Annual Report
2001

Astronomical Institute “Anton Pannekoek”
Front cover:

Simulated star cluster with 65536 stars in orbit around the center of the Milky-way Galaxy. The distance to the central black hole is about 7 pc. The cluster is gradually disrupted due to the tidal effect of the central black hole and spirals inwards towards this black hole. Only the stars which once were part of the cluster are shown, the stars which make up the Galaxy are not shown but only some background stars are. This simulation is performed on the GRAPE-6 special purpose computer at the University of Tokyo. The results will be published by Portegies Zwart and McMillan (2002, submitted to ApJ).
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REPORT OF THE DIRECTOR

The institute continued on the course set out in previous years in the framework of the national research school NOVA for which the University of Amsterdam carries the responsibility as “penvoerder” for the period 1-9-1997 till 1-9-2002. In 1999 NOVA started its ten-year “Dieptestrategie” research program “Astrophysics: Unravelling the History of the Universe” as a national “top-researchschool”. Our institute plays a major role in two of NOVA’s three research themes: “Late Stages of Stellar Evolution: Physics of Neutron Stars and Black Holes” and “Birth and Death of Stars: The Lifecycle of Gas and Dust”.

Notable events and developments in the year 2001 were:

- The Jan van Paradijs Memorial Symposium which was held from 6 – 8 June 2001 in Amsterdam. Some 125 colleagues and friends of Van Paradijs came to Amsterdam and in the spirit of Van Paradijs, presented exciting new scientific results in the fields of science in which Jan was active. The proceedings of the Symposium will be published by the Astronomical Society of the Pacific in San Francisco.

- The fact that this year, for the first time in the history of the Institute, eight Doctoral degrees were awarded. Among the eight defendants there were three special cases:
  • Dr. David McDavid from Texas, who has his own private astronomical observatory, where he carried out all research for his Ph. D. thesis, with his own state of the art professional instrumentation.
  • Dr. Bernard Deufel, of the Max Planck Institut für Astrophysik in Garching, who chose to defend his thesis in Amsterdam.
  • Dr. Lodie Voûte, who carried out his Ph. D. research fully on his own private account: the design and construction of the “pulsar machine” PUMA-1 for the Westerbork Synthesis Radio Telescope; he carried out important pulsar research with this instrument. This was the first “Pulsar Ph. D.” awarded in Amsterdam, and the second one in the country.

- The Dean of the Faculty of Science agreed to establish a new 0.7 professor position in Astrophysics, which in combination with the 0.3 chair of the Vrije Universiteit (VU) will form one full professor chair. The new 0.7 chair will for the first years be funded from the special CvB grant awarded to the Institute in 2000 for the 2000-2005 program “Frontiers in Astronomy and Cosmic Physics”.

- The Dean at the same time (May 2001) agreed that a NOVA-overlap position on level UD/UHD could be advertised for the institute. Nomination committees were established both for the Chair in High Energy Astrophysics (Jan van Paradijs' position) and the new UvA + VU chair and both positions were advertised in July and August 2001. Candidates for both chairs were invited to give colloquia at the institute and were interviewed in the months November and December. The “overlap position” will be filled later, once it is clear who will be appointed to the two professor chairs.

- The awarding of a substantial NWO-grant in the framework of the program “Computational Science” for studying the combined stellar and dynamical evolution of dense star clusters, using a combination of GRAPE computers and workstations. For this program Dr. S. Portegies Zwart was elected to a KNAW-Fellowship, such that in his place a new postdoctoral fellow could be appointed in the Computational Science project, which he is now leading.

Some Research Highlights

- Discovery of a double ring structure in the very luminous and peculiar star Eta Carina, by Hony, Waters et al.
- Discovery of the presence in the Infrared spectra of metal-poor, carbon-rich planetary nebulae and very evolved (AGB) stars, of a variety of compounds not found earlier outside the solar system, such as Titanium-Carbide, by Kemper, Waters, de Koter et al.
- The determination of the grain sizes (in the range 0.1 to 2 micron) of the silicates in the disks around Herbig Be stars, from the wavelengths of their absorption bands in the range 9.7 to 11.0 microns, by Bouwman, Waters et al.
- The detection of prominent emission features of Polycyclic Aromatic carbo Hydrates (PAHs) in the peculiar post-AGB binary HR 4049 and in the carbon star IRAS 04925-6040, by Cami, Yamamura, Molster, Hony et al.
- The work of de Jong on interpretation of Babylonian and Greek observations of the planets.
- The discovery by Vreeswijk of absorption lines with redshift 1.619 in the optical afterglow of the Gamma Ray Burst (GRB) of May 10, 1999. These are absorption lines due to the Interstellar Matter in the host galaxy of this GRB. The host itself, pictured with the Hubble Space Telescope, appears to be so faint (V= 28 magnitudes) that taking its spectrum is impossible, even with the largest telescopes on Earth. Nevertheless, thanks to the GRB we now know its spectrum and its redshift. This demonstrates how GRBs can provide a way to determine the redshifts of extremely faint and distant galaxies, which otherwise could never be measured.
- The discovery of 0.59 second-period X-ray pulsations in the 5.57-hour orbital period Low-Mass X-ray Binary 2A 1822-371, a system that was already known some 25 years, by Jonker and van der Klis. The pulsar has a strong magnetic field, very unusual for a LMXB and appears to be rapidly spinning up.
- Determination of limits to the masses of two black-hole binary X-ray sources by Orosz, Kuulkers and van der Klis: between 8.7 and 11.7 solar masses for the jet source SAXJ1819.3-2525 (V4641 SGR) and > 6.7 solar masses for the source XTEJ1550-564.
- The discovery by Fender and Kuulkers that accreting black holes in X-ray binaries are more "radio loud" in comparison to their X-ray emission than accreting neutron stars in X-ray binaries.
2. GENERAL INFORMATION

Mission and Research Themes

The ultimate goal of astronomical research is to understand the Universe and the objects within it in terms of the laws of physics. The structure of the Universe and its development over the course of time, the nature, formation, and evolution of planets, stars, galaxies, clusters and superclusters of galaxies, and the properties of the medium in which these are embedded, are all important objects for study. Cosmological questions concerning the nature and evolution of the Universe relate directly to such questions as the geometry of space-time, the nature of dark matter which constitutes over 90% of the gravitating mass in the Universe but leaves no trace in the form of electromagnetic radiation, the formation of the elements and, ultimately, the origin of the Earth and of life. Furthermore, the Universe provides a unique laboratory for investigating and testing the laws of chemistry and physics under conditions far more extreme than can be reached in laboratories on Earth: astrophysicists study phenomena involving enormous scales of length and mass (the Universe as a whole), huge densities (e.g., neutron stars, black holes), extreme vacua (interstellar and intergalactic media), immense energies (explosive phenomena such as supernovae and quasars), and intense fluxes of particles and radiation (neutrinos, gamma-ray bursts).

Since 1992, all graduate astronomy education in the Netherlands has been concentrated in NOVA, the Netherlands Graduate School for Astronomy. NOVA is a federation of the astronomy institutes at the universities of Amsterdam (UvA), Groningen (RuG), Leiden (RuL), and Utrecht (UU), and also includes the astronomy group at the Free University of Amsterdam (VU). The University of Amsterdam since 1997 carries the responsibility (penvoerderschap) for NOVA. The mission of the four university institutes that together constitute NOVA is two-fold:
* to train students and young astronomers at the highest international level;
* to carry out frontline astronomical research in the Netherlands.

In 1998 NOVA as selected by the Minister of Science as one of the six “Top Research Schools” in the country, granting it substantial extra funding for a period of ten years, starting 1-1-1999.

NOVA has three main research themes:
1. Formation and Evolution of galaxies: from high redshift to the present
2. Birth and Death of Stars: the life cycle of matter in the Universe

Research at the University of Amsterdam largely concentrates on the last-mentioned two themes, which we, according to the energies of the electromagnetic radiations emitted by the objects, indicate as “Low Energy Astrophysics” and “High Energy Astrophysics”, respectively. These names will be used throughout this report. Through the studies of Gamma Ray Burst sources, the research of the institute now also branches out into the first-mentioned theme. The table on page (10) gives an overview of the present research fields in the Institute.

The Astronomical Institute "Anton Pannekoek" also considers as an important part of its mission: the dissemination of the results of astronomical research to the general public and to schools. NOVA's national Office of Public Outreach is located at the institute.
Institute Management

**Scientific Director**
Prof.Dr. Edward P.J. van den Heuvel

**Business Manager**
Mrs. Lidewijde Stolte

**Management Assistants**
Mrs. Drs. J. Ayal, Mrs. Drs. F. E. Kroon, Mrs. Drs. A. Lenssen

**Management Team**

**Scientific Advisory Committee**
Prof. Dr. Ir. J.A.M. Bleeker, director Space Research Organization of the Netherlands (SRON), Utrecht
Prof. Dr. P. Charles, Universities of Oxford and Southampton (UK)
Prof. Dr. C. Waelkens, Sterrenkundig Instituut, Katholieke Universiteit Leuven, België
Table 1: Areas and subjects of planned research

**HIGH-ENERGY AND RELATIVISTIC ASTROPHYSICS**

*Final stages of stellar evolution: physics of neutron stars and black holes*

<table>
<thead>
<tr>
<th>AREA</th>
<th>SUBJECT</th>
</tr>
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<tbody>
<tr>
<td>Physics of Neutron Stars and Black Holes</td>
<td>* Measurement of fundamental parameters of neutron stars (mass, radius rotation period, magnetic field) and black holes (mass, angular momentum)</td>
</tr>
<tr>
<td></td>
<td>* Observed behaviour of matter in ultrastrong gravitational fields; tests of general relativity: frame dragging, last stable orbit</td>
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<tr>
<td></td>
<td>* Studies of relativistic outflows</td>
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<tr>
<td></td>
<td>* Study of (binary) radio pulsars; tests of general relativity</td>
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<td></td>
<td>* Theoretical studies of the formation and evolution of neutron stars (NS) and black holes (BH) in binary systems; formation rate of double neutron stars and black holes</td>
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<td></td>
<td>* Evolution of stellar populations (clusters) with a realistic binary fraction; dynamical formation of NS and BH binaries</td>
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<tr>
<td>Gamma-Ray Burst Sources</td>
<td>* Optical identifications, light curves, redshift distributions, cosmological evolution</td>
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<td></td>
<td>* Study of population of parent galaxies as function of redshift</td>
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<td></td>
<td>* Theoretical modeling of bursts; relativistic acceleration mechanisms</td>
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</tbody>
</table>

**LOW-ENERGY ASTROPHYSICS**

*Birth and death of stars: the life cycle of matter in the Universe*

<table>
<thead>
<tr>
<th>AREA</th>
<th>SUBJECT</th>
</tr>
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<tbody>
<tr>
<td>Star- and Planet Formation, &quot;Starbursts&quot;</td>
<td>* Studies of protostars and protoplanetary disks: spectroscopy, chemical composition</td>
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<tr>
<td></td>
<td>* Search for proto-planets and planets around other stars, using VLTI, ALMA, FIRST etc.</td>
</tr>
<tr>
<td></td>
<td>* Study of formation of massive stars in Local Group and &quot;Starburst Galaxies&quot;; relation to chemical evolution and dust formation in galaxies in the early Universe</td>
</tr>
<tr>
<td></td>
<td>* Theoretical modeling of spectra of circumstellar gas and dust</td>
</tr>
<tr>
<td>Solar System Studies, Lab. Astrophysics</td>
<td>* Spectroscopic and photometric studies of planets, comets and asteroids, in order to compare with observed properties of (proto-) planetary systems around other stars, laboratory experiments in light scattering and polarization</td>
</tr>
<tr>
<td>Late Stages of Stellar Evolution, Mass Loss</td>
<td>* Studies of dense circumstellar matter around highly evolved stars; AGB and post-AGB stars; formation of dust in envelopes of these stars; Studies of winds of massive stars and mass loss from luminous blue variables (LBVS)</td>
</tr>
</tbody>
</table>
3 RESEARCH

3.1 HIGH-ENERGY ASTROPHYSICS OBSERVATIONAL STUDIES

3.1.1 Study of Gamma Ray Bursts (GRB)

The Jan van Paradijs Memorial Symposium, which was held from 6 – 8 June 2001 in Amsterdam, was in large part devoted to the field of Gamma Ray Burst studies. The Amsterdam-led European Gamma Ray Burst (GRB) collaboration initiated by Van Paradijs (consisting of groups in Denmark, France, Germany, Italy, The Netherlands, Spain and the United Kingdom, and associated with three groups in the USA) was awarded in 1999 by the European Southern Observatory (ESO) in Chile an ESO Large Program for following up the optical and infrared GRB-afterglows in the 2-year period April 1, 2000-April 1, 2002. The PI of this proposal (van den Heuvel) organized on 9 and 10 June a collaboration meeting in Amsterdam for coordinating the research, which is largely aimed at following up GRBs to be observed with the HETE-II satellite, which was launched in October 2000. Also, of course, bursts observed with the Italian-Dutch BeppoSAX satellite are being followed-up.

Dr. Isabel Salamanca joined the group as a postdoctoral in February 2001. Dr. T. Galama, working as a postdoctoral fellow at the California Institute of Technology was awarded a “Vernieuwings Impulse” grant of NWO for working at the UvA but for personal reasons decided not to accept this.

Vreeswijk, Rol, Kaper and Van den Heuvel continued the study of GRB afterglows and their host galaxies. They were awarded also considerable observing time on the telescopes of the Isaac Newton Group on Palma (PI: P.Vreeswijk, C.Kouveliotou (US) and N.Tanvir (UK)). In collaboration with PI A.Fruchter, Vreeswijk and Salamanca studied images and high-resolution spectra of GRB afterglows and host galaxies with the Hubble Space Telescope. Access to the mm and radio wavelength domain is provided by the James Clerk Maxwell Telescope in Hawaii (PI: Smith) and the Westerbork Synthesis Radio Telescope (WSRT: PI: Rol), respectively.

Although the launch of the HETE-II satellite was delayed to October 2000 and the calibration of the instrument took longer than anticipated, several GRBs, located by BeppoSAX and the InterPlanetary Network, could be followed up. The Amsterdam GRB group was involved in the identification and/or follow-up study of the following Gamma-Ray Bursts (the GCN-numbers are the numbers of the GRB-circulars in which the discovery regarding that burst was first announced): GCN Circular, 955 Rol, E., et al. "GRB010214, candidate optical afterglow"; GCN Circular, 1059 Rol, E., et al. "GRB010214, optical observations"; GCN Circular, 1124 Rol, E., et al. "GRB 011030, WSRT radio observations".

Vreeswijk discovered absorption lines with a redshift of 1.619 in the afterglow of GRB990510. The strengths of the lines are indicative of a dense interstellar environment in the host galaxy. This galaxy is so faint (28 magn.) that spectroscopic studies are impossible. However, thanks to the bright afterglow of its GRB, we now know its redshift and gas density.

Vreeswijk also conceived the idea of studying the host galaxy star formation rate by measuring its continuum radio intensity. The continuum emission is due to the combined emission of all supernova remnants in the galaxy and therefore is an excellent probe of massive star formation. He successfully applied this to several GRB host galaxies for which he derived the star formation rates.

Rol continued his studies of the polarization of Gamma Ray Bursts and of Radio afterglows. He started, together with C. Kouveliotou of the Marshall Space Flight Center (Huntsville Alabama) a
systematic study of the luminosities and spectra of bursts observed with the BATSE experiment on NASA’s GRO spacecraft.

### 3.1.2 Studies of Neutron Stars and Stellar Black Holes

#### 3.1.2.1 X-ray Pulsars

Jonker and van der Klis discovered 0.59 s X-ray pulsations from the low-mass X-ray binary 2A 1822–371. The discovery of a pulsar in this system was a surprise, because this is a well-known source that had been studied intensively since the early 1980's because it is oriented in space in such a way that we are looking at it sideways (it has a high orbital inclination), which causes the accretion disk and, every 5.57 hrs, also the companion star, to cover up the emitting regions near the neutron star. The reason that this pulsar took so long to find is its extreme weakness: the pulsations are only a small fraction of the total flux of the source. Pulse arrival time analysis now makes it possible to accurately measure the orbital motion of the neutron star, and indicates a circular orbit with an eccentricity of less than 3% and an orbital radius for the neutron star of about a lightsecond (300000 km). (see Figure). The pulse period was 0.59325(2) s in 1996.270 and 0.59308615(5) s in 1998.205, indicating an average spin up with $\dot{P} / P = (-1.52 \pm 0.02) \times 10^{-4}$ yr$^{-1}$. The long pulse period, in the second rather than in the millisecond range was another surprise, because 2A 1822–371, as a low-mass X-ray binary, was expected on general grounds to be an old system (more than a hundred million years or so), this time scale is set by the evolution of the low-mass donor star in the system. The accretion of matter onto the neutron star would have been expected to have made its magnetic field much lower than the $\sim 10^{12}$ Gauss such a long spin period suggests.

![X-Ray Pulsar 2A1822-37. The arrival time delay in light seconds of the pulses due to the orbital motion of the neutron star as a function of binary phase. The sinusoid is the best fit to the dots. The residuals of the fit (crosses) are shown at a 10 times expanded scale. Error bars are shown for the dots; for clarity they are omitted for the residuals.](image-url)
The long life of LMXBs allows for considerable accretion, and hence higher neutron star masses are expected in those systems than in others. Mass determinations in LMXBs are hampered by the fact that these systems hardly ever are found to contain a pulsar (2A 1822–371 is only the fourth LMXB pulsar with a measurable orbit), so this discovery opens up a new opportunity to possibly measure a high neutron star mass. While in other systems the ill-constrained orbital inclination still allows a large range of neutron star masses even if pulsations do allow for a mass measurement, in 2A 1822–371 the inclination is well known. For the first time measuring the mass of a neutron star exceeding the canonical 1.4 M\(_\odot\) would be of great interest, as it would constrain the still unknown equation of state of supra-nuclear density matter in ways not otherwise possible. We requested and immediately obtained – 6 hours of Directors Discretionary Time for follow-up optical spectroscopic observations of this system with ESO's 8.2 m Very Large Telescope that will be performed in 2002.

Work continued on the only known accreting millisecond pulsar, SAX J1808.4-3658, discovered in 1998 by Wijnands and Van der Klis. By the end of 2001 this object had already been referred to in a total of 125 articles in refereed journals. The pulsar, which is a transient X-ray source, must have had another (eagerly awaited) outburst in the early days of 2000, which unfortunately could not be observed because of proximity in the sky of the Sun to the source in that time of the year. After January 21 the aftermath of this outburst was observed by Wijnands, Mendez, van der Klis et al. in the form of exceptionally erratic X-ray luminosity variations, with changes in luminosity by more than a factor 1000 in just a few days.

3.1.2.2 Black holes

Simultaneous twin high-frequency QPOs were discovered by Miller (MIT), Wijnands, Homan, Belloni, van der Klis et al. These QPOs, at frequencies of 180 and 270 Hz, form only the second example above 100 Hz of what appears to be an emerging class of oscillations in accreting black holes characterized by an approximate 2:3 frequency ratio. In an exciting proposal, Kluzniak and Abramowicz recently conjectured that such QPOs could be related to resonances occurring at those radii in an accretion disk where the general relativistic azimuthal and radial orbital frequencies have small integer ratios. That these frequencies are different at all is due to relativity: in classical mechanics they are the same. That they would be different by as much as 50% is only possible in the strongest of gravitational fields, very close to a black hole (or a neutron star). If the Kluzniak/Abramowicz conjecture is correct, then out of the many frequencies present in the accretion disk of XTE J1550-564, strong field general relativity is selecting just two, at 180 and 270 Hz, for us to observe.

Brocksopp (Open University), Jonker, Fender, van der Klis et al. studied an outburst of the black hole candidate system GS 1354-64 by X-ray, optical and radio observations. The source turns out to be exceptional as it stayed in the so-called low/hard state during the entire outburst.

