density of dense molecular clouds.

The overall far-infrared/submillimeter spectrum longwards of 100μm can be fit by a bimodal population of dust grains at temperatures of 18 K and 27 K. Shortwards of 100μm, de spectrum is dominated by emission from PAH particles and small dust grains; the 60/100μm emission ratio is therefore not a good measure of dust temperatures in the galaxy. The total hydrogen mass of NGC 891 is estimated at 3×10^9 $M_\odot$. Consequently, the CO to H_2 conversion ratio in NGC 891 is lower than the 'standard' Galactic ratio by a factor of two to four: per unit CO luminosity, NGC 891 contains less molecular hydrogen.

Molecular Gas in the Bulge and Ring of NGC 7331

NGC 7331 is an isolated SB galaxy with prominent dust lanes encircling a large, luminous bulge. Various infrared, submillimeter and radio continuum images show a ringlike distribution of material at the radius of the dust lanes. Israel and Baas have used the JCMT to map the J=2–1 CO distribution out to 7 kpc (assuming a galaxy distance of 14.3 Mpc), and also measured the strength of the J=1–0, J=2–1 and J=3–2 ^{12}CO transitions as well as that of the J=1–0 and J=2–1 ^{13}CO and the 492 GHz [CI] transitions in the center of the galaxy.

The J=2–1 CO map shows the presence of enhanced CO emission peaking at a radial distance of 3.5 kpc. This 'molecular ring' has a contrast ratio of about 0.6 with respect to the more smoothly distributed disk CO emission. Contrary to earlier claims, the central bulge of NGC 7331 is not devoid of molecular material. In the central region, CO luminosities drop rapidly with increasing J transition; J=3–2 emission is quite weak. At the same time, ^{12}CO/^{13}CO isotopic ratios are 6 – 7 in both the J=1–0 and J=2–1 transition. Weak [CI] emission was also detected from the central region. The line ratios are similar, but not identical to those observed in the M 31 dark cloud complex D 478. Modeling the molecular gas properties, Israel and Baas find that it must consist of 10 K gas present at both low (a few hundred per cc) and high (a few thousand per cc) densities in addition to a warm, high-density component at about 20–30 K. The generally low column densities suggest that most of this gas is in clumpy or filamentary form. They also find that the CO to H_2 conversion ratio in NGC 7331 is of the order of five times lower than the 'standard' Galactic ratio, consistent with both the high metallicity of NGC 7331 and its submillimeter dust content. Gas to dynamic mass ratios are about 1% in the bulge, and 1.5% in the ring.

The molecular ring coincides with the mostly nonthermal radio ring, and with the 850μm ring of cold dust. However, emission from warmer dust, seen at shorter wavelengths, peaks well inside the ring, suggesting a radial temperature gradient. HI peaks well outside the molecular ring. As the molecular ring is well inside the radius of peak rotation velocity, it is unlikely to be caused by an inner Lindblad resonance. Instead, Israel and Baas suggest that the molecular ring is caused by wind-driven gas removal from the bulge. They also show that the molecular gas in the bulge may have originated from mass loss by the late type stars populating the bulge. With all these characteristics, the molecular properties of the center of NGC 7331 are completely different from those in the centers of most other galaxies mapped in CO.

Molecular Hydrogen Emission in the Disk of NGC 891

Van der Werf completed, in collaboration with Valentijn (SRON Groningen), the analysis of the rotational line emission from H_2 in the disk of the nearby edge-on spiral galaxy NGC 891. The 2 lowest rotational transitions of H_2 (S(0) at 28 μm and S(1) at 17 μm) were both detected at every position along the disk of NGC 891, out to a distance of 11 kpc from the nucleus, where even CO is barely detected. This is the first detection of extragalactic H_2 emission in regions other than starburst nuclei. The H_2 emission originates from a warm ($T \sim 100\,$K), moderate density ($n \sim 200\,\mathrm{cm}^{-3}$) molecular medium, which can most easily be identified with the warm UV-irradiated envelopes of molecular clouds, where CO is photodissociated. The warm H_2 mass involved is several tens of percent of the cold H_2 mass derived from CO observations.

HI in IC 10

IC 10 is an enigmatic and important barred Magellanic dwarf galaxy in the Local Group. While similar to the Small Magellanic Cloud in many respects, IC 10's current star formation rate is twice as high as in the SMC and the surface density of Wolf-Rayet stars is five times higher than in the SMC. Thus, IC 10 is the only galaxy in the Local Group that can be considered a starburst galaxy. Bryan Miller and Wilcots (U. Wisconsin) are studying the interaction between the stellar populations and the ISM in this important system. They have investigated the ISM by comparing high resolution HI cubes from the B, C, and D arrays of the VLA with Hα images. The HI content of IC 10 is characterized by a regularly rotating disk embedded within an extended and complex distribution of gas. The distribution of gas within the disk is dominated by holes and shells and has been and continues to be shaped by stellar winds associated with the numerous Wolf-Rayet and O stars. The stellar winds have likely triggered secondary generations of star formation within the shells surrounding many of the holes. They have detected the kinematic signature of the previously reported young superbubble (Yang & Skillman 1993) in a large HI cloud at the southeastern tip of the optical galaxy. Finally, the complex distribution and kinematics of the extended gas around IC 10 suggests that this is a galaxy that is still forming via the accretion of the surrounding gas.

Globular Clusters in Dwarf Galaxies

Since globular clusters (GCs) are among the oldest stellar systems in the universe, they have been one of the most important probes of the early formation of the Galaxy. Thus, they are also useful for comparing the star formation histories of dwarf and giant galaxies. Miller, in collaboration with Ferguson, Stiavelli, and Whitmore (STScI), and Lotz (Johns Hopkins) have studied the GC systems of 24 nearby dE galaxies imaged with the *Hubble Space Telescope.* The upper limit to the effective radii of the cluster candidates is 3.5 pc, in good agreement with Galactic globulars. They find that the specific GC frequency, S_N, in dEs is more like the values found in giant ellipticals rather than in spirals, and the mean S_N for nucleated dEs is roughly a factor of 2 higher than for non-nucleated dEs. Also, S_N increases with M_V. This could be due to the inhibition of star formation by supernovae in low mass galaxies. Colors suggest that most of the GCs are more metal-poor than the nuclei or the galaxies themselves. This implies that the GCs formed before the bulk of the stars in the galaxies. The surface brightness profiles of these dEs are like those of *exponential bulges* in spiral galaxies rather than the $R^{1/4}$ shapes of giant ellipticals. Future work on this project will focus on the internal velocity dispersions in dEs (data has been successfully obtained with the NTT), and comparing the properties of clusters in dEs and dIs.

The Pattern Speed of NGC 2915

The pattern speed is arguably the most important parameter describing a bar and its effects on a host galaxy. Bureau and Freeman (Mount Stromlo and Siding Spring Observatories, Australia), with Pfitzner (Mount Stromlo and Siding Spring Observatories, Australia) and Meurer (Johns Hopkins University, USA), have measured directly the bar pattern speed in the galaxy NGC 2915, the first time this has been achieved in a late-type gas-rich system. NGC 2915 is a unique object, possessing a blue compact dwarf galaxy core and a HI disk with a bar and spiral arms pattern extending far beyond the optical galaxy. The measured bar pattern speed is slow, putting co-rotation at more than 1.7 bar radii, a value hardly compatible with self-consistent models of barred disks. The group demonstrated that the spiral pattern could not be due to interactions, be sustained by swing amplification, or be driven by the bar. Because the disk of NGC 2915 is dominated by dark matter, they considered the possibility of dark matter distributed in a disk, but showed that it was unlikely. They argue that an extensive triaxial dark halo with a slow figure rotation could drive the disk morphology. The existence of such halos is supported by a preliminary analysis of a set of CDM simulations. If this interpretation is right, objects like NGC 2915 could offer new opportunities to probe the structure and dynamics of dark halos.

Bar Diagnostics in Edge-On Spiral Galaxies

Many theories concerning the vertical structure of bars have emerged in recent years, but they are hard to test observationally because bars can not be identified easily in edge-on spiral galaxies. Bureau and Athanassoula (Observatoire de Marseille, France), with Freeman, Kalnajs (both at Mount Stromlo and Siding Spring Observatories, Australia) and Bosma (Observatoire de Marseille, France), have thus set out to develop bar diagnostics for edge-on spirals. They use the kinematical signature that a bar imposes on the position-velocity diagram (PVD) of an edge-on disk. They used periodic orbit families as building blocks to model the structure of real galaxies. They showed that the global structure of the PVDs is a reliable bar diagnostic in edge-on disks. Gaps between the signatures of the various periodic orbit families arise in the PVDs due to the non-homogeneous distribution of orbits in a barred disk. The group also showed specifically how the signatures of the main families of periodic orbits can be used to determine the viewing angle with respect to a bar.

Following-up on the work with periodic orbits, bar diagnostics for edge-on disks were also developed using hydrodynamical simulations, which specifically target the gaseous component of spiral galaxies. It was shown that, when a nuclear spiral is present in a galaxy, associated with the existence of an inner Lindblad resonance, the presence of a gap in the gaseous PVDs, between the signature of the nuclear spiral and that of the outer parts of the disk, reliably indicates the presence of a bar. This gap is caused by shocks and inflows in the bar, which lead to depletion of the gas in the outer bar region. The shape of the signature of the nuclear spiral also allows to determine the viewing angle to the bar.

The Nature of Boxy/Peanut-Shaped Bulges

The formation mechanism of boxy/peanut-shaped (B/PS) bulges has been a long standing puzzle. Many models link these bulges with puffed-up bars, but observational confirmation of this picture has been hard to come by. Using bar diagnostics they recently developed, Bureau and Freeman (Mount Stromlo and Siding Spring Observatories, Australia) tackled the issue. Using emission line spectroscopy, they searched for bars in a large sample of edge-on spiral galaxies with a B/PS bulge, and in a smaller control sample of spirals with more spheroidal bulges. They showed that almost all B/PS bulges are due to a thick bar viewed edge-on, while only a few extreme cases may be due to the accretion of external material. This strongly supports the bar-buckling mechanism for the formation of B/PS bulges, and implies that accretion plays at most a minor role in the formation of these objects. None of the galaxies in the control sample showed evidence for a bar, which suggests conversely that all bars are B/PS. Studies of this type open up for the first time the possibility of studying observationally the vertical structure of bars.

Breakdown of the Tully-Fisher Relation

Stil and Israel reported a breakdown of the Tully-Fisher relation for galaxies fainter than $M_B \approx -16$. Rotationally supported dwarf galaxies exist in a luminosity regime where the Tully-Fisher relation predicts a velocity which is smaller than the HI velocity dispersion. However, pressure supported dwarf galaxies exist in the same luminosity range. A correlation with the ratio of HI mass to blue luminosity was reported for these samples. However, the excess HI mass in the deviating galaxies was shown to be insufficient to account for their underluminosity. Stil initiated a study of this effect for samples of dwarf galaxies from nearby galaxy groups.

The significance of this breakdown of the Tully-Fisher relation is in its application as a test for models of galaxy formation and evolution. A breakdown of this relation at a particular luminosity/rotation velocity essentially introduces a scale to the power law relationship between rotation velocity and luminosity of disk galaxies.

Stil & Israel reported the discovery of an HI cloud near the starburst dwarf galaxy NGC 1569. Infall of HI into NGC 1569 may have provided a semi-continuous trigger of the continuing violent star formation in this galaxy. Stil further separated emission of the rotating HI disk of NGC 1569 and high-velocity HI. The high-velocity HI is associated with the Hα filaments, but represent an order of magnitude more mass than the ionized gas.

AGB stars in both Magellanic Clouds

Habing and Cioni, in cooperation with Loup in Chile, have continued a study of AGB stars in both Magellanic Clouds based on data from the DENIS survey (see section 2.1). They expect to find almost all AGB stars in the Clouds, missing only those with very red colors, indicative of a circumstellar shell. Data about these missing stars have been taken at 8 and 15 μm with the ISO satellite. It is the intent of these three authors to publish a catalogue of all AGB stars in both clouds, and to study their luminosity function and their distribution over the face of the Clouds.

2.8 Elliptical Galaxies

Dynamical Modeling

Cretton completed his tests of the software to construct dynamical models for galaxies using numerically integrated orbits and analytic components. The tests were performed in the scale-free regime very near a central black hole and were compared to the (analytic) study of de Bruijne, van der Marel and de Zeeuw. They showed that the orbit models are satisfactorily accurate (e.g. the errors in the velocities fall well below the observational errors).

Copin (Lyon), Zhao and de Zeeuw investigated the properties of orbits using techniques from spectral stellar dynamics. This allows an improvement in the accuracy of the computation of the orbital properties that are used in model construction methods such as described above. The technique works well, but is cpu intensive.

Continuing their study of the dynamics of galactic nuclei, Zhao, de Zeeuw and Carollo (JHU) investigated whether non-axisymmetric galactic nuclei with power-law density profile can be supported by the boxlet orbits. They have found an analytical result which suggest that most of the parameter space (cusp strength vs flattening) is not physically accessible.

Melief concluded his study on the dynamics of elliptical galaxies. A set of analytically known axisymmetric distribution function components was generalized to the triaxial case. The corresponding triaxial density components could be determined analytically. These components were combined numerically to obtain the total density distribution as well as the full distribution function.

Intrinsic shapes

Vlemmings and de Zeeuw concluded their work on intrinsic shapes of elliptical galaxies, and derived exact expressions for the joint probability distribution of observing a flattening ϵ and a kinematic misalignment angle Υ for triaxial ellipsoids with arbitrary intrinsic misalignment. The probability distributions were combined numerically by means of a non-negative least squares method, in order to fit the observed distribution of ϵ and Υ for elliptical galaxies.

Radio-loud galaxies

Verdoes Kleijn (stationed at STScI), de Zeeuw, and Baum (STScI) continued their HST study of the central regions of a complete sample of 21 nearby radio-loud early-type galaxies. The galaxies have velocities less than 7000 km s^{-1} and are classified as Faranoff Riley Type I (FR I) radio galaxies. The primary goal is to obtain a better understanding of the formation, working and evolution of FR I nuclei. HST/WFPC2 observations were obtained for the sample in V, I and in narrow band filters centered on Hα+[NII]. Observations will be completed in February 1999. An isophotal analysis was performed, and the dust and emission gas content in the centers of these galaxies was studied. The galaxies contain small nuclear disks and lanes of gas and dust.

Nearby Elliptical Galaxies

With Holland Ford, v.d. Bosch and Ferrarese have started an HST snapshot survey of a complete sample of nearby elliptical galaxies. Approximately 30 WFPC2 images will be taken to determine to what extent nuclear dust and stellar disks, and other small scale dust and stellar features are found in "average" elliptical galaxies. Previous samples used for morphological investigations were usually chosen on the basis of unusual behaviour (such as radio or optical line emission). Galaxies with nuclear disks are good targets for follow-up searches for nuclear black holes. Earlier spectroscopy of nuclear disks showed black holes far more massive than predicted by Kormendy's relation on the basis of their bulge mass.

2.9 Active Galaxies

Low Redshift 3CR Radio Galaxies

De Koff, Best, Miley and Röttgering at Leiden, together with Sparks, Baum, Macchetto, Golombek and Biretta (STScI) and McCarthy (Carnegie), have continued to analyse the properties of the nuclear dust features observed in HST snapshot program of a large subset of 3C radio galaxies with redshifts $z \leq 0.5$. Substantial differences are seen between the dust masses, morphologies and orientations of FRI and FRII type sources, the FRI's possessing small ordered dust disks typically perpendicular to the radio axis, and the FRII's possessing more clumpy dust on larger scales. This suggests a different origin for the nuclear dust in the two different radio galaxy types.

The Redshift One 3CR Galaxies

Best and Röttgering, together with Longair (Cambridge), have continued their studies of the 28 3CR radio galaxies with redshifts $z \sim 1$ in their Hubble Space Telescope sample. Deep spectroscopic observations at the William Herschel Telescope have shown that the kinematics and ionisation of the emission line gas shows a strong dependence upon the size of the radio source, with small sources having their emission line gas properties dominated by the shocks associated with the radio source activity. These results further suggest that the similar radio size evolution of the continuum alignment effect seen in the earlier HST images is likely to also be associated with radio source shocks.

For two galaxies from the sample, 3C324 and 3C368, very deep VLA data have been obtained to investigate the correlations between the radio and optical structures. Jets are detected in both sources, lying directly along the bright strings of aligned optical knots, This confirms that interactions between the radio jet and its environment play a key role in producing the excess ultraviolet emission of these sources. Best, Röttgering, Miley, Pentericci and van der Werf, together with Bremer (Paris), Cimatti (Firenze), Mack (Bologna) and Tilanus (JAC), have taken deep submillimetre observations of 2 of the $z \sim 1$ 3CR galaxies using SCUBA. 3C324 (z=1.2) was marginally detected at the 4.2 sigma level, corresponding to a possible star formation rate of about 300 solar masses per year.

Together with Eales (Cardiff) and Rawlings (Oxford), Best, Röttgering and Longair have also been investigating a sample of lower power 6C radio galaxies, selected in the same redshift range as the 3CR sample. Deep radio data for these galaxies indicate that, although the rotation measures detected are in no cases extreme (generally averaging below $40\,\mathrm{rad\,m^{-2}}$), strong gradients in the rotation measures and similarly in the depolarisation measures are seen between the two lobes of many sources, and also within individual lobes, suggesting that these galaxies also are located in clumpy environments. The ratio of core to extended radio flux is found to be almost independent of radio luminosity showing that the high radio luminosity of the most powerful radio sources originates in the active nucleus, rather than being just due to a dense confining medium boosting the lobe fluxes.

