The Adolph C. and Mary Sprague Miller Institute for Basic Research in Science
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Miller Institute News

Miller Fellow Focus: Michiel Hogerheijde

Deadline To Note

Monday, February 7: Nomination deadline for Visiting Miller Professorships (for term in 2000-2001).

All materials are due in the Miller Institute office by 4:00pm.

Second year Miller Fellow Dr. Michiel Hogerheijde uses molecules and dust particles in interstellar space to trace the formation of stars and planets. He is hosted by Professor Leo Blitz, head of the Radio Astronomy Laboratory at UC Berkeley.

Radio emission from molecules and dust grains is an ideal probe of the conditions in interstellar clouds. In this cold and dilute environment, the most common molecule, molecular hydrogen, does not emit any observable radiation. Up to a few hundred parts per million in these clouds consist of carbon monoxide, hydrogen cyanide, formaldehyde, silicon monoxide, carbon monosulfide, protonated nitrogen, the formyl ion, and other exotic molecules. These species do have emission lines observable at wavelengths of a few millimeters and shorter, associated with transitions between rotational energy levels.

The intensity and shape of the emission lines provide valuable information on the physical conditions in interstellar clouds, such as their density, temperature, and velocity field, and on their chemical composition. At the same (sub) millimeter wavelengths, small dust particles emit thermal radiation, which gives a complementary view of the distribution of the material. Interstellar clouds are the nurseries of stars and planets. As dense condensations inside these clouds become unstable against their own gravity, they collapse and form a star or a small group of stars. Around each star, the collapsing cloud forms an accretion disk through which material is funneled onto the star. It is thought that planets condense from the remains of such disks.

Dr. Hogerheijde's research focuses on comparatively small condensations in star-forming clouds located in the constellations Taurus, Serpens, and Ophiucus. These regions form relatively isolated stars with masses up to that of our own Sun. They are also quite close, at a few hundred light years away, so that they can be studied in large detail. The ultimate aim of Hogerheijde's research is to help understand the link between interstellar clouds and planetary systems. How does the physics of cloud-core collapse determine the formation, properties, and evolution of a circumstellar disk? How does the chemical composition of the cloud

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material evolve throughout this process? What was the chemical composition of the early solar system during the formation of the planets?

To find answers to these questions, Dr. Hogerheijde has been collecting data at several millimeter-wave telescopes. The molecules in the Earth's atmosphere, especially water, obscure the view, so these telescopes are only found in high and dry places. The Radio Astronomy Laboratory, together with the University of Illinois and the University of Maryland, operates an array of ten antennas, each with a diameter of six meters, in Hat Creek near Mount Lassen in Northern California. The California Institute of Technology operates a similar array consisting of six ten-meter antennas in Owens Valley, on the eastern side of the Sierra Nevada. By using these arrays as interferometers, a resolving power can be generated from a telescope as big as the largest separation between two antennas in the array. For the Hat Creek array, that can be as large as two kilometers. These two arrays operate at wavelengths between one and three millimeters. Observing at even shorter wavelengths, where absorption due to atmospheric water is more severe, requires a higher site, such as the summit of Mauna Kea on the Big Island of Hawaii. There the United Kingdom, Canada, and The Netherlands jointly operate the 15 meter James Clerk Maxwell Telescope.

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Over the past year and a half in Berkeley, Dr. Hogerheijde has collected data at all of these observatories during several observing runs, each lasting up to a week. After a successful run, the data are transferred to his computer in Berkeley. Then, the obtained spectra and images are calibrated and analyzed with specialized software. An essential part of the subsequent interpretation is formed by a computer code developed by Dr. Hogerheijde which solves the transfer of radiation through a model cloud together with the excitation of the molecules in that cloud. In general, this is a complex problem, because the radiation transfer depends on the excitation of the molecules through their emission and absorption of protons, while the excitation depends on the amount of radiation each molecule receives. By using his code, Hogerheijde is able to produce 'synthetic' observations of model clouds which can be directly compared to the actual data.