The defining characteristic that observationally distinguishes an accreting black hole candidate from an accreting neutron star is its mass. For this reason, mass determinations are a central issue in black hole studies. Two new dynamical black hole masses were determined by optical spectroscopic observations by Orosz (UU), Kuulkers, van der Klis et al. In the superluminal jet source SAX J1819.3-2525 (V4641 Sgr) a black hole with a mass of 8.7–11.7 Solar masses was found. In the system XTE J1550-564 (where we also found the twin QPOs) a lower limit on the compact object mass was determined of 7.4 +/- 0.7 Solar masses, indicating that this object, too, definitely is a black hole and not a neutron star.

In the area of relativistic jets from black hole candidates a major accomplishment was the modeling of the broadband radio-through-X-ray spectrum of the newly discovered transient black hole
candidate XTE J1118+480 with a jet model by Markoff (MPIfR), Fender et al. For the first time this model demonstrated that the hard X-ray emission observed in this accretion state may arise from the jet, possibly as optically thin synchrotron emission (see figure below).

Jet-modeling of the newly discovered black hole candidate XTEJ1118+480: a model in which the broadband, radio through X-ray spectrum in the low/hard X-ray state is dominated by the jet. From Markoff, Falcke & Fender (2001).

Further direct evidence for a jet in the low/hard state was established with the imaging of the jet in this state from the archetypal black hole binary Cygnus X-1 by Stirling (CfA), Fender et al. on milliarcsecond scales with the VLBA. Fender (2001a,b) argues that such a powerful jet is present in all low/hard state systems.

Another highlight was the survey of radio and X-ray fluxes from both black hole and neutron star X-ray transient transients, by Fender and Kuulkers. In this study it was found, as expected, that there is a (rank) correlation between the radio and X-ray emission, indicating a coupling between accretion and outflow at the highest accretion rates. Unexpectedly, it was also found that black holes are more 'radio loud' than neutron stars – possible interpretations of this important result are [a] black holes are more efficient at making jets (deeper potential and/or more spin energy), [b] black holes are less efficient at making X-ray emission (due to the lack of a solid surface c.f. neutron stars).

J. Homan completed his Ph. D. thesis and left to take up a postdoctoral position in Milan, Italy.

3.1.2.3 Quasi-periodic oscillators

In the field of the kHz quasi-periodic oscillations (QPOs), the fastest X-ray phenomena in X-ray binaries, a large amount of work was aimed at understanding the enigmatic ‘parallel lines’ observed in the QPO frequency vs. X-ray luminosity diagram of accreting low-magnetic field neutron stars (see figure below), which paradoxically seem to suggest that QPO frequency is both strongly, and not at all, dependent on the rate of mass accretion onto the neutron star. Van der Klis proposed the first quantitative, albeit phenomenological, explanation for this phenomenon in the form of a numerical description in which QPO frequency depends on the inner radius of the accretion disk, which in turn is determined by the ratio between X-ray luminosity and amount of matter at the inner
edge of the disk. If part of the X-ray luminosity responds 'sluggishly' to the variations in the amount of matter at the inner edge, which can be accomplished in a number of different ways, the model produces parallel lines remarkably similar to those (see figure on the next page).

Parallel lines as observed in the diagram of QPO frequency versus X-ray luminosity of the source 4U 1608–52.

Parallel lines in the diagram of QPO frequency versus X-ray luminosity as calculated with the model of van der Klis (see text).

The parallel lines observed in the neutron star low mass X-ray binary and atoll source 4U 1636–53 were placed in the perspective of the spectral variations of the source by di Salvo, Méndez and van der Klis. They analyzed ~ 600 ks data from the X-ray observatory RXTE of the source spanning
almost three years, from April 1996 to February 1999. The color-color and hardness-intensity diagrams show significant secular shifts of the atoll track, exhibiting two parallel branches in the upper banana, corresponding to two different intensity levels. This is most evident in the hardness-intensity diagram, where shifts in intensity up to ~20% are observed (Fig. next page, left panel). In the kHz QPO frequency vs. count rate diagram at the same time two parallel tracks are observed corresponding to two different flux levels (Fig. next page, right panel). The intensity shifts in the hardness-intensity diagram are found to be responsible for the parallel tracks observed in the kHz QPO frequency vs. intensity diagram. This is the first time that secular motion in an atoll source (already known for this source from 1997 work by Prins and van der Klis) could be explicitly coupled to kHz QPO properties and their 'parallel lines'.

Méndez, van der Klis and Ford studied the amplitude of the kHz QPOs in three atoll sources as a function of X-ray luminosity. The idea of this work was to investigate if the intensity variations underlying the parallel lines occur in the form of 'extra light' not participating in the QPOs and hence diluting them in the overall signal. The result of this work was that such a scenario can with certainty be excluded.

kHz QPOs were discovered by Jonker, van der Klis, Homan, Méndez, van Paradijs, Belloni, Ford et al. in the faint low-mass X-ray binary 2S 0918-549, bringing the total number of kHz QPO sources to 20.

**Left panel:** hardness-intensity diagram of 4U 1636–53. Each point represents 64 s of data. The hard color is defined as the ratio of the count rate in the bands 9.7–16 keV/6.4–9.7 keV. The intensity is defined as the source count rate in the energy band 2–16 keV. The hard color and the source intensity are normalized to the Crab values. Different colors indicate datasets from different observations (P10072: black; P10088: red; P30053: green; P30056: blue; P40028: light blue). The arrows in the hardness-intensity diagram indicate those parts of the diagram where the shifts (due to secular motion) are particularly evident. **Right panel:** The lower kHz QPO frequency in 4U 1636–53 plotted vs. the 2–16 keV source count rate in Crab units. Different colors indicate different datasets, as above. The parallel lines in the frequency vs. count rate diagram are seen to be related to the secular motion in the hardness vs. intensity diagram.
Van Straaten, van der Klis, di Salvo and Belloni used Fourier power density spectra to study the timing properties of two low mass X-ray binaries, 4U 0614+09 and 4U 1728-34. Both these sources are known to show quasi-periodic oscillations with frequencies ranging from a few hundred Hz to more than 1000 Hz. Most models describing the kilohertz QPO phenomenon assume that the upper kHz peak (the QPO with the highest centroid frequency of the pair of kilohertz QPOs) is determined by the Keplerian frequency at the inner edge of the disk. Several timing features were identified in these two sources and the relation between the frequency of the upper kHz QPO and the frequencies of all other timing features were found to be almost identical in 4U 0614+09 and 4U 1728-34 at luminosities a factor 5 different as shown by the figure on the next page, suggesting that this figure exhibits a fundamental set of physical oscillations of an accretion disk, which is relatively independent of the average accretion rate through the disk. Note also that while most frequencies vary together, one feature seems to keep an approximately constant frequency between 100 and 200 hz. Similarly constant-frequency oscillation features are seen in black hole candidates (see, e.g., the Miller et al. work reported in that section of this report) and are suspected to reflect the (constant) properties of the warped space-time around the compact object rather than any (time variable) disk configuration property dependent on instantaneous mass accretion rate.

Correlations between the characteristic frequencies of the several timing features found in 4U 1728-34 and 4U 0614+09 and the characteristic frequency of the upper kilohertz QPO. The grey symbols are the 4U 1728-34 points, the black symbols the 4U 0614+09 points. The symbols mark the different features (see text on previous page).

### 3.1.2.4 Transient neutron stars

The source KS 1731-260, which suddenly turned off as an X-ray source in 2001 after having been bright for more than ten years was studied in X-rays and optical by Wijnands (MIT), Groot, van der
Klis et al. Making use of the drop in flux the optical counterpart of the source was identified, and using the sensitive Chandra X-ray observatory the quiescent flux of the source was measured. This quiescent flux was lower than predicted by some theories for neutron star cooling, with potentially important consequences for our understanding of neutron star interiors.

A search for millisecond oscillations in X-ray bursts of the enigmatic 'Rapid Burster' by Fox (MIT), van der Klis et al. led to an intriguing, but inconclusive, result of the possible detection of 306 Hz pulsations. The Chandra observatory grating spectrograph was used by Marshall (MIT), van der Klis et al. to perform a detailed study of the spectrum of this source. No lines were detected.

### 3.1.2.5 X-ray spectroscopy of NS LMXBs

Investigations continued of the properties of X-ray emission from bright low mass X-ray binaries and their correlation with the source state (and probably mass accretion rate) as determined from the position of the source in the X-ray color-color diagram.

![Color-color diagram of GX 349+2. The hard color is the ratio of the counts in the 7–10.5 keV and the 4.5–7 keV energy bands, and the soft color is the ratio of the counts in the 4.5–7 keV and 1.8–4.5 keV energy bands. Each bin corresponds to 200 s. Right panel: Unfolded spectrum of GX 349+2 and the best-fit model, shown as the solid line on top of the data. The individual model components are also shown, namely the blackbody (dashed line), the Comptonized spectrum (dotted line), two Gaussian emission lines at 1.2 keV and 6.7 keV (triple-dot-dashed lines), and the power law (solid line).](image)

A BeppoSAX observation of the Z source GX 349+2 was analyzed by di Salvo et al., during which the source was at the transition between the so-called normal and flaring branches (see the figure in this paragraph, left panel). The X-ray continuum below 30 keV was dominated by blackbody emission interpreted as emission from an accretion disk and a component due to Compton scattering.
of soft photons produced within a few km from the neutron star off electrons in a hot corona surrounding the neutron star. Two emission lines, at 1.2 keV (probably from the L shell of Fe XXIV) and 6.7 keV (identified as Fe K α emission line), respectively, and an absorption edge, at 8.5 keV, are also significantly detected in the spectrum of GX 349+2. The high energy of both the Fe line and edge indicates that these features are produced in a highly ionized region (corresponding approximately to Fe XXV). An exceptionally hard spectral component is detected above 30 keV, with no evidence of a high energy cutoff up to ~100 keV. The spectrum of GX 349+2 is shown in the above figure (right panel). A general trend is emerging that the hard component is weaker at higher accretion rates, and GX 349+2 fits in this trend. The spectra of Z sources seem quite similar to the spectra of black hole candidates in some soft spectral states. It is therefore probable that the same mechanism is responsible for the hard tails observed in black hole candidates and in Z sources. This would imply that this mechanism does not depend on the presence or absence of an event horizon. di Salvo et al. have proposed that non-thermal, high energy electrons, responsible for the hard tails observed in Z sources, might be accelerated in a jet. In fact all the Z sources are detected as variable radio sources, with radio fluxes weakening when the source moves along the Z-track from the horizontal branch to the normal branch and to the flaring branch, consistent with the presence of a variable jet.

Iaria (Palermo Univ.), di Salvo et al. performed a broad band (0.1–200 keV) spectral analysis on the LMXB 2A 1822–371 (see the section on X-ray pulsars) using data from the BeppoSAX satellite. The best fit to the continuum spectrum of this source consists of a partially absorbed Comptonization component, representing scattering off soft seed photons by electrons at a temperature of ~4.8 keV. The equivalent hydrogen column obtained for the absorbed component is ~4.5 × 10^{22} cm^{-2}, an order of magnitude larger than the Galactic absorption for this source, and the covering fraction is ~71%. This model gives a reasonable scenario for the source: the Comptonized spectrum could come from an extended accretion disk corona (ADC), probably the only region that can be directly observed as a result of the high inclination. The excess matter producing the partial covering could be placed close to the equatorial plane of the system, above the outer disk, occulting most of the emission from the inner disk and the inner part of the ADC. An iron emission line is also present at ~6.5 keV with an equivalent width of 150 keV. This strong iron line cannot be explained as reflection of the Comptonized spectrum by the accretion disk, and it is probably produced in the ADC. An emission line at ~1.9 keV and an absorption edge at 8.7 keV are also required to fit this spectrum. These discrete features are produced by highly ionized elements (Fe XXIV, Si XIV or Mg XI) present in the outer part of the ADC, where the density is ~10^{11} – 10^{12} cm^{-3} and photo-ionized plasma can be present.

3.1.2.6 Optical and Ultraviolet observations of High-mass X-ray binaries and OB-runaway stars

A high-mass X-ray binary (HMXB) represents an important phase in the evolution of a massive close binary. When the initially most massive star has ended its life, its remnant, a neutron star or a black hole, is likely to remain in orbit with the massive secondary star. As a consequence of the supernova, the system is expected to receive a kick resulting in a space velocity of several tens to a hundred km/s (yielding an "OB-runaway" star). Hipparcos’ observations of the HMXB HD153919/4U1700-37 indicate that the system is traveling with a space velocity of 75 km/s. Reconstruction of its path through space shows that the system originates in the OB association ScoOB1 where it left about 2 million years ago. With the current age of ScoOB1 of about 8 million years, important constraints can be put on the properties and evolution of the progenitor system (Ankay, Kaper).
Material from the stellar wind of the massive secondary will be intercepted by the strong gravitational field of the compact remnant and accretes, powering a bright X-ray source. In case the X-ray source is an eclipsing X-ray pulsar, the orbital motion of the massive companion star is a direct measure of the neutron-star mass, an important quantity for our understanding of matter at supra-nuclear densities. A nine-month observing campaign at the European Southern Observatory in La Silla, Chile, has resulted in the accurate determination of the mass of the neutron star in Vela X-1, an eclipsing X-ray pulsar. So far, all neutron stars for which the mass has been accurately measured, such as the binary radio pulsars, have a mass close to 1.4 times the mass of the sun. Vela X-1 is an exception with a mass of $1.86 \pm (0.16) M_{\odot}$ and is the most massive neutron star known. It is very important to know up to which mass neutron stars can exist, as this provides crucial information about their internal structure. Several theoretical models describing the physics valid for neutron-star interiors only work for neutron stars with masses close to $1.4 M_{\odot}$. Therefore, the high mass of Vela X-1 poses a challenge to our understanding of matter at supra-nuclear densities (Barziv, van Paradijs, Kaper, Van Kerkwijk, 2001).

A sketch of the high-mass X-ray binary system hosting Vela X-1, the most massive neutron star known (Barziv et al. 2001). The X-ray pulsar creates a Strömgren zone in the stellar wind. A photo-ionization wake is formed at the trailing border of the Strömgren zone where the stagnant flow meets the fast, accelerating stellar wind.

The X-ray source in a HMXB can be used to probe the stellar wind of the OB-supergiant companion. Strong resonance lines in the ultraviolet spectrum of the OB star are formed in the stellar wind; the shape of these profiles is modulated by the ionizing radiation from the X-ray source and varies with the aspect angle (orbital phase) of the system. These line-profile modulations are modeled and used to determine the detailed structure of the stellar wind (Van Loon, Kaper, Hammerschlag-Hensberge). X-ray observations of 4U1700-37, obtained with XMM/Newton, are analysed to study its X-ray spectrum as a function of orbital phase, to analyse the X-ray flaring behavior, and to search for X-ray pulsations (Van der Meer, Kaper).
The reconstructed path of the runaway HMXB 4U1700-37 intersects with the location of OB association Sco OB1; the error cone is indicated by the dotted straight lines. The Hipparcos confirmed members of Sco OB1 are shown as filled diamonds. The proper motion of 4U1700-37 translates into a space velocity of 75 km/s with respect to Sco OB1 (distance 2 kpc). The corresponding kinematical age of 4U1700-37 is about 2 million year.

### 3.1.3 High Resolution X-Ray Spectroscopy – Derivation of basic atomic parameters

Since the launches of the two X-ray observatories CHANDRA and XMM-Newton in 1999 'hot' (high energetic) processes in the universe can be studied in detail as images and as spectra. The Low Energy Transmission Grating Spectrometer (LETGS) on board CHANDRA covers the range from 5 to 175 Å (0.07-2 keV). The Reflection Grating Spectrometers (RGS) on board XMM-Newton cover the range from 5 to 40 Å (0.3-2 keV) but with higher sensitivity, while the high sensitive low resolution EPIC-MOS covers the high energy range from 1 to 40 Å (0.3-10 keV). Spectra from these instruments result in temperature-, abundance-, density-, emission measure-, and plasma velocity-diagnostics for a variety of sources. The spectra are investigated by A. Raassen in close collaboration with the SRON National Institute for Space Research.

#### 3.1.3.1 Coronae of cool stars

Many late type F-M stars with photospheric temperatures between 7000 and 4000 K show hot outer atmospheres (coronae) with temperatures around 1-10 MK. Due to the high temperature these plasmas emit X-ray radiation. This steep rise of the temperature, above the stellar surface, by 3 orders of magnitude is -after decades of investigations- still a puzzling problem and not well understood. The solar corona shows rich details on structures, mass motions, abundance patterns, loops and flares. These phenomena are driven by magnetic activity. A study to coronal behavior and spectral type (F-M) and stellar rotation is carried out in collaboration with PSI (Switzerland) and the University of Hamburg. A publication on the coronal properties of Procyon (F5 IV-V), observed
with LETGS, RGS and EPIC-MOS, was prepared and appears in 2002 (Raassen et al. 2002). In the same project the analyses of the coronal spectra of α Cen A and B (G2V and K1V) has been extended and a publication is in preparation. The relatively 'cool' (< 4 MK) and inactive coronae of α Cen, observed with LETGS show a so-called FIP-effect: over-abundancies for elements with a low First Ionization Potential (Mg, Si, Fe, and Ni) relative to elements with higher First Ionization potentials (C, N, O, Ne). The investigations of spectra of the two M-dwarfs AT Mic (observed by EPIC-MOS and RGS) and AD Leo (observed by EPIC-MOS, RGS, and LETGS) have been started. A general study of the density and temperatures of ten stellar coronae, especially based on density sensitive He-like transitions of C, N, O, Ne, Mg, and Si has been finished. The publication was accepted by A&A.

3.1.3.2 Hot stars

The X-ray spectra of the WR+O binary WR25 and the single B-star τ Sco has been observed by means of RGS and EPIC-MOS on board XMM-Newton. Both objects show strong X-ray luminosity. For the WR+O binary this is caused by the collision of the strong stellar winds. The dense wind of the WR-star, however, absorbs the longer wavelength radiation and suppresses the spectrum above 15 Å. The hot component of the colliding winds produces a strong Fe Kα feature around 6.7 keV. For the single B-star τ Sco falling clumps in the wind seem to be the mechanism for X-ray radiation. For τ Sco the high nitrogen abundance is striking, while the strong radiation field of this B-star dePopulates the 'forbidden' 1s2s level of the He-like ions, mimicking a high density. Publications of both the objects are in preparation.

3.1.3.3 Seyfert 1 galaxy NGC 5548

The X-ray spectrum of the Seyfert 1 galaxy, NGC 5548, has been observed and analyzed. Strong absorption features have been established in the spectrum of this galaxy. After calculations of the positions and oscillator strengths (f-values) of innershell transitions of a number of iron ions these features could be interpreted. A publication appeared in 2002 (Kaastra et al. 2002).

3.1.3.4 MEKAL-database

Due to the high resolution of the spectra obtained with CHANDRA and RGS-XMM-Newton the MEKAL code (atomic line list) needs some updating and extension. In 2001 the collision strengths and transition probabilities of Fe-ions from Fe XVII to XXIV, calculated on the basis of the HULLAC-code, have been implemented in the new SPEX. The MEKAL code will be completed for all other elements with transition up to n=3 or n=4.

3.1.4 Radio Pulsar Studies

Ramachandran, Voûte, Van der Klis and Stappers carried out a number of observing runs with the first generation pulsar machine PUMA-I on the Westerbork Synthesis Radio Telescope (WSRT), in which they particularly concentrated on:
- Very accurate timing of single and binary pulsars. Stappers and collaborators measured with high accuracy the relativistic periastron motion of the wide elliptic double neutron star system PSR 1518 + 4904 and refined the determination of the total mass of the system.
- Giant pulses. Voûte carefully studied the occurrence, nature and incidence of giant pulses in the Crab Nebula pulsar.
- Ramachandran and visiting professor Joanna Rankin (University of Vermont) made a series of simultaneous multi-frequency & dual polarization studies of some key pulsars with “drifting” subpulses; in order to get better insight in the pulsar emission mechanism. The visit of Professor
Rankin, with financial support by NWO, was very successful and gave an important impulse to the study of pulsar emission mechanisms. It now appears, from her studies, in collaboration with our group, that the radio emission of pulsars originates in 10 to 20 equidistant “sparks”, separated by about 10 meters distance, which rotate in a circle around the pulsar magnetic pole.