Distant Radio Galaxies

HST Observations

Pentericci, Röttgering and Miley in collaboration with McCarthy and van Breugel continued their study of high redshift (1.7 < z < 3.6) radio galaxies (HZRGs) using the Hubble Space Telescope. 12 radio galaxies have been observed with the WFPC2 camera in a broad band corresponding roughly to R band; 19 radio galaxies have been observed with NICMOS in the H band. The characteristics of the HST morphologies and their relationship with the radio emission vary strongly from object to object. Interestingly, a large fraction of the objects with $z < 2.5$ have radial profiles that nicely resemble those of nearby elliptical galaxies. This suggest that at $z = 2$ a significant fraction of the powerful radio galaxies are hosted by mature ellipticals. The scenario that emerges from the data is that the clumpy HZRGs are forming from aggregates of objects similar to the Ly break galaxies, and that they will evolve, through merging and star formation into extremely massive systems, most probably nearby brightest cluster galaxies.

CO

A good way of probing relatively cold gas associated with high redshift radio galaxies is to observe emission from CO using millimetre or submillimetre telescopes. Many of the past searches have been dramatically unsuccessful. However, Papadopoulos, Röttgering, van der Werf in collaboration with Guilloteau (Grenoble), Omart (IAP), Tilanus (JACH) van Breugel (univ Cal.) obtained two solid detections for the two radio galaxies 4C60.07 ($z = 3.8$) and 1909+722 ($z = 3.6$), indicating that the total amount of molecular gas present in each of these systems has a mass of order 10^{11} $M_\odot$.

Mid-Infrared Emission

Van der Werf completed the analysis of ISOCAM ($12\,\mu$m) and ISOPHOT (60, 90 and $175\,\mu$m) of a number of high-redshift radio galaxies. Of six sample galaxies, two were detected at $12\,\mu$m. Combining these results with photometry at 450 and $850\,\mu$m obtained with SCUBA at the JCMT, the spectral energy distribution (SED) of the dust emission can be characterized. Remarkably, the SEDs are characteristic of those of quasars, showing a very prominent hot dust component.

Gas

High-redshift radio galaxies are often associated with giant halos of ionized gas. Radio galaxy 0943-242 at z=2.9 shows absorption in both Lyman α and CIV lines, due to a cloud within or close to the galaxy. Using CLOUDY, Kurk, Röttgering, and Miley, showed that the amount of Carbon in the absorber must be higher than 10 per cent of the Solar value, suggesting that the cloud does not consist of primordial material. Using the new tunable Westerbork receivers, Kurk, Röttgering, and Miley are continuing the search for HI absorption in objects of known redshift, in collaboration with de Bruyn (Dwingeloo). In particular, in the very dusty galaxy 1019+0535 at z=2.76 HI absorption could be present.

Simulations of Jet Induced Star Formation

The alignment of the optical/IR continuum emission with radio emission in distant radio galaxies is difficult to explain by a single model. Popular models include nebular emission, scattering and star formation along the jet. To investigate whether jet-induced star formation is a physically plausible model, Kurk, Icke and Röttgering are building a two dimensional hydrodynamical code, including cooling to first order. Simulations by this code of a shock moving through the two phase ISM should give insight under which circumstances interstellar clouds collapse or disappear after the jet driven shock has passed. Collapsed clouds can be places of star formation if they have sufficiently cooled.

Searches for the Most Distant Radio Galaxies

To find more z>4 galaxies, De Breuck, van Breugel, Röttgering and Miley continued an extensive search programme combining the WENSS catalogue with the new 1.4 GHz VLA D-Array NVSS and B-Array FIRST surveys, the Texas 365 MHz survey with the NVSS 1.4 GHz survey. During 1998 a programme to obtain K-band images of the optically undetected sources using the NIRC camera on the Keck 10m telescope was continued. The faintest objects from these observations are the best targets for $z > 4$ radio galaxies. In December 1998 0924-22 was identified with a galaxy at a redshift of $z = 5.2$ making it the most distant AGN known.

Radio Observations

Van Reeven in collaboration with Röttgering, Miley, Pentericci and Carilli carried out multifrequency observations of a sample of 30 $z > 2$ radio galaxies. The aim was to double the existing sample of sources with extreme rotation measures, very good candidates for radio galaxies located in high-z clusters.

Giant Radio Galaxies

Schoenmakers (Leiden, Utrecht), with Röttgering (Leiden), De Bruyn (NFRA, Groningen) and Van der Laan (Utrecht) have continued their work on Giant Radio Galaxies (GRGs, i.e. radio galaxies with linear sizes above 1 Mpc). Two samples of these sources have now been defined, one containing GRGs with redshifts below 0.3, and one with redshifts above 0.3.

The Low Redshift Sample

The low ($z < 0.3$) redshift GRG sample consists of 46 sources with angular sizes above 5 arcminutes, selected from the 325-MHZ WENSS survey. For almost all sources in this sample Schoenmakers et al. have obtained high quality optical spectra with the INT telescope on La Palma. These will be used to investigate the emission line properties of the AGN, the correlations of these with radio properties such as core strength, total radio power, etc. In collaboration with K.-H. Mack (RAIUB Bonn, IRA Bologna), Schoenmakers et al. have obtained 10.4 GHz radio maps of all sources in the 1-Jy sample using the 100-m Effelsberg radio telescope in Germany, with a typical rms noise of 1 mJy. Together with the data available from WENSS and the NVSS, this allows studying the radio properties of these sources over a large range in frequency, allowing for the first time ever a detailed statistical study of an almost complete sample of Giant Radio Galaxies.

The High Redshift Sample

WENSS and the VLA B-array FIRST survey have been used to select a sample of high redshift GRG candidates consists of 91 sources. For optical identification of the host galaxies we have used the Digitized Sky Survey, the new POSS II survey (where available) and the JKT telescope on La Palma. After the first spectroscopical results (17 redshifts obtained in February 1997 with the WHT telescope on La Palma), Schoenmakers et al. has had a succesfull second run on the INT telescope in February 1998, in collaboration with G. Cotter (RGO, Cambridge UK). Redshifts of 13 more sources have been obtained, so that the total fraction of spectroscopically identified sources now is close to 30%.

A GPS Source With a Mpc-Scale Radio Structure

Schoenmakers et al. discovered a Mpc-scale radio structure associated with the GPS source WNB 1144+352. GPS sources are very compact extragalactic radio sources with sizes upto a few hundred pc, characterized by a convex radio spectral shape with the turn-over frequency in the GHz-range. Only a few GPS sources are known to have extended emission on scales of kpc and only one other is known to have emission on Mpc-scale (B1245+676; de Bruyn et al. in preparation). B1144+352 is one of the most nearby GPS sources at $z = 0.067$ and was already known to have kpc-scale radio emission.
The discovery of a GPS source with extended radio structure on both kpc en Mpc-scales strongly suggests that this source has gone through several distinct phases of jet activity, separated by short periods of non-activity.

Double-Double Radio Galaxies

Work has progressed on the explanation of the phenomenon of the 'Double-double' radio galaxies (DDRGs). These are radio sources which consist of a pair of double radio sources with a common center. Furthermore, the two lobes of the inner radio source have a clearly extended, edge-brightened radio morphology. Together with C.R. Kaiser (ITP Oxford, now MPA Munich), Schoenmakers and

Röttgering have developed a model for the origin and evolution of the inner radio structure, which can explain the observed properties of these sources. The model assumes that the inner radio lobes develop inside the 'cocoons' which are blown up in by the radio jet in an earlier phase of activity. The density inside such cocoons has formerly been considered too low to allow the formation of a radio lobe, since it mainly consists of shocked jet material which is believed to consist of light particles only (electrons/positrons). However, it was shown that clouds present in the ambient medium are able to survive the passage of the bowshock surrounding the cocoon, and penetrate into the cocoon region. There, the clouds will be slowly (typical timescale 10^7 yr) shredded and hence contaminate the cocoon. This will significantly increase the density of the cocoon material. If the jet formation process in the AGN is then temporarily halted, the cocoon material can act as a working surface to halt the restarted jet and allow the formation of a new hotspot and radio lobe. In normal radio sources, these clouds might cause the alignment between the radio axis and extended optical/UV emission often seen in powerful radio galaxies at $z > 0.6$.

Space-VLBI Observations of GHz Peaked-Spectrum Radio Sources

For his thesis, Tschager is studying samples of compact radio using radio data with a range of angular resolution, limiting flux density and observing frequency. As a part of this programme, Tschager, Schilizzi, Snellen (IoA Cambridge), Röttgering, Miley, van Langevelde (JIVE, Dwingeloo), Fanti C. and Fanti R. (both IRA, Bologna) were granted observing time within the VLBI Space Observatory Programme (VSOP) at 5 GHz and 1.6 GHz for a sample of 11 and 8 Ghz Peaked Spectrum (GPS) sources, respectively. The VSOP observation are combined with ground-based matched-beam images at 15 GHz and 5 GHz, respectively.

So far, Tschager has analysed VSOP and global VLBI data at 5 GHz and VLBA + Effelsberg data at 15 GHz for 2021+614. By identifying the core as being between two bright hotspots, Tschager showed that 2021+614 is a compact symmetric object of size $\sim$ 40 pc. From comparison with observations at earlier epochs from the literature Tschager deduced an apparent age of $\gtrsim$ 450 yr for 2021+614. This provides additional support for the contention that compact symmetric radio objects associated with galaxies are in fact young radio sources and the possible precursors of the classical FR1 or FR2 radio galaxies.

A New Sample of Faint Compact Steep-Spectrum Radio Sources

Compact Steep Spectrum (CSS) sources are thought to form an intermediate evolutionary stage between the young ($\sim 10^{3-4}$ yr) GHz Peaked-Spectrum (GPS) sources and the old (10^{7-8} yr), double-lobed FR1/FR2 radio sources. Our interests are pointing toward a deeper understanding of the early stages of radio-source evolution.

Using the three new, major radio surveys (WENSS, NVSS, FIRST) Tschager, Schilizzi, Röttgering, Snellen (IoA, Cambridge) and Miley constructed for the first time a sample of faint CSS sources. A working sample of 99 sources of this new CSS sample is currently studied in detail in the optical and in the radio: 8.4-GHz observations have been carried out in August 1998 using the VLA in B configuration. The angular resolution of these snapshot observations is $\sim 0.7''$, which gives a first indication of the morphologies of the sources.

Gas Dynamics of the Central Region of 3C 48

Chatzichristou and Jaffe are investigating the gas dynamics of the central region of 3C 48. Her CHFT spectroscopy showed strong interaction between the radio jet and gas clouds in the nuclear region. HST/STIS observation time has been received to follow this up at higher resolution.

Extremely Red Objects – Young and Starbursting Galaxies ?

Near-infrared surveys have revealed a substantial population of enigmatic faint galaxies with extremely red optical-to-near-infrared colors. It is important to understand their nature, since these galaxies are missed by the surveys that constrain the peak of the global star formation rate in the Universe to be around $z \sim 1 - 1.5$. There are two scenarios for these extreme colors: (i) these distant galaxies have formed virtually all their stars at very high redshifts and, due to the absence of recently formed stars, the colors are extremely red and (ii) these distant galaxies contain large amounts of dust, severely reddening the rest-frame UV–optical spectrum. Following up on the detection at 850μm using the new SCUBA submillimeter bolometer-array of HR10 ($z = 1.44$), Röttgering in collaboration with Cimatti (Arcetri), Andreani (Padova) and Tilanus (JAC, Hawaii) continued to use SCUBA to observe very red objects. The aim is to observe a complete sample of extremely red objects to address what fraction of the very red galaxy population are indeed starbursters.

Advection Dominated Accretion Onto Black Holes

Dullemond has continued his work on theoretical models of advection dominated accretion onto black holes. This is a rapidly developing field of research, aimed at explaining many observational phenomena of black hole Soft X-Ray Transients and other black hole candidates. An advection dominated accretion flow (ADAF) is a nearly spherical, extremely hot ($T_{ion} \simeq 10^{12}$K) and very tenuous ($\rho \ll 10^{-5}\,\mathrm{g\,cm^{-3}}$) magnetized plasma cloud accreting onto a black hole. The research focused on the question whether such hot plasma clouds can originate from an existing cool accretion disk by evaporation of its surface. The models have indicated that any mechanism for evaporation that involves electron conduction will strongly modify the electron temperature in the ADAF, thereby putting into question the simplified spectral models of ADAFs that are currently used to describe Soft X-ray Transient spectra.

2.10 Clusters of Galaxies and Cosmology

Kinematics of Galaxies in Clusters, Observations

With Biviano (Trieste, Italy) and Thomas, Katgert has studied the kinematics of different types of galaxies in clusters, as a follow-up to the earlier work of de Theije and Katgert. In addition to using a principal component decomposition of the ENACS spectra, a large number of CCD images was used to estimate galaxy types. Using this information together with data from the literature it has become possible to study the projected spatial distributions and projected velocity dispersion profiles of elliptical galaxies, lenticulars, early and late spirals and of galaxies with emission lines. Applying the Jeans equation, these data have been used to derive the radial dependence of the total mass within a given radius, assuming isotropic galaxy orbits for a composite clusters of more than 4000 galaxies in total. The resulting mass and density profiles derived with this assumption for elliptical galaxies, lenticulars, and early and late spirals are quite consistent, lending support to the assumption of isotropic orbits. However, for the galaxies with emission lines there is a clear suggestion that the assumption of isotropic orbits is not valid. Using the mass profile derived for all galaxies without emission lines, the anisotropy function $\beta(r)$ was derived for the galaxies with emission lines.

Kinematics of Galaxies in Clusters, models

In a parallel effort, Heyligers and Katgert continued their study of the kinematics of (galaxy-) particles in numerical simulations of clusters. It appears that the details of the kinematics do not depend very strongly on the cosmological parameters of the scenarios used (at least for the ranges of cosmological parameters probed). The kinematics, and in particular the orbital anisotropy, is studied for different subsets of the (galaxy-) particles, viz. those which have crossed the cluster core, and have spent a large fraction of their lives in the densest part of the cluster, and those who have not. It appears that this identification enables one to reproduce, at least qualitatively, the observed differences between galaxies with and without emission lines.

Cooling Flow Regions

With Bremer, now at Bristol, Jaffe has found evidence for optical line emitting gas up to 60 kpc away from the nuclei of the central galaxies in several cooling flow clusters of galaxies. Up to now, no such gas had been seen beyond about 10 kpc, in a region strongly influenced by the central AGN. Our data shows that the "reionization problem" of maintaining a large amount of gas at about 10,000 K exists throughout the cooling flow regions of these clusters. They are also continuing their earlier work of analyzing K-band IR spectra of the clusters which show substantial amounts of dense molecular gas at about 1500 K in the central regions of these flows.

Star Forming Galaxies at $z \sim 2.2$

Van der Werf, in collaboration with Moorwood and Cuby (ESO) and Oliva (Florence) used the new SOFI camera at the NTT to carry out a new, deep survey for emission line galaxies at $z \sim 2.2$, by searching for their Hα emission redshifted into the near-infrared K-band. The search technique consists of combining deep narrow-band imaging (in custom narrow-band filters that avoid the OH night sky emission) with shorter broad-band exposures; objects with excess narrow-band emission are emission-line galaxy candidates, with Hα at $z \sim 2.2$ as the most likely identification for the emission line. The survey was designed for depth, reaching in 6 hours (per field) higher sensitivity than the deepest survey so far (which was carried out with the Keck telescope), and covering a considerably larger area. The survey is also unique as the first blank-field survey of this type, i.e., it is not targeted at a particular "marker" object at a known redshift that would bring Hα into the narrow-band filter.

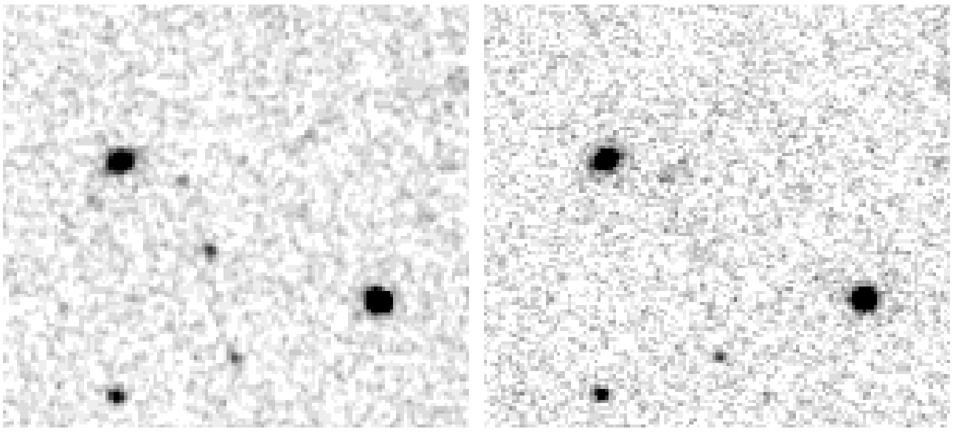

Figure 2.14: An emission-line candidate from the SOFI survey by van der Werf and collaborators; the object close to the center of the narrow-band $2.09\,\mu$m frame (left-hand panel) is not detected in the broad-band K_s frame (right-hand panel).

The survey resulted in 10 very good emission-line candidates (one of which is shown in Fig. 2.14), and another 10 additional, lower quality candidates. These results allow a first estimate of the star formation density at $z \sim 2.2$ based on Hα emission only, which can be directly compared with local Hα results and with other star formation tracers at $z \sim 2.2$.

Submillimetre Galaxies Lensed by Foreground Clusters

Van der Werf obtained the first spectacular results of a major project aimed at finding distant dusty starburst galaxies using the SCUBA instrument on the JCMT. The survey is targeted at gravitationally lensing clusters, which provide an amplification of a factor 2–3, which is just sufficient to make surveys of this type possible in reasonable integration times. A pilot project targeting the cluster A2218 was very succesfull: four submillimetre galaxies were detected, of which only 2 have optical counterparts in deep HST imaging (to $R \sim 26$). The remaining 2 sources could be very distant or extremely obscured. Remarkably, the spectacular optical arcs and arclets in A2218 are not detected at all, showing that optical and submillimetre surveys for star forming galaxies select totally different populations. This result has profound implications for the (optically-derived) star formation history of the universe. Following this extremely encouraging pilot project, a major project was started which is aimed at obtaining deep SCUBA images of equatorially located gravitationally lensing clusters, suitably located for follow-up with the VLT.