Currently, Dr. Hogerheijde is refining a popular theoretical model that describes the collapse of cloud cores, and captures the essence of their density and velocity structure by taking a closer look at the inner regions of these cores, which appear flattened, and from which the accretion disk around the young star is presumed to originate. Extending this to later stages of protostellar evolution, where only a disk surrounds the young star but the cloud core has dispersed, he plans to investigate the chemical composition of these disks through observations and model calculations based on recent theoretical predictions of the disk's physical structure. Together with researchers from Caltech, Hogerheijde has analyzed the chemical composition of the comet Hale-Bopp. Comets are thought to preserve the chemical composition of the early solar system, and they found that at least 15 to 40 percent of the comet consists of pristine interstellar ices.

Dr. Hogerheijde's research is interdisciplinary, touching on the fields of astronomy, chemistry, and planetary science. Currently, there is much interest in this area, with the recent discovery of planetary systems around other stars and the ongoing exploration of Mars and Jupiter's moons for possible life-sustaining environments. Several new, powerful (sub) millimeter and far-infrared telescopes will become operational in the next decade. Dr. Hogerheijde hopes to use these telescopes to continue with his work on the interstellar link of the origin of stars, planets, and life.

Recent Miller Institute Awards

Visiting Miller Professorships

The Executive Committee and Advisory Board of the Miller Institute have granted awards to the following Visiting Miller Professors for terms ranging from two months to one semester during the 2000-2001 academic year. A second competition cycle is currently underway, also for visits during the year 2000-2001. The next deadline is Monday, February 7.

Astronomy	Prof. Charles Lada, Smithsonian Astrophysical Observatory
Chemistry	Prof. Piergirogio Casavecchia, Università di Perugia, Italy and Prof. David Clary, University College London
ESPM, Earth & Planetary Science & Integrative Biology	Prof. Michael DeNiro, University of California, Santa Barbara
Mathematics	Prof. Gunther Ziegler, Technical University of Berlin
Molecular & Cell Biology	Prof. Fredrick Dahlquist, University of Oregon
Physics	Prof. Wick Haxton, University of Washington

Miller Research Professorships

The Executive Committee and Advisory Board also granted nine new Miller Research Professorship awards. Terms will be either one full academic year or one semester during the 2000-2001 academic year.

Integrative Biology	Prof. Mimi Koehl and Prof. William Murdoch (from UC Santa Barbara)
Mathematics	Prof. Richard Borcherds, Prof. Michael Christ, and Prof. Bernd Sturmfels
Molecular & Cell Biology	Prof. Stuart Linn
Mechanical Engineering & Bioengineering	Prof. Lisa Pruitt and Prof. Tony Keaveny
Physics	Prof. Seamus Davis

Tuesday Lunch Talks

January

11 - Stephen Zatman, Miller Fellow, Earth & Planetary Science
18 - Alberto Grünbaum, Miller Professor, Mathematics
25 - David Chandler, Miller Professor, Chemistry

February

1 - Umesh Vazirani, Miller Professor, EECS
8 - John Taylor, Miller Professor, Plant & Microbial Biology
15 - Marco Ziegler, Miller Fellow, Chemistry
22 - TBA
29 - Zac Cande, Miller Professor, MCB: CDB

March

7 - Michiel Hogerheijde, Miller Fellow, Astronomy
14 - TBA
21 - William Arveson, Miller Professor, Mathematics
28 - TBA

April

4 - Deborah Croteau, Miller Fellow, MCB: BMB
11 - Arup Chakraborty, Miller Professor, Chemistry/Chemical Engineering
18 - Daniel Neumark, Miller Professor, Chemistry
25 - TBA

Lunches are held in the Seaborg Room at The Faculty Club and begin at 12:00 noon. All lunches are open to Miller Institute members only.

Members' Recent Publications

Miller Professor William Dietrich completed two papers during his term (January - December 1998) with the Miller Institute: "SHALSTAB: a digital terrain model for mapping shallow landslide potential," with D. R. Montgomery, NCASI Technical Report, February 1998, 29pp, and "River longituindal profiles and bedrock incision models: stream power and the influence of sediment supply, (in. Tinkler, K. J. and, Wohl, E. E. Edts), Rivers over rock: fluvial processes in bedrock channels," with L. Sklar, Am. Geoph. Union Geophysical Monograph 107, p. 237-260.