- Ramachandran and Mitra (MPI-Bonn) continued their studies of scatter broadening of pulsar-pulses due to the Interstellar medium.
- Ramachandran, Voûte, Van der Klis and Stappers continued their work on the design and construction of the second generation “pulsar machine” PUMA-II for the Westerbork Synthesis Radio Telescope (WSRT), in collaboration with Utrecht University.
- Stappers discovered an H-alpha bowshock Nebula around pulsar PSRB 0740-28 and studied with the Hubble Space Telescope several other pulsar nebulae.
- L. Voûte successfully defended his Ph.D. thesis on the design and construction of PUMA-I and the study of radio-pulsars with his instrument. This was the first pulsar Ph.D. thesis at the University of Amsterdam, and the second one in the Netherlands.
- Unfortunately, Jouteux decided for personal reasons, to stop his Ph.D. this project of acceleration searches of binary pulsars, and returned to France.
- A very important new addition to the pulsar group is Dr. Russell Edwards from Australia, who joined the pulsar team as a Postdoctoral Fellow. He made important new contributions in the field of searches for new pulsars with the Parkes radio telescope. In these searches he discovered, among many other things, two new Relativistic Neutron Star – White dwarf Binaries.

3.1.5 Theoretical Studies

3.1.5.1 Stellar Structure and Evolution

J. Dewi, in collaboration with O. Pols (Utrecht) continued her study of the evolution of helium-star binaries, in order to gain a better understanding of the formation of double neutron stars. She studied the evolution of a collection of Helium star plus neutron star binaries with a range of initial system parameters (orbital periods, helium star masses). It was found that systems with helium stars less massive than about 3.5 solar masses always enter into a Common-Envelope phase and that thus very narrow binary systems may result, consisting either of a neutron star and a massive white dwarf, or of two neutron stars. This work needs further investigation, but already now it promises to yield important new results for understanding the strong sources of gravitational waves in galaxies.

Dr. Lev Yungelson visited the Institute twice this year (2 times 90 days) to cooperate with van den Heuvel, Nelemans and Dewi in studies of the evolution of binaries with compact objects. He completed a number of important studies on the formations of close white-dwarf binaries with Nelemans and continued studies of the evolution of black-hole binaries with low-mass companion stars, in collaboration with Dewi and van den Heuvel.

Nelemans completed his Ph.D. thesis on the formation of very close white dwarf binaries, and left for a postdoctoral position at Cambrigde University.

3.1.5.2 Tidal Evolution of Binaries

Savonije and Witte extended the study of the tidal evolution of eccentric binary systems to Low Mass systems with solar type stars. The 2D-oscillation code that was used to calculate the tidally forced oscillations in rotating massive stars appeared impractical when applied to solar type stars. The solar type stars have radiative cores and convective envelopes, a structure complementary to that of massive stars. The tidal oscillations now appear in the deep interior where radiative damping is very weak, so that their spectrum extends to very low frequencies. The corresponding short wavelength of the oscillations requires high spatial resolution which makes the 2D code extremely time consuming. To that end a new code was developed based on the 'traditional approximation' for which the oscillation equations for a rotating star can be fully separated in the three spherical coordinates. The angular part of the oscillation follows from the numerical solution of an eigenvalue problem, and this can be used for the numerical solution of the radial part.

The inclusion of stellar rotation (which has never been studied before in these systems) appears to be very important for the tidal evolution speed of Low Mass binaries. It means that prograde (same direction as rotation) and retrograde tidal oscillations can be excited simultaneously in (very) eccentric binaries. These two types of modes have opposing effects on the stellar spin, whereby the binary system can get locked at some (weak high order) resonance with one of the stellar oscillation modes, resulting in significantly enhanced tidal evolution during relatively long periods of time. The separately developed and adapted code which integrates the orbital and spin momentum balance equations of the evolving stars by using the torque spectra calculated by the oscillation code can follow the detailed tidal evolution of eccentric binaries.

When the rotation of the oscillating stars is taken into account the tidal evolution due to the dynamical tides appears to be significantly enhanced by the frequent resonance lockings and much faster than found in previous theoretical studies. In most previous studies it was assumed that the low frequency 'equilibrium tide' on the convective envelope was the dominant tidal mechanism (Zahn). However, this appears to be incorrect: the weakly damped tidal oscillations in the radiative cores of solar type stars are more important if proper account is given of rotation and locking effects. The Low Mass binary systems appear to be locked at some resonance most of the time as long as the orbital eccentricity remains above about 0.25. These new results indicate that wide eccentric binary systems (with orbital periods beyond 10 days) can be circularized by the dynamical tides during their main sequence phase, as indeed shown by observations.

Witte completed his Ph.D. thesis and took up a software job.

3.1.5.3 Evolution of Dense Star Clusters

S. Portegies Zwart joined the institute on December 1, 2001. He studies the dynamical evolution of dense star clusters in combination with the internal evolution of the stars and binaries. Stellar and binary evolution calculations are combined with N-body simulations to examine the interplay between stellar dynamics and stellar evolution. The applications range from open star clusters, young populous clusters, globular clusters and the nuclei of active galaxies. Theoretical predictions are tested using data obtained with HST.

In 2001 he mainly worked on modeling the evolution of young populous clusters, such as the Arches and Quintuplet systems near the Galactic center. This work is a milestone as for the first time model calculations which include the evolution of the stars, the dynamical interactions between the stars and the external tidal influence of the Galaxy are taken self consistently into account. The figure shows how a cluster spirals in towards the center of the Galaxy and is partly disrupted in the process. At the moment Portegies Zwart is working on more extensive model calculations which include the
effect of dynamical friction between the cluster and the surrounding background stars of the Galactic center. As a byproduct it was discovered that the dense star cluster R136 contains a dozen bright X-ray point sources. The X-rays are produced when the stellar wind of the WN and O3If stars collide. Portegies Zwart derived a simple quantitative analytic model that explains the colliding wind binaries in the galactic disk and the star cluster R136. (Portegies Zwart S.F., Pooley D., Lewin W., ApJ in press).

Portegies Zwart also studied the characteristics of star cluster like Arches and quintuplet. These clusters are within a distance of 30pc to the galactic center. We only know two of these clusters and both are very young. With model calculations he demonstrated that clusters like Arches and Quintuplet are easily missed by earth based observations. Infrared observations with HST or X-ray observations with Chandra may reveal that the galactic center is richly populated with clusters of similar character (Portegies Zwart et al. 2001).

Simulated star cluster with 65536 stars in orbit around the center of the Milky-way Galaxy. The distance to the central black hole is about 7 pc. The cluster is gradually disrupted due to the tidal effect of the central black hole and spirals inwards towards this black hole. Only the stars which once were part of the cluster are shown, the stars which make up the Galaxy are not shown but only some background stars are. This simulation is performed on the GRAPE-6 special purpose computer at the University of Tokyo. The results will be published by Portegies Zwart and McMillan (2002, submitted to ApJ).

In collaboration with Fred Rasio Portegies Zwart worked on the dynamical evolution of brown dwarfs and planets in globular clusters and of the probability that stars collide upon an encounter between two binaries. Their findings will soon be submitted to ApJ. (Fregeau J., Joshi K., Portegies

As a side project (and a hobby) Portegies Zwart was working on a deterministic model for explaining the light curves of long duration gamma-ray bursts. In the new detailed theoretical model we combine a precessing jet with its interaction with the interstellar medium. Since the model is deterministic we are able to fit the theoretical model to observed gamma-ray burst light profiles. The complicated (14 dimensional) parameters space, however, makes accurate fitting a challenge a genetic algorithm was developed to fit the observed light curves to the theoretical model (Portegies Zwart & Totani MNRAS).

In December 2001, shortly after his appointment at the University, Portegies Zwart was awarded a Royal Academy Fellowship, which he took up starting January 1, 2002.

3.1.5.4 Three-Dimensional Hydrodynamics

The Theory Group entered a new phase with the inception of the AstroHydro3D Project. Because theoretical astronomy in the Netherlands is not staffed or funded in proportion to the observational programs, Icke and Mellema took the initiative to draw the more theoretically inclined among the NL staff together under a single research heading, thus strengthening by closer collaboration. Obviously, one cannot do all of astrophysics in one program, but one can do ‘most’ of it by concentrating on hydrodynamics, which is actively worked on by many NL astrophysicists. Not unwise, considering that the vast majority of the baryonic matter in the Universe is in gaseous form. Three dimensions are the ultimate in hydro, and current developments in numerical technique (AMR) and computerware (massively parallel architectures) allow realistic 3D simulations. Besides, astrophysically crucial physics is intrinsically 3D: gravitation, radiative transfer, and magnetic fields (because of the cross product of velocity and field). Icke and his group were very fortunate and gratified that NWO decided to support the AstroHydro3D Project through a major grant from the NWO program for Large Scale Computing. The proposers (Icke, Mellema, Van de Weygaert (RUG) and Langer (UU)) intend to make this project evolve towards a more permanent national collaboration.

In the context of the AstroHydro3D project, Icke embarked on a study of the principles of ‘adaptive mesh refinement’ (AMR), a technique in which a hydrodynamical computational grid adapts itself to spatially resolve the details of a developing flow pattern, while leaving 'uninteresting' regions less resolved. His work focuses on two points: first, what precisely is 'uninteresting' in various hydrodynamical contexts; second, how can AMR work well enough in environments where the structures are extremely complex and almost scale-free, such as a fractal distribution? The results so far are perplexing, which is a sure sign of something potentially interesting. Icke concluded his study of the hydrodynamic mechanism that is responsible for the shape of the Red Rectangle. In previous investigations of bipolar nebulae, he concentrated on disk-wind interactions that are 'energy driven'. A central star blows a spherical wind into a toroidal nebula; the wind has such a low density and high speed that the surrounding (inner) shock generates a very hot, pressure dominated layer that then drives the outer shock. Because flow in the high pressure region is very subsonic, inhomogeneities in this layer are mostly smoothed out, so that the outer shock and the nebular shape are well rounded. However, the density of the Red Rectangle nebula is very high, and the central star(s) cool. If the flow is strongly compressible due to radiative cooling, a thick high-pressure smoothing shell does not develop. This regime is often called 'momentum driven'. Focusing of a spherically symmetric stellar wind through an inner shock creates a biconical pattern that may be responsible for the characteristic X-shape of the outer nebula. Icke computed the evolution of periodic biconical outflow. Observations made available for this purpose by Van Winckel (Leuven) can thus be modeled in great detail. Features that were initially thought to be problematic for this interpretation, such as the occurrence of intersecting shocks on the symmetry axis, turned out to be present on closer inspection of the Hα image.
3.2 LOW ENERGY ASTROPHYSICS

3.2.1 The Most Massive Stars in Galaxies

3.2.1.1 The winds of OB stars

Investigations continued into the hydrodynamics of the stellar winds of the most massive stars. A highlight of this work has been the predictions of the mass-loss rates of O- and B-type stars as a function of metal content. These predictions are of great interest for understanding the properties of the first several generations of stars in the universe, and have caused a flurry of activity on the part of both observers and theorists, aimed at testing these new theoretical results. (Vink, de Koter, Lamers).

3.2.1.2 The Baldwin effect in Wolf-Rayet stars

The observed relation between the measured strength of He II emission lines and the monochromatic continuum luminosity at the line wavelength in the spectra of Wolf-Rayet stars has been investigated theoretically. The aim was to provide an explanation for this so called Baldwin-relation in these highly evolved massive stars and to explore the possibility of using it as an independent distance measurement method, which would be a fundamental result. For the first time, we have explained the effect as being the result of a correlation between extreme mass loss -- hence luminosity -- and stellar radius -- hence continuum flux. Our predictions show that for certain sub-groups of Wolf-Rayet stars our calibration may indeed provide reliable distances, albeit only after certain deficiencies in our model calculations have been accounted for. (van Gent, Lamers, de Koter, Morris).

3.2.1.3 η Carinae

The peculiar star η Carinae was studied by means of mid-infrared imaging of its famous "homunculus". The new 10 and 20 μm images for the first time revealed the presence of a regular structure, which can best be described as (sections of) two separate rings, offset with respect to the central point source, and with a diameter of the order of 1.5 arcsec as depicted in the figure. This structure is reminiscent of that seen in the HST images of SN1987A, and is also seen in some planetary nebulae. In all these cases the origin of the rings is believed to be related to the interaction between a fast wind and a slower one preceding the fast wind. A simple model of two rings was applied. If this geometric picture is correct, it implies that the orientation of the system has changed with respect to that of the homunculus since its formation in the 19th century. (Hony, Waters, et al.).

![Double ring structure observed in the infrared images of Eta Carinae.](image-url)
3.2.2 Star Formation

3.2.2.1 Spectroscopy of massive stars in the making

Massive stars are born in optically obscured gas and dust clouds. Very little is known about the processes that govern their build up and early evolution. A very promising approach to study these young objects is by infrared spectroscopy, as at these wavelengths the extinction of dust present at these star forming sites is less severe. We approach this problem from both an observational and a theoretical direction.

Near-infrared spectra of newly formed massive stars have been obtained with ESO's Very Large Telescope. At visible wavelengths these young stars are totally obscured by gas and dust in the parental molecular cloud. However, in near-infrared images the target stars appear as bright objects located in the center of ultra-compact H II regions. Near-infrared spectra reveal the photospheric properties of the newly born massive stars, such as their effective temperature, luminosity, and rotation rate. Furthermore, we inspect the spectra for features possibly related to a circumstellar disk, remnant of the formation process, and/or to a stellar wind. This is the first time that the photospheric properties of young massive stars can be studied in detail. Our ultimate goal is to better understand the formation process of the most massive stars (Bik, Kaper, Waters).

From a theoretical perspective, ISO spectra of optically visible dwarf and (sub)giant late-O and early-B stars were compared with predictions of non-LTE blanketed model atmospheres. As the basic properties of these stars are known from optical studies, this allows to identify and calibrate the line diagnostics present in the infrared part of the spectrum. In this way, we could establish that a combination of hydrogen lines allows a fairly accurate determination of the surface temperature. (Zaal, de Koter, Waters).

3.2.2.2 Proto-planetary disks around Herbig Ae/Be stars

Studies of the first steps towards the formation of planetary systems focused on the pre-main sequence evolution of intermediate mass stars. These so-called Herbig Ae/Be (HAEBE) stars have large amounts of circumstellar gas and dust, probably in a disk-like geometry, left over from the star formation process. It is thought that eventually cometary objects and planets may form from this material.

A key issue in the field of HAEBE stars is placing individual systems in an evolutionary sequence in terms of grain processing and/or disk geometry. A detailed study of the shape of the 10 μm silicate feature in HAEBE stars has shown that it can be used to order the development of these systems in terms of chemical processing and grain growth. The 10 μm band has contributions from SiO$_2$ (silica), and from amorphous and crystalline silicates. A quantitative analysis shows that the change of the peak of the band from 9.7 to 11 μm can be understood if the grain size increases from ≈ 0.1 μm to ≈ 2 μm. In addition, the abundance of crystalline silicates and silica increase in a way which is consistent with thermal annealing of amorphous silicates with a non-stoichiometric composition. (Bouwman, Meeus, de Koter, Hony, Dominik, Waters).

The ISO spectra of a small sample of HAEBE stars was analyzed in order to gain more insight into the dust composition and disk geometry. The sample could be split into two groups, depending on the presence or absence of a rise in the spectrum between 12 and 40-60 μm. The difference between both groups can be qualitatively understood as a difference in flaring of the disk, the flat spectra corresponding to non-flaring or weakly flaring disks, and the rising spectra corresponding to flaring...
disks. Remarkably, several stars show very weak or even no silicate emission at 10 or 18 µm. This can be due to a lack of small grains or due to geometric effects, suppressing the emission in a certain temperature range. (Meeus, Bouwman, Waters, Dominik, de Koter, Waelkens, et al.).

An investigation of the ISO-SWS spectrum of the HAEBE star 51Oph showed that the 2-8 µm region is dominated by prominent gas-phase molecular bands, of molecules as CO, CO₂ and H₂O. This is very unusual: all other well-studied HAEBE stars have 2-8 µm spectra dominated by a prominent dust continuum. This raises the question whether or not 51Oph is in fact a genuine member of the class of HAEBE stars. In addition, the silicate band shape of 51Oph at 10 µm is somewhat different from that of other HAEBE stars, possibly pointing to a dust composition which differs from what is commonly seen in HAEBE stars. (van den Ancker, Meeus, et al.).

3.2.2.3 The DDN model of passive circumstellar disks with inner holes

Dominik worked together with Dullemond and Natta on the development of a model of passive circumstellar disks with an inner hole. When a star forms, it is at first surrounded by an active accretion disk through which matter flows to the star. The energy budget in the inner regions is dominated by the gravitational energy set free by the accretion process and dissipated through viscous processes. In the outer regions of the disk, the contribution from the viscous processes is negligible and the energy budget there is determined by the radiation received from the star. When the inflow of new matter from the environment stops, the entire disk becomes dominated by stellar radiation and is then called a passive disk.

Passive disks have been used very successfully to explain the SEDs of T Tauri stars. Under the influence of the stellar radiation the disks assume a flaring shape, i.e. the scale height increases faster than the distance from the star. The disks have a hot surface layer which is responsible for the emission of solid state features, and a cool midplane which dominates the submm fluxes.

Since Herbig Ae stars are thought to be the more massive counter parts of T Tauri stars, their disks should be consistent with similar models, but up to now this was not the case because passive disk models consistently strongly underpredicted the flux around 3 µm. 25% of stellar flux should be present in this missing component and is missed by these models.

The DDN model (Dullemond, Dominik, Natta 2001) introduces an inner hole into passive disk models (topfigure on next page). The hole is an opacity hole rather than a surface density hole, and it is located at the sublimation temperature of dust grains. The inner rim, directly illuminated by the star puffs up significantly, absorbs up to 25% of the stellar radiation and re-emits it at a temperature of 1500K. With this extended model of passive disks, also the spectra of Herbig Ae stars can be fitted perfectly well (lower figure on next page). This is another indication that the main source of the IR excess of Herbig Ae stars is indeed due to disks, no halo is required in the fit.
DDN model of passive circumstellar disks with inner holes, as developed by Dullemond, Dominik and Natta (2001). Explanation in the text.

Spectrum of the Herbig Ae star AB-Aurigae as fitted with the DDN model shows the almost perfect fit (see text).

3.2.2.4 Dust in Vega-like stars

Dominik continued to work on the dust content of debris disks around main-sequence stars. In order to understand the 400Myr dissipation timescale found for disks around main-sequence stars with ISO (Habing, Dominik et al, 2001), an analytical description was developed describing the decay of a collisionally dominated disk. It was found that massive disks similar to the early Kuiper Belt in the solar system would drop below the detection limit after 400Myrs only if the orbits of comets in the system are excited to large eccentricities and inclinations, possibly a witness of gravitational perturbations due to planets in the disk.
3.2.3 Late Stages of Stellar Evolution

3.2.3.1 The composition of gas and dust in AGB and post-AGB stars

The analysis of ISO spectra of AGB and post-AGB stars continued in 2001. The ISO archive allows a study of the changes in dust composition of oxygen-rich and carbon-rich dust envelopes surrounding AGB stars as these stars increase their mass loss rate, and eventually evolve off the AGB to become planetary nebulae (PNe).

A spectral band near 21 $\mu$m has drawn attention because it is only seen in a small number of, mostly metal-poor, carbon-rich post-AGB stars, but not in their evolutionary predecessors (AGB stars) or successors (PNe). This would imply that the carrier of the band (possibly TiC) is produced briefly only at the very end of the AGB, and is destroyed when the star reaches high effective temperature. A detailed study of ISO spectra of PNe however resulted in the detection of the 21 $\mu$m band in two nebulae that have a [WC] central star, NGC40 and NGC6369. This shows that the carrier of the band is not volatile and can survive the harsh conditions in the nebula. The presence of the 30 $\mu$m MgS band in these two PNe with [WC] central stars shows that the stars were carbon-rich before they became H-poor. The detection of the 21 $\mu$m band shows that the last thermal pulse, i.e. the one that turned the objects H-poor, did not trigger the superwind phase. The age of the nebulae also precludes that a thermal pulse triggered the onset of the superwind. Interestingly, both PNe with the 21 $\mu$m feature are metal-poor which may suggest a link between metallicity and the formation of the carriers of the 21 $\mu$m band. (Hony, Waters, Tielens).