Clustering Around High-z Radio Galaxies

Venemans in collaboration with Röttgering, Miley, Pentericci and Carilli (NRAO, Socorro) analyzed very deep multi color imaging data taken with the NTT (ESO) and WHT (La Palma). The fields were centered around radio galaxies with very high rotation measures, indicating that they might be situated in very distant clusters. A significant number of cluster candidates were detected for which VLT observing time was awarded to determine their redshift.

3 Education, Popularization and Social Events

3.1 General Educational Matters

Faculty Rules and Regulations

A final draft of the new Faculty Rules and Regulations (a consequence of the law "Wet Universitaire Bestuurshervorming") appeared in May 1998, but the rules were already effective from September 1997. One aspect is a change in the management of education. The "Director of Education" is formally responsible for the entire teaching program. A "Committee for Education", consisting of staff and students, provides checks and balances.

In the last two decades the number of educational tasks and the associated administration has grown significantly. Therefore, some of the Director's tasks are delegated to other staff members, often members of the Committee for Education.

In 1998 Prof. van Schooneveld acted as Director of Education and Prof. Franx as Chairman of the Committee. In December 1998 van Schooneveld reached the age of 65; his successor is Prof. Burton.

Many tasks of the Director and his delegates were executed as part of the day-to-day work. Examples are counseling to junior and senior students, the binding judgment of first year students (BSA), maintenance of the curriculum, preparation of next year's teaching roster, the attendance at meetings on university, faculty and departmental levels and the connected paperwork.

The optional courses given in 1998 were Active Galaxies, Evolution of Stars, VLBI, Cosmochemistry, Interstellar Matter, Cosmic Dust, and the Inter academic Course this year held in Utrecht.

Five Years' Curriculum; "Beta Convenant"

In September 1996 the Astronomy Department as well as the Physics Department, replaced the then existing 4 years curriculum with a new one that takes 5 years. The new program is identical to the old one but is spread over 5 years. Arguments were given in the 1996 annual report. Student allowances in the fifth year are provided by the University on a provisional basis since it was foreseen that eventually the Ministry of Education would take care of that burden.

The new curriculum was finalized in the spring of 1997 and was first published in the Studiegids 1997/98. Experience obtained until today (first, second and third year) is positive.

In June 1998 a gentleman's agreement ("Beta Convenant") was reached between the Dutch universities (VSNU) and the Ministry. The agreement covers the Faculties of Natural Sciences, Mathematics and Computer Sciences with the exception, surprisingly, of Biology. The Ministry provides student allowances in the fifth year (in addition to those in the preceding years) under a number of conditions.

Towards the end of the study every curriculum in the Faculty, including Astronomy, must be divided in 3 specialities:

- A research speciality (the traditional curriculum)
- A "management" speciality (a new curriculum)
- An "educational" speciality (a.o. the traditional training of physics teachers)

Further, efforts must be made to ease the transition from school to university to increase the pass rate in the first year, and to recruit more female students.

Early in 1999 proposals are expected from all universities, explaining how these conditions will be met.

Much time was spent within the Faculty discussing the Management Specialism. It was decided that the "professional" branch will be realized on the Faculty level and will accept students from all departments. It will be a management training aimed at future positions in science related organizations ("Beta management").

3.2 Degrees Awarded in 1998

Master's Degrees ("doctoraal diploma's") in 1998

In 1998 9 (nine) students passed the final examination for the doc in Astronomy. They are:

Date	Name
27-01	M.H. Storm
30-06	H.W. Melief
25-08	J.D. Kurk
25-08	Mw. C. Ponsioen
25-08	W.H.T. Vlemmings
29-09	R. Cornelisse
24-11	Mw. J.M.T. vd Heijden
15-12	B.M.R. Heijligers
15-12	A.P. Hulsbosch

Ph.D. Theses in 1998

Date	Name (thesis advisor)	Title
10–06	M.R. Hogerheijde (van Dishoeck/Blake)	The Molecular Environment of Low-Mass Protostars
02–09	A. Li (van Dishoeck/Greenberg)	Theoretical Studies of Interstellar Dust with Applications to Comets

These Ph.D. Theses are also listed in Appendix **X**.

3.3 Courses and Teaching Activities

Astronomy Kaleidoscope

Freshman students were introduced to current research projects by Observatory and Physics personnel in a series of lectures that were held in March and May. Three lectures in astronomy were given:

Date	Speaker	Title
06-03	Dr. H.J.A. Röttgering	Hubble telescoop waarnemingen van verst weggelegen radio bronnen: de geboortegolf van massieve melkwegstelsels
13-03	Dr. P. Katgert	Vorming van structuur in het uitdijende heelal
03-04	Prof. Dr. E.F. van Dishoeck	Nieuwe waarnemingen van de kraamkamers van sterren en planeten

Regular Courses by the Observatory Staff

Compulsory Courses (Verplichte Vakken)

Name	Title	Semester
V. Icke	Inleiding Astrofysica	1
A.M. van Genderen	Sterrenkundig Practicum 1	2
H.J. Habing	Elementaire Sterrenkunde	3
P. Katgert	Sterrenkundig Practicum 2	4
W.B. Burton	Spreekbeurt 1	4
R.S. le Poole	Sterren	5
R.S. le Poole	Spreekbeurt 2	5
C. van Schooneveld	Astronomische Waarneemtechnieken 1 + Ruis	5
P. van der Werf	Astronomische Waarneemtechnieken 2	5
E.F. van Dishoek	Stralingsprocessen	5
W.B. Burton	Studenten Colloqium	8/10

Normal Selected Courses (Regelmatige Keuzevakken)

Name	Title	Semester
W. Jaffe	Aktieve Sterrenstelsels	7 and 9
J. Lub	Sterevolutie	7 and 9
W.B. Burton	Interstellaire Materie	8 and 10

Incidental Selected Courses (Incidentele Keuzevakken)

Name	Title	Semester
R.T. Schilizzi	VLBI	7 and 9
J.M. Greenberg	Cosmic Dust	8 and 10
various	Inter Academiaal College	7 and 9

We refer to the Faculty Education Guides and rosters for 97/98 and for 98/99, "Mathematics and Natural Sciences", for a complete listing of the undergraduate curriculum.

HOVO Course "Sterrenkunde"

In the framework of academic courses for the Elderly - HOVO: Hoger Onderwijs voor Ouderen - organized by the University, Prof. Dr. A. Ollongren (member of the organizing committee) gave for the second time an introductory Astronomy course for a group of 40 participants. A booklet was produced containing the lectures.

3.4 Popularization and Media Contacts

General

The Outreach Committee (Commissie Publiekscontact, CP) consisted of the following members:

Name	Function
Icke (chair)	Media contacts, National Science Day
Israël	Newspaper contacts, museum liaison
Van Genderen	Liaison Leiden amateur groups, including Werkgroep Leidse Sterrewacht
De Bruijne & De Koff	Telephone info, Incoming mail
Dispuut 'F. Kaiser'	Old Observatory visitors

During the year, De Koff retired on parental leave. Hoogerwerf took up some of the work, but a successor did not appear until 1999.

Although outreach is a crucial activity for the Sterrewacht, it relies on the personal goodwill and initiative of the Observatory members. It is therefore good news that the funding of the *toponderzoekschool* NOVA includes a modest amount for outreach. Much is expected of this initiative in 1999.

Popular Lectures and Interviews

Below are listed most of the popular lectures, interviews and some newspaper contributions by members of the Sterrewacht in 1998.

J.H.J. de Bruijne:

"De resultaten van de Hipparcos satelliet" (Leidse Weer- en Sterrenkundige Kring (LWSK; NVWS), woensdag 25 februari 1998)
"Een diamantster" (Tijd voor 2, Radio 2 [KRO], Frits Spits, maandag 18 mei 1998)
"Spanning" (Scholierenmanifestatie wetenschap- en techniekweek, 6, 7, 8, 15 oktober 1998)

Amina Helmi:

"Gegrepen door het heelal" (IQ, March 1)
ZAPP (Stichting FNV Pers, June 1)
"Uitreiking Amelia Earhart Award: Galaxy Formation: From the present to the past" (Utrecht, February 14)

Hoogerwerf:

"Spanning" (Scholierenmanifestatie wetenschap- en techniekweek, 6, 7, 8, 15 oktober 1998)
"Top Onderzoek Scholen" (Twee voor elkaar (EO), november 13)

Vincent Icke:

"De wiskunde van zwarte gaten" (Nationale Wiskunde Dagen, Noordwijk, 30-01-98)
"De geologie van de Oerknal" (Ned.ver.Geofysica, Naturalis, 07-02-98)
"Toepassingen van de Algemene Relativiteitstheorie" (Masterclass, UvA, 13-02-98)
"Zwarte gaten" (Masterclass, UL, 14-02-98 en 21-02-98)
"Tijd in de natuurkunde" (Rotary Club, Leiden, 18-02-98)
"Alle fysica is astrofysica" (OMO Docentencursus, Amsterdam, 19-02-98)
"De astronomische context van de mens" (Humanistisch Verbond, Groningen, 08-03-98)
"Astrofysica van zwarte gaten" (Masterclass, UvA, 09-03-98 en 10-03-98)
"Interview" (radio Maximaal, Middelburg, 23-03-98)
"De mens in het Heelal" (Humanistisch Verbond, Middelburg, 24-03-98)
"Laat anderen stuurlui aan de wal blijven" (VSNU, Amersfoort, 08-04-98)
"Veertig stappen in het Heelal" (Comeniusleergang, Den Bosch, 23-04-98)
"De kracht van symmetrie" (Studium Generale, Amsterdam, 28-04-98)
"Een sterrenkundige boterham" (Rotary Club, Leiden, 11-05-98)
"Kunst en sterrenkunde" (Stichting Tengel, Zaandam, 12-05-98)
"Over TGV en OCW" (Afscheidsdiner Minster Ritzen, 17-06-98)
"Veertig stappen in het Heelal" (Comeniusleergang, Den Bosch, 25-06-98)
"Zwarte gaten" (TU Delft, 02-07-98)
"Nep-wetenschap" (Scholierendagen UL, 06/07-10-98)
"Kosmologie" (Studium generale, TU Twente, 13-10-98)
"De dood van Zon-achtige sterren" (Studium generale, Groningen, 14-10-98)
"Sturing van de wetenschap" (Staring Symposium, Leiden, 15-10-98)
"Het imago van de wetenschappen" (Lerarencursus, UvA, 16-10-98)
"Wat doet de sterrenkundige?" (Wartburg College, Gorlaeus Lab, 22-10-98)
"Alle fysica is astrofysica" (ANW Docentencursus, Amsterdam, 05-11-98)
"Veertig stappen in het Heelal" (Freia Facta, Groningen, 13-11-98)
"Alle fysica is astrofysica" (ANW Docentencursus, Amsterdam, 25-11-98)
"De lange arm van de Leidse sterrenkunde" (Cleveringa Lezing, Rotterdam, 26-11-98)
"Veertig stappen in het Heelal" (Comeniusleergang, Drunen, 03-12-98)
"De mens in het Heelal" (Humanistisch Verbond, Groningen, 13-12-98)
"Uitkijken in de ruimte" (Stedelijk Gymnasium, Gorlaeus Lab, 16-12-98)

Israel:

“Waarom Bemande Ruimtevaart?” (VARA tv-programma ‘Barend en Witteman’, April 23)
“Sterren boven het IJs” (dagblad Trouw, November 4)
“Kosmische Straling” (theatergroep ‘The Lunatics’, November 12)
“Leoniden” (radio Noordwijk, November 17)
“Leven buiten de Aarde” (PAC Symposium ’98 ‘Chemie Leeft’, Leiden March 6)
“Ontstaan van Sterren en Planeten” (Vrije School Den Haag, NSE Noordwijk, October 9)
“Buitenaards Leven” (Artis Planetarium, Amsterdam, November 16)
“Planetoïden” (Studievereniging Leonardo da Vinci, Delft, November 25)
“Vooruitzichten op Leven in het Zonnestelsel” (Leidse Biologen Club, Leiden, November 27)
“Het ontstaan van het Heelal” (Dispuut Prometheus, Leiden, December 9)

Miley:

"The alpha, beta and gamma of astronomy" (February 9, Diesrede, Lecture delivered in the Pieterskerk on the occasion of the 423rd anniversary of the founding of the University of Leiden)

A. Ollongren:

"Eigenaardige boodschappen voor buitenaards gebruik - informatische en astronomische aspecten" (NVWS, Afd. Den Haag, 20-2-98)
"Eigenaardige boodschappen voor buitenaards gebruik - communicatie met buitenaardse intelligentie" (NVWS, Afd. Appingedam, 1-12-98)

Perryman:

“Nuestra Galaxia Vista en Tres Dimensiones” (Madrid Planetarium, Spain, May 25)
“A New Angle on the Universe” (Invited Popular Lecture, British Association for the Advancement of Science, Cardiff (UK), September 8)

Veen:

“Heet, snel en stoffig: de Wolf-Rayet sterrewind” (AWSV “Metius”, Alkmaar, 23 April)

3.5 The Leidsch Astronomisch Dispuut ‘F. Kaiser’

The *Leidsch Astronomisch Dispuut ‘F. Kaiser’* is an association founded by five astronomy students on March, 1^{st}, 1993. Its major goal is to improve the contact between undergraduate students and the Observatory. The association is named after the founder of the Old Observatory, Frederik Kaiser. His birthday and dying day are commemorated every five years. The activities are open to all astronomers and astronomy students.

The current board, consisting of Maurits Hartendorp, Guido Kosters, Roderik Overzier, Jasper Arts and Uri Shimron, tries to prolongate the success of the previous years. The main activities are *studentenlezingen*, *studententhee*, *instruction courses at the Old Observatory* and the famous *Sterrewachtbarbecue*. The association also contributes to the popularization of astronomy by giving tours at the Old Observatory.

Every last Friday of the month a Sterrewacht Borrel is organized, for students and staff to meet informally.

Since 1994 tours at the Old Observatory are given for first and second year undergraduate students in order to make them aware of the rich history of astronomy in Leiden. Other activities for this group of students to make them feel at home at the Observatory, include borrels and lectures by senior students.

The Birth of Frederik Kaiser, 190 years ago, was commemorated on the 10th of June by unveiling a plaquette in the Common room, now renamed the Kaiser Lounge.

Each year an exuberant *dispuutseten* is organized just for members, this year at an astronomically apt location, viz. *de Grote Beer*. The fifth anniversary of the association was celebrated a whole week long, which included a free borrel, cookies and a great anniversary party at *Einstein* where, despite the terrible weather, many old and current Kaiser members met each other and had a great time.

Current information about the Association, its activities and plans for the future is available on the internet at `http://www.strw.leidenuniv.nl/~kaiser`.

Studentenlezingen

Date	Speaker (affiliation)	Title
February 4	Prof. Dr. W. de Graaff (Nederlandse Vereniging tot Wetenschappelijk Onderzoek naar de Astrologie)	*Astrologie: wetenschap of bedrog*
March 17	Dhr. Scheele (Koninklijk Instituut voor de marine)	*Klassieke en moderne navigatiemethoden*

Tours Old Observatory

For the popularization of astronomy, for which there is a broad interest, the *Leidsch Astronomisch Dispuut 'F. Kaiser'* is happy to organize tours at the Old Observatory, located in the historical center of Leiden. To honor the glorious past of the oldest academic observatory in the world, the association shows the participants the four historical telescopes, which belonged to the Institute. If requested, it also provides a lecture on an astronomical subject before visiting the instruments.

Date	Group	Speaker
January 23	Children's birthday party	Maurits Hartendorp
January 27	Vereniging voor vrouwen met academische opleiding	Jaron Kurk
February 16	Ex-dispuutsleden uit Utrecht	Maurits Hartendorp
February 24	Gepensioneerden van de belastingdienst	Annemieke Boonman
March 23	Kids	Guido Kosters
March 30	Catena	Sebastiaan v.d. Laan
September 19	Small Group	no lecture
October 8	Small Group	no lecture
October 29	Lions, Alphen a.d. Rijn	Maurits Hartendorp
November 6	Small Group	no lecture
December 6	Prometheus	Guido Kosters
December 8	ING	no lecture

Studententhee (Student's Tea)

Occasionally, the *Leidsch Astronomisch Dispuut "F. Kaiser"* organizes a *studententhee*, a more official version of the daily tea break, mainly visited by senior students. Regularly a lecture is held by one of the students, often about their student project. This year the lectures were organized by Annemieke Boonman.

Date	Speaker	Title
February 2	Wouter Vlemmings	*Intrinsic Shapes of Elliptical Galaxies*
March 30	Frodo Wesseling	*NGC 1052*
April 22	Tom Voskes	*The Structure of the outer-Galaxy HI-layer*

3.6 Social Committee

The aim of the social committee (founded October 1996), is to organize, and encourage others to organize, social, non–scientific activities for all members of the Observatory. In doing so, the committee cooperates with the association of undergraduate students, L.A.D. F. Kaiser.

The members of the social committee in 1998 were:

Name	Function
S.R.R. van der Laan	chairman
M. Reuland	treasurer, contact undergraduate students
Y.J.W. Simis	secretary, contact graduate students
J.R. Soulsby–Pitts	contact supporting staff
C. Dominik	contact postdoctoral fellows and guests
G.K. Miley	contact scientific staff and management team
R.S. le Poole	contact scientific staff and management team

In 1998, the committee organized the following activities:

Date	Activity
13 March	Ice–Skating, de Uithof, den Haag
28 May	Bowling
9 September	Sterrewachtdag: cycling tour to Meijendel
16 November	Borrel: Anniversary Leiden Observatory (founded 1633)
11 December	Ice–Skating, de Uithof, den Haag
18 December	Christmas borrel
18 December	Bowling

The social committee has initiated a system for the maintenance of the common room or Kaiser Lounge. On a voluntary basis and for the duration of one month, one person (from student to staff) takes care of room 555.

The host system for newcomers was continued. The Observatory tour was updated for the Oort building by F. van der Tak.