Miller Professor Martin Halpern wrote one paper during his spring 1999 term with the Miller Institute entitled: "Infinite Dimensional Free Algebra and the Forms of the Master Field," with C. Schwartz, International Journal of Modern Physics A.

Miller Professor Alexander Pines had a prolific term with the Miller Institute during the academic year 1998-1999 publishing ten papers: "NMR of Supercritical Laser-Polarized Xenon," with Mathias Haake, Boyd M. Goodson, David D. Laws, Eike Brunner, Michelle C. Cyrier, and Robert H. Havlin, Chem. Phys. Lett. 292, 686-690 (1998), " Enhancement of 13C NMR Signals in Solid C60 and C70 Using Laser-Polarized Xenon," with E. Brunner, M. Haake, J. A. Reimer, and R. Seydoux, Chem. Phys. Lett. 290, 112-116 (1998), "Time Reversal of the Cross-Polarization Process in Solid-State NMR," with Matthias Erns, Beat H. Meier, and Marco Tomaselli, Mol. Phys. 95 (5), 849-858 (1998), "Gas Flow MRI Using Circulating Laser-Polarized Xenon," with E. Brunner, M. Haake, L. Kaiser, and J. A. Reimer, J. Magn. Reson. 138, 155-159 (1999), "NMR Study of InP Quantum Dots: Surface Structure and Size Effects," with Marco Tomaselli, Jeffery L. Yaeger, Marcel Bruchez Jr., Robert H. Havlin, David deGraw, and A. Paul Alivisatos, J. Chem. Phys. Communication 110 (18), 8861-8864(1999), "NMR with a Continuously Circulating Flow of Laser-Polarized 129Xe," with Roberto Seydoux, Mathias Haake, and Jeffrey A. Reimer, J. Phys. Chem. B, 103, 4629-4637 (1999), "NMR and MRI Using Laser-Polarized Xenon," with Yi-Qiao Song, and Boyd M. Goodson, Spectroscopy 14 (7), 26-34 (1999), "Relaxation Selective Magnetic Resonance Imaging," with Seth D. Bush, David P. Rourke, and Lana G. Kaiser, Chem Phys. Lett. 311, 379-384 (1999), "NMR and MRI Using Laser Polarized Xenon," with Boyd M. Goodson and Lana Kaiser, Proc. of Int. School of Physics "Enrico Fermi", 211-260 (1999), and "Lectures on Pulsed NMR (3rd edition)," with Lyndon Emsley and David D. Laws, Proc. Of Int. School pf Physics "Enrico Fermi", 45-210 (1999).

Obituary

Former Executive Committee member ('61-'67) and Miller Professor ('61 and '69) **Richard Marshall Eakin** of the Department of Zoology, died Thursday, November 25, 1999, at his home in Danville, California. He was 89.

Former Miller Professor ('66-'67) **John Kelly** of the Department of Mathematics, died on November 26, 1999, at Kaiser Permanente Medical Center in Oakland. He was 82.

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Awards & Honors

Former Miller Professor (Spring '96) and Miller Fellow ('84-'86) **Alexei Filippenko** of the Department of Astronomy at the University of California, Berkeley, discovered the supernova dubbed 1999em using a robotic telescope, the Katzman Automatic Imaging Telescope at Lick Observatory. According to Professor Filippenko the 1999em may become one of the century's best observed supernova.

Former Miller Fellow ('94-'96) Professor **Eileen Lacey** of the Department of Integrative Biology at the University of California, Berkeley, was awarded the Hellman Family Research Grant, which was established by Warren Hellman to help junior faculty at a crucial stage in their careers.

Former Miller Fellow ('95-'96) Professor **Michael Manga** of the Department of Geological Sciences at the University of Oregon, received an award from the Richard A. Bray Faculty Scholars in Arts and Sciences endowment for excellence in teaching, superior scholarship and dedicated service.

Former Visiting Miller Professor (S'99) **Jean E. Taylor** of the Department of Mathematics at Rutgers University, has joined a distinguished list of elected scholars and professionals as a Fellow of the American