Work on the dust composition of oxygen-rich stars led to the question whether or not all oxygen-rich AGB stars may produce crystalline silicates. ISO observations show that crystalline silicates are only observed in stars with high ($\dot{M} > 10^{-5}$ M$_{\odot}$/yr) mass loss rates. However, radiative transfer studies show that crystalline silicates may be abundant in stars with low mass loss rates as well, but can escape detection because of a contrast effect. While amorphous silicates are Fe-rich, their crystalline counterparts are Mg-rich and Fe-poor. This results in considerable differences in temperature, because Fe-poor grains lack opacity in the near-IR where the AGB star emits most of its energy. Thus, the amorphous silicates produce a prominent emission in the 10-40 $\mu$m region and swamp the emission of the colder crystalline silicates. Only when the optical depth of the inner parts of the envelope is sufficiently high that its radiation cannot reach the observer, and the cold outer parts of the envelope are visible, the contrast between both types of silicates improves and the crystalline silicates become easily detectable. Model calculations show that low mass loss rate AGB stars may have several tens of percent of the silicates in the form of crystalline silicates before bands would appear in the spectrum at the ~5 per cent level. (Kemper, Waters, de Koter, et al.).

The ISO spectrum of the peculiar post-AGB binary HR4049 shows prominent emission from polycyclic aromatic hydrocarbons (PAHs). Surprisingly, the gas-phase molecular species are oxygen-rich: CO$_2$ is prominently present, as well as H$_2$O (Cami, et al.). This mixed chemistry is probably related to the binary nature of the star: the present-day post-AGB star lost a substantial part of its envelope while being an oxygen-rich AGB star. Part of this material was stored in a circum-binary disk, and the star subsequently evolved to become carbon-rich. The isotopic ratios of $^{16}$O, $^{17}$O, and $^{18}$O are highly unusual, and one order of magnitude different from any other determination in evolved stars. This may indicate a non-standard chemical evolution of the star. (Cami, Yamamura).

An object that might be evolutionary related to HR4049 is the carbon star IRAS04925-6040. Its ISO spectrum shows a mixed chemistry: while the 2-15 $\mu$m part of the spectrum is dominated by the carbon star, the longer wavelength emission shows the strongest crystalline silicate emission bands detected so far. The abundance of small crystalline silicates significantly exceeds that of the small
amorphous ones. Sub-millimeter photometry has resulted in the detection of the cold dust in the system. The shape of the IR spectrum shows that a broad range of dust temperatures must be present, which is difficult to understand in terms of a spherical outflow, but would be consistent with a disk-like distribution of the material. While there is no direct spectroscopic evidence for binarity, it is likely that IRAS04925-6040 in fact is a binary similar to HR4049, but in an earlier evolutionary phase. (Molster, Yamamura, et al.).

Investigations of the nature of the famous 'unidentified infrared bands' focused on the properties of these bands in the 10 to 15 \(\mu m\) region. ISO spectra of a wide variety of objects were studied, and revealed bands at 11.0, 11.2, 12.0, 12.7, 13.5 and 14.2 \(\mu m\). Considerable variations in band strength ratios are observed. The observed bands are identified with out-of-plane bending modes of C-H bonds in polycyclic aromatic hydrocarbons (PAHs). The precise structure of the PAHs is still elusive, but certain patterns emerge, e.g. concerning the typical size of the PAHs produced by evolved stars, and those seen in the ISM. (Hony, van Kerckhoven, Peeters, Tielens, Hudgins, Allamandola).

3.2.3.2 Dust-gas drift instabilities in AGB stars

Dominik has continued to work with Simis and Icke (Leiden) on the hydrodynamics of dust driven winds around AGB stars. We developed a code which studies such winds in a completely selfconsistent way, using two-fluid hydrodynamics, gas chemistry and a time dependent calculation of grain growth. We were able to show that the balance between radiation force on the grains and friction forces between dust and gas lead to an instability in the wind. This instability causes significant variations in the mass loss rate which leads to density structure in the outer regions of the wind. The changes occur on a time scale of a few hundred years and provide a quantitative match to the circular shell structures seen around many planetary nebulae, including asymmetric planetary nebulae. This is the first self-consistent theory which explains these structures (Simis, Icke, Dominik 2001).

3.2.3.3 The [WC9pec] central star HD167362 and its planetary nebula SwSt1

The hydrogen-deficient [WCL] type central star HD167362 and its planetary nebula Swings-Struve 1 have been investigated. The central star has a carbon-rich emission line spectrum and yet the nebula exhibits a 10 \(\mu m\) emission feature from warm (oxygen-rich) silicate dust. As dust is expected to be either carbon based or oxygen based due to locking of all of the least abundant element in the stable CO molecule, this may indicate a recent origin for the carbon-rich stellar spectrum. The high temperature of the silicate dust indicates that the thermal pulse that transformed it into a hydrogen-deficient central star, and possibly also caused it to become carbon rich, may have occurred as recent as 150-330 yr ago. Unfortunately, a careful assessment of the spectral variability of the star reported in the literature shows that this event did not occur in the past century. (De Marco, Crowther, Barlow, Clayton, Geoffrey, de Koter).

3.2.3.4. CO\(_2\) gas around W Hya

Justtanont, de Jong, Tielens, Feuchtgruber and Waters attempted to analyze the Fabry-Perot measurements of CO\(_2\) bands in the semi-regular variable W Hya made with the ISO/SWS. The FP observations have the highest spectral resolution (about 2 \(10^4\)) obtainable by ISO and therefore provide a unique data set. FP observations were obtained for three different CO\(_2\) bands in the 13-17 \(\mu m\) wavelength range. The spectra show individual Q-branch emission lines in all three bands, even in the 14.97 \(\mu m\) band which is in absorption. The excitation temperatures derived from the rotational diagrams of the Q-branch lines amount to about 450 K for all three bands. On the other hand the
absorption bands at 4.27 and 14.97 µm are due to gas at 1000-2000 K. Thus apparently there are two regions containing CO₂ molecules that contribute to the observed spectrum: a hot layer close to the star with a temperature of about 1500 K that is seen in absorption against the stellar photosphere of about 2500 K and a warm layer with a temperature of about 500 K further out in the circumstellar envelope that is seen in emission.

3.2.3.5. Time variation of the infrared spectral energy distribution in Mira variables

In collaboration with Onaka (Department of Astronomy, Tokyo, Japan) and Yamamura (ISAS, Japan) de Jong analyzed the time variation of the ISO/SWS spectra of two Mira variables, Z Cyg and T Cep. Both stars were observed with the ISO/SWS at about two month intervals covering about 1.5 pulsation period. The analysis of Z Cyg was prepared for publication. The infrared spectrum of Z Cyg shows prominent silicate emission bands at 10 and 18 µm and it displays large variations over the observed timespan. The variation of the infrared spectrum is synchronized with the visual light curve. The integrated infrared flux and the 10 µm to 18 µm silicate band ratio is largest at maximum and smallest at minimum, indicating a variation in dust temperature with phase. The dust temperature variation is probably caused by the variation in stellar luminosity during the pulsation cycle. Dust optical properties for silicate dust are derived. There is evidence that dust forms at minimum. The inner dust shell probably has a temperature of 700 ± 100 K at maximum.

3.2.3.6. Magnetic Fields, Pulsations and Emission-line Characteristics of Early Type Stars

H. Henrichs, together with his Ph.D. student C. Neiner, continued his studies for non-linear pulsations and magnetic fields in slowly rotating early-type stars, making use of the excellent facilities of the Pic-Du-Midi Observatory in the French Pyrenees.

His Ph.D. student Jeroen de Jong defended his Ph.D. thesis on the same subject in January 2001, and took up a part-time position in Leiden Observatory, in combination with a part-time position in software industry.

Another Ph.D. student of Henrichs, David McDavid of Texas, completed his Ph.D. thesis on polarization studies of B-emission stars, which he successfully defended at the University of Amsterdam in May 2001. This was a very special Ph.D. project, as Dr. McDavid carried out all this research at his own private astronomical observatory in Texas. Apart from being a very good astrophysicist, Dr. McDavid is also a musician; he devotes his time roughly equally between astrophysics and music.

3.3 FAINT SKY VARIABILITY SURVEY (FSVS)

3.3.1 Main Objectives of the Survey

The Faint Sky Variability Survey (FSVS) is an international effort (led by the University of Amsterdam, started by J. van Paradijs; present PI: E.P.J. van den Heuvel) to perform the first deep wide-field, multi-colour (BVI), time-sampled CCD photometric and astrometric survey of sources towards moderate and high galactic latitudes. The survey started in 1998 and was completed in 2001. Using the Wide Field Camera at the Isaac Newton Telescope on La Palma, we observed each of our fields to detect sources as faint as 25th magnitude in V and B and 24.2 in I. The V-band observations consist of an irregular time-series to detect photometrically variable objects on timescales between 12 minutes and 5 days, with a re-visit at one year. To date, we have observed about 16 square degrees of sky containing over 100,000 point sources (including thousands of variables) and over
300,000 extended sources. The FSVS dataset is applicable to a wide range of astrophysical projects including a search for faint cataclysmic variables, identification of very low-mass stars and nearby objects (late M & L stars and brown dwarfs), statistics of eclipsing binaries, cool white dwarfs, trans-Neptunian objects, and RR Lyrae stars. Apart from galactic sources, the FSVS can also be used for extra-galactic projects as well. Two preliminary papers have been submitted and include details of how we will make our data available over the internet. A main driver of the survey is: to search for “Orphan afterglows” of Gamma-Ray Bursts: afterglows for which no GRB was observed. The incidence of such afterglows will give very important information on the amount of “beaming” of Gamma Ray Bursts.

3.3.2 Summary of Observations to Date

3.3.2.1 Summary of Progress in Reduction, Analysis, and Findings to Date

We have fully reduced, assigned magnitudes to, and produced light curves for all 100,000 point sources from our survey to date. We also have lightcurves for the 300,000 extended sources as well. Objects have been separated into candidate groups by
1) long and short term variability types to investigate the forms and sources of variability seen in the faint sky,
2) colors to calibrate our BVI color space with better known astrophysical sources such as main sequence type stars, and
3) extreme color sources (photometry lacking detections in one or two filter measurements) to explore rarer and unknown sources such as very low-mass objects or sources with colors that do not correspond to a known astrophysical object.

Cataclysmic variables and very low-mass object candidates from the FSVS photometry dataset are also being matched to on-line datasets including 2MASS in order to extend the known spectral energy distribution of the sources. However, we find very red candidates that are fainter than what 2MASS can observe indicating the usefulness of the faintness limits of the FSVS in the I band.

Using the FSVS datasets, the environments of quasars in the context of large scale structure is being studied by I. Machura and R. Clowes at the University of Central Lancashire. The goal of the study is to investigate whether quasars trace the mass (galaxy) distribution, if so how, and determine the galaxy environment that favors the formation of quasars. The FSVS dataset provides a deep and wide-field source to confirm membership of quasars in clusters by photometric redshift, define the periphery of the clusters more precisely with the deep faintness limit at 25 mags and fainter with coadded images, test for quasar formation by galaxy mergers/interactions to the faintness limit, and test for quasar formation by merging clusters out to intermediate redshifts of $z < 0.9$.

3.3.2.2 Summary of Effort and Resources Attached to the Survey

Most of the FSVS survey work has been carried out by five investigators (Everett, Groot, Huber, Vreeswijk, and Howell) who have dedicated a cumulative effort equivalent to 3-4 man years. The hardware used is standard; reduction and analysis is performed using Unix workstations and raw data is now pipelined to reduced light curves for distribution, allowing others to efficiently apply the results to a wide variety of investigations. Currently the reduced survey images total approximately 70 Gbytes and the data tables are 1.5 Gbytes. The time to fully reduce the data from a weeklong observing run is now 2-3 weeks. The aforementioned five investigators, as well as Co-Is (eg., D. Davis [TNO], N. Tanvir [RR Lyr], P. Charles [globulars], R. Clowes [variable QSO's]), have used the FSVS data catalogues for research. Meanwhile, observing at the INT has become efficient requiring only the standard situation of a telescope operator only on the first night of each run.
3.4 HISTORY OF ASTRONOMY

3.4.1. Greek Horoscopes

T. de Jong continued his collaboration with UvA papyrologist K.A. Worp on the dating and interpretation of Greek horoscopes found among the remains of the ancient settlement Kellis (Ismant el-Kharab) in the Dakleh oasis a few hundred miles West of the river Nile in middle Egypt. Two horoscopes written on both sides of a small wooden board and three horoscopes on scraps of papyrus were recently uncovered. Together with the earlier horoscope on a wooden board (de Jong and Worp 1995, ZPE 106, 235-240) in total six horoscopes have now been found among the remains of Kellis. The last five were all found at the same location: in waist deposits located in the N/W corner of the remains of the Temple of Tutu. The newly found horoscopes on wood could not be astronomically dated. However, the horoscope on the front side of the board mentions “Year 108 of Diocletian” equivalent to 392 AD. The planetary positions listed in the horoscopes on the wooden board do not make astronomical sense and may have been used for educational purposes. On paleographical grounds all three horoscopes on wood may have been written by the same author. The three quite fragmentary horoscopes on papyrus can all be dated astronomically. Using a computer program that calculates planetary positions according to Ptolemaic theory the following dates were obtained: 2 June 332 AD, 14 May 337 AD and 6 November 364 AD. Apparently, a genuine astrological practice was part of the activities associated with the Temple of Tutu in Kellis in the fourth century AD.

Remains of a papyrus sheet (~6 x 9 cm) reconstructed from three fragments found in a waste heap near the Temple of Tutu in the Dakleh Oasis, Egypt (the location of ancient Kellis). The text on the papyrus refers to two horoscopes in Greek. It contains just enough information to date both horoscopes. The first four lines are part of a horoscope drawn for 6 November 364 AD at 11 p.m. and the remaining lines refer to a horoscope of 14 May 337 AD at 1:30 p.m.
3.4.2. Early Babylonian observations of Saturn

De Jong studied the oldest known collections of Babylonian observations of Saturn. These observations contain lists of dates of first and last visibilities of Saturn. One set on Tablet BM 76738+76813, originating from Babylon, contains observations from the first 14 years of the reign of Kandalanu (647-627 BC); the other set on Tablet SBTU 171, originating from Uruk, contains observations from three years of the reign of Nebuchadnezzar (604-562 BC). These observations were analyzed using a computer program developed by Drs. Frank Inklaar for his ‘afstudeeronderzoek informatica in de sterrenkunde’ in 1989. With this computer code one can calculate dates of first and last visibility of stars as a function of magnitude and atmospheric extinction. Using the best available ephemerides of the Sun, Moon and planets for historical times and taking account of the effect of Saturn’s rings on its visual magnitude, the Babylonian and Uruk observations were fitted by varying the visual extinction of the atmosphere. The resulting distribution of extinction values makes sense for the climate of Mesopotamia. This study shows that the commonly used method of calculating dates of first and last visibility of stars and planets based on the concept of the so-called ‘arcus visionis’ has severe shortcomings and that the new more ‘physical’ method developed by Inklaar is superior. This has potentially far-reaching consequences for the astronomical dating of Babylonian cuneiform texts. The results of this study were presented at a conference "Under One Sky” held at the British Museum in London in June.
4. ONDERWIJS (this section is in Dutch language)

4.1. Inleiding


Sterrenkunde is traditioneel een belangrijk bijvak en keuzevak bij de studie natuurkunde en deels ook bij wiskunde. Het grootste deel van de onderwijsinspanningen van het instituut is gelegen in dit bijvak- en keuzevakonderwijs. Deze colleges vallen voornamelijk in de eerste twee studiejaren. Het college sterrenkunde IA (Van der Klis) en de bijbehorende werkcolleges zijn verplicht voor alle eerstejaars studenten wis-, natuur-, en sterrenkunde. Voor laatstgenoemde studenten is ook het practicum Sterrenkunde 1 verplicht.

In het tweede jaar – de colleges sterrenkunde IIA en IIB – is de sterrenkunde een belangrijk keuzevak, dat door een groot deel van de natuurkunde studenten wordt gevolgd, evenals het practicum Sterrenkunde 2.

De meer gespecialiseerde colleges in het 3e en 4e jaar (doctoraalfase), waarin diep op de stof wordt ingegaan worden voornamelijk gevolgd door de hoofdvakstudenten sterrenkunde. Dit betreft relatief kleine aantallen studenten. Een vijftal basiscolleges behoren hier tot de verplichte stof van de hoofdvakstudenten sterrenkunde, de overige colleges zijn capita en keuzecolleges.

Naast de opleiding voor het doctoraal examen is de primaire onderwijsactiviteit van het instituut: de opleiding tot zelfstandig onderzoeker, die plaatsvindt in het kader van de Toponderzoekschool NOVA.

Het Sterrenkundig Instituut en het Centrum voor Hoge Energie Astrofysica zijn in feite in hoge mate een “graduate school”, met thans een twintigtal promovendi. In het jaar 2001 behaalden acht promovendi de doctorsgraad (§4.3).

4.2. Sterrenkundig deel van de opleiding tot het doctoraal examen Sterrenkunde

1e jaar: College Inleiding sterrenkunde/astrofysica IA (1e trimester, met werkcollege en practicum I), verplicht voor alle studenten wis-, natuur- en sterrenkunde, gevolgd door IB (2e trimester), verplicht voor alle studenten natuur- en sterrenkunde.


3e en 4e jaar: zes verplichte doctoraal colleges (+werkcolleges): Bouw en evolutie van sterren, Sterratmosferen, Interstellaire en circumstellaire materie, Numerieke sterrenkunde, Kosmologie en Hydrodynamica van vloeistoffen en plasma’s.
Keuzecolleges: Radioastronomie, Hoge energie astrofysica, Interacademial college (wisselt).

Eigen werk: III en IV, Waarneemstage, (Onderzoekstage)

Colloquium: wekelijks – verplicht in 3e en 4e jaar.

Post-doctoraal: In het kader van NOVA, wisselend:
- Massaverlies van sterren, Late evolutiestadia
- Infrarood astronomie
- Geavanceerde dynamica van sterrenstelsels
- Technieken van ruimte onderzoek en sterrenkunde.

4.3 Doctoraal examens en promoties in 2001

Doctoraal Examens (“Masters degrees” awarded)
In 2001 deden 3 studenten met goed gevolg het doctoraal examen:
F. Huthoff 29 januari 2001
A.W. Volp 29 januari 2001
R. Mokiem 16 november 2001

Promoties (Ph.D. degrees awarded)
J. Homan 14 maart  X-Ray timing studies of low-mass X-ray binaries
G. Nelemans 28 maart  White dwarfs, black holes and neutron stars in close binaries
D. McDavid 29 mei  Polariometry of Early Emission Line Stars
B. Deufel 6 juli  On the Origin of the Hard X-ray Spectra of Neutron Stars and Black Holes
J. Bouwman 25 september  The processing and evolution of dust in Herbig Ae/Be systems
L. Voûte 9 oktober  The many shapes of Giant Pulses
P. Jonker 19 oktober  Probing low-mass X-ray binaries with X-ray timing
M. Witte 12 december  Tidal evolution of eccentric binaries

Studentenaantallen hoofdvak sterrenkunde (Number of astronomy students)
In het studiejaar 2000/2001 zijn er 49 (7) studenten met natuur- en sterrenkunde begonnen, waarvan er 13 (4) de specialisatie sterrenkunde volgen. Het aantal dat is doorgegaan met natuur- en sterrenkunde is 34 (5); voor de specialisatie sterrenkunde is dit 7 (2). In totaal zijn er in 2001 190 (25) studenten actief voor natuur- en sterrenkunde, waarvan 40 (8) voor het hoofdvak sterrenkunde.
Tussen haakjes: aantal vrouwelijke studenten.