4 Facilities

4.1 Operating Budget

Table 4.1: **Status of the Observatory's operating budget in 1998**

	Debit	**Credit**
1998 Opening balance		fl. 607
1998 Budget		721.200
Director's Budget	98.792	
Ethernet JHO Building	30.000	
Subsidy CVB Oortroom		30.000
Idem LUF/Kruytbosch legaat		25.000
LSF Subsidy Meade Telescope		13.000
Library costs : journals	56.714	
Library costs : binding backlog	4.649	
Library costs : books	16.767	
Publications	21.984	
Ph.D. Theses	3.114	
Technical work	1.533	
Photographic work	7.561	
Reproduction	20.673	
Photocopying	16.883	
Secretariate and Office supplies	27.432	
Telephone costs 4)	1.275	
Postage/Freight	9.894	
Travel costs	72.584	
Guests	27.650	
Computing facilities	275.717	
Contribution to EARA	5.419	
Contribution to KSW	25.000	
Contribution to La Palma	15.498	
Contribution to LOL	25.000	
Contribution to LSF	64.000	
Mainframe computing	16.845	
Social Activities	474	
Matching EU HCM	59.000	
1998 Closing balance	fl. 114.588	

The Observatory's accounts were supervised by Dr. J. Lub with assistance from the newly assigned account manager Mrs. M. van der Poel and financial officer Mr. H. van den Berg. Table 4.1 gives the financial situation at the end of 1998.

Equipping the new Jan Hendrik Oort Building imposed a burden on the Observatory's budget. In 1998 the cost for the equipment of the so called 'Oort Room' was largely covered by a subsidy from the Universitity and from the Leids Universiteits Fonds, largely from the so called 'Kruytbosch Legaat'. Both contributions are gratefully acknowledged. Additional expenses included a fl. 60.000,– contribution to a fast datanet for the Oort Building, to be paid in two instalments of fl. 30.000,– .

Dr. R. Klessen who accepted a postdoc position in the fall of 1998 was provided with a so called Grape-card and other special computing equipment. Together with a replacement program of ageing servers and other computer hardware, which was partially paid out of a reservation made from the 1997 balance, this placed a heavy burden on the computer budget.

A final few further remarks on the budget are in order:

1. The operating budget for 1998 was somewhat lower than in the previous years, due to long-term agreements made with the Faculty in order to appoint new staff.

2. Together with the move of the library to the Gorlaeus Laboratories there was an additional outlay to cover the binding backlog. New books had not been sufficiently acquired over the last few years. The large increase in subscription rates is especially worrying.

3. The actual spending on computers and software packages (such as for example IDL) is still slightly larger than foreseen because of matching contributions from NWO-grants, ASTRON projects, TMR networkgrants and EU scholarships.

4. Because of the above mentioned problem with the financial services, a final statement of the telephone bill had not been provided at the time of writing. The Observatory was only informed that it will be charged later following an indication based upon previous usage.

5. Under the heading "Postage/Freight" is the cost of all postal services outside the centrally provided budget with the Faculty. It reflects a large increase in the use of courier services.

4.2 Astronomical Computing

In 1998, several members of the Computer Advisory Committee rotated off the committee. Care was taken to ensure that the composition of the Committee continues to reflect the large variety in the community of computer users, both as regards employment status (postdocs, Ph.D. students, permanent staff, secretarial staff etc.) and as regards the various research interests, and computer needs. In that way the Committee is best able to obtain comments, suggestions, criticism etc. of the user community, not only formally but also through 'inside knowledge' of its members.

The addition and replacement of the computer hardware continued, both for PCs running LINUX and UNIX workstations. First, about ten PC's were bought and those are used with Linux. The present-day PC's are sufficiently powerful that the major astronomical data reduction packages can be run locally on the PC, while large local disks are also becoming more affordable. This development (which started several years ago) means that to some extent we are moving away from the group concept, in which several users with similar interests share a cpu and one or more large disks, using several terminals. However, we have not gone all the way in this direction, as several of the groups (in particular the larger ones) still use powerful workstations.

This is also evident from the second important element in the strengthening of the hardware infrastructure in 1998, which has been the acquisition of 4 powerful Ultrasparc workstations. Some of these are used in groups (especially those which have very good I/O performance), but one of them is a two-processor machine that replaces the top-of-the-line number cruncher that is available to all users for specially demanding applications. Its predecessor was moved to replace the server which connects the Observatory network to the outside world. Special GRAPE hardware was bought that, when installed in an existing Ultrasparc, will allow very efficient use for very demanding numerical simulations.

Finally, several smaller peripherals were acquired, as well as some software.

Appendix I Sterrewacht Staff on 31-12-98

Hoogleraren

Prof.dr. W.B. Burton	Prof.dr. H.J. Habing
Prof.dr. E.F. van Dishoeck	Prof.dr. G.K. Miley
Prof.dr. M. Franx	Prof.dr. P.T. de Zeeuw

Buitengewoon Hoogleraar

Prof. Ir. C. van Schooneveld

Bijzondere Hoogleraren

Prof.dr. R.T. Schilizzi (JIVE, voor het J.H. Oort Fonds)
Prof.dr. V. Icke (RUL, Beta Plus Foundation, aan de Universiteit van Amsterdam)
Prof.dr. M.A.C. Perryman (ESTEC, voor het Leids Universiteits Fonds)
Prof.dr. R.P.W. Visser (UU, Teyler's Hoogleraar)

Universitaire Hoofddocenten en Docenten

Dr. F. Baas	Dr. J. Lub
Dr. A.M. van Genderen	Dr. J. Luu
Prof.dr. V. Icke	Drs. R.S. le Poole
Dr. F.P. Israel	Dr. H.J.A. Röttgering
Dr. W. Jaffe	Dr. W.A. Schutte
Dr. P. Katgert	Dr. P.P. van der Werf

Andere leden van de Wetenschappelijke Staf, Postdocs en Gastonderzoekers

Dr. P.N. Best	Postdoc (EC)
Drs. M.J. Betlem	Gastmedewerker
Dr. J.B.G.M. Bloemen	Gastmedewerker (SRON)
Dr. M. Bureau	Postdoc (NWO/ASTRON)
Dr. C. Dominik	Postdoc (EC/NWO)
Dr. P. Foing-Ehrenfreund	Postdoctoral Fellow (EC/Oostenrijk)
Dr. J.K. Katgert-Merkelijn	Gastmedewerker (Oort Archief/Astronomy &Astrophysics)
Dr. R.S. Klessen	Postdoc (RUL)
Dr. B. Miller	Postdoc (NWO/ASTRON)
Prof. dr. E. Nezhinsky	Gastmedewerker
Dr. R. Pereira Ortiz	Postdoc (Brazilië)
Dr. P.P. Papadopoulos	Postdoc (EC/TMR)
Dr. N. Robichon	Postdoc (EC)
Dr. J. Roland	Gastmedewerker (CNRS, Frankrijk)
Dr. I. Salamanca	Postdoc (EC)
Dr. P. Sonnentrucker	Gastmedewerker (ESTEC)
Dr. J. Tinbergen	Gastmedewerker (Roden)
Dr. W. Verschueren	Gastmedewerker (Antwerpen, België)
Dr. H.S. Zhao	Postdoc (RUL)

Emeriti

Prof. dr. A. Blaauw	Emeritus Hoogleraar
Dr. L.L.E. Braes	Emeritus Docent
Prof. dr. J.M. Greenberg	Emeritus Hoogleraar
Dr. M.S. de Groot	Gastmedewerker
Dr. I. van Houten-Groeneveld	Gastmedewerker
Dr. C.J. van Houten	Gastmedewerker
Prof. dr. H.C. van de Hulst	Emeritus Hoogleraar
Dr. K.K. Kwee	Gastmedewerker
Prof. dr. A. Ollongren	Emeritus Hoogleraar

Doctorandi (AiO, OiO, Beurspromovendi)

Drs. A. Boonman	Onderzoeker in Opleiding
Drs. J. de Bruijne	Assistent in Opleiding
Drs. M.R. Cioni	Assistent in Opleiding
Drs. V. de Heij	Assistent in Opleiding
Drs. A. Helmi	Assistent in Opleiding
Drs. M. Haverkorn	Onderzoeker in Opleiding
Drs. R. Hoogerwerf	Onderzoeker in Opleiding
Drs. J. Kurk	Assistent in Opleiding
Drs. R. van der Meulen	Onderzoeker in Opleiding
Drs. G. MunozCaro	Beurspromovendus (Max Planck)
Drs. L. Pentericci	Assistent in Opleiding
Drs. Y. Simis	Assistent in Opleiding
Drs. F.S.S. van der Tak	Onderzoeker in Opleiding
Drs. W.F.D. Thi	Assistent in Opleiding
Drs. T. Thomas	Assistent in Opleiding
Drs. W. Tschager	Beurspromovendus
Drs. M. Tuemmers	Assistent in Opleiding
Drs. W. Vlemmings	Onderzoeker in Opleiding
Drs. A.A. Wielders	Assistent in Opleiding
Drs. G. van Zadelhoff	Assistent in Opleiding

Drs. C. De Breuck	Gastmedewerker (Livermore)
Drs. E. Chatzichristou	Gastmedewerker
Drs. N. Cretton	Gastmedewerker
Drs. P.G. van Dokkum	Gastmedewerker (RUG)
Drs. C. Dullemond	Gastmedewerker
Drs. F. Favata	Gastmedewerker (ESTEC)
Drs. S. de Koff	Gastmedewerker
A. Holl	Gastmedewerker (Hongarije)
Drs. R. Rengelink	Gastmedewerker (ESO)
Drs. A.P. Schoenmakers	Gastmedewerker (Utrecht)
Drs. J.M. Stil	Gastmedewerker
Drs. P.M. Veen	Gastmedewerker
Drs. G. Verdoes Kleijn	Gastmedewerker (STScI)

Technische Staf

A.J. van der Helm	Electronicus (Dwingeloo)

Technische Staf in dienst bij ASTRON (op declaratiebasis)

A.P.M. de Jong	Senior Instrumentmaker
A.A. Schoenmaker	Optisch Ontwerper (Dwingeloo)
R.J. Pit	Telescooptechnicus/Electronicus (La Palma)

Programmeur Staf

Dr. E.R. Deul	Senior Project Medewerker
A. Vos	Programmeur
Dr. D. J. Jansen	Wetenschappelijk Programmeur
M. Feleus	Programmeur (0.5)

Technisch en Administratief Personeel

H.A. Versteege-Hensel	Adm. medewerker (ASTRON)
K. Weerstra	Adm. ambtenaar (ASTRON)

Secretariële Staf

J.G.C. Slegtenhorst	Secretaresse
J.R. Soulsby-Pitts	Secretaresse
M. Zaal	Secretaresse

Astronomy & Astrophysics Office

Prof. H.J. Habing	Editor
Dr. J.K. Katgert-Merkelijn	Assistant Editor
B. Smit	Secretaresse
M. Wisse-Schouten	Assistente
S. van der Laan	Assistent

Seniore Studenten

J. Arts
W. Claus (Gent)
B. van Dam
M. Feleus
J. Gerritsen
M. Hartendorp
Drs. G. van den Heuvel
R. den Hollander
O. Janssen
M. Kamerbeek
T. van de Kamp
O. Kerkhof
M. Kloppenburg
G. Kosters
S. van der Laan
I. Labbé
A. van der Meer
M. van Mil
J. Novozamsky
D. Pronk
W. van Reeven
M. Reuland
U. Shimron
K. Steenbrugge
M. Storm
B. Venemans
S. Veijgen
E. Verolme
T. Voskes
F. Wesseling

Staf Mutaties en Bezoekers in 1998

Naam (Locale Financier):	start :	eind :
Staf		
Drs. A. Boonman (SRON)	01-01-98	
Dr. M. Bureau (NWO)	01-1-98	
Drs. N. Cretton (RUL)		01-01-98
Drs. C.P. Dullemond (RUL)		30-09-98
M. Feleus (RUL)	01-12-98	
Prof. dr. M. Franx (RUL)	01-03-98	
Drs. M. Haverkorn (ASTRON)	01-07-98	
Dr. R.S. Klessen (RUL)	01-09-98	
Drs. J. Kurk (RUL)	01-10-98	
Dr. M.D. Lehnert (RUL)		30-09-98
Dr. A. Li (RUL)		30-09-98
Dr. J. Luu (RUL)	01-10-98	
Drs. G. MunozCaro (MaxPlanck)	01-11-98	
Dr. P.P. Papadopoulos (EU/TMR)	01-09-98	
Dr. R. Pereira Ortiz (Brazil)	01-02-98	
Dr. N.R. Robichon (EU)	01-05-98	
Dr. H.J.A. Röttgering (NWO)		31-08-98
idem (RUL)	01-09-98	
Dr. W.A. Schutte (ASTRON)		31-08-98
idem (RUL)	01-09-98	
Dr. I. Salamanca (EU)	01-08-98	
Drs. W.F.D. Thi (RUL)	01-10-98	
Drs. W. Tschager (RUL)	10-01-98	
Drs. P.M. Veen (RUL)		21-02-98
Drs. W. Vlemmings (ASTRON)	01-09-98	
Dr. C. Wright (ASTRON)		30-09-98
Bezoekers		
Drs. P.G. van Dokkum (RUG)	01-04-98	
Prof. dr. J. Mould (J.H. Oort Fonds)	27-04-98	31-05-98

Appendix II Committee Membership

STERREWACHT COMMISSIES

Sterrewachtdirectie

G.K. Miley (directeur)
J. Lub (secretaris)
H.J. Habing (plaatsvervangend directeur)

Sterrewacht Management Team

G.K. Miley (voorzitter)
W.B. Burton (vanaf augustus)
M. Franx
H.J. Habing
Y. Slegtenhorst (notuliste tot augustus)
J. Lub
F.P. Israel
D. Jansen
N. van Wijngaarden (beheer)
J. Soulsby (notuliste vanaf augustus)

Onderzoekscommissie

V. Icke (voorzitter)
W.B. Burton
E.F. van Dishoeck
H.J. Habing (vice-voorzitter)
F.P. Israel
H.J.A. Röttgering

Opleidingscommissie Sterrenkunde

C. van Schooneveld (onderwijs directeur)
M. Franx (voorzitter)
A. Boonman
W.B. Burton
(seniore studentenbegeleider)
A.M. van Genderen
Mariska Kniele
F.P. Israel
(juniore studentenbegeleider)
Sebastiaan van der Laan
Arjen van der Meer
Glenn van de Ven
P.T. de Zeeuw

Examencommissie Sterrenkunde

C. van Schooneveld (voorzitter)
A.J. van Duyneveldt
F.P. Israel
G. Nienhuis
P.P. van der Werf
P.T. de Zeeuw

Bibliotheekcommissie

W. Jaffe (voorzitter)
A.M. van Genderen
L. Pentericci (secretaris)

Computercommissie

- P. Katgert (voorzitter)
- P. Best
- C. Dominik
- Y. Simis
- J. Soulsby
- G.K. Miley
- F. van der Tak
- P.P. van der Werf
- P.T. de Zeeuw

Computer Groep

- W. Jaffe (voorzitter)
- A. Vos
- M. Feleus
- E. Deul
- D. Jansen

Wetenschappelijke Raad Onderzoekinstituut

- V. Icke (voorzitter)
- F. Baas
- J.B.G.M. Bloemen
- E.F. van Dishoeck
- M. Franx
- A.M. van Genderen
- H.J. Habing
- W. Jaffe
- J. Lub (secretaris)
- J. Luu
- M.A.C. Perryman
- R.S. Le Poole
- H.J.A. Röttgering
- R.T. Schilizzi
- C. van Schooneveld
- R.P.W. Visser
- P.P. van der Werf
- P.T. de Zeeuw

Commissie Publiekscontact

- V. Icke (voorzitter)
- J. de Bruijne
- F.P. Israel
- S. de Koff

Commissie Begeleiding Promovendi

- W. Jaffe (voorzitter)
- H.J. Habing
- W. Boland (ASTRON)
- P.P. van der Werf

UNIVERSITAIRE COMMISSIES

W.B. Burton:	Lid, Gemeenschappelijke Opleidings Commissie Natuur- en Sterrenkunde
E.F. van Dishoeck:	Onderzoekscommissie Faculteit (WECO) Lid, Raad van Toezicht, Leiden Natuurkundig Instituut (LION)
M. Franx:	Lid, Gemeenschappelijke Opleidings Commissie Natuur- en Sterrenkunde
A.M. van Genderen:	Voorzitter Studiegidscommissie, Faculteit WN Lid, Afdelingscommissie Lid, Roostercommissie
V. Icke:	Lid, de 'Rector Magnificus' Onderwijs Advies Groep Lid, Mare Redactieraad
F.P. Israel:	Lid, Faculteitsraad Wiskunde en Natuurwetenschappen Lid, Gemeenschappelijke Opleidings Commissie Natuur- en Sterrenkunde
W.J. Jaffe:	Lid, Faculteit Millenium Coördinatie Commissie Lid van het Bestuur van het Centrum voor Wetenschappelijk Computing in Leiden Facultaire Bibliotheek Commissie Directeur Zomerschool Astrofysica Leiden-Dwingeloo
J. Lub:	Commissie Publiekscontact van de Afdeling SN Facultaire Biblotheek Commissie
G.K. Miley:	Lid, Overlegcommissie Wetenschappelijk Directeuren Faculteit W & N
C. van Schooneveld:	Opleidingscommissie Faculteit WN
Van der Werf:	Organist van het Groot Auditorium
P.T. de Zeeuw:	Lid, Steering Committee, Lorentz Center (Internationaal Centrum voor Astronomie, Wiskunde, en Natuurkunde Lid, Adviescommissie Lorentz Professor, Universiteit Leiden Lid, Adviescommissie Kloosterman Professor, Universiteit Leiden Lid van het Bestuur, Mathematische Instituut, Universiteit Leiden