4.4 Onderwijs en voorlichtingsactiviteiten van de staf in 2001

(Colleges aangeduid met I: propedeuse, de andere colleges en practica: doctoraalfase)

Rooster 2000-2001
2e trimester 8 januari t/m 6 april 2001

E. van den Heuvel  Sterrenkunde IB (Hoorcollege)  4 uur/week
M. van der Klis (coord.)  Sterrenkunde practicum I  6 uur/week
G. Hammerschlag (coord.)  Sterrenkunde IB (Werkcollege)  4 uur/week
T. Raassen  Keuzevoorlichting/Stud.sem.  1 uur/week
H. Henrichs  Zonnestelsel  4 uur/week
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<td>L. van den Horn</td>
<td>Hydrodynamica</td>
<td>4 uur/week</td>
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<td>R. Waters</td>
<td>Interst. en circumst.materie (HC)</td>
<td>2 uur/week</td>
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<tr>
<td>C. Dominik</td>
<td>Interst. en circumst. Materie (WC)</td>
<td>2 uur/week</td>
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<td><strong>3e trimester 9 april 2001 t/m 13 juli 2001</strong></td>
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<tr>
<td>T. Raassen</td>
<td>Highlights I</td>
<td>2 uur/week</td>
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<td>E. van den Heuvel / R. Fender</td>
<td>Astrofysica van compacte sterren</td>
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<td>Numerieke sterrenkunde</td>
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<td>Sterrenkunde colloquium</td>
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<td><strong>1e trimester 10 september 2001 t/m 14 december 2001</strong></td>
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<td>R. Waters</td>
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<tr>
<td>G.J. Savonije</td>
<td>Bouw en evolutie van sterren (HC)</td>
<td>2 uur/week</td>
</tr>
<tr>
<td>L. Kaper</td>
<td>Bouw en evolutie van sterren (WC)</td>
<td>2 uur/week</td>
</tr>
</tbody>
</table>

**Inzet promovendi bij werkcolleges en practica**

*Werkcollege sterrenkunde IA* (2x 2 uur/week)
M. Klein Wolt, S. van Straaten, J. Dewi, E. Rol

*Werkcollege sterrenkunde IB* (2x 2 uur/week)
A. Bik, E. Rol, R. Dijkstra

*Sterrenkunde practicum 1 (1e jaars)* (2x 3 uur/week)
M. Klein Wolt, C. Kemper, A. Lenorzer

*Sterrenkunde practicum 2 (2e jaars)*
L. Kaper (coördinator),

**Projecten Sterrenkunde voor 1e jaars studenten**

*De samenstelling van komeet Hale-Bopp*
Begeleider: A. de Koter
Studenten: D. Meerburg
           G. v.d. Plas

*Het nagloeien van gammaflitsen*
Begeleider: M. v.d. Klis
Studenten: G. v.d. Akker
           J. v.d. Berk

*Accretie in nauwe dubbelsterren*
Begeleider: G.J. Savonije
Studenten: J. v. Vollenhoven
           A. Teenstra
           A. de Vries
           R. Tooren
Projecten Sterrenkunde voor 2e jaars studenten

*Ultra-precieze metingen aan pulsars*
Begeleider: M. v.d. Klis
Studenten: M. Niemantsverdriet
S. Westerhout

*Exoplaneten*
Begeleider: H. Henrichs en R. Ramachandran
Studenten: F. v. Deuveren
S. Walg

Begeleiding onderzoekstage 4e jaars studenten

*H. Henrichs*
B. Plaggenborg, E. ten Kulve

*L. Kaper*
F. Huthoff, S. Schroder, G. Spil, A. Tijani, A. van der Horst

*M. van der Klis*
T. Reerink, R. Schnerr, Klaas Wiersema

*A.de Koter*
R. Mokiem

*G.J. Savonije en L. van den Horn*
A.J. van Marle

*B.Stappers*
P. Weltevrede

*R. Waters*
A.Volp

Andere onderwijs activiteiten

**Colleges buiten de afdeling FNWI**

- *Colleges Wereld en Mensheidsgeschiedenis:*
  - “De Oerknal, Ontstaan en Evolutie van het Heelal” (4 uur), *E.P.J. van den Heuvel*, 19 en 23 januari
  - “Geschiedenis in het Groot”, (2 uur), *H. Henrichs*, 30 januari

- *Planetaire Evolutie:*
  - 9 colleges aan de Universiteit van Utrecht, bestemd voor 1e jaars Sterrenkunde, Natuurkunde, Geofysica en Oceanografie, (2 uur), *H. Henrichs*, 14 mei tot 13 juni

- *Beta-Gamma Propedeuse:*
  - “Ontstaan en Evolutie van het Heelal” (4 uur),
    *E.P.J. van den Heuvel*, 14 en 28 september
Voorlichting:
- Voorlichting voor Middelbare Scholieren: E.P.J. van den Heuvel, 24 februari en 28 oktober
  - Project “Zwarte Gaten”, verzorgd door M. van der Klis,
    22 maart, 20 studenten, m.m.v. M. Klein Wolt, A. van der Meer, R. Mokiem, E. Rol, S. van Straaten
- Aansluitingsproject
  - Scholenbezoek, F. Kemper, gastcollege OSG Willem Blaeu, Alkmaar, 16 januari
  - Scholierenbezoek ivm profielwerkstuk over “Wormgaten” M. van der Klis, 21 december (Mark Sypesteyn, Charlie Visser, Boudewijn Brouwer en Jol Israels)
- Masterclass “Back Holes” E.P.J. van den Heuvel, 22 en 23 november (ca. 30 deelnemers, waaronder 2 uit Duitsland en 1 uit België.)

Postdoctoraal Onderwijs:
- NOVA-School Dwingeloo (verplicht voor alle promovendi in de Nederlandse Sterrenkunde):
  - “Astrophysics of Compact Objects”, E.P.J. van den Heuvel, 8-12 okt.

Personeelsoverzicht 2001
Rens Waters werd op 1 januari 2001 benoemd tot hoogleraar Sterrenkunde.
Rob Fender landde per 1 januari 2001 op een UD-positie in de reguliere 1e geldstroom formatie van het instituut. Voorheen werd hij door de Spinozagelden van Prof. Van den Heuvel gefinancierd.

Secretariaat
Per 1 januari ging Erica Veenhof 12 uur per week minder werken. Zij bleef nog 20 uur per week op het secretariaat totdat zij per 6 augustus helemaal vertrok en als ambtelijk secretaris bij de Centrale Studentenraad in dienst trad.
Op 12 maart kwam Fieke Kroon het secretariaat versterken voor 12 uur per week.
Per 1 oktober 2001 nam Jane Ayal voor 18 uur per week ontslag vanwege haar opleiding in de verpleging. Zij bleef nog voor 20 uur per week in dienst.
Annemiek Lenssen kwam in dienst per 1 oktober 2001 voor 21 uur per week.
Vanaf oktober is de bezetting op het secretariaat als volgt:
  - Jane Ayal: 20 u/week
  - Fieke Kroon: 12 u/week
  - Annemiek Lenssen: 21 u/week
Totaal komt dit neer op 53 uur per week, of 1,39 fte.

Nieuwe promovendi in 2001
Michiel Min, AIO bij J. Hovenier, L.B.F.M. Waters en A. de Koter
Rohied Mokiem, OIO bij E.P.J. van den Heuvel en A. de Koter
Elena Gallo, NOVA AIO bij M.B.M. van der Klis en R.P. Fender
Simone Migliani, OIO bij M.B.M. van der Klis en R.P. Fender

Nieuwe Postdoc’s
Tiziana di Salvo, EC-TMR postdoc bij M.B.M. van der Klis
Isabel de Salamanca, postdoc op NWO-project “Gamma-Ray Bursts Afterglows” bij E.P.J. van den Heuvel

Gijs Nelemans, van 16 maart tot 1 september postdoc op het NWO-project “Gamma-Ray Bursts Afterglows” bij E.P.J. van den Heuvel

Russell Edwards, NOVA postdoc op PUMA-project bij M.B.M. van der Klis

Wenfei Yu, postdoc op NWO-project “Fundamentele eigenschappen van neutronensterren en zwarte gaten” bij M.B.M. van der Klis

Jane Dennet-Thorpe, werkte ca. 1 dag/week onbezoldigd als postdoc bij R. Strom aan “interstellar scintillation”

5. PUBLIC OUTREACH ACTIVITIES, AWARDS, PRIZES, ETC

The main public activities of the institute staff members concern: public outreach, i.e.: popularization of astronomy towards the general public. In this field the following activities took place in 2001:

- A number of popular lectures by staff members presented in various parts of the country, to groups of amateur astronomers, school children and interested general public (see list of popular presentations in this report).
- Several interviews on radio and television about astronomical topics that were in the news.
- E.P.J. van den Heuvel, as one of the founders of the Zeiss Planetarium Artis, continued as a member of the Board of the Amsterdam Zoo 'Artis' till December 2001, when he was succeeded by Prof. T. de Jong. The Planetarium hosts between 200,000 and 300,000 visitors per year.

The public outreach office of the Netherlands Research School for Astronomy (NOVA), which started in the UvA Astronomical Institute on January 1st 2000, continues its work, by two public outreach officers: Mr. A.Jaspers and Mr. J.Visser. Important tasks of the NOVA Information Center (NIC) are:

- Publication of press releases about new developments in Dutch Astronomy.
- Development of a WEB-encyclopedia on general astronomy.
- Production of exposition materials.

5.1 Popular publications

M. van der Klis
- De zoemtoon van relativiteit, Natuur en Techniek 68, 26-29, 2000.

H. Henrichs
- Waar is het water op Mars?, Zenit, januari 2001, 6 – 10

5.2 Popular lectures

E.P.J. van den Heuvel
- Supernovae Explosions, Planetarium Artis, 6 maart
- Press Briefing Dedication MIDI en VIZIR, Dwingeloo, 19 april
- De oerknal en de Geschiedenis van het Heelal, Allied Circle, Amsterdam, 24 april
- The History of the Universe, from Big Bang till Present, Cursos CASCAIS, Portugal, 7 juli
- Het onderzoek met de Nederlandse Radio Telescopen, voor de UvA Hoogleraren Vereniging “Unitas”, ASTRON, Dwingeloo, 22 september
- toespraak bij prijsuitreiking voor ESO-CERN-wedstrijd voor middelbare scholieren “Life in the Universe” (als voorzitter van de jury), Planetarium Artis, 12 oktober
- Cosmologie: de Grote Vragen, Planetarium Artis, 15 oktober
- Cosmologie: de Grote Vragen, Planetarium Artis, 17 december

T. de Jong
- Sterren à la carte, Nationale Wetenschapsdag bij SRON, Utrecht, 7 oktober
- Babylonische Sterrenkunde, Publickslezing Artis Planetarium, Amsterdam 6 november
L. Kaper
- *Het woeste leven van zware sterren*, NVWS, Delft, 20 november
- *Het ontstaan van zware sterren*, NVWS, Arnhem, 19 december

A. de Koter
- *Is er leven op Mars?*, Artis Planetarium, in het kader van de “Leven in het heelal”-lezingen”
tijdens de wetenschapsweek 2001, 10 oktober

E Rol
- *Gammaflitsers: van raadsel tot kosmische superexplosies*, Nederlands Jongerenwerkgroep
Sterrenkunde, Utrecht, 20 oktober

R. Strom
- *De kans dat wij worden getroffen door een asteroïde voor het jaar 2100 is 1 op 10.000, zegt
men. Maar wat zegt het ons?*, NVWS, Appingedam, 9 januari, 29 september, 5 oktober
- *Pulsars: supersnelle tollen van 3000 biljoen biljoen ton neutronen*, Sterrenkundevereniging
Galileo, Heerlen, 13 januari, 25 januari
- *Wat zijn zwarte gaten? Hoe zien ze er van dichtbij uit?*, NVWS, Assen, 19 januari
- *China: Cultuur en Wetenschap van een zeer oude beschaving*, NVWS, Enschede, 13 maart
- *Gammastralers: het tipje van de sluiter wordt opgelicht*, NVWS, Arnhem, 28 november

L.B.F.M. Waters
- *Kometen*, Artis Planetarium, 4 september
- *Exoplaneten*, NVWS symposium, 13 oktober
- *Proto-planetaire schijven*, Studentenvereniging AS2 Utrecht,

5.3 Interviews and appearances on radio/tv

H. Henrichs
- *Uitleg over Mars*, Ontbijt TV, 6 april, 7:15

A.de Koter
- *Sterren en sterrenbeelden*, gastoptreden EMMA TV, life-uitzending in het AMC Amsterdam
voor langdurig zieke kinderen (12 – 16 jaar), 28 september
- *Uitleg over de HST/Keck waarneming van o.a. Koen Kuijken van een mogelijk primordial
galaxy seen using gravitational lensing technique*, RTL4 18:00 nieuws, 5 oktober

5.4 Prizes, Distinctions, Special Celebrations

S. Portegies Zwart
- Honorable mention by the Gravity Research Foundation: award for essay for 2000 *Gravitational
- Dedicated parallel super computer for calculating forces between stars. Received in April 2001 from
the University of Tokyo.

5.5 Memberships of learned Societies

G. Hammerschlag-Hensberge
Member Nederlandse Astronomen Club (NAC)
H. Henrichs
Member Nederlandse Astronomen Club (NAC)

E.P.J. van den Heuvel
Member Koninklijke Nederlandse Akademie van Wetenschappen, Amsterdam (KNAW)
Member Hollandse Maatschappij van Wetenschappenen, Haarlem
Member Academia Europea, London
Honorary Fellow Indian Academy of Sciences
Member New York Academy of Sciences
Member Nederlandse Astronomen Club (NAC)
Member Netherlands Physical Society (NNV)
Member International Astronomical Union (IAU)
Member European Astronomical Society (EAS)

L. van den Horn
Member Nederlandse Astronomen Club (NAC)

J. Hovenier
Boardmember Nederlandse Onderzoeksschool voor Astronomie (NOVA)
Member Nederlandse Astronomen Club (NAC)
Member NCA and Kamer Sterrenkunde VSNU

V. Icke
Member Nederlandse Astronomen Club (NAC)

T. de Jong
Member International Astronomical Union (IAU)
Member American Astronomical Society (AAS)
Member Royal Astronomical Society (RAS)
Member European Astronomical Society (EAS)

L. Kaper
Member Nederlandse Astronomen Club (NAC)
Member European Astronomical Society (EAS)
Member International Astronomical Union (IAU)

M. van der Klis
Member Nederlandse Astronomen Club (NAC)
Member International Astronomical Union (IAU)
Member European Astronomical Society (EAS)
Member American Astronomical Society (AAS)
Member COSPAR
Member HEAD

A.de Koter
Member Nederlandse Astronomen Club (NAC)

T. Raassen
Member Nederlandse Astronomen Club (NAC)

G.J. Savonije
Member Nederlandse Astronomen Club (NAC)
R. Strom
Fellow Royal Astronomical Society

R. Waters
Member International Astronomical Union (IAU)
Member Nederlandse Astronomen Club (NAC)
Key researcher Nederlandse Onderzoeksschool voor Astronomie (NOVA)
6. STAFF and BUDGET

The scientific staff working at the institute and the vacant positions on December 31, 2001 are listed below.

theme 1 = High energy Astrophysics
tHEME 2 = Low energy Astrophysics

A. University funded permanent staff/positions

<table>
<thead>
<tr>
<th>Staff Member</th>
<th>Theme</th>
<th>FTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>E.P.J. van den Heuvel (HL)</td>
<td>1</td>
<td>1.0</td>
</tr>
<tr>
<td>M. v.d. Klis (HL)</td>
<td>1</td>
<td>1.0</td>
</tr>
<tr>
<td>T. de Jong (HL)</td>
<td>2</td>
<td>0.2</td>
</tr>
<tr>
<td>L.B.F.M. Waters (HL)*</td>
<td>2</td>
<td>1.0</td>
</tr>
<tr>
<td>Vacancy position Prof. van Paradijs (HL)</td>
<td>1</td>
<td>1.0</td>
</tr>
<tr>
<td>Vacancy UvA + VU (HL)</td>
<td>2</td>
<td>0.7</td>
</tr>
<tr>
<td>G.J. Savonije (UHD)</td>
<td>1+2</td>
<td>1.0</td>
</tr>
<tr>
<td>H.F. Henrichs (UHD)</td>
<td>1+2</td>
<td>1.0</td>
</tr>
<tr>
<td>L.J. van den Horn (UHD)</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>A. de Koter (UD)</td>
<td>2</td>
<td>1.0</td>
</tr>
<tr>
<td>R.P. Fender (UD)</td>
<td>1</td>
<td>1.0</td>
</tr>
<tr>
<td>G. Hammerschlag-Hensberge (UD)</td>
<td>1</td>
<td>0.2</td>
</tr>
<tr>
<td>A. Raassen (UD)</td>
<td>1</td>
<td>(0.125)¹</td>
</tr>
<tr>
<td>Position Waters (U(H)D)-vacancy for KNAW Fellow Kaper</td>
<td>1+2</td>
<td>1.0</td>
</tr>
<tr>
<td>Vacancy (2001) Ground-based observational astronomy. (UD)*</td>
<td>1+2</td>
<td>1.0</td>
</tr>
<tr>
<td>Th. Nieuwenhuizen (UHD ITFA)</td>
<td>-</td>
<td>(0.2)²</td>
</tr>
</tbody>
</table>

Total (of which 2 overlap): 11.6

Formation Scientific Staff

We summarize below the allocation of permanent positions (formation) as given above under A.

<table>
<thead>
<tr>
<th>2001</th>
<th>HL</th>
<th>UHD</th>
<th>UD</th>
</tr>
</thead>
<tbody>
<tr>
<td>fte</td>
<td>3.9</td>
<td>2.5 (⁺0.2)²</td>
<td>3.2 (⁺0.125)¹</td>
</tr>
</tbody>
</table>

B. Externally funded permanent staff/positions

<table>
<thead>
<tr>
<th>Staff Member</th>
<th>Theme</th>
<th>FTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>V. Icke (UL, bijz. HL)</td>
<td>1</td>
<td>0.2</td>
</tr>
<tr>
<td>R. Strom (ASTRON; HL b.b.)*</td>
<td>1+2</td>
<td>0.2</td>
</tr>
<tr>
<td>J. Hovenier (Vrije Univ., HL b.b.)*</td>
<td>2</td>
<td>0.2 (emeritus UvA since Oct. 2001)</td>
</tr>
<tr>
<td>H. Spruit (AUV CHEAF bijz.HL)</td>
<td>1</td>
<td>0.2</td>
</tr>
</tbody>
</table>

¹ Funded by NOVA-overlap position till mid-2005
² 0.125 SRON + 0.25 Faculty funded, for a period of 10yrs from 1-1-99
³ We pay this position from our budget, but it is not part of our official formation (due to WINS-reorganization)

Funded by NOVA-overlap position till mid-2005
buiten bezwaar = not funded by the UvA
Present temporarily staff UvA Astronomy

**Postdocs and Fellows**

- Dr. L. Kaper (KNAW-Fellow, 5 yr., will go to UD, position Waters)
- Dr. C. Dominik (NWO-Pionier)
- Dr. K. O’Brien (EC-TMR)
- Dr. J. Dennet-Thorpe (buiten bezwaar)
- Dr. M. Fluks (private funding)
- Dr. B. Stappers (NWO-Spinoza)
- Dr. Ramachandran (ASTRON)
- Dr. T. di Salvo (EC-TMR)
- Dr. I. de Salamanca (NWO)
- Dr. R. Edwards (NOVA)
- Dr. W. Yu (NWO)
- Dr. S. Portegies Zwart (NWO)

**Guest-researcher (permanent)**

- Dr. H.R. Tjin A Djie (private funding)

**Ph.D. Students**

There are at present a total of 25 graduate students working at the Institute of which 20 are externally funded: four from NWO, two from NWO-Pionier (the Pioneer Grant to L. Waters), three from the Spinoza-grant to E. van den Heuvel, and 5 from NOVA (Nederlandse Onderzoekschool voor Astronomie). There are officially 8 University-funded AIO-positions, of which at present three have to remain vacant because of insufficient University budget.

**C. Allocation of supporting staff**

In 2001 the supporting staff of co-manager (0.84 fte) and secretaries (1.17 fte), that used to belong to the central formation of the Science Faculty, was transferred to the Institute’s formation, together with the budget (kƒ 169,4).

<table>
<thead>
<tr>
<th>Name</th>
<th>Function</th>
<th>Fte Funded by</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Institute</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1st gs)</td>
</tr>
<tr>
<td>M. Heemskerk</td>
<td>Software sp</td>
<td>1.0</td>
</tr>
<tr>
<td>L. Stolte</td>
<td>Co-manager</td>
<td>0.8</td>
</tr>
<tr>
<td>J. Ayal</td>
<td>Secretary</td>
<td>0.3</td>
</tr>
<tr>
<td>F. Kroon</td>
<td>Secretary</td>
<td>0.32</td>
</tr>
<tr>
<td>A. Lenssen</td>
<td>Secretary</td>
<td>0.55</td>
</tr>
<tr>
<td>D. Edel</td>
<td>System manager</td>
<td>1.0</td>
</tr>
<tr>
<td>L. Iterson</td>
<td>Librarian</td>
<td>0.3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>2.97</strong></td>
</tr>
</tbody>
</table>
### 2001

**Budgets: UvA and External**

<table>
<thead>
<tr>
<th>Year</th>
<th>1997</th>
<th>1998</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
</tr>
</thead>
<tbody>
<tr>
<td>UvA budget (Kf)</td>
<td>1855</td>
<td>1749.6</td>
<td>1820</td>
<td>1857</td>
<td>2270</td>
<td>2200</td>
</tr>
<tr>
<td>External</td>
<td>~1800</td>
<td>1830</td>
<td>~1800</td>
<td>~2200</td>
<td>2400</td>
<td>~1700</td>
</tr>
</tbody>
</table>

The jump in budget per 2001 is due to:

- end of yearly budget-cut due to WINS reorganization of 5% (which started 1-1-1998);
- structural budget increase of 80 kƒ (250-170) for termination Spinoza;
- management transfer from faculty budget to institute budget (170 kƒ) (salaries of co-manager and secretaries);
- compensation for raise in salary for 8 Ph.D students (102 kƒ), to be divided over several projects.

On the other hand, at the end of 2001 the faculty cut again 62 kƒ because of an overall faculty default of several million guilders.

External budgets are composed of:

1$^{e}$ gs

- NOVA 870 kƒ
- CvB matching Pionier Waters 120 kƒ
- CvB COF Frontiers in Astronomy 200 kƒ
- KNAW-Fellow Kaper 137 kƒ
- 1327 kƒ

2$^{e}$ en 3$^{e}$ gs

- NWO Spinoza (E.P.J. van den Heuvel) 350 kƒ
- NWO Pionier Waters 290 kƒ
- Projects 2$^{e}$ en 3$^{e}$ gs 440 kƒ
- 1080 kƒ

**Total University Funded staff of Astronomy Institutes in the Netherlands**

<table>
<thead>
<tr>
<th>University</th>
<th>Full Professors</th>
<th>UHD + UD</th>
<th>Graduate Students</th>
<th>Postdoc Positions</th>
</tr>
</thead>
<tbody>
<tr>
<td>UvA (Amsterdam)</td>
<td>3.9</td>
<td>5.7</td>
<td>8$^{a}$</td>
<td>-</td>
</tr>
<tr>
<td>RU (Groningen)</td>
<td>5.3</td>
<td>9.7</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>RU (Leiden)</td>
<td>6.0</td>
<td>11.0</td>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>UU (Utrecht)</td>
<td>3.2</td>
<td>5.3</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>VU (Amsterdam)$^{b}$</td>
<td>1.0</td>
<td>1.0</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>21.7</td>
<td>32.0</td>
<td>29</td>
<td>4</td>
</tr>
</tbody>
</table>

$^{a}$ funding for only 4 in 2001

$^{b}$ terminated at the end of 2001
APPENDIX I

INSTITUTE STAFF on 31-12-2001

Gewoon Hoogleraren
Prof.Dr. E.P.J. van den Heuvel
Prof.Dr. M.B.M. van der Klis
Prof.Dr. L.B.F.M. Waters
Vacature

Deeltijd- en Bijzonder Hoogleraren en gasthoogleraren
Prof.Dr. J. Hovenier  (affiliated prof.: Vrije Univ. Amsterdam)
Prof.Dr. V. Icke  (bijz. h.l., Stichting Beta-Plus)
Prof.Dr. T. de Jong  (0.2 fte)
Prof.Dr. R. Strom  (affiliated prof.; NWO Foundation ASTRON, Dwingeloo)
Prof.Dr. H. Spruit  (Max Planck Institut für Astrophysik, Garching; bijz.h.l. AUV)
Vacature  (0.7 fte UvA + 0.3 fte VU)

Universitaire hoofddocenten
Dr. H. F. Henrichs
Dr. L. J. van den Horn (0.5 fte)
Dr. G.J. Savonije

Universitaire Docenten
Dr. R.P. Fender (NWO Spinoza)
Mw. Dr. G. Hammerschlag-Hensberge (0.2 fte)
Dr. A. de Koter
Dr. T. Raassen (0.125 fte +0.25 fte Fac.)

Emeriti
Prof.Dr. P.S. The
Dr. H.R.E. Tjin A Die

Co-manager
Mw. L. Stolte (1.0 fte) (0.8 fte 1e geldstroom, 0.2 fte NWO-Spinoza)

Wetenschappelijk Systeemontwerper
Dr. M.H.M. Heemskerk (1.0 fte 1e geldstroom)

Systeembeheerder
D. Edel (1.0 fte 1e geldstroom)

Management-assisttenen
Mw. Drs J. Ayal (0.4 fte ASTRON, 0.3 fte 1e geldstroom, 0.3 NWO-Spinoza)
Mw. Drs. F.E. Kroon (0.32 1e geldstroom)
Mw. Drs. A. Lenssen (0.55 1e geldstroom)

Bibliothecaris
Mw. E.S. van Iterson (0.6 fte, bibliotheekformatie)
Nova Information Centrum
Drs. A. A. Jaspers, communication manager (0.6 fte NOVA)
Dr. J. Visser, project manager communication (0.4 fte NWO Spinoza, 0.1 fte NOVA)
### Sterrenkundig Instituut “Anton Pannekoek” FNWI **PROMOVENDI** in het jaar 2001

<table>
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<tr>
<th>AIO’s/OIO’s/bursalen</th>
<th>promotor/co-promotor</th>
<th>begin/einde contract</th>
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<td>01-01-94</td>
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Sterrenkundig Instituut ‘Anton Pannekoek’, F W N I **POSTDOC’s** in het jaar 2001

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<td>C. Dominik</td>
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<td>van der Klis</td>
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APPENDIX II

COMMITTEE MEMBERSHIPS

Facultaire commissies

R. Fender
Jurylid in ‘VLT contest’
Coordinator Wetenschapsdag 2001

H. Henrichs
Examencommissie Faculteit WINS
Bibliotheekcommissie Sterrenkundig Instituut
Huisvestingcommissie Faculteit NWI

L. van den Horn
Onderwijscoördinator WNS

M. van der Klis
Lid UvA Opleidingscommissie Natuur- en Sterrenkunde
Lid Computer Netwerk Groep Gebruikers Commissie
Lid Promotiebegeleidingscommissie Sterrenkundig Instituut

A. de Koter
Colloquiumcommissaris van de Colloquia aan het Sterrenkundig Instituut
Voorzitter Promotiebegeleidingscommissie Sterrenkundig Instituut

A. Raassen
Lid Ondernemingsraad van de Faculteit NWI

G.J. Savonije
Onderwijscoördinator sterrenkunde UvA
Stagecoördinator Sterrenkunde
Beheerder kleine kas LKB-fonds
Lid studierichtingcommissie van de faculteit

Universitaire commissies

E.P.J. van den Heuvel
Universitaire Onderzoek Commissie
Commissie Ad-Hoc Verbreding Bachelore-fase aan de UvA (chair)
APPENDIX III

SCIENCE POLICY FUNCTIONS

J. Dewi
Member of International Astronomical Union (IAU)
Member of Selection Committee of professorship position in High Energy Astrophysics

C. Dijkstra
Attended several meetings of LOCNOC in 2001

R. Fender
Member management team Astronomical Institute
Member of Scientific Advisory Committee for “3rd microquasar workshop”

M. Heemskerk
Secretaris Nederlandse Astronomen Club

E.P. J. van den Heuvel
Chairman management team Astronomical Institute
Chairman, Board of the Netherlands Research School for Astronomy NOVA
Chairman Netherlands Foundation for Research in Astronomy (NFRA/ASTRON/NWO)
Member, Board of the Amsterdam zoological garden Artis
Chairman Leids Kerkhoven Bosscha Fonds, Leiden
Member, Board of Directors Leids Sterrewacht Fonds Leiden
Member, Board of Directors “Jan Hendrik Oort Fonds”, Leiden
Member, Science Advisory Board (Wetensch. Raad), Space Research Organisation of the Netherlands (SRON)
Member, NWO, Advisory Committee for Astronomy (ACA)
Member, SAX Science Steering Committee for Italian-Dutch BeppoSAX satellite, Rome
Member, Netherlands Committee for Astronomy (NCA)
Member, Kamer Sterrenkunde, VSNU
Member, International Advisory Board, Inter University Centre for Astronomy and Astrophysics, Puna, India (1998-2004)
Member, Evaluation Committee Swedish Astronomy (2000)
Foreign Member of Jury on Mathematics & Physics of Flemish National Science Foundation, Brussels (1997-)
Member, Fraenqu Prize Jury, Brussels, Belgium (1996 - )
Elector, Plumian Professor Chair, University of Cambridge, UK (1998 - )
Member, Jury Deutsche Forschungsgemeinschaft SFB Astro Particle Physics, Garching (1993-)
Co-editor “New Astronomy” (Elsevier), Amsterdam
Co-editor Astronomische Nachrichten (J. Wiley Publishers) Berlin
Member Editorial Board “Astrophysics and Space Science” (Kluwer Academic Publishers) Dordrecht
Member Editorial Board “Astrophysics and Space Science Library” (Kluwer Acad. Publishers) Dordrecht
Chairman, Sectie Astrofysica, Dutch Physical Society, NNV
Chair, Amsterdams Fonds voor Astrofysica
Chair, Scientific Organizing Committee “Jan van Paradijs Memorial Symposium” (June 2001)
Chair, INTEGRAL - satellite Time Allocation Committee, ESA-ESTEC
Member, “Raad voor Natuur- en Sterrenkunde”, KNAW
J. Hovenier
Vice Chairman of the Board of the Space Research Organisation of the Netherlands (SRON)
Chairman Science Advisory Board of SRON
Board member NCA
Board member Kamer Sterrenkunde (VSNU)
Board member NOVA

V. Icke
Board Science Museum “Mew Metropolis”, Amsterdam

T. de Jong
Member Instrument Science Team for CONICA/ESO-VLT
Member Scientific Committee NLR/NIVR
Member International Astronomical Union (IAU)
Member American Astronomical Society (AAS)
Member Royal Astronomical Society (RAS)
Member European Astronomical Society
Board member Stichting Artis Natura Magistra

P. Jonker
Penningmeester Nederlandse Astronomen Club

L. Kaper
Member management team Astronomical Institute
Member ASTRON Program Committee
Member board Vereniging van Akademie Onderzoekers
Member Programma Commissie Nederlandse Telescoop
Member ESO Contact Committee
Member Nederlandse Astronomen Club (NAC)
Member European Astronomical Society (EAS)
Member International Astronomical Union (IAU)

A. de Koter
Member management team Astronomical Institute
Minnaert Commissie, NOVA publieksvoorlichting, member representing Amsterdam
Member ESO Observing Programmes Committee, Stellar Evolution
Member National Teacherday Committee
Member “Klankbordgroep” Beowulf Cluster

M. van der Klis
Member management team Astronomical Institute
Network co-ordinator & key researcher NOVA network “High-Energy Astrophysics”, Netherlands
Research School for Astronomy (NOVA)
Node chief EU TMR Network “Accreting onto Black Holes, Compact Stars and Protostars”
Member European Pulsar Network
Member NASA Rossi X-ray Timing Explorer (RXTE) User Group
Member NASA Constellation-X Scientific Working Group
Member ESA XEUS Scientific Working Group
Member Integral Time Allocation Committee
Project Scientist NOVA PuMa ii instrumentation project
Member NOVA Instrument Steering Committee
Member NOVA Research Committee
Member Science Advisory Board (Scientific Board), Space Research Organisation of the Netherlands (SRON)
Chairman Stichting Amsterdams Fonds voor de Astrofysica
Member board Kapteynfonds
Member board Stichting Pastoor Schmeyts
Member Board of reviewing editors, Science Magazine
Editor New Astronomy

I. de Salamanca
Member of the “Marie Curie Fellowship Association” (MCFA)

G.J. Savonije
Member management team Astronomical Institute
Member Education Committee NOVA

B.W. Stappers
Member, Raad van Toezicht PuMa II
Chair, Technical Committee PuMa II
Member, LOFAR Science Committee
Chair, PuMaScI (Dutch Pulsar Community Science Group)

R.G. Strom
Member of the European VLBI Network Program Committee
Member of the Working-Committee of the International Conference on Oriental Astronomy

L.B.F.M. Waters
Member management team Astronomical Institute
Co-pi Mid-infrared Instrument for VLTI MIDI
Chairman, Dutch Science Team for VISIR
Co-chair, NOVA VLTI team
Coordinator, INTAS programme ‘Theoretical and experimental investigations of light scattering by heterogeneous non-spherical cosmic grains’
Member, science team for HIFI, the heterodyne receiver for FIRST
Member VLTI Implementation Committee of the European Southern Observatory (ESO)
Member MIDI science team
Member VLT Science Demonstration Team
Member, science advisory board MPIA Heidelberg
Member, advisory board Lorentz Center
Member, Dutch Science team MIRI instrument for JWST
Member, Planet finder consortium
Member, science organizing committee Stardust Workshop
Member, Stichting Amsterdams fonds voor Astrofysica
Member, ACA Adviescommissie Astronomie
## APPENDIX IV

### VISITING SCIENTISTS

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
<th>Dates</th>
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<tr>
<td>Andrea Lommen</td>
<td>Univ.C. Berkeley, USA</td>
<td>1 February - 14 February</td>
</tr>
<tr>
<td>Joanna Rankin</td>
<td>University of Vermont, Burlington, USA</td>
<td>1 February - 1 July (with support from NWO and NOVA)</td>
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<tr>
<td>Dr. Kees Dullemond</td>
<td>Max-Planck-Institut für Astrophysik, Garching, Germany</td>
<td>18 February - 24 February, 28 March - 30 March</td>
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<tr>
<td>Mike Revnitzev</td>
<td>Max-Planck-Institut für Astronomie, Garching, Germany</td>
<td>20 February – 23 February, 01 September - 29 November</td>
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<tr>
<td>Lev Youngelson</td>
<td>Inst. of Astron. of the Russian Acad. of Sciences, Russia</td>
<td>05 March - 02 June, 28 October - 21 December (with support from NOVA and NWO-Spinoza)</td>
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<tr>
<td>Sera Markoff</td>
<td>Max-Planck-Institut für Radioastronomie, Bonn, Germany</td>
<td>07 March – 08 March, 19 June - 21 June, 09 December – 14 December</td>
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<tr>
<td>Heino Falcke</td>
<td>Max-Planck-Institut für Radioastronomie, Bonn, Germany</td>
<td>07 March – 08 March</td>
</tr>
<tr>
<td>Chryssa Kouveliotou</td>
<td>Univ. of Alabama, Huntsville, USA</td>
<td>13 March - 21 March, 04 June - 21 June, 30 October - 02 November</td>
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<tr>
<td>Dan Stinebruig</td>
<td>Oberlin College, USA</td>
<td>15 March</td>
</tr>
<tr>
<td>Danny Steeghs</td>
<td>Univ. of Southampton, United Kingdom</td>
<td>23 – 29 March</td>
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<tr>
<td>Simon Portegies Zwart</td>
<td>MIT Center for Space Research, Boston, USA</td>
<td>26 March – 02 April</td>
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<tr>
<td>Luciano Burderi</td>
<td>Osservatorio Astronomico di Roma, Italy</td>
<td>29 March - 03 April, 16 – 23 July, 23 – 30 October, 20 – 30 November</td>
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<tr>
<td>Coralie Neiner</td>
<td>Observatoire de Meudon, GEPI, France</td>
<td>13 April - 27 May</td>
</tr>
<tr>
<td>Jorrick Vink</td>
<td>Imperial College, London, United Kingdom</td>
<td>19 April</td>
</tr>
<tr>
<td>Name</td>
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<td>Rob Hynes</td>
<td>Univ. of Southampton, United Kingdom</td>
<td>19 November - 23 November</td>
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<tr>
<td>M.I. Mishchenko</td>
<td>NASA Goddard Inst. For Space Studies, New York, USA</td>
<td>02 May - 08 May</td>
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<tr>
<td>Simon Clark</td>
<td>University of Hertfordshire, England</td>
<td>05 May - 11 May</td>
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<tr>
<td>Sean Dougherty</td>
<td>Dominion Radio Astronomical Observatory (DRAO), Canada</td>
<td>06 May - 11 May</td>
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<tr>
<td>Jeremiah P. Ostriker</td>
<td>Princeton University</td>
<td>05 December - 07 December</td>
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<tr>
<td>Henrik Nuebold</td>
<td>Univ. of Braunschweig, Germany</td>
<td>10 May</td>
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<tr>
<td>David McDavid</td>
<td>Limber Observatory, Texas, USA</td>
<td>19 May – 22 May</td>
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<tr>
<td>John Brown</td>
<td>Univ. of Glasgow (Astronomer Royal for Scotland)</td>
<td>24 May - 30 May</td>
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<tr>
<td>Catherine Brocksopp</td>
<td>Liverpool John Moores University, United Kingdom</td>
<td>30 May - 30 May</td>
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<tr>
<td>Virginia Trimble</td>
<td>Univ. of Maryland</td>
<td>05 June - 13 June</td>
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<tr>
<td>Y. Sobouti</td>
<td>Inst. For Advanced Studies in Basic Sciences Zanjan, Iran</td>
<td>24 June - 25 June</td>
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<tr>
<td>Dipanjan Mitra</td>
<td>Raman Research Institute, Bangalore, India</td>
<td>24 June - 25 June</td>
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<tr>
<td>Anne Dutrey</td>
<td>Institut de Radio Astronomie Millimétrique, France</td>
<td>24 June - 25 June</td>
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<td>Klaus Meisenheimer</td>
<td>Max-Planck-Institut für Astronomie, Heidelberg, Germany</td>
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<td>Patrick de Laverny</td>
<td>Observatoire de la Côte d’Azur, Nice, France</td>
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<td>Christoph Leinert</td>
<td>Max-Planck-Institut für Astronomie, Heidelberg, Germany</td>
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<td>Markus Feldt</td>
<td>Max-Planck-Institut für Astronomie, Heidelberg, Germany</td>
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<td>Bruno Lopez</td>
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<td>Hans Zinnecker</td>
<td>GeoForschungsZentrum Potsdam, Germany</td>
<td>24 June - 25 June</td>
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<tr>
<td>Bernhard Deufel</td>
<td>Max-Planck-Institut für Astrophysik, Garching, Germany</td>
<td>05 July - 08 July</td>
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<tr>
<td>Linda Petrov</td>
<td>ASTRON</td>
<td>16 July - 18 July</td>
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</tbody>
</table>
Stan Owocki, Univ. of Delaware, USA 18 July - 25 July
Eva Verdugo, ISO Data Centre, VILSPA, Madrid, Spain 25 July - 26 July
Sudip Bhattacharya, Raman Research Institute, Bangalore, India 12 August - 26 August
Garth McCormick, Jodrell Bank, Manchester, United Kingdom 10 September - 13 October
Yuri Levin 10 September - 15 September
Issei Yamamura, Institute of Space and Aeronautical Science (ISAS), Japan 12 September - 13 September
Antonella Natta, Osservatorio Astrofisico di Arcetri, Italy 24 September - 26 September
Slobodan Jankov, Observatoire de la Côte d’Azur, Nice, France 15 October - 15 November
H.J. Grimm, Max-Planck-Institut für Astronomie, Garching, Germany 15 November - 18 November
Prof.dr. R. Wijers, State Univ. of New York, Stony Brook, USA 15 November - 16 November
Dr. J. Wilms, University of Tübingen, Germany 16 November
Prof.dr. P. Jetzer, University of Zürich, Switzerland 19 November - 20 November
Dr. M. van Putten, M.I.T., Cambridge, USA 21 November - 22 November
Prof.dr. F. Aharonian, Max Planck Institut für Kernphysik, Heidelberg, Germany, 21 November
Phill Uttley, University of Southampton, England 29 November - 02 December
Will Zhang, NASA Goddard Space Flight Center, USA 29 November
Pranab Ghosh, Tata Inst. Of Fundamental Research, India 30 November - 08 December
Don Backer, Univ. of California, Berkely, Astron. Dept. USA 04 December - 10 December
Noam Soker, Univ. of Haifa at Oranim and Univ. of Virginia, USA 11 December - 15 December
APPENDIX V

COLLOQUIA AT THE “ANTON PANNEKOEK INSTITUTE”

Thursday 11 January, -- AFSTUDEER Colloquium
Fredrik Huthoff, The runaway nature of high-mass X-ray binaries

Thursday 8 February
Dr. Andrea Lommen, Berkeley, Is the Galactic Center a massive black hole binary?