Appendix III Science Policy Functions

W.B. Burton:	Chairman, Editorial Board, Astrophysics and Space Science Library, Kluwer Academic Publishers
	Director, Leids Kerkhoven–Bosscha Foundation
	Director, Jan Hendrik Oort Foundation
	Director, Leids Sterrewacht Foundation
	Chairman of Board, Expertisecentrum for Astronomical Image Processing
	Chairman, Appointment Advisory Committee, Oort Visiting Professorship
	Member, Supervisory Committee, Oort Adjunct Professor
	Member, Board of Curators, Adjunct Professorship in Cosmology, Beta Plus Foundation, University of Amsterdam
	Member, Appointment Advisory Committee, Leiden University Foundation Adjunct Professorship
J.H.J. de Bruijne:	Member of board (Leiden Observatory representative), Leidse Weer- en Sterrenkundige Kring (LWSK; NVWS)
E.R. Deul:	Member, DENIS project team
E.F. van Dishoeck:	Member, JCMT Board
	Secretary, IAU Working Group on Astrochemistry
	Member, Organising Committee of IAU Commission 34 on Interstellar Matter
	Chair, Working Group 5 on Molecular Data, IAU Commission 14
	Member, SRON Science Board
	Member, SRON/GOA proposal evaluation panel
	Member, LSA Science Advisory Committee
	Member, NRAO Advisory Committee for the Millimeter Array
	Member, ESA Astronomy Working Group
	Member, ESA–NGST Science Study Team
	Member, NASA–NGST Ad Hoc Science Working Group
	Member, FIRST–HIFI Science Advisory team
	Member, VLT–VISIR Science Advisory team
	Secretary, Scientific Organising Committee of IAU Symposium 197 "Astrochemistry: from molecular clouds to planetary systems"
	Member, U.K. Royal Society of Chemistry, Astrophysical Chemistry Committee
	Member, Scientific Advisory Board of New Astronomy
	Member of the Board, J.C. Kapteyn and Pastoor Schmeits Foundations
	Secretary, National Committee for Research on Interstellar Matter (LWG Interstellaire Materie)

P. Ehrenfreund:	Comité des utilisateurs de l'Observatoire Haute Provence Member, Working Group: "Composition and evolution of cometary grains in the coma" ISSI, International Science Institute, Bern, Switzerland Convener Session PS7, European Geophysical Society: "Laboratory studies and observations on dust, ices and organics in the Solar System" April 20–24, Nice, France Convener Session F3.1, 32nd COSPAR Scientific Assembly: "New Insights into complex organics in space", July 10–18, Nagoya, Japan Co-Convener, International Space Science Institute, ISSI "Cometary material: Composition and Origin" September 14–20, Bern, Switzerland
M. Franx:	Member, ESO Science and Technology Committee Chair, STC working group on LSA/MMA Member, ING visiting panel Member, ESO contact committee Member, Advanced Camera for Surveys Science Team Chair, Organising Committee for symposium in honour of Henk van de Hulst Member, NOVA Instrument Steering Committee
A.M. van Genderen:	Member, Secretary, Dutch Program Committee for the Dutch 90-cm telescope on La Silla, Chile Member, Indonesia/Netherlands Astrophysics Collaboration, as part of the Cultural Exchange between the two countries
H.J. Habing:	Member, Royal Academy of Sciences Chairman, Teylers Tweede Genootschap Member, Hollandse Maatschappij van Wetenschappen Member, Academia Europea Member, Academia Astronautica Member, Board Space Research Organisation of the Netherlands Chairman, Advisory Council about Astronomy to GB-E, NWO Chairman, National Committee for Astronomy Chairman, Kamer Sterrenkunde van de VSNU Chairman, Nederlandse Astronomen Club Vice-chairman, Science Team for ESA's Infrared Space Observatory Editor-in-Chief, "Astronomy and Astrophysics" Member, Committee for the preparations for the 425th anniversary of Leiden University Treasurer, Board of Trustees "Legatum Stolpianum" Member, "Committee for the J. Verlinden-award", Royal Academy of Sciences for Flemish Belgium Member, Committee for awarding the Livio Gratton Price (Rome, Italy)
V. Icke:	Member, National Committee on Astronomy Education Member, Minnaert Committee (NOVA Outreach) Member, Netherlands Astronomical Society Education Committee Member, 'Natuur & Techniek' Editorial Council Member, 'Ned. Tijdschr. Natuurkunde' Board of Editors

F.P. Israel:	Member, Noordwijk Space Expo Foundation (NSE) Exposition Committee Chairman, LOFAR Study Committee
W. Jaffe:	Member, IAU Commissions 37 and 48 Member, Dutch Panel for Telescope Time allocation Substitute Member, National Supercomputer Facility Advisory Committee Member, AIPS++ Technical Advisory Group
P. Katgert:	Secretary/Treasurer, Leids Sterrewacht Fonds Secretary/Treasurer, Jan Hendrik Oort Fonds Secretary/Treasurer, Leids Kerkhoven-Bosscha Fonds
J. Lub:	Member, ESO Contact Committee Substitute Member, ESO Observing Programs Committee (OPC) Director, Leids Sterrewacht Fonds Director, Leids Kerkhoven Bosscha Fonds Director, Jan Hendrik Oort Fonds Member, Dutch Programs Committee for the Dutch 90-cm telescope on La Silla, Chile Secretary, Nederlands Comité Astronomie Secretary, Kamer Sterrenkunde van de VSNU
J. Luu:	Associate Editor of Journal of Geophysical Research - Planets
G.K. Miley:	Member, ESO Visiting Committee Member, Dutch National Science Team, VISIR Member, Science Team, Advanced Camera for Surveys on the HST Member, NCA Member, Board of Stichting ASTRON Member, Board of NOVA Member, Board of EARA Member of the KNAW Leiden PI, EU TMR Programme: European Large Area ISO Survey (ELAIS) Leiden PI, EU TMR Programme: Formation and Evolution of Galaxies Chairman, Netherlands VLTI Team Representative, VLTI Tripartite Steering Committee Panel member, ESO Observing Programme Committee Cosmology Panel Member, International Astronomical Union Member, SOC ESO VLT Opening Symposium on Science in the VLT Era and Beyond
M. Perryman:	Chairman, NOVA Instrument Steering Committee Chairman, GAIA Science Advisory Group Scientific Committee, IAU Commission 33

Röttgering:	Member of Panel A ("Galaxies, Clusters of Galaxies and Cosmology") of the ESO programme committee
	Deputy coordinator of the European Association for Research in Astronomy (EARA)
	Member of the ESO Interferometry Science Advisory Committee (ISAC)
	Leiden coordinator of the EU programme "Training and Mobility of Researchers", "The Formation and Evolution of Galaxies"
	Member, ESO Imaging Survey Working Group
	Member, Dutch Joint Aperture Synthesis Team (DJAST)
	Member, Netherlands VLTI Team
	Member, Mid-Infrared interferometric instrument for VLTI (MIDI) working group
	Member, Science Advisory Group on ESA's InfraRed Space Interferometer DARWIN
	Member, LOFAR Study committee
	Member, panel of LUF Internationaal Studie Fonds (LISF)
	Member, Dutch National Science Team, VISIR
R.T. Schilizzi:	Director, Joint Institute for VLBI in Europe
	Member, Editorial Board, Experimental Astronomy
	Member, International Association of Geodesy - Subcommission on International Radio Interferometric Surveying (IRIS)
	Co-Chairman, RADIOASTRON International Scientific Council
	Member, VSOP International Scientific Council
	Member, Netherlands Geodetic Commission
	Chairman, URSI Global VLBI Working Group
W. Schutte:	Member, Gebruikerscommissie "Light on ice"
P.P. van der Werf:	Member, ESO User's Committee
	Member, EU - TMR Network "European Large Area ISO Survey (ELAIS)"
	Member, Next Generation Space Telescope IFMOS Study team
	Member, Next Generation Space Telescope Payload Study team
	Member, VISIR Science team
	Member, FIRST/HIFI Science team
	Member, steering committee ISO data centre Groningen (DIDAC)
	Member, JCMT Advisory Panel
	Associate Member, ISO SWS Science team
	Member, ASTRON Telescope Time Allocation Committee
	Member, ASTRON/NOVA Jury for project and programme grants
	Associate Investigator, European Large Area ISO Survey (ELAIS)

P.T. de Zeeuw:

Director, NOVA (Netherlands Research School for Astronomy)
Chair, Brouwer Award Selection Committee, American Astronomical Society
co–Chair, SOC Oort Workshop 1998, on *Science with AUSTRALIS*
co–Chair, SOC of Lorentz Center Workshop on *Calibration of the Extragalactic Distance Scale*
Member, SOC of Lorentz Center Workshop on *GAIA*
Member, National Committee Astronomy (NCA)
Member, Scientific Advisory Board of *New Astronomy*
Chair, Users Committee, Space Telescope European Coordinating Facility
Member, Science Advisory Group for GAIA, European Space Agency
Member, Commission 28 (Galaxies) of the International Astronomical Union
Member, IFMOS Study Consortium for ESA contributions to NGST
Member, Hubble Space Telescope Second Decade Study
Vice-chair, Joint Steering Committee UK/NL Collaboration on La Palma
Vice-chair, Space Telescope Science Institute Council

Appendix IV Visiting Scientists

Name :	Dates :	Institute, Source of Support
R. Jimenez	25/05-27/05	Royal Observatory, Edinburgh, UK
R. Lachaume	07/01- 01/07	ENS, Paris, France
Dr. O. Lopez-Cruz	22/01-30/01	INAOE, Puebla, Mexico
Dr. J. Wall	15/01	Royal Greenwich Observatory, Cambridge, UK
Dr. E. Grebel	28/01-30/01	Lick Observatory, Santa Cruz, CA, USA
Dr. W. Wall	03/02-08/02	INAOE, Puebla, Mexico
Dr. S. Gaudi	17/02-18/02	State University of Ohio, Ohio, USA
Dr. F. van den Bosch	09/02-01/04	University of Seattle, WA, USA
G. Cotter	12-02/13-02	Royal Greenwich Observatory, Cambridge, UK
Prof.dr. P.O. Vandervoort	03/03-30/05	Astronomy and Asytrophysics Center, Chicago, IL, USA
Prof.dr. T.M. Bania	11/03-13/03	Boston University, Boston, MA, USA
Dr. K. Martin	09/03-20/03	University of Jena, Jena, Germany
Dr. K. Kerp	18/03-20/03	University of Bonn, Bonn, Germany
Prof.dr. K. Freeman	30/03	MSSO, Canberra, Australia
Drs. F. Lahuis	30/03-03/04	ISO, Vilspa, Spain
Dr. F. Bertoldi	02/04-03/04	MPI, Garching, Germany
Dr. L. Danese	06/04-07/04	Trieste, Italy
Dr. B. Guiderdoni	06/04-07/04	IAP, Paris, France
Drs. R. G. Slijkhuis	02/04-10/04	ESO, Garching, Germany
Dr. M. Rauch	18/04-21/04	Caltech, CA, USA
Dr. J. Luu	16/04-19/04	Harvard-Smithsonian Center for Astrophysics, MA, USA
Dr. M. Creech	18/04-29/04	Caltech, CA, USA
Prof.dr. G. Blake	20/04-28/04	Caltech, CA, USA
Dr. A. Brown	18/05-14/06	UNAM, Mexico
Prof.dr. G. Blake	06/06-11/06	Caltech, CA, USA
Dr. A. Kembhavi	09/06	Inter University Centre for Astronomy and Astrophysics, Pune, India
Drs. B. Tersic	24/06-30/06	Florida State University, Florida, USA
Prof.dr. B. Balick	29/06-03/07	University of Washington, Seattle, WA, USA
Dr. C.R. Kaiser	01-06/05-06	Institute of Theoretical Physics, Oxford, UK
Prof.dr. T. Gehrels	30/06	LPG, Tuscon, AZ, USA
Dr. P. Yanguas-Sayas	13/07-14/07	University of Navarra, Pamplona, Spain
Dr. J. Palacian	13/07-14/07	University of Navarra, Pamplona, Spain
Dr. H. de Ruiter	20-07/31-07	Osservatorio Astronomico di Bologna, Bologna, Italy
Dr. P. Parma	20-07/31-07	IRA, Bologna, Italy
Y. Copin	29-07/03-08	University of Lyon, France
Prof. J. Krelowski	17-08/31-08	University of Torun, Poland
A. Bolatto	17-08/08-09	Boston University, MA, USA
Drs. R.G. Slijkhuis	07-09/11-09	ESO, Germany

Name :	Dates :	Institute, Source of Support
Dr. W. Wall	28/09-03/10	INAOE, Puebla, Mexico
Drs. H. Jones	23/09-27/09	MSSO, Canberra, Australia
Dr. P.R. Maloney	28/09-06/10	CASA, Boulder, CO, USA
Dr. A. Biviano	02/10-09/10	Osservatorio Astronomico, Trieste, Italy
Dr. A.G. Brown	18/10-27/10	UNAM, Ensenada, Mexico
G. D. Illingworth	19/11-/22/11	University of California, Santa Cruz, USA
Dr. F.C. van den Bosch	11/12-22/12	University of Washington, Seattle, USA
Dr. A. Biviano	09/12-17/12	Osservatorio Astronomico, Trieste, Italy

Appendix V Colloquia and lectures

This appendix includes the regular 1998 colloquia series as well as some other lectures and informal talks. Also attached are the programs of the workshops.

V.1 Scientific Colloquia

The Leiden Observatory Colloquia are generally held weekly, on Thursday afternoon at 16:00 hours, preceded by an Astronomers' Tea at 15:45 hours. In 1998, the colloquium series was organized by Paul van der Werf.

Date	**Speaker (affiliation)**	**Title**
January 15	A. Theuwissen (Philips Eindhoven)	*Recent developments in imaging detector technology*
January 22	J. Wall (Royal Greenwich Observatory)	*The cosmology of beamed radio sources*
January 29	E. Grebel (Lick Observatory)	*Star formation histories of Local Group Dwarf galaxies*
February 5	M. Hanson (Steward Observatory)	*Near-infrared observations of massive stars at early evolution*
February 10	R. Ibata (ESO Garching)	*The shape and nature of the Galactic dark halo*
February 19	Y. Hoffmann (Hebrew University, Jerusalem)	*Wiener reconstruction of the large-scale structure*
February 26	J.P. Beaulieu (Kapteyn Institute, Groningen)	*Differential study of Cepheids in the Magellanic clouds - stellar pulsation, stellar evolution and the distance scale*
February 27	R. Klessen (MPIA, Heidelberg)	*Fragmentation of molecular clouds and the origin of stellar clusters*
March 2	I. Aretxaga (MPA, Garching)	*The host galaxies of luminous high redshift QSOs*
March 5	R. van der Marel (STScI)	*HST observations of galactic nuclei*
March 12	T. Bania (Boston University)	*Stalking the interstellar ^{3}He abundance*
March 19	F. van den Bosch (University of Washington, Seattle)	*The formation of disky ellipticals and the origin of the Hubble sequence*
March 23	W. Schutte (Sterrewacht, Leiden)	*Laboratory simulation of solid state processes in space: tracing the evolution of interstellar ices*
March 26	G. Mellema (Stockholm Observatory)	*Bullets under fire: the photo-evaporation of dense clumps*
March 30	C. Dominik (Sterrewacht, Leiden)	*Vega-like stars: ISO results, statistics, and evolutionary processes*
April 2	F. Bertoldi (MPE, Garching)	*ISO news: the dust extinction curve and warm H_2*

Date	Speaker (affiliation)	Title
April 7	P. Ehrenfreund (Sterrewacht, Leiden)	*Dust, ices, and organic molecules: from interstellar medium to Solar system*
April 16	B. Miller (Sterrewacht, Leiden)	*Globular clusters and the formation of elliptical galaxies*
April 17	J. Luu (Harvard - Center for Astrophysics)	*The Kuiper belt: the solar system's circumstellar disk*
April 23	J. North (University of Groningen)	*Stonehenge astronomy*
May 11	M. Hogerheijde (Sterrewacht, Leiden)	*The molecular environment of low-mass young stellar objects*
May 25	R. Jimenez (University of Edinburgh)	*Galaxy and star formation at very high z - have we discovered the first objects to be formed in the universe?*
May 28	R. Rengelink (Sterrewacht, Leiden)	*WENSS and the cosmological evolution of radio sources*
June 4	D. Thompson (MPIA, Heidelberg)	*Wide-field infrared surveys and the search for high redshift galaxies*
June 8	I. Bonnell (Institute of Astronomy, Cambridge)	*The formation of stellar clusters*
June 11	T. Bridges (Royal Greenwich Observatory)	*Halos of elliptical galaxies: kinematics and dark matter*
June 18	H. Röttgering (Sterrewacht, Leiden)	*The most distant radio galaxies as probes of the formation of central cluster galaxies*
June 25	I. de Pater (University of California, Berkeley)	*Keck observations of planets and satellites*
September 10	D. Johnstone (CITA, Toronto)	*Destroying circumstellar disks in the Orion nebula*
September 17	T. de Zeeuw (Sterrewacht, Leiden)	*Stars, gas and dark matter in the Galactic halo*
September 24	H. Jones (Mount Stromlo and Siding Spring Observatories)	*Narrow-band surveys with the Taurus Tunable Filter (TTF)*
October 8	B. Burton (Sterrewacht, Leiden)	*About high-velocity clouds*
October 29	K. Dwarakanath (Raman Research Institute, Bangalore)	*How hot is the intercloud medium?*
November 12	P. Hudson (Universiteit Leiden)	*To Boldly Go: considerations on developing robots for autonomous exploration of planetary surfaces*
November 19	A. van Genderen (Sterrewacht, Leiden)	*The last Helium flash - a rare observable stellar explosion*
November 26	F. Israel (Sterrewacht, Leiden)	*Centaurus A - the nearest radio galaxy*
December 3	G. Medina-Tanco (University of Sao Paolo)	*Ultra-high energy cosmic rays and the local universe*
December 7	S. Shostak (SETI Institute)	*The search for extraterrestrial intelligence*
December 10	S. Portegies Zwart (University of Tokyo)	*Cannibals in young star clusters*
December 17	M. Harwit (MPIfR, Bonn)	*The cosmic infrared background radiation - star formation rate and metallicity*

V.2 Student Colloquia

Date	Speaker	Title
April 27	Harm Melief	*Triaxial Galaxies in Spherical Potentials*
July 13	Wouter Vlemmings	*Intrinsic Shapes of Elliptical Galaxies*
July 27	Remon Cornelisse	*Near Infrared Populations in the Galactic Bulge*
August 3	Celeste Ponsioen	*A COMPTEL Study of the Second Galactic Quadrant*
August 10	Jaron Kurk	*Does Jet Induced Star Formation Exist?*
October 12	Arjan Hulsbosch	*Proper Motions and the Young Open Cluster NGC1502*
November 2	Björn Heijligers	*Velocity fields in clusters of galaxies; Results from N-body simulations*
November 16	Petra van der Heijden	*Molecular Line Imaging in Cooling Flows in Clusters of Galaxies*

V.3 Seminars of the Molecular Astrophysics Group: Astrochemistry: basic principles and recent results

Date	Speaker	Title
January 13	W.-F. Thi	*SWS AOT-02 Ultimate Sensitivity*
January 30	Aigen Li	*The dust extinction, polarisation and emission in the high latitude cloud towards HD21021*
February 20	Geert-Jan Kroes	*The ozone hole: Heterogeneous chemistry run out of control*
March 6	Willem Schutte	*SWS spectroscopy of dust and Polycyclic Aromatic Hydrocarbons*
March 13	Gerd-Jan van Zadelhoff	*Jet formation near young stellar objects*
March 20	Paule Sonnentrucker	*News from the diffuse interstellar band front*
March 31	Fred Lahuis	*ISO observations of HCN and* C_2H_2

V.4 Informal Talks

Informal talks on a variety of topics were given both by visitors and by members of the Observatory community. In 1998 these talks were organized by Floris van der Tak.