Thursday 22 February
Dr. Mike Revnivtsev, The fastest X-ray variability of compact objects

Thursday 8 March
Dr Heino Falcke, Bonn, The silent majority - radio cores from weakly active black holes

Thursday 15 March
Prof. Dr. Dan Stinebring, Physics Dept. Oberlin College, USA, Faint Scattering Around Pulsars: Probing the Interstellar Medium on Solar System Size Scales

Thursday 22 March -- SPECIAL NOVA SPRING COLLOQUIUM
Dr. Kate Spence, Faculty Oriental Studies, Univ. Cambridge UK
Ancient Egyptian chronologie and the astronomical orientation of pyramids

Friday 23 March
Dr. Danny Steeghs, Univ. of Southampton, Observations of spiral waves in accretion disks

Thursday 29 March
Dr. Simon Portegies Zwart, MIT Cambridge, Black hole Billiard

Monday 9 April -- EXTRA Colloquium
Dr. Patrick Woudt, Department of Astronomy University of Cape Town, Large-Scale Structures behind the southern Milky Way; Unveiling the Great Attractor

Thursday 19 April
Dr. Jorick Vink, Imperial College, London, New Aspects of radiation-driven winds of massive stars

Thursday 3 May
Dr. Rob Hynes, University of Southampton, Just how quiescent are quiescent black hole binaries?

Thursday 10 May -- NOVA Colloquium
Dr. Michael Mishchenko, NASA Goddard Inst. for Space Studies NY, Light scattering by nonspherical particles: current status, challenges, and prospects

Monday 28 May -- EXTRA Colloquium
Dr. David McDavid, Limber Observatory, Texas, Polarimetry of early emission line stars

Friday 1 June
Dr. Diah Y.A. Setia Gunawan, Kapteyn Institute Groningen/ATNF Australia, Colliding winds in Wolf-Rayet binaries
Monday 11 June
Dr. Catherine Brocksopp, Liverpool John Moores University, *Soft X-ray Transients which aren't always soft*

Wednesday 13 June -- NOVA Colloquium
Prof. Dr. Virginia Trimble, Univ. of Maryland, *Astrophysics Faces the Millenium*

Thursday 14 June
Dr. Rien v.d. Weygaert, Universiteit Groningen, *The Cosmic Matter Distribution: Foamlike Patterns and the Scaling of Spatial Clustering*

Friday 22 June -- EXTRA Colloquium
Prof. Dr. Yousef Sobouti, Institute for Advanced Studies in the Basic Sciences. Zanjan, Iran, *r-Modes of Rotating Stars and the Interplay of r- and g- Modes*

Monday 25 June -- EXTRA Colloquium
Dr. Maurice van Putten, MIT dept. of Mathematics, *Gamma-ray bursts: short for HETE-II, long for LIGO/VIRGO*

Thursday 19 July
Prof. Dr. Stan Owocki, Univ. of Delaware, *Hot-Star Winds: Initial MHD simulations and other recent results*

Friday 20 July -- EXTRA Colloquium
Dr. Luciano Burderi, Rome observatory, *Where May Ultra-Fast Rotating Neutron Stars Be Hidden?*

Thursday 13 September
Dr. Garrelt Mellema, Leiden, *Cometary Knots in the Helix Nebula*

Thursday 18 Oktober
Dr. Yanqin Wu, CITA Toronto, *Tidal evolution in close-in exoplanets*

Thursday 1 November
Dr. Jeroen Bouwman, Amsterdam, *Crystalline silicates and planets around HD 100546*

Thursday 8 November -- AFSTUDEER COLLOQUIUM
Rohied Mokiem, Amsterdam, *Radiative transfer modeling of circumstellar dust disks around Herbig Ae/Be stars*

Friday 9 November -- EXTRA COLLOQUIUM
Dr. Luc Dessart, University of Utrecht, *The influence of radiation pressure on mass transfer by RLOF in massive binary star systems*

Wednesday 14 November -- EXTRA COLLOQUIUM
Prof. Dr. Xander Tielens, University of Groningen, *PAHs, MAH, and GrandPAH: a family history*

Friday 16 November -- EXTRA COLLOQUIUM
Prof. Dr. Ralph Wijers, SUNY Stony Brook, *Gamma-ray Bursts from massive stars*
Friday 16 November -- EXTRA COLLOQUIUM
Dr. J. Wilms, Universität Tübingen Germany, *Long-term monitoring of galactic black holes*

Tuesday 20 November -- EXTRA COLLOQUIUM
Prof. Dr. Phillipe Jetzer, Universität Zürich, *Microlensing and dark matter in the Milky Way*

Tuesday 20 November -- EXTRA COLLOQUIUM
Dr. Pascale Ehrenfreund, Leiden Observatory, *Ices and organics: A voyage from interstellar clouds to the early Earth*

Wednesday 21 November -- EXTRA COLLOQUIUM
Prof. Dr. Felix Aharonian, MPI fur Kernphysic, Heidelberg, *TeV Blazars and the Diffuse Extragalactic Infrared Background Radiation*

Wednesday 21 November -- EXTRA COLLOQUIUM
Dr. Maurice van Putten, MIT dept. of Mathematics, *Gamma Ray Bursts: the tip of the iceberg?*

Thursday 22 November
Dr. Jacco Vink, Columbia Astrophysics Laboratory, New York, *The peculiar X-ray emission from the supernova remnant RCW 86*

Monday 26 November -- EXTRA COLLOQUIUM
Dr. Marten van Kerkwijk, *The nearby neutron star RX J1856.5-3754 and its peculiar H alpha nebula*

Thursday 29 November
Dr. Michaela Kraus, University of Utrecht, *The peculiar B[e] star MWC349: Do we see hints for a flared disk?*

Friday 7 December
Ramon Brasser, Tuorla Observatory, Finland, *Secular resonances of Terrestrial-planet Trojans*

Monday 10 December -- EXTRA COLLOQUIUM
Dr. Sera Markoff, Max-Planck-Institut fur Radioastronomie, *All jets great and small: modeling the emission of outflows from XRBs to LLAGN*

Thursday 13 December
Prof. Dr. Noam Soker, University of Haifa at Oranim and University of Virginia, *Planets and Planetary Nebulae*

Friday 14 December -- CHRISTMAS COLLOQUIUM
Prof. Dr. Teije de Jong, Univ. van Amsterdam, *Babylon: bakermat van de sterrenkunde*
APPENDIX VI

A. PARTICIPATION IN SCIENTIFIC MEETINGS
(Details about the scientific talks presented at these meetings are given in the next section (B))

“Cosmic explosions”, winterschool, Jeruzalem, Israel, December 27 – January 5
P. Vreeswijk (talk and poster)

Max Planck Institut für Radioastronomie, Bonn, Germany, January 26
T. de Jong (talk)

Max Planck Institut für Astrophysiks, Garching, Germany, January 29 – Febr. 4
R. Fender

Aspen workshop on Gravitational wave radiation, Aspen, USA, January
Simon Portegies Zwart

“Magnetic fields across the Hetzsprung-Russell diagram”, Santiago, Chile, January
C. Neiner (poster)

LOFAR Meeting, Groningen, February 13
R. Fender

JIVE Meeting, Dwingeloo, February 27
R. Fender

Dutch Astrophysics Days, Leiden, March 1 - 2
M. van der Klis
R. Fender
C. Dominik (talk)

I. de Salamanca

LOFAR Meeting, Leiden, March 9
R. Fender

Workshop on 2nd generation NOVA instrumentation projects, Utrecht, March 13
A. de Koter
R. Fender
E.P.J. van den Heuvel
L.F.B.M. Waters

DAC Workshop, Glasgow, UK, March 22 - 23
L. Kaper

European Geophysical Society, XXVI General Assembly, Nice, France, March 25-30
J. Hovenier (talk)
MIDI Science team meeting, Max Planck Institut für Astrophysiks, Heidelberg, Germany, March 27 - 28
R. Waters

ESO VLTI implementation meeting, Garching, Germany, April 10
R. Waters

Meeting on Interstellar and Circumstellar Matter, Astronomical Institute “Anton Pannekoek”, Amsterdam, April 10
C. Dijkstra
F. Kemper
S. Hony
T. de Jong
A. Bik
L. Waters
C. Dominik
M. Min
V. Icke

Workshop on Interstellar Silicates, Leiden, April 17 - 20
A.de Koter
F. Kemper
C. Dijkstra (talk)
J. Hovenier
R. Waters

ESO workshop on “The Origins of Stars and Planets: The VLT View”, Garching, Germany, April 24 - 27
J. Bouwman (poster)
A.de Koter (poster)
C. Dominik (talk)
L. Kaper (talk)
A. Bik
R. Waters

Symposium in honour of Cees de Jager’s 80st birthday, Utrecht, May 3
L. Kaper (talk)
A. de Koter (talk)
H. F. Henrichs,
E.P.J. van den Heuvel

RAS meeting, London, UK, May 11
R. Fender (invited talk)

56e Nederlandse Astronomen Conferentie, Dalfsen, May 16–18
A.de Koter
S. Hony
L. Kaper
C. Neiner (poster)
A.Bik
E. Rol
C. Kemper
J. Hovenier

INTEGRAL Satellite Time Allocation Committee Meeting, Estec, Noordwijk, May 14-19 and May 31-June 1
E.P.J. van den Heuvel
M. van der Klis

JCMT board meeting, Cambridge, United Kingdom, May 21-22
R. Waters

“Multifrequency Behavior of High Energy Cosmic Sources”, Frascati Workshop, Vulcano, Italy, May 21-26
T. di Salvo (talk)

American Astronomical Society meeting, Pasadena, USA, June 3-7
P. Vreeswijk (talk)

Jan van Paradijs Memorial Symposium, Amsterdam, June 6-8
M. van der Klis (talk)
R. Strom
R.P. Fender
L. Kaper
T. di Salvo
A. van der Meer
E.P.J. van den Heuvel (talk)
H.F. Henrichs
E. Rol
P. Vreeswijk
I. Salamanca
J. Dewi
G. Hammerschlag
M. Heemskerk
J. Hovenier
P.G. Jonker
V. Icke
M. Mendez
G. Nelemans
R. Ramachandran
J. Rankin
B.W. Stappers
J.L.L. Voûte
L.B.F.M. Waters
L.J. van den Horn
R. Edwards

ESO Conference on Scientific Drivers for ESO Future VLT/VLTI Instrumentation, Garching, Germany, June 11-15
P. Vreeswijk (talk)
MIDI Science team meeting, Amsterdam, June 25
R. Waters

T. de Jong (talk)

Stellar Coronae in the Chandra and XMM-Newton Era, ASP Conference, Noordwijk, June
A. Raassen

Aspen workshop on stellar dynamics, Aspen, USA, June – July
Simon Portegies Zwart

ESO meeting, Garching, Germany, July 5
R. Waters

“The 2nd NEON observing school”, Summerschool, Haute-Provence Observatory, France, July 9 – 21
A. Bik

MIDI Consortium meeting, Paris, France, July 10 – 12
R. Waters

International Astronomical Union Symposium 208, Astrophysical Supercomputing using Particle Simulations, Tokyo, Japan, July 10 - 13
Simon Portegies Zwart

MIDI meeting, Max Planck Institut für Astrophysiks, Heidelberg, July 30
R. Waters

“Pulsations as probe of stellar physics”, Leuven, Belgium, July
C. Neiner (2 posters)

12th Cambridge Workshop on Cool Stars, Stellar Systems, and the Sun, Boulder, USA, July – August
A. Raassen

“The Physics of Cataclysmic Variables and Related Objects”, Göttingen, Germany, August 5 – 10
J. Dewi (poster)

Hot Star Workshop III: The Earliest Phases of Massive Star Birth, Boulder, USA, August 6 - 8
L. Kaper (talk)
A. Bik
A. Lenorzer
“Lighthouses of the Universe: The Most Luminous Celestical Objects and their use for Cosmology”, Garching, Germany, August 6 - 10
I. de Salamanca
E.P.J. van den Heuvel

“Neutron Stars in supernova remnants (II)”, CfA/MIT, Boston, USA, August 14-17
Simon Portegies Zwart
R. Edwards

4th International Conference on Oriental Astronomy (ICOA4), Nanyang, China, August 20 - 24
R. Strom (talk)

Two Years of Science with Chandra, Washington DC, USA, September 2 - 7
P. Jonker
R. Fender (talk)
K. O’Brien

MIDI Science team meeting, Max Planck Institut für Astrophysiks, Heidelberg, September 7
R. Waters

ESO visit, Garching, Germany,
R. Waters

Symposium in honour of the 80th birthday of J. Mayo Greenberg: “From Interstellar Dust to Comets: A Journey through Space and Time”, Leiden, September 17
A.de Koter
J. Hovenier
E.P.J. van den Heuvel

CNOC-II (Italian national meeting on astrophysics of compact objects), CNR, Bologna, Italy, September 18 - 21
R. Fender (talk)
T. di Salvo (talk)

JIVE Meeting, Dwingeloo, October 1
R. Fender

MIDI Science team meeting, Max Planck Institut für Astrophysiks, Heidelberg, October 11 – 12
R. Waters

HIFI meeting, Lorentz Centre, Leiden, October 16 – 19
R. Waters

Hubble Symposium in STScI, Baltimore, USA, October
Simon Portegies Zwart
Avond van Wetenschap en Maatschappij, Ridderzaal, Den Haag, October 29
E.P.J. van den Heuvel

Meeting on Interstellar and Circumstellar Matter, Department of Astronomy “Leiden Observatory”, Leiden, November 8
C. Dijkstra
M. Min
A. Lenorzer
C. Dominik

Meeting of the FOM section “Molecular Physics”, November 8
R. Waters

SRT Workshop, Cagliari, Sardinia, Italy, November 7 - 9
R. Strom

Symposium “Brabant Breedband”, TU Eindhoven, 15 november
E.P.J. van den Heuvel

IAU Symposium 209 “Planetary Nebulae: Their Evolution and Role in the Universe”, Canberra, Australia, November 19 – 23
S. Hony
C. Dijkstra (poster)
C. Kemper

“New visions of the X-ray Universe in the XMM-Newton and Chandra Era”, ESTEC, Noordwijk, November 26 - 30
R. Fender
W. Yu
M. Klein Wolt
T. di Salvo
A. van der Meer
A. Raassen

Afscheidssymposium Prof. H. van der Laan, Leiden, 29-30 november
E.P.J. van den Heuvel
H. F. Henrichs

JWST MIRI kick-off meeting, ESTEC Noordwijk, December 4
R. Waters

Workshop for the Saeckler Lecturer G. Marcy, Leiden, December 6
C. Dominik (talk)

MIDI Consortium meeting, Max Planck Institut für Astrophysik, Heidelberg, Germany, December 12 – 13
R. Waters

Planet finder Consortium meeting Max Planck Institut für Astrophysik, Heidelberg, Germany, December 19
B. SCIENTIFIC TALKS at ASTRONOMICAL INSTITUTES and CONFERENCES

A. Bik
- Catching Massive Stars at Birth?, NOVA Network 2 meeting, Amsterdam, April 11

J. Dewi

C. Dominik
- Passive circumstellar disks with inner holes, Dutch Astrophysics Days, Leiden, March 1
- From Protoplanetary to Vega-like disks, Star Formation with the VLT, Garching, Germany, April 24 - 27
- Dust Coagulation, AMOLF, Amsterdam, October 8
- Dust Coagulation, Florence Observatory, Italy, November 8
- Crystalline Silicates and Planet Formation, Workshop for the Saeckler Lecturer G. Marcy, Leiden, December 6

C. Dijkstra
- The atmospheres of evolved stars, ASTRON, Dwingeloo, October 24

R. Fender
- The coupling between accretion and outflows in X-ray binaries, RAS meeting, London, UK, May 11
- Chandra imaging of X-ray binary jets, Two years of science with Chandra, Washington DC, USA, September 5 - 7
- Jets from X-ray binaries, CNOC-II, Bologna, Italy, September 18 - 21
- Relativistic outflows from black holes and neutron stars, University of Amsterdam Beta Lecture, Amsterdam, October 25
- Relativistic outflows from black holes and neutron stars, Seminar at University of Groningen, October 26

E.P.J. van den Heuvel
- The Scientific Legacy of Jan van Paradijs, “Jan van Paradijs Memorial Symposium”, Amsterdam, June 6
- Neutrone Stars and Black Holes, Farewell Colloquium for Prof. Dr. J. Trümper, MPI für Extraterrestrische Physik, Gardung, Germany, July 24
- The LOFAR Project, Symposium “Brabant Breedband” Technical University Eindhoven, November 15
- The discoveries in the field of Gamma-ray Bursts by Jan van Paradijs, Algemeen Natuurkunde Colloquium, University Groningen, January 25

J. Hovenier
- Scattering Matrices of Mineral Particles, European Geophysical Society XXVI General Assembly, Nice, France, March 29
T. de Jong
- *Warm Gas around Cool Stars*, Max Planck Institut für Radioastronomie, Bonn, January 26

L. Kaper
- *High-mass X-ray binaries and OB-runaway stars*, Colloquium Dwingeloo, March 16
- *Observational overview of the DAC phenomenon and its conventional interpretation*, DAC workshop, Glasgow, UK, March 22
- *VLT/ISAAC spectroscopy of young massive stars embedded in ultra-compact H II regions*, ESO workshop on The Origins of Stars and Planets: the VLT view, Garching, Germany, April 26
- *Young massive stars in ultra H II regions*, Symposium in honour of Cees de Jager’s 80th birthday, Utrecht, May 3
- *The infancy of massive stars: looking into the cradle*, Hot Star Workshop III: The Earliest Phases of Massive Star Birth, Boulder, USA, August 6

F. Kemper
- *Detection of carbonates in planetary nebulae NGC 6302 and NGC 6537*, ICM meeting, Amsterdam, April 10
- *Crystalline silicates in the spectra of O-rich AGB stars*, Workshop on Interstellar Silicates, Leiden, April 17
- *Mineralogy in the circumstellar environment of evolved stars*, IPAC, Pasadena, USA, November 26
- *The discovery of extrasolar carbonates*, UCLA, Los Angeles, USA, November 27
- *Mineralogy in the circumstellar environment of evolved stars*, NASA Ames, Moffett Field, USA, November 28
- *The discovery of extrasolar carbonates*, Steward Observatory, Univ. of Arizona, Tucson, USA, November 30
- *Mineralogy in the circumstellar environment of evolved stars*, Univ. of Illionois, Urbana, USA, December 4
- *Mineralogy in the circumstellar environment of evolved stars*, Harvard Smithsonian Center for Astrophysics, Cambridge, USA, December 7