Date	Speaker (affiliation)	Title
July 1	Prof. Bruce Balick (Univ. Washington)	*New Tricks of Old Stars*
August 26	Alberto Bolatto (Boston Univ.)	*Antarctic Observations of CI in the Magellanic Clouds*
October 13	Prof. Butler Burton (Sterrewacht Leiden)	*Discovery of a Large Nearby Spiral Galaxy*

Other informal talks were held in 1998 under the name of "SWELL Talks", which stands for "Sterrewacht WEekLy Lunch Talks". These were organized by HongSheng Zhao.

Date	Speaker	Title
21-10	B. Miller	astro-ph/9810245
26-10	P. van Dokkum	"evolution of early-type galaxies"
28-10	V. Icke	a book by D. Frenkel & B. Smit "Understanding molecular simulation" Academic Press, 1998
11-11	P. Katgert	conference summary (ISM)
18-11	M. Franx	ApJL, 501, 171
25-11	M. Bureau	Barred galaxies
09-12	G. Miley	"The Dutch contribution to VLT"

V.5 Workshops

V.5.1 Oort Workshop 1998

Prof. Dr. Jeremy Mould, who was at the Leiden Observatory in April and May, as the 1998 Oort Professor, and Prof. Dr. P.T. de Zeeuw organised an informal workshop at the Observatory, on May 14 and 15, entitled **"Science with AUSTRALIS"**. The programme for the workshop follows below:

Date	Speaker Affiliation	Title
Thursday 14 May	Mould (MSSO)	Setting the scene
	Couch (Sydney)	Galaxy evolution and AUSTRALIS
	Franx (Leiden)	High redshift galaxies
	Kennicutt (Tucson)	Emission-line diagnostics of galaxy evolution
	Ford (Baltimore)	ACS and the high redshift Universe
	Ferguson (STSI, Baltimore)	The HDF and future deep surveys
	van de Weygaert (Groningen)	Tessellations and the reconstruction of large scale velocity fields
	Lamers (Utrecht)	Pre-main-sequence stars in the LMC and SMC; Triggered star formation in M51
Friday 15 May	Renzini (ESO)	The VLT: planning the study of galaxy evolution
	Taylor (Epping)	Results of the AUSTRALIS design concept study
	Maccagni (Milano)	VIMOS/NIRMOS
	Parry (Cambridge)	COSHI - The Cambridge OH Suppression Instrument
	Illingworth (Lick Observatory)	Results from DEEP
	Miley (Leiden)	The first epoch of AGNs
	Mould (MSSO)	Closing remarks

V.5.2 Yearly meeting of the TMR network "The Formation and Evolution of Galaxies"

The EU network "Formation and Evolution of Galaxies" has 6 participating institutions (MPA für Astrophysik Garching (D), Sterrewacht Leiden (NL), University of Cambridge (GB), Institut d'Astrophysique de Paris (F), University of Durham (GB), Osservatorio Astronomico di Padova (I)) and is funded by the Training and Mobility of Researchers Programme of the European Commission The annual meeting of the network was held in castle Poelgeest, Oegstgeest from 31st August to 5th September 1998, with 71 participants from the 6 network sites. The Organizing Committee was formed by: Philip Best, Marijn Franx, George Miley, Huub Röttgering (Chair), Simon White, Isabel Salamanca, Janet Soulsby, Wolfgang Tschager, Hong Sheng Zhao.

Monday 31 August

Richard Ellis	Faint field galaxy evolution
Richard Bower	Early-type galaxy evolution
Pieter van Dokkum	Evolution of cluster ellipticals
Bianca Poggianti	Evolution of galaxies in and out clusters at z=0.4 star formation history as a function of the Hubble type.
Nicole Vogt	The Epoch of Disk Formation: Observational Constraints on High Redshift Disk Galaxies
Roberto Terlevich	Surveys of starburst galaxies at all redshifts
Pierre-Alain Duc	Properties of ISO galaxies in Butcher-Oemler clusters
Dimitra Rigopoulou	Nature and evolution of Ultraluminous Infrared galaxies

Tuesday 1 September

Bressan	Review Population synthesis
Julien Devriendt	Modelling galaxy counts in the IR-submm window
Tadayuki Kodama	Identification of High-z Clusters.
Marcella Longhetti	Star formation indicators
Daniel Thomas	Abundance ratios in hierarchical galaxy formation
Gian Luigi Granato	Dust in Galaxies: the models
Luiz da Costa	ESO surveys
Alan Moorwood	VLT instrumentation:ISAAC
Marijn Franx	VLT instrumentation:FORS
Michel Dennefeld	HDF-S: Overview
Patrick Petitjean	QSO and QSO absorbants in the HDF-S
Stefano Cristiani	Selection and observation of high-z galaxies
Alfonso Aragon	Star formation rate and its evolution

Wednesday 2 September

Simon White	The evolution of disk galaxies
Cedric Lacey	Star formation in the Universe
Barbara Lanzoni	Models of halo merging and clustering
Andrew Benson	Galaxy clustering at z=0
Guinevere Kauffmann	The evolution of galaxy clustering
Francois Bouchet	Galaxy formation in the infrared.
Kelvin Wu	The effect of heating on the properties of galaxy clusters
Carlton Baugh	The new Durham semi-analytic models

Thursday 3 September

Frenk/Jenkins/Pierce	Review of VIRGO results
Tom Abel	The Formation and Fragmentation of Primordial Molecular Clouds
Sebastiano Ghigna	Halos within Halos: distribution and dynamics
Giuseppe Tormen	Simulations of Galaxy Clusters
Volker Springel	Simulating starbursts in interacting galaxies
Vincent Icke	Colliding galaxies with all the fixings
Reinhard Genzel	ISO observations of starburst
Matt Lehnert	Winds in starburst
Itziar Aretxaga	The detection of young population in radio galaxies with the CaT index
Walter Jaffe	Cold gas in cooling flows

Friday 4 September

Huub Röttgering	Review on Distant Radio Galaxies
Philip Best	The evolution of z=1 radio galaxies
Laura Pentericci	HST observations of distant radio galaxies
Keith Baxter	Investigating the Physics of Star Formation in Single and Interacting galaxies
Christian Kaiser	On the cosmological evolution of the steep spectrum radio luminosity function
Patrick Petitjean	Damped Lyman-alpha systems
Stefano Cristiani	Quasar pairs and groups
Tom Theuns	The evolution of the Lyman-alpha forest
Adi Nusser	Lyman-alpha absorbers and cosmology

V.5.3 NVWS Symposium "Ontstaan en Evolutie van het Zonnestelsel"

On October 10, the "Nederlandse Vereniging voor Weer-en Sterrenkunde" and Leiden Observatory organised a one-day symposium on "Ontstaan en Evolutie van het Zonnestelsel: van Interstellaire Wolken tot Kometen en Planeten" ("Formation and Evolution of the Solar System: from Interstellar Clouds to Comets and Planets") for a general public (chair: H. van Woerden, Groningen). This symposium was attended by more than 300 people, and had a lively atmosphere. The local organisation was in the very capable hands of J. Soulsby, with help from NVWS volunteers, G.J. van Zadelhoff and W.F. Thi. The scientific program was organised by E.F. van Dishoeck and H. van Woerden.
The program consisted of:

E.F. van Dishoeck (Leiden)	*De kraamkamers van sterren en planeten*
C. Waelkens (C.U. Louvain, Belgium)	*De vorming van planetenstelsels*
W.A. Schutte (Leiden)	*Hale-Bopp en de chemie van kometen*
C. de Jager (Utrecht)	*Wat de kleintjes ons leren*
P. Koenraad (Eindhoven)	*De Leoniden: een meteorenstorm in 1998?*
R. Waters (UvA)	*Exoplaneten: Planeten bij andere sterren*

V.5.4 PAC Symposium "Chemie Leeft"

On March 5–6, the Dutch chemistry students "Stichting PAC" organised their annual 2–day symposium "Chemie Leeft" ("Chemistry is alive") at Leiden University. This included a session on "Astrochemistry" on March 6, of which the scientific content was organised by E.F. van Dishoeck. The scientific program consisted of:

E.F. van Dishoeck (Leiden)	*Chemische processen in de ruimte: een uniek laboratorium*
A.G.G.M. Tielens (RUG)	*Grote moleculen in de ruimte*
F.P. Israel (Leiden)	*Leven buiten de aarde: waar?*

V.5.5 LSA/MMA Receiver Working Group Workshop

On June 8–9, a two–day workshop was organized at Leiden Observatory to review the design and development of heterodyne receivers for the LSA/MMA, and to investigate the interests in European laboratories for participating in this effort. This workshop was attended by about 30 scientists from about 10 European countries and from the USA.

V.5.6 GAIA Workshop

On November 23–27 a **"GAIA Workshop"** was held in the Lorentz Center, organised by Michael Perryman and Tim de Zeeuw. It was attended by 60 scientists with direct interest or involvement in the design and optimisation of the GAIA astrometric satellite, which is currently under study by ESA as a possible cornerstone mission. The scientific case for GAIA was examined in detail, and many ideas for optimising the astrophysical impact of the mission were debated. Working groups on the instrument, simulation activities, and photometry also presented results of their studies, and plans for the finalisation of the study report were prepared.

V.5.7 Workshop: Calibration of the Extragalactic Distance Scale

The concentration period on **Calibration of the Extragalactic Distance Scale**, in short the H_0 **workshop**, was held on 15–30 May, in the Lorentz Center. The topic was determination of the value of the so-called Hubble Constant, H_0, i.e., the speed of the expansion of the Universe. This is one of the three original Key Projects for the Hubble Space Telescope. Its aim is to determine accurate distances to the nearby galaxies by means of the Cepheid PLC relation. The participants consisted of members of the Hubble H_0 team, as well as 'competitors and critics'. They carried out a number of systematic comparisons between the different methods for distanced determination, which resulted in an improved and more reliable value for H_0.
Taking part were 14 scientists from abroad, about a dozen local promovendi, postdocs and members of staff, as well as some colleagues from the sister–institutes in the Netherlands. The workshop was organised by the 1998 Oort Professor Jeremy Mould (co-PI of the H_0-team), and Tim de Zeeuw.

V.5.8 A Symposium in Honor of the 80th Birthday of Prof. Henk van de Hulst

A symposium in honor of the 80th birthday of prof. Henk van de Hulst was held on December 2, in Leiden. It was organised by Marijn Franx and Annette Vermond of the Lorentz Center. Speakers included:

Hovenier	"Light scattering by small particles. Where are we ?"
Ivanov	"Unique Radiative Transfer Art of Henk van de Hulst"
Spiegel	"Vortices on Disks"
de Zeeuw	"Dynamics of Galaxies"
Macchetto	"HST/FOC impact on our understanding of AGNs"
Bleeker	"Henk van de Hulst: helmsman in space"

Appendix VI Participation in Scientific Meetings

The attendance of Leiden Staff members at various meetings is indicated here, together with the titles of presentations made at the meetings.

Best:

IAU Colloquium 174: Activity in Galaxies and Related Phenomena (Byurakan, Armenia; August 16–22)
contribution: "The emission line properties of the 3CR radio galaxies at redshift one: shocks, evolution and the alignment effect"

Boonman:

Nato ASI: The Physics of Star Formation and Early Stellar Evolution (Iraklion, Crete, Greece; May 24–June 5)
contribution: "ISO and JCMT observations of Massive star-forming regions in Orion/Monoceros: First results" (poster)

De Bruijne:

NATO–ASI Summerschool "The physics of star formation and early stellar evolution" (Hersonissos, Crete, Greece; May 24–June 5)
contribution: "Moving groups in the Hipparcos Catalogue" (poster)

Lorentz Center Workshop "The Global Astrometric Interferometer for Astrophysics: GAIA" (Leiden, the Netherlands; November 23–27)

Bureau:

When and How do Bulges Form and Evolve (Baltimore, USA; October 5–7)
contribution: "The Nature of Boxy/Peanut-Shaped Bulges in Spiral Galaxies"

Atelier Groupe de Recherche Galaxies (Marseille, France; October 29–30)
contribution: "The Nature of Boxy/Peanut-Shaped Bulges in Spiral Galaxies"
contribution: "The Dark Halo of NGC 2915"

Burton:

New Perspectives on the Interstellar Medium (Naramata, BC, Canada; August 22–28)
contribution: "On the Distribution of Compact, Isolated High–Velocity Clouds Throughout the Local Group"

3rd Cologne–Zermatt Symposium "The Physics and Chemistry of the Interstellar Medium" (Zermatt, Switzerland; September 22–26)
contribution: "The Kinematic and Spatial Deployment of Compact High–Velocity Clouds"

Cioni:

Workshop: "The Magellanic Clouds and other Dwarfs Galaxies" (Bad-Honnef, Germany; January 19–22)
contribution: "DENIS Observations on the Magellanic Clouds"

IAU Symposium 190: "New Views of the Magellanic Clouds" (Victoria, Canada; July 13–17)
contribution: "DENIS AGB Stars in the Magellanic Clouds"

IAU Symposium 191: "AGB Stars" (Montpellier, France; August 27–September 1)
contribution: "DENIS: Colour-Magnitude diagrams and Luminosity Function towards the Magellanic Clouds"

IAU Symposium 192: "The Stellar Content of Local Group Galaxies" (Cape Town, South Africa; September 7–11)
contribution: "Near Infrared Catalogue of the Magellanic Clouds: Deep Near–IR Southern Sky Survey"

Cretton:

Galaxy Dynamics (New Brunswick, New Jersey, USA; August 8–12)
contribution: "Evidence for a Massive Black Hole in the S0 Galaxy NGC 4342"

Van Dishoeck:

Solid Interstellar Matter: The ISO Revolution (Les Houches, France; February 2–6)
contribution: "ISO observations of gas-phase species in star-forming regions"

Chemistry and Physics of Molecules and Grains in Space: Faraday Discussion 109 (Nottingham, U.K.; April 15–17)
contribution: "What does ISO tell us about gas-grain chemistry?"

The Physics of Star Formation and Early Stellar Evolution (Iraklion, Crete; May 24–June 5)
contribution: "Models and observations of the chemistry around YSOs"

Astrophysics with Infrared Surveys: a Prelude to SIRTF (Pasadena, USA; June 22–24)
contribution: "Gas-phase molecules in the interstellar medium: from ISO to SIRTF"

Protostar and Planets IV (Santa Barbara, USA; July 5–11)
contribution: "Chemical evolution and dynamics of protostellar matter"

Molecular Processes in Astrophysics — A Meeting Honouring the 70'th Birthday of Alexander Dalgarno (London, U.K.; July 20–22)
contribution: "Molecular hydrogen in astrophysical environments"

Physics and Chemistry of the Interstellar Medium: third Cologne-Zermatt Symposium (Zermatt, Switzerland; September 22–25)
contribution: "Recent developments in astrochemistry"

The Universe as Viewed by ISO: ESA symposium (Paris, France; October 20–23)
contribution: "ISO Spectroscopy of young stellar objects"

Spectroscopy from the Laboratory to Space (Nottingham, U.K.; December 20–22)
contribution: "Infrared spectroscopy in outer space"

Dominik:

Solid Interstellar Matter: The ISO Revolution (Les Houches, France; February 2–6)
contribution: "Vega–like Stars"

Protostars and Planets IV (Santa Barbara, California, USA; July 6–11)
contribution: "Evolution of Vega–like stars"
contribution: "Formation of Compact Chondrule Rims by Accretion of Dust Aggregates"

The Universe as Seen by ISO (Paris, France; October 20–23)
contribution: "Vega–like Stars"

Jahrestagung der Deutschen Astronomische Gesellschaft (Heidelberg, Germany; September 20–25)
contribution: "ISO Observations and Models of Vega–like Stars"

Ehrenfreund:

Solid State Interstellar Matter: the ISO Revolution (Les Houches, France; February 2–6)
contribution: "Comparison of ices and silicates in comets and the ISM"

Faraday Discussion No. 109: Chemistry and Physics of Molecules and Grains in Space (Nottingham, UK; April 15–17)
contribution: "Apolar ices"

European Geophysical Society (Nice, France; April 20–24)
contribution: "Observations and laboratory studies of interstellar and cometary ices: an ISO view"

International Rosetta Mission: 2nd Science Working Team Meeting (ESTEC, The Netherlands; May 5–6)
contribution: "Interstellar and cometary ices: an ISO view"

53ste Nederlandse Astronomen Conferentie (Hengelhoef, Belgium; May 6–8)
contribution: "From the interstellar medium to comets: an ISO view"

IAU Colloquium 168: Cometary Nuclei in Space and Time (Nanjing, China; May 18–22)
contribution: "From the Interstellar Medium to Comets: an ISO view"

32nd COSPAR Scientific Assembly (Nagoya, Japan; July 12–19)
contribution: "Interstellar and cometary ices: an ISO view"
contribution: "Laboratory spectroscopy of cometary ice analogs"

The Origin and Composition of Cometary Material (Bern, Switzerland; September 14–18)
contribution: "An ISO view on interstellar and cometary ice chemistry"

3rd Cologne-Zermatt Symposium: The Physics and Chemistry of the Interstellar Medium (Zermatt, Switzerland; September 22–25)
contribution: "ISO observations and laboratory studies of interstellar ices in star-forming regions"

MIDAS-Workshop (ESTEC, The Netherlands; October 5–6)
contribution: "From the interstellar medium to comets"

SEBA-EXPOSE Investigator Meeting (ESTEC, The Netherlands; November 18–19)
contribution: "The ORGANIC experiment"

Franx:

Gravitational Lensing Network meeting (Groningen, The Netherlands; December 6–8)
contribution: "Mass of lensed galaxy at z=4.92"

Van Genderen:

SUA (Working group Stars with Extended Atmospheres) (Amsterdam,The Netherlands; March 20)
contribution: "η Carinae - a celestial Chinese lantern - a massive binary?"

SUA (Working group Stars with Extended Atmospheres) (Leiden, The Netherlands; November 27)
contribution: "News and Views on η Carinae"

IAU Colloquium 169: Variable and Non-Speherical Stellar Winds in Luminous Hot Stars (Heidelberg, Germany; June 17–19)

Greenberg:

International Conference on the "Role of Radiation in the Origin and Evolution of Life" (Osaka, Japan; March 1–5)
contribution: "UV processes leading to prebiotic and chiral organics in interstellar dust"

Workshop on "Future Programs on Exobiology Experiments" (Tanashi, University of Tokyo, Institute for Cosmic Ray Research, Japan; March 7–9)
contribution: "Exobiology with UV radiation"

COSIMA, CIDA workshop (ROSETTA mission) (Glurns, Italy; March 23–25)
contribution: "Size distribution and material strength of comet dust"
contribution: "Constraints on comet nucleus composition"
contribution: "Morphology and chemistry of comet dust"

IAU Colloquium 168 on "Cometary nuclei in space and time" (Nanjing, China; May 18–22)
contribution: "Comets: the key to our origins" (summary of meeting)
contribution: "Interstellar dust in comets: from Halley to Borrelly to Pictoris to Hale-Bopp"

32nd COSPAR Scientific Assembly, 40th Anniversary (Nagoya, Japan; July 12–17)
contribution: "Tracking the organics from interstellar space to comets"
contribution: "Chirality in interstellar dust, comets and meteorites"
contribution: "Space irradiation at cryogenic temperature"
contribution: "Solar ultraviolet photoprocessing of organics on a space platform as an analog of chemical evolution in interstellar space and the outer solar system"

Workshop on "Detecting Life on Mars and Exobiology Experiments" (Tanashi, University of Tokyo, Institute for Cosmic Ray Research, Japan; July 18–19)
contribution: "Interstellar dust chemistry and chemical evolution experiments in earth orbit"

Annual Planetary Emergencies Meeting (Erice-Sicily, Italy; Augustus 18–24)
contribution: Organised working group on "Hazards posed by Cosmic Objects"

ISSI workshop "The Origin and Composition of Cometary Material (Bern, Switzerland; September 14–19)
contribution: "Morphological and chemical properties of comet dust"
Co-director of Working group 2: "From coma abundance to nucleus composition"

ISSI workshop "Dust in the Local Interstellar Medium" (Bern, Switzerland; October 12–16)
contribution: "Diffuse cloud dust"

World Laboratory (Geneva (CERN), Switzerland; November 19–22)
contribution: "Report on World Laboratory Project E-17: Chemistry in Star Forming Regions and the Composition of Comets"

2nd European Symposium on "Utilisation of the International Space Station" (Noordwijk, The Netherlands; November 16–18)
contribution: "Solar ultraviolet irradiation at cryogenic temperatures" (poster)

Habing:

Dwarf Galaxies (Bad Honnef, Germany; January 19–21)
contribution: "DENIS Observations on the Magellanic Clouds"

School for Astrophysics (les Houches, France; August 8–17)
contribution: Ten Lectures on "Infrared Radiation from Stars"

IAU Symposium 191: "AGB Stars" (Montpellier, France; August 27–September 1)
contribution: "DENIS: Colour-Magnitude diagrams and Luminosity Function towards the Magellanic Clouds"

The Universe as seen by ISO (UNESCO, Paris, France; October 20–24)

Haverkorn:

Workshop "New Perspectives on the Interstellar Medium" (Naramata, Canada; August 22–28)

Workshop "Galactic Foreground Polarisation" (Bonn, Germany; September 7–9)

De Heij:

3rd Cologne-Zermatt Symposium: "The Physics and Chemistry of the Interstellar Medium" (Zermatt, Switzerland; September 22–25)
contribution: "Neutral hydrogen at Intermediate Velocities"

"New Perspectives on the Interstellar Medium" (Naramata, Canada; August 22–28)
contribution: "Neutral hydrogen at Intermediate Velocities"

Helmi:

International Symposium on Astrophysics (Rome, Italy; June 14–20)
contribution: "Accretion and the stellar halo of the Galaxy"

Third Stromlo Symposium: The Galactic Halo (Canberra, Australia; August 17–21)
contribution: "Building up the stellar halo of the Milky Way"
contribution: "Detecting halo streams with GAIA"

Hogerheijde:

The Physics of Star Formation and Early Stellar Evolution (Iraklion, Crete; May 24–June 5)
contribution: "The molecular environment of low-mass protostars (poster)"

Protostar and Planets IV (Santa Barbara, USA; July 5–11)
contribution: "The molecular environment of low-mass protostars (poster)"

Hoogerwerf:

NATO–ASI Summerschool on "Physics of Star Formation and Early Stellar Evolution" (Iraklion, Crete, Greece; May 24–June 5)
contribution: "A Hipparcos Census of the Nearby OB Associations" (poster)

Icke:

Workshop on Galactic Foreground Polarisation (Bonn, Germany: September 7 – 9)
contribution: "Dynamics of random MHD fields"

Israel:

Workshop on a 10-meter Millimetre Telescope for Antarctica, (Boston, USA; March 26–30)
contribution: "Prospects for External Galaxies"

Photodissociation and Photochemistry in the Interstellar Medium: the Spectroscopy of Neutral Carbon (Boston, USA; June 1 – 4)
contribution: "Review of Extragalactic [CI] Observations"

Jaffe:

Dynamics Symposium (New Jersey, U.S.A; July 11–18)
contribution: "Nuclear Disks in Galaxies"

Katgert:

Cluster Workshop (Marseille, France; June 8)
contribution: "Fundamental Planes of early-type galaxies in 25 nearby Abell clusters"

Development of Galaxy Systems (Sesto Pusteria, Italy; June 30–July 3)
contribution: "ESO Nearby Abell Cluster Survey: Properties of the galaxies"

New Perspectives on the ISM (Penticton, Canada; August 22–28)
contribution: "Small-scale structure in the polarized radio background"

Galactic foreground polarisation (Bonn, Germany; September 7–9)
contribution: "Fabry-Perot Hα imaging of regions with interesting radio polarisation"

Klessen:

Interstellar Turbulence (Puebla, Mexico; January 12–16)
contribution: "Fragmentation of Molecular Clouds: The Initial Phases of a Stellar Cluster"

NATO ASI – The Physics of Star Formation and Early Stellar Evolution (Iraklion, Greece; May 24–June 5)

Protostars and Planets IV (Santa Barbara, U.S.A.; July 6–11)
contribution: "On the Formation of Stellar Clusters: Fragmentation of Molecular Clouds"

Annual Meeting of the German Astronomical Society (Heidelberg, Germany: September 14–19)
contribution: "Fragmentation of Molecular Clouds: Implications for the IMF"

Annual Meeting of European Star-Formation Network (Heidelberg, Germany; October 12–14)

Kurk:

First XMM Workshop on "Science with XMM" (Noordwijk, The Netherlands; September 30–October 2)

Lub:

Distance Indicators in a Post Hipparcos Era (Haguenau, France; September 15–17)

Luu:

Minor Bodies in the Outer Solar System (Garching, Germany; November 2–5)
contribution: "Coagulation and Fragmentation in the Kuiper Belt"

Van der Meulen:

Meeting of the COMPTEL Team (Garching, Germany; April 15–17)
contribution: "3–7 MeV emission from the Vela region"

3rd INTEGRAL Workshop "The Extreme Universe" (Taormina, Italy; September 14–18)
contribution: "An unidentified extended COMPTEL source in the Vela/Carina region"

Miley:

Barry Clark Symposium (Socorro, USA; June 25–27)

Miller:

191st meeting of the American Astronomical Society (Washington DC, USA; January 6–10)
contribution: "The Mass Function of Young Star Clusters in Merging Galaxies"

23rd Rencontres de Moriond: Dwarf Galaxies and Cosmology (Les Arc, France; March 14–21)
contribution: "Globular Clusters in Dwarf Elliptical Galaxies"

IAU Colloquium 171, The Low Surface Brightness Universe (Cardiff, Wales; July 6–10)
contribution: "The Connection Between dE and dI Galaxies"

Ortiz:

IAU Symposium 191: Asymptotic Giant Branch stars (Montpellier, France; August 27–September 1)
contribution: "Abundance analysis of post-AGB candidates" (with B.V. Castilho)

Papadopoulos:

The Universe as seen by ISO (Paris, France; October 20–23)

Astronomy 2000+ (Athens, Greece; November 10–13)

Pentericci:

Xth rencontres de Blois "The birth of galaxies" (Blois, France; June 29–July 4)
contribution: "Near infrared properties of HzRGs observed with NICMOS"

III National Italian conference on AGN (Rome, Italy; May 18–21)
contribution: "Optical and near infrared properties of the most distant radio galaxies"

Perryman:

AAS (Washington DC, USA; January 7–10)
contribution: "Recent Results from Hipparcos", Invited Plenary Lecture

Robichon:

Harmonising cosmic distance scales in a post-Hipparcos era (Haguenau, France; September 14–16)
contribution: "Main sequences of open clusters with Hipparcos"

Galaxy Evolution: Connecting the Distant Universe with the Local Fossil Record (Meudon, France; September 21–25)
contribution: "Contribution of Hipparcos on the determination of age and chemical composition of open clusters"

Röttgering:

Xth rencontres de Blois "Birth of Galaxies" (Blois, France; June 29 - July 4)
contribution: "Distant radio galaxies: tracing the formation of brightest cluster galaxies"

EVN/JIVE Symposium No. 4 (Dwingeloo, The Netherlands, October 22-24)

Schutte:

Solid Interstellar Matter - The ISO Revolution (Les Houches, France; February 2–6)
contribution: "Ice Evolution in the Interstellar Medium"

Faraday Discussion No. 109: Chemistry and Physics of Molecules and Grains in Space (Nottingham, United Kingdom; April 15–17)

3rd Cologne–Zermatt Symposium: The Physics and Chemistry of the Interstellar Medium (Zermatt, Switzerland; September 22–25)
contribution: "ISO-SWS Observations of Infrared Absorption Bands of the Diffuse ISM: The 6.2 micron Aromatic Absorption Feature"

Simis:

IAU Symposium 191 Asymptotic Giant Branch Stars (Montpellier, France; August 27–September 1)
contribution: "Starting a stellar wind"

Van der Tak:

NATO ASI "The Physics of Star Formation and Early Stellar Evolution (Crete, Greece; May 24–June 5)
contribution: "The Impact of the Massive Young Star GL 2591 on its Circumstellar Envelope"

Protostars & Planets IV (Santa Barbara, USA; July 5–12)
contribution: "The Impact of the Massive Young Star GL 2591 on its Circumstellar Envelope"

Thi:

ISO Detector Workshop (Villafranca del Castillo, Spain; January 14–16)
contribution: "SWS AOT-02 Ultimate Sensitivity"

Solid Interstellar Matter : The ISO Revolution (Les Houches, France; February 2–6)
contribution: "IR spectra of nano-size Al_2O_3 and SiC particles"

The Universe as seen by ISO (Paris, France; October 20–23)
contribution: "H_2 emission from disks around Herbig Ae and T Tauri stars"
contribution: "Weak H_2 emission from diffuse and translucent clouds"

Tschager:

Sixth Synthesis Imaging Summer School (Socorro, NM, USA, June 17–23)

EVN/JIVE Symposium No. 4 (Dwingeloo, The Netherlands; October 22–24)
contribution: "VSOP/global VLBI observations of 2021+614: Detection of hotspot advance"

Verdoes:

Winterschool on 'Galaxy Formation and Evolution' (Jerusalem, Israel; December 29 1997–January 7 1998)

AAS Meeting Washington (Washington, USA; January 6–10)
contribution: "A complete sample of nearby radio loud early-type galaxies"

Rutgers Conference on 'Galaxy Dynamics' (Piscataway, NJ, USA; August 8–12 1998)
contribution: "Nearby radio loud early-type galaxies"

STScI Mini-Workshop on 'When and How do Bulges Form and Evolve?' (Baltimore, MD, USA; October 5–7)
contribution: "Nearby radio loud ellipticals"

Veen:

IAU Colloquium 169, Variable and Non-spherical Stellar Winds in Luminous Hot Stars (Heidelberg, Germany; June 15–19)
contribution: "Is WR 103(WC9) as violent as WN8 stars ?"

IAU Symposium 193, Wolf-Rayet Phenomena in Massive Stars and Starburst Galaxies (Puerto Vallarta, Mexico; November 3–7)
contribution: "Long-term changes in binary system WR 46 (WN3p+?)"
contribution: "Is WR 103(WC9) as violent as WN8 stars ?"

Vlemmings:

EVN/JIVE Symposium No.4 (Dwingeloo, The Netherlands; October 22–24)

Wright:

Solid Interstellar Matter: The ISO Revolution (Les Houches, France; February 6–8)
contribution: "The 2.4–45.2 μm ISO–SWS spectrum of Orion IRc2"

SRON Wetenschapsdag (Dalfsen, The Netherlands; June 15–16)
contribution: "Warm gas around Young Stellar Objects"

van Zadelhoff:

NATO ASI Summerschool: The Physics of Star Formation and Early Stellar Evolution (Iraklion, Crete, Greece; May 24–June 5)
contribution: "Modelling line emission from the circumstellar disks around the double binary GG Tau"

Protostars & Planets IV (Santa Barbara, USA; July 6–11)
contribution: "Modelling ISO Observations of Circumstellar Disks and Envelopes around YSOs"

De Zeeuw:

13th Gainesville Meeting (Gainesville, FL, USA; February 12–14)
contribution: "Three-integral galaxy models"

Annual Meeting Dynamical Division of the AAS (Charlottesville, VA, USA; April 1–3)
contribution: "Schwarzschild's Method for Building Galaxy Models"

Internal Symposium (Leiden, The Netherlands; April 9)
contribution: "Hipparcos studies of OB associations"

34th Liege Astrophysics Colloquium: The Second NGST Conference (Liege, Belgium; June 17–18)

Third Stromlo Symposium, The Galactic Halo (Canberra, Australia; August 17–21)
contribution: "Conference Summary"

STScI Miniworkshop on Galactic Bulges (Baltimore, USA; October 5–7)

Zhao:

3rd Stromlo Symposium, The Galactic Halo (Stromlo, Australia; August 16–22)
contribution: "A model for the encounter of the Sagittarius galaxy with the Magellic Cloud"
contribution: "Studying Evolution of the Galactic Potential and Halo Streamers with Future Astrometric Satellites"

COSMOS98 (Asilomar, CA, USA; November 19–20)
contribution: "What Machos Could Be?"