M. van der Klis
- *Strong gravity and dense matter with stellar-mass compact objects*, Kapteyn Institute, Groningen, February 9
- *Neutron Star timing*, “Jan van Paradijs Memorial Symposium”, Tropenmuseum, Amsterdam, June 6
- *Frequency/count rate correlations in kHz QPOs*, NASA Goddard Space Flight Center, Greenbelt, USA, October 22

A. de Koter
- *New puzzling TIMMI2 observations of dust in the waist of Eta Carinae*, SUA meeting in honour of Cees de Jager’s 80th birthday, May 3

C. Neiner
- *Non radial pulsations, magnetic fields, activity and wind modulation in Be and beta Cephei stars*, Max Planck Institut für Aeronomie, Lindau, Germany, August
T. di Salvo
- Discovery of Extended Hard tails in the X-Ray spectra of Low mass X-Ray Binaries, Multifrequency Behavior of High Energy Cosmic Sources, Frascati Workshop, Vulcano, Italy, May 21 – 26
- Spectral Properties of Neutron Stars in LMXBs, CNOC-II (Italian national meeting on astrophysics of compact objects, CNRI, Bologna, Italia, September 19 - 21

R. Strom
- “Was there a brightness or ‘magnitude’ scale in historical Chinese records?”, ICOA4, Nanyang, China, August 22

P. Vreeswijk
- GRB Optical and Infrared afterglows, American Astronomical Society Meeting 198, Pasadena, USA, June 3 – 7
- GRB Afterglows, ESO Conference on Scientific Drivers for ESO Future VLT/VLTI Instrumentation, Garching, Germany, June 11 - 15

M. Witte
- Tidal Evolution of Eccentric Binaries, SRON, Utrecht, November 28
APPENDIX VII

OBSERVING SESSIONS

C. Dijkstra
JCMT, Mauna Kea, Hawaii, USA, 3-18 October

S. Hony
ESO 3.6m, La Silla, Chile, 16-27 January
ESO 3.6m, La Silla, Chile, 21-29 December

P. Jonker
ESO Danish 1.5m, La Silla, Chile, 20-30 July

L. Kaper
ESO-VLT/FORS2 observation at Paranal, Chile, with high-school student Marcel Haas (and TV crew VPRO Noorderlicht), 7-13 July
VLT/UVES observations at Paranal, Chile, (program 67.C-0281), “Diffuse Interstellar Bands (DIBs) and large molecules in galactic and extragalactic environments”, 20-29 September

F. Kemper
JCMT, Mauna Kea, Hawaii, USA, 21-28 March
ESO Timmi2 at the 3.6m, La Silla, Chile, 17-20 June
ESO Timmi2 at the 3.6m, La Silla, Chile, 8-12 August

A. van der Meer
ESO Dutch 90cm, La Silla, Chile, 1 month March-April
ESO-VLT2/UVES observations (program 67.C-0281), Paranal, Chile, “Diffuse Interstellar Bands (DIBs) and large molecules in galactic and extragalactic environments”, 4 nights (20 – 29) September

C. Neiner
TBL, Observatoire du Pic du Midi, France, 1 month June-July
TBL, Observatoire du Pic du Midi, France, 6 nights December

G. Nelemans
Isaac Newton Telescope, 4.2m WHT, La Palma, Spain, 3-5 March
Kitt Peak National Observatory 4m, Arizona, USA, 14-17 June
ESO 2.2m, La Silla, Chile, 18-24 July
Isaac Newton Telescope, 2.5m INT, La Palma, Spain, 26 October-1 November

K. O’Brien
McDonald Observatory 2.1m, Texas, USA, 16 nights June

P. Vreeswijk
Isaac Newton Telescope, ING, La Palma, Spain, 19 – 30 July

R. Waters
ESO Telescope, 3.6m telescope, Paranal, Chile, 26 February – 9 March
(P. Vreeswijk, E. Rol, I. Salamanca, L. Kaper, E.P.J. van den Heuvel: A Variety of Gamma Ray Burst observations with the ESO Telescopes on la Silla and the ESO-VLT on Paranal, in the framework of the ESO Large Program “Gamma Ray Bursts”.)
APPENDIX VIII

WORK VISITS TO INSTITUTES ABROAD

A. Bik
European Southern Observatory Headquarters, Garching, Germany, October 23 – December 21

L. Kaper
European Southern Observatory Headquarters, Garching, Germany, October 22 – 31
European Southern Observatory Headquarters, Garching, Germany, December 10 - 21

M. van der Klis
NASA Goddard Inst. For Space Studies, New York, USA, October 21 – 25

C. Neiner
Max Planck Institut für Aeronomie, Lindau, Germany, August
Meudon Observatory, Meudon, France, November

P. Vreeswijk
Marshall Space Flight Center, USA, February 9 – 12
Space Telescope Science Institute, USA, February 13 – March 5
Space Telescope Science Institute, USA, August 12 – September 19

M. Witte
SRON, Utrecht, November 28
APPENDIX IX

SCIENTIFIC PUBLICATIONS

1. Dissertations


2. High Energy Astrophysics

2.1 Publications in international refereed journals


Supplement Series, 132, 377-402.


2.2 Publications in conference proceedings


Jonker, P.G. & Klis, M. van der (2001). The newly discovered X-ray pulsar 4U 1822-37. In -- (Ed.), *Two Years of Science with Chandra*.


### 2.3 GCN circulars


### 2.4 IAU circulars


### 2.5 Publications in non-refereed journals


### 2.6 Books


### 2.7 Popular publications


3. Low Energy Astrophysics

3.1 Publications in international refereed journals


### 3.2 IAU circulars


### 3.3 Publications in conference proceedings


### 3.4 Publications in non-refereed journals


### APPENDIX X

**Phonenumbers and e-mail addresses**  
10 December 2001

<table>
<thead>
<tr>
<th>Phone</th>
<th>Name</th>
<th><a href="mailto:user@astro.uva.nl">user@astro.uva.nl</a></th>
</tr>
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<tbody>
<tr>
<td>7491</td>
<td>J. Ayal</td>
<td>jane</td>
</tr>
<tr>
<td>7473</td>
<td>A. Bik</td>
<td>bik</td>
</tr>
<tr>
<td><em>025097</em></td>
<td>P. Blondel</td>
<td><a href="mailto:blondel@sara.nl">blondel@sara.nl</a></td>
</tr>
<tr>
<td>7467</td>
<td>J. Bouwman</td>
<td>jeroenb</td>
</tr>
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</table>
APPENDIX XI

OVERZICHT VAN DE STERRENKUNDESTUDIE (uit studiegids)

5.1.5 Het kandidaatsprogramma Sterrenkunde

Hieronder is de opbouw van de eerste twee jaar van de doctoraalstudie (het kandidaatsprogramma) Sterrenkunde schematisch weergegeven. Het kandidaatsprogramma heeft een studielast van 84 studiepunten en bestaat uit de volgende onderdelen:

- het verplichte pakket: 56 studiepunten
- projecten: 8,5 studiepunten
- keuzeruimte: 14 studiepunten
- keuze voorlichting en studenten seminarium: 2 studiepunten
- communicatie, presentatie en oriëntatie: 3,5 studiepunten

Dit programma wordt gevolgd door studenten die in 1999 met hun studie zijn begonnen. Het studieprogramma leidt tot het kandidaatsexamen Sterrenkunde en geeft daarna toegang tot de doctoraalopleiding Sterrenkunde.

<table>
<thead>
<tr>
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<th>Trim I</th>
<th>Trim II</th>
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<td>Hoge-energie fysica</td>
<td>CPO</td>
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<tr>
<td>Studentenseminarium</td>
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</table>

Keuze

In het derde trimester van het tweede jaar kan een sterrenkunde student in principe kiezen tussen Statistische mechanica 2 of een ander vak uit de FNWI. Het wordt echter sterk aangeraden het eerst genoemde vak te kiezen. Het keuzevak in het derde trimester van het derde jaar is vrij te kiezen binnen de FNWI. Voor studenten die overwegen de communicatieve en educatieve variant (ECV) te volgen of die geïnteresseerd zijn in een inleiding in didactiek en communicatie is het vak Oriëntatie ECV aan te raden. Voor studenten die overwegen de maatschappelijke variant (M) te volgen of die geïnteresseerd zijn in een beleids- en journalistiekgewricht blok dat gegeven wordt vanuit een natuurwetenschappelijke achtergrond is het vak Oriëntatie M aan te raden.
Sterrenkundestudenten kunnen hun keuzepakket uitbreiden naar totaal 14 stp, door een of twee van de met een sterretje gemerkte vakken te vervangen door een vak uit het natuurkundeaanbod voor het derde jaar, door een keuzevak FNWI, of door een andere bij de examencommissie gemotiveerde keuze. In het bijzonder komt hiervoor het jaarlijks door het I2O aangeboden vak ‘Geschiedenis in het groot’ (7 stp, trimesters II en III) in aanmerking.

**CPO**
Het onderdeel Communicatie, Presentatie en Oriëntatie (CPO) biedt de student de gelegenheid zijn/haar communicatieve en presentatieve vaardigheden te ontwikkelen. De studiepunten hiervoor staan vermeld in het derde trimester van het derde jaar maar in feite bestaat dit onderdeel uit verschillende activiteiten, waaronder het schrijven van een verslag en het geven van een voordracht, die gespreid zijn over de studiejaren en die voor een deel gekoppeld zijn aan andere studielasten, i.h.b. de projecten (zie vakbeschrijving). Deze activiteiten worden apart beoordeeld.

5.1.6 **Gecombineerd kandidaatsprogramma Natuurkunde en Sterrenkunde**
Er bestaat de mogelijkheid om een gecombineerd kandidaatsprogramma Natuurkunde en Sterrenkunde te doen. Het gecombineerde kandidaatsprogramma Natuurkunde en Sterrenkunde heeft een studielast van 97 studiepunten en omvat het kandidaatsprogramma Natuurkunde met daarin opgenomen binnen de keuzeruimte de vakken:
- Zonnestelsel
- Elemntodynamica en Relativiteitstheorie 2
- Hoge-energie fisica

en verder een aanvulling in de vorm van de vakken:
- Melkwegstelsels
- Waarnempracticum
- Project sterrenkunde 3

5.1.7 **Kandidaatsprogramma Natuurkunde en Sterrenkunde vrije richting**
Naast de hierboven beschreven programma’s is het mogelijk een vrij kandidaatsprogramma samen te stellen. Het kandidaatsprogramma Natuurkunde en Sterrenkunde vrije richting omvat in ieder gevAPPENDIX XI.overzichtstudiegids.docal de examenonderdelen natuurkunde en sterrenkunde met een gezamenlijke omvang van tenminste 56 studiepunten. De vakken Wiskunde N worden hierbij tot de natuurkunde gerekend. Het is vereist dat vroegtijdig een verzoek voor goedkeuring wordt ingediend bij de examencommissie.

5.2 **DE DOCTORAALSTUDIE NATUUR- EN STERRENKUNDE (5 jaar)**

5.2.1 **Algemeen**
Het doctoraalprogramma van de 5-jarige opleiding na het kandidaatsexamen omvat een curriculum van twee jaar. Dit curriculum zal met ingang van 1 september 2002 aangeboden worden. Vanaf deze startdatum zullen alle doctoraalprogramma’s van de FNWI de vorm hebben van 2-jarige masterprogramma’s, die ook openstaan voor studenten afkomstig van andere universiteiten. Om de internationale uitwisseling te stimuleren zullen belangrijke onderdelen van de masterprogramma’s in de en geleidelijke taal worden gegeven.

5.2.2 Opbouw van de studie

Hieronder is de schematische opbouw weergegeven van de masterprogramma’s natuurkunde en sterrenkunde. Het studieprogramma dat leidt tot het doctoraalexamen (masterexamen), heeft een omvang van 84 studiepunten. Er is uitgegaan van een nieuwe indeling van het studiejaren in semesters van 20 weken. Dit is onder voorbehoud omdat deze indeling nog niet officieel is vastgesteld. Het zou kunnen dat in 2002 de trimesterindeling nog van toepassing is; dit is niet van invloed op de studiepunten.

<table>
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<td>Sollicitatie en loopbaanoriëntatie 2</td>
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</table>

De verschillende vakken van het cursorisch onderwijs zullen over het algemeen een omvang hebben van 4 studiepunten. De invulling is afhankelijk van het gekozen masterprogramma. Het seminarium is een flexibele onderwijsvorm waarin de student zelfstandig of met anderen een stuk literatuur bestudeert en daarover mondeling en schriftelijk rapporteert.

Alle mastertrajecten worden gekenmerkt door zelfstandig onderzoek onder begeleiding van de wetenschappelijke staf. Dit onderzoek vindt plaats op een laboratorium of instituut waar wetenschappelijk onderzoek wordt verricht, afhankelijk van het masterprogramma. De student werkt een half tot een heel jaar in een groep van fysici en leert op die manier zelfstandig onderzoek te doen. Het onderzoeksproject wordt afgesloten met het schrijven van een verslag en het geven van een voordracht over het verrichte werk; zie verder de afstudeerhandleiding.

Tijdens het onderzoek zal er geregeld een tussentijdse voordracht over het verrichte onderzoek of de bestudeerde literatuur moeten worden gegeven, en er zullen ook tussenverslagen moeten worden gemaakt. Ter voorbereiding volgt de student een cursus spreek- en schrijfvaardigheid. Aan het einde van de studie kan de student zich voorbereiden op een functie na het afstuderen door het volgen van een cursus sollicitatie en loopbaanoriëntatie.

5.2.3 Varianten

Om de afgestudeerden van deze masteropleidingen een zo breed mogelijk carrièreperspectief te bieden, worden de masterprogramma’s in drie varianten aangeboden: de Onderzoeksvariant (O-
variant), de Communicatieve- Educatieve variant (CE-variant), en de Maatschappelijke variant (M- variant). In het derde studiejaar kan men de oriëntatiecursussen op de CE- en de M-variant volgen als keuzevak.

**O-variant**

De O-variant is gericht op het wetenschappelijk onderzoek en bereidt eventueel voor op een promotietraject. Een dergelijke specialisatie biedt naast vakhoudelijke verdieping ook aandacht voor wetenschappelijke verslaglegging. De afstudeerfase bestaat uit een onderzoek onder begeleiding van een afstudeerdocent en kan worden aangevuld met een seminarium of caputcollege op het gebied van het afstudeeronderzoek. Verder neemt de afstudeerstudent deel aan werkbesprekingen van de groep waarbinnen hij zijn onderzoek doet, en bezoekt hij door het onderzoeksinstituut georganiseerde colloquia. Het min of meer zelfstandig omgaan met gespecialiseerde literatuur en vraagstellingen, indelen van de tijd gedurende een langere periode, en verslagleggen vormen belangrijke aspecten van de afstudeerfase.

**CE-variant en lerarenopleiding**

In de CE-variant ligt de nadruk op overdracht van kennis, wetenschapsorganisatie en voorlichting, met grote aandacht voor aspecten van communicatie. Na het cursorisch onderwijs volgt een onderzoekspériode van 28 studiepunten, inclusief een verslag en een colloquium. De opzet van het disciplinaire deel is om de studenten kennis te laten nemen van onderzoek i.v.m. de baanuitoefening. Het tweede deel van de master wordt ingevuld met onderdelen die zich toespitsten op maatschappelijke, educatieve en communicatieve aspecten m.b.t. de sciences. (educatieve multimedia ontwerpers, “public understanding of science” , etc).


**M-variant**

De Maatschappelijke (M-)variant is gericht op verbreding van kennis, ten dele interdisciplinair, integratie van verschillende gebieden, werken in teams aan complexe problemen. De nadruk ligt minder op fundamenteel onderzoek en meer op toepassingen van de natuurwetenschappen en wiskunde. De M-variant kan ook gericht zijn op het vervullen van een maatschappelijke functie gelieerd aan fundamenteel of toegepast onderzoek. Men volgt een cursorisch M-deel van 16 sp en een externe stage van minimaal 14 sp. Voor alle bèta-studenten zal een gemeenschappelijke M-variant aangeboden worden, waarbij de student kan kiezen uit drie richtingen: Ruimte & Milieubeleid, Medische Zorg & Beleid en Industriële Eigendom & Kennisbeleid. In tegenstelling tot andere universiteiten heeft de UvA gekozen voor een M-variant die niet alleen inzicht biedt in de commerciële sector, maar vooral ook in de overheids- en semi-overheidssector.

**5.2.4 Afstudeerrichtingen**

Er zullen de volgende afstudeerrichtingen (masterprogramma’s) aangeboden worden:
- Sterrenkunde (Astronomy and Astrophysics)
- Theoretische natuurkunde (Theoretical Physics)
- Experimentele natuurkunde (Experimental Physics)
- Experimentele hoge-energie fysica (Experimental High-energy Physics)
- Mathematische fysica (Mathematical Physics)
- Medische fysica (BioMedical Physics and BioMedical Engineering)

In principe worden alle afstudeerrichtingen als O-, zowel als CE- en M-variant aangeboden. Voor alle afstudeerrichtingen is een kandidaatsexamen natuurkunde of sterrenkunde vereist en een zekere voorkennis van kandidaatsvakken zoals die hieronder vermeld staat.

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<th>Experimentele natuurkunde</th>
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<td>Statistische mech 2 3,5</td>
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Hieronder volgt een korte beschrijving van de O-varianten.

**Masterprogramma Sterrenkunde**
Sterrenkundig Instituut "Anton Pannekoek" (afgekort API)
http://www.astro.uva.nl

Het API is penvoerder van de landelijke toponderzoekschool NOVA. In het kader van NOVA worden ook in landelijk verband sterrenkundige keuze-colleges aangeboden.

**Voorkennis**
Het wordt aangeraden de voor-kandidaats colleges sterrenkunde te volgen. In geval van deficiënties zal er een regeling worden getroffen, waarvoor een gedeelte van de vrije keuze kan worden benut.

**Colleges**
Voor alle opleidingsvarianten (O, EC en M) is een standaardblok van 4 sterrenkunde colleges verplicht, te weten: Sterratmosferen, Inter/Circumstellaire materie, Bouw en Evolutie van sterren en Kosmologie (voor de vakinhoud, zie elders in deze gids). Voor de O-variant dienen daarnaast tenminste drie andere sterrenkundevakken te worden gekozen, voor de andere varianten tenminste een. Hierbij kan gekozen worden uit de sterrenkunde colleges: Accretieprocessen, Stralingsprocessen in de astrofysica, Ster/Planeetvorming, Observationele hoge energie astrofysica, Radiosterrenkunde of een in NOVA-kader gegeven landelijk IAC-college. Verder is voorzien (O-variant) in de mogelijkheid van drie keuze colleges binnen de FNWI. Het cursorisch aanbod geeft de
student een goede basis om zich als professioneel sterrenkundige (O-variant) te ontplooijen, of wat betreft de EC-variant bijvoorbeeld als wetenschapsjournalist.

Afstudeerproject
Het afstudeerproject begint voor het einde van het eerste masterjaar. Studenten krijgen dan een eigen werkplek op het API en nemen deel aan de werkbesprekingen van de onderzoeksgroep waar ze deel van uitmaken. Hierbij dienen zij zelf minstens drie keer zelf een presentatie te verzorgen. Het afstudeerproject is een essentieel onderdeel van de opleiding, waar de student leert zelfstandig wetenschappelijke problemen te analyseren en op te lossen, en zijn/haar bevindingen zowel schriftelijk als mondeling helder te presenteren in een internationale onderzoeksomgeving. In tegenstelling tot het natuurkundig onderzoek is er bij het sterrenkundig onderzoek meestal geen duidelijk onderscheid tussen observationeel (experimenteel) en theoretisch/interpretatief onderzoek. Wat betreft de observationele aspecten wordt tijdens het project ervaring opgedaan met allerlei technieken die gebruikt worden bij het vergaren en reduceren van waarnemingen met behulp van de modernste telescopen, zowel op Aarde als in de ruimte. Voor zover mogelijk maakt een waarnemrreis naar een buitenlandse sterrenwacht deel uit van het afstudeerproject. Het project wordt afgesloten met een scriptie en een voordracht.