Appendix VII Observing Sessions Abroad

Arts:
Dutch 90cm telescope (ESO, La Silla, Chile; August 8 – September 5)

Best:
WHT (La Palma, Spain; February 8-9, February 23–24, August 12–13))
3.6m (ESO, Chile; April 21–22)
UKIRT (Hawaii, USA; September 13–14)
3.6m (ESO, Chile; November 20–21)

W.B. Burton:
Apache Point Observatory (Sunspot, New Mexico; March)
Dominion Radio Astrophysical Observatory (Penticton, BC, Canada; April)

Cioni:
NTT–ESO (Chile; December 23–23)
3.6–ESO (Chile; December 25–26)

Ehrenfreund:
ESO/CAT(La Silla, Chile; January 18–27, July 17–24)
WHT 4 m (La Palma, Spain; December 29–31)

Franx:
W.M. Keck Observatory (Hawaii, USA; April 17–24)

Israel:
SEST 15m (ESO-La Silla, Chile; June 26 – July 9)

Jaffe:
WHT (La Palma, Spain; September 11–18)

Kurk:
JKT (La Palma, Spain; September 11–17)

Lub:
1.54m (ESO, La Silla, Chile; July 17–19)

Luu:
Keck Telescope (Mauna Kea, Hawaii, USA; November 9–14)
Kitt Peak 0.9m (Kitt Peak, AZ, USA; September 24–27)

van der Meer:
Dutch 90cm telescope (ESO, La Silla, Chile; November 4–24)

Miller:
NTT (La Silla, Chile; December 12–15)

Papadopoulos:
JCMT (Mauna Kea, Hawaii, USA; January 3–5)

Pentericci:
Telescope (La Silla, Chile; April 26–30)

Röttgering:
JCMT (Mauna Kea, Hawaii, USA; April 11-16)
Keck Telescope (Mauna Kea, Hawaii, USA; April 17-18)
Keck Telescope (Mauna Kea, Hawaii, USA; Dec 18-19)

Schoenmakers:
WHT (La Palma, Spain; February 6–7)
INT (La Palma, Spain; February 22–26)
100-m Effelsberg (Effelsberg, Germany; April 11–14)

Simis:
JKT (La Palma, Spain; April 3–11)

Van der Tak:
JCMT (Mauna Kea, Hawaii, USA; January 15–19)
Kitt Peak 2.1m (AZ, USA; June 6–8)

Thi:
IRAM 30m Telescope (Pico Veleta, Spain; December 23–29)

Tschager:
MPIfR 100-m Telescope (Effelsberg, Germany; April 7–9)
JKT (Roque de los Muchachos, Spain; September 6–11)
IRAM 30-m Telescope (Pico Veleta, Spain; December 8–11)

Veen:
ESO 1.5m Telescope (La Silla, Chile; February 10–12)
Dutch 90cm (La Silla, Chile; February 10–12)
2.2m ESO Telescope (La Silla, Chile; April 2–5

Verdoes-Kleijn:
KPNO, 2.1meter (Kitt Peak, AZ, USA; April 17–24, July 1–4, December 4–6)
IRTF (Mauna Kea, Hawaii, USA; September 24–25)

Van der Werf:
James Clerk Maxwell Telescope (Mauna Kea, Hawaii; March 12–24, December 10–22)
ESO/MPI 2.2 m telescope (La Silla, Chile; March 30–April 8)
NTT (La Silla, Chile; August 3–14)

Van Zadelhoff:
JCMT (Hawaii, USA; September 14–19)

Appendix VIII Working Visits Abroad

Best:
MRAO (Cambridge, England; December 13–16)
MPA (Munich, Germany; December 19–23)

Bureau:
Observatoire de Marseille (Marseille, France; October 28–November 7)

Cioni:
Calar Alto Observatory (Almeria, Spain; November 20–December 3)

Dominik:
ISO Science Center (Madrid, Spain; June 1–8)

Ehrenfreund:
Institut d'Astrophysique Spatiale (Orsay, France; April 28–30)

Franx:
ESO (Garching, Germany; January 28–30)
Isaac Newton Group (La Palma, Spain; April 5–9)
ESO (Garching, Germany; April 14–16)
Harvard Smithsonian Center for Astrophysics (Cambridge, USA; June 13–20)
ESO (Garching, Germany; September 30–October 3)
ESO (Santiago, Chile; October 20–24)
Harvard Smithsonian Center for Astrophysics (Cambridge, USA; October 30–November 2)
Johns Hopkins University (Baltimore, USA; November 2–6)
Munich University (Munich, Germany; December 10–11)

Habing:
Consortium, AGB star abundances VILSPA, Madrid, Spain; January 2–3
A&A Executive Committee l'Observatoire, Paris, France; February 5
DENIS Progress Meeting Observatoire de Côte d'Azur, Nice, France; March 23
ISO Science Team Meeting VILSPA, Madrid, Spain; April 2–3
Selection Mission Scientists for FIRST ESA-HQ, Paris, France; April 9
Board meeting A&A Heidelberg, Germany; May 9
Meeting on DENIS and ISOGAL Institut d'Astrophysique, Paris, France; June 3
ISO Science Team Meeting VILSPA, Madrid, Spain; June 11–12
DENIS Progress Meeting Paris, France; September 25

De Heij:
Radioastronomisches Institut der Universität Bonn, Germany, March 11–14

Helmi:
Max Planck Institut für Astrophysik (Garching, Germany; April 1–9; October 5–12; November 2–20)
Mount Stromlo Observatory (Canberra, Australia; August 23–26)

Israel:
ESO Computer Outsourcing Evaluation (Garching, Germany; January 7–8)
ESO User Committee (Garching, Germany; April 24–25)
Institut d'Astrophysique/EARA (Paris, France; June 13–14)

Jaffe:
Max Planck Institut für Astrophysik (Heidelberg, Germany; October 27–28)
Observatoire de Paris (Paris, France; November 12–13)
ESO (Garching, Germany; December 14–16)

Katgert:
Lab. Astronomie Spatiale (Marseille, France; June 4–10)
Osservatorio Astronomico (Trieste, Italy; 24–31 July)
Lab. Astronomie Spatiale (Marseille, France; Oct 19–26)

Kurk:
National Radio Astronomy Observatory (Socorro, USA; February 12–June 15)

Lub:
ESA Vilspa (Madrid, Spain; January 2–4)
ESO (Garching, Germany: June 2–4)
Universidad de Concepcion (Concepcion, Chile: August 5–7)
ESO (Garching, Germany: November 30–December 2)

Miller:
DTM/CIW (Washington DC, USA; January 12–16)
CRAL (Lyon, France; June 20–24)

Ortiz:
Institut d'Astrophysique de Paris (Paris, France; December 1–21)

Pentericci:
Observatories of the Carnegie Institute (Pasadena, CA, USA; January 19–February 28)
Monteporzio Observatory (Rome, Italy; July 20–August 5)
Durham University (Durham, UK; November 16–20)

Röttgering:
ESO (Munchen, Germany, January 21-22)
IGPP/LLNL (Livermore, USA, April 19 - May 02)
ESO (Munchen, Germany, June 3-4)
Alcatel (Cannes, France, November 12-13)

Schoenmakers:
RAIUB (Bonn, Germany; January 6–8)
MPA (Munich, Germany; December 10–13)

Schutte:
Institut d'Astrophysique Spatiale (Orsay, France; August 31– September 1)

Van der Tak:
University California (Berkeley, USA; January 20–27)
University Texas (Austin, USA; January 28–February 2)
Caltech (Pasadena, USA; July 13–17)

Veen:
Department of Physics & Astrophysics, University College (London, UK; January 20–25)

Van der Werf:
European Southern Observatory (Garching, Germany; April 20–21)
Max-Planck-Institut für extraterrestrische Physik (Garching, Germany; July 13–17)
ESA Headquarters (Paris, France; October 26–27)
University of Kent (Canterbury, England; November 9–10)
Laboratoire d'Astrophysique Spatiale (Marseille, France; December 7–8)

De Zeeuw:
ST-ECF/ESO (Garching, Germany; January 22–23)
Penn State University (State College, PA, USA; February 3)
STScI (Baltimore, MD, USA; February 4–10)
Dept. of Math., Florida State Univ. (Tallahassee, FL, USA; February 11)
Dept. of Astron., Univ. of Florida (Gainesville, FL, USA; February 12–14)
STScI (Baltimore, MD, USA; April 3–7)
Astron. Dept, Univ. of Maryland (College Park, MD, USA; April 8)
Institute of Astronomy (Cambridge, UK; May 6–8)
STScI (Baltimore, MD, USA; July 6–10)
Mt. Stromlo Observatory (Canberra, Australia; August 9–22)
STScI (Baltimore, MD, USA; October 2–21)
Obs. Roque de los Muchachos (La Palma, Spain; November 2–7)
Dept. of Physics and Astronomy (Durham, UK; November 12)
ST-ECF/ESO (Garching, Germany; November 16–20)

Zhao:
Princeton University (Princeton, NJ, USA; March 20–April 19)

Appendix IX Colloquia Given Outside Leiden

Bureau:
"The Nature of Boxy/Peanut-Shaped Bulges in Spiral Galaxies", Université de Montréal, Montréal (Canada), September 25

W.B. Burton:
"On the Kinematic and Spatial Deployment of Compact High–Velocity Clouds", University of Utrecht, Utrecht (The Netherlands), October 6

Van Dishoeck:
"From the interstellar medium to the formation of stars: new results from the Infrared Space Observatory", Columbia University, New York (USA), May 4
"ISO's view on the interstellar medium and star formation", University of Maryland, College Park (USA), May 6
"The ISO-SWS 2.4–45.2 μm spectrum toward Orion-IRc2", California Institute of Technology, Pasadena (USA), June 29
"ISO-SWS spectroscopy of star-forming regions", Onsala Space Observatory, Onsala (Sweden), August 21
"Astrochemistry: Basic Processes and Recent Developments (6 lectures)" Royal Institute of Technology, Stockholm (Sweden), August 24–27
"ISO-SWS spectroscopy of star-forming regions", Stockholm Observatory, Saltsjöbaden (Sweden), August 28
"ISO-SWS spectroscopy of the interstellar medium and star-forming regions", NASA-Ames Research Center, Moffett Field (USA), November 13
"Chemical evolution of protostellar matter: ISO's view", University of California, Santa Cruz (USA), November 16
"ISO's view of star-forming regions", University of California, San Diego (USA), November 17
"Mid-infrared spectroscopy: from ISO to NGST", ESA, Paris (France), December 18

Dominik:
"Vega–like Stars", Astronomical Institute, Utrecht (The Netherlands), March 17

Ehrenfreund:
"From the Interstellar Medium to Comets: an ISO view", SRON, Utrecht (The Netherlands), March 31
"Interstellarer Staub: Neue Resultate vom Infrared Space Observatory ISO", University of Vienna, Vienna (Austria), December 14

Franx:
"Discovery of a pair of galaxies at z=4.92", ESO, Garching (Germany), January 29
"Discovery of a pair of galaxies at z=4.92", Estec, Noordwijk (The Netherlands), October 9
"Evolution of the M/L ratio out to z=0.83", Munich University, Munich (Germany), December 11

Hogerheijde:
"The Molecular Environment of Low-Mass Protostars", ASTRON, Dwingeloo (The Netherlands), May 15

Vincent Icke:
"Death Becomes Them", Ehrenfest Colloquium, Leiden, April 01
"Hydrodynamics of dying stars", TU Delft, May 19
"Hydrodynamics of dying stars", FOM, Rijnhuizen, May 28

Israel:
"Molecules in Centres of Galaxies", Astronomical Institute, Utrecht (The Netherlands), January 28

Katgert:
"Properties of galaxies in clusters", Osservatorio Astronomico, Trieste (Italy), July 29

“Galaxies in clusters: inferences from ENACS”, Kapteyn Institute, Groningen (The Netherlands) September 15

Lub:
“Las estrellas RR Lyrae como indicadores de distancia”, Universidad de Concepcion, Concepcion (Chile), August 6

Miller:
“Globular Clusters and the Formation of Elliptical Galaxies”, SRON, Utrecht (The Netherlands), May 19
“Globular Clusters and the Formation of Elliptical Galaxies”, University of Göttingen (Germany), June 29
“The Globular Clusters of Dwarf Elliptical Galaxies”, Graduiertenkolleg, Bochum (Germany), July 2
“Globular Clusters and the Formation of Elliptical Galaxies”, Armagh Observatory, Armagh (Northern Ireland), July 15
“The Globular Clusters of Dwarf Elliptical Galaxies”, STScI, Baltimore (USA), September 14

Pentericci:
“High redshift radio galaxies and the formation of brigthest cluster galaxies”, ESO, Garching (Germany), December 18

Perryman:
“Determining Star Positions with Extremely High Accuracy from Space: How and Why”, Cavendish Laboratory Physics Seminar, Cambridge (UK), February 11
“Scientific Results from the Hipparcos Mission”, ESTEC Colloquium, Noordwijk (The Netherlands), March 4
“Determining Star Positions with Extremely High Accuracy from Space: How and Why”, Institute of Advanced Study, Princeton (USA), March 24
“Hipparcos Results”, Washington Area Astronomers Conference, US Naval Observatory (USA), March 26
“Hipparcos Results”, Invited Plenary Lecture, Joint European Regional Astronomy Meeting, Prague (Czechia), September 11

Van der Tak:
“GL 2591 – A Developing Hot Core?”, University of California, Berkeley (USA), January 21
“GL 2591 – A Developing Hot Core?”, University of Texas, Austin (USA), January 30

De Zeeuw:
“Astrophysics: Unravelling the History of the Universe”, Presentation together with E.P.J. van den Heuvel for the NWO Selection Committee for National Research Combinations, Radisson Hotel, Amsterdam (The Netherlands), February 24
“A HIPPARCOS Census of Nearby OB Associations”, Astronomy Department, University of Maryland, College Park (MD, USA), April 8
“A HIPPARCOS Census of Nearby OB Associations”, Institute of Astronomy, Cambridge (UK), May 6
“Massive Black Holes in Galactic Nuclei: Dynamical Evidence”, Institute of Astronomy, Cambridge (UK), May 7
“Het NOVA Dieptestrategie programma”, Presentation for Crownprince Willem Alexander, and His Excellency Hermans, Rijksmuseum, Amsterdam (The Netherlands), September 29
“Dynamics of Galaxies and Integral Field Spectroscopy”, Isaac Newton Group of Telescopes on La Palma (Canary Islands), November 2
“A HIPPARCOS Census of Nearby OB Associations”, Sterrenkundig Instituut Utrecht (The Netherlands), November 11

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“Tidal streams and microlensing towards the Magellanic Clouds”, Santa Cruz (USA), December 18

Appendix X Scientific Publications

X.1 Ph.D. Theses, Books and Catalogues

Hogerheijde, M.R.: **The Molecular Environment of Low-Mass Protostars**, Leiden University, pp. 1–200

Klessen, R.S.: **Fragmentation of Molecular Clouds: The Initial Phases of a Stellar Cluster**, Ph.D. Thesis, Ruprecht-Karls-Universität Heidelberg, pp. 1–200

Li, A.: **Theoretical Studies of Interstellar Dust with Applications to Comets**, Ph.D. Thesis, Leiden University, pp. 1–175 (defence September 2nd, 1998)

Papadopoulos, Padeli P.: **Molecular gas in Seyfert Galaxies**, Ph.D. Thesis, University of Toronto, Canada pp. 1–132 (defence May 1998)

Röttgering, H.J.A., Best, P.N., Lehnert, M.: **The Most Distant Radio Galaxies**, Proceedings of the KNAW Colloquium, KNAW, pp. 1–516

X.2 Papers in Refereed Journals

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X.5 Awards

Prof. dr. M. Perryman was awarded:

1) Prix Janssen of the Société Astronomique de France
2) ADION Medal of the Observatoire de la Côte d'Azur (Nice, France)

Appendix XI Phone, Room Numbers and E-mail Addresses

e-mail - note : only usernames which are different from the family name are given.

Family Name :	Tel. :	Room nr.	user@strw.LeidenUniv.nl
Arts	5866	567	
Best	5847	453	pbest
Blaauw	5834	532	
Bloemen	5891	570	
Boland	5873	464	
Boonman	5815	504	
Bruijne, de	5878	451	debruyne
Bureau	5882	455	
Burton	5848	535	
Chatzichristou	5826	561	chatzich
Cioni	5815	504	
Cretton	5882	455	
Dam, van	5845	436	bdam
Deul	5827	509a	
Dishoeck, van	5814	505	ewine
Dokkum, van	5861	551	
Dominik	5812	507	
Dullemond	5841	569	dullemon
Ehrenfreund	5812	507	pascale
Feleus	5860	560	
Franx	5870	553	
Genderen, van	5863	568	genderen
Gerritsen	5884	434	wieke
Greenberg	5804	501	greenber
Habing	5853/5916	539/525	
Hartendorp	5877	562	mhartend
Haverkorn	5831	506	haverkrn
Heij, de	5866	567	deheij
Heijden, van der	5842	534	heijden
Heijligers	5866	567	heyliger
Helmi	5847	453	ahelmi
Den Hollander	5825	468	rholland

Name :	Tel. :	Room nr.	user@strw.LeidenUniv.nl
Hoogerwerf	5878	451	hoogerw
Houten, C. van	5876	432	
Houten-Groeneveld, I. van	5881	435	vhouten
Hulst, van de	1224	365	
Icke	5843	470	
Israel	5891	570	
Jaffe	5862	563	
Jansen	5810	509c	
Janssen	5826	561	olafj
Kamerbeek	5813	537	mkamerbe
Kamp, van de	5877	562	tijmen
Kan-Schäefer, van	5837	456	pita
Kanter, de	5801	521	
Katgert	5817	502	
Katgert-Merkelijn	5916/5845	525/464	merkelijn
Klessen	5738	467	
Kloppenburg	5851	465	klop
Kosters	5829	440	
Kurk	5838	571	
Kwee	5881	435	
Labbé	5842	534	ivo
Lub	5840	564	
Luu	5846	441	
Meer, van der	537	5818	vdmeer
Meulen, van der	5812	507	vdmeulen
Mil, van	5831	506	mil
Miley	5849	469	
Miller	5880	462	bmiller
MunozCaro	5809	503	munoz
Nezhinsky	5839	439	nezh
Novozamsky	5829	440	novozam
Ortiz	5826	561	
Papadopoulos	5850	457	papadop
Pentericci	5813	437	laura
Perryman	5891	570	mperryma@estsa2.estec.esa.nl
Le Poole	5871	541	lepoole
Pronk	5825	468	
Reeven, van	5845	436	reeven
Reuland	5825	436	
Robichon	5875	463	
Roland	5818	537	
Röttgering	5851	465	rottgeri

Name :	Tel. :	Room nr.	user@strw.LeidenUniv.nl
Salamanca	5838	571	salamanc
Schilizzi	5839	439	rts
Schoenmakers	5839	439	schoenma
Schutte	5801	521	
Shimron	5805	558	
Simis	5841	569	
Slegtenhorst	5832	460	slegten
Smit	5916	525	
Sonnentrucker	5865	536	sonnentr
Soulsby	5833	458	
Steenbrugge	5851	465	steenbr
Stil	5883	565	
Tak, van der	5831	506	vdtak
Thi	5809	503	
Thomas	5860	560	
Tschager	5839	439	tschager
Veen	5861	551	
Venemans	5884	434	
Verolme	5836	438	
Versteege	5818	537	versteeg
Visser	5891	570	rvisser
Vlemmings	5831	506	vlemming
Vos	5828	509b	avos
Voskes	5805	558	
Weerstra	5818	537	klaasw
Werf, van der	5883	565	pvdwerf
Wesseling	5839	439	wesselin
Wielders	5863	438	arnoux
Wisse	5916	525	
Witmer, NOVA	5845	464	
Zaal	5852	459	
	Fax NOVA: 071-5275743		
Zadelhoff, van	5809	503	zadelhof
Zeeuw, de	5879	461	dezeeuw
Zhao	5875	463	hsz
Zhang	5738	467	

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Editors: H.J.A. Röttgering, J. Lub, Y. Slegtenhorst, M.J. Hartendorp, G.M. Kosters
With thanks to D. Jansen, E. Deul