University of Maryland
Department of Astronomy
College Park, Maryland 20742

[S0002-7537(93)22641-5]

This report covers the period 1 October 1999 to 31 August 2001.

1. PEOPLE

The teaching and research staff consisted of Full Professors: Marvin Leventhal (chair), Michael A'Hearn (Distinguished University Professor), J. Patrick Harrington, Mukul Kundu, Lee Mundy, Dennis Papadopoulos, William Rose, James Stone (new promotion), John Trasco (associate director), Virginia Trimble (visiting), Stuart Vogel, and Andrew Wilson.

Associate professors: Douglas Hamilton (new promotion), Andrew Harris, Eve Ostriker (new promotion), and Sylvain Veilleux (new promotion).

Assistant professors: Stacy McGaugh, Coleman Miller, Chris Reynolds (new appointment), and Derek Richardson (new appointment).

Instructors: Grace Deming (new permanent rehire status), Beth Hufnagel (now at Anne Arundel Community College), Ramon Lopez (now at University of Texas, El Paso), and David Theison.

Professors Emeriti: Roger Bell, James Earl, William Erickson, Frank Kerr (d. 2000), and Donat Wentzel.

Senior Research Scientists: Roger Bell, Charles Goodrich, Carey Lisse (new promotion), and Surjaial Sharma.

Associate Research Scientists: Keith Arnaud, Suchitra Balachandran, Lucy-Ann McFadden, Gennady Milihk, Edward Schmahl, and Stephen White.

Assistant Research Scientists: Wan Chen (now at Global Internetworking Technologies, Inc.), Thejappa Golla, Tilak Hewegama, John Hillman (new promotion), Timothy Livengood (now at the Challenger Center), Michael Loewenstein, Grzegorz Madjeski (now at Stanford University), Chee Ng, Marc Pound (new promotion), Peter Teuben (new promotion), and Mark Wolfire.

Research associates and assistants: Dennis Chornay, John Cordes, Moijsuini Das, Siobhan Dinyes (now teaching,), Fred Finkbeiner, Vladimir Garaimov, Andrew Gibb, Edwin Grayzeck, Una Hwang, Sophia Khan, Stephen Kortenkamp, Virgil Kunde, Craig Markwardt, Stephanie McLaughlin, Alexander Nindos (now at Univ. of Ioannina, Greece), Conor Nixon, Kevin Rauch, Anne Raugh, Ian Richardson, Leslie Sage (shared with Nature), Robert Samuelson, Takayoshi Sano, Patrick Shopbell (now at California Inst. of Technology), Mikhail Sitnov, David Smith, Philip Sprangle, Johannes Staguhn (now at Goddard Space Flight Center), Yuichi Terashima, Neal Turner, Gretchen Walker, Elizabeth Warner, Dennis Wellnitz, Friedrich Wyrowski, and Andrew Young. Many of the research staff are headquartered at GSFC.

Visiting and Adjunct faculty: Stephen Holt (Olin College of Engineering), John Lyon, Richard Mushotzky (GSFC), and David Neufeld (Johns Hopkins).

Recipients of PhD degrees and their current affiliations are Yanga Fernandez (Inst. of Astronomy, U. Hawaii), Jie Zhang (Naval Research Lab), Sven Geier (ISOMAX at Caltech), Neil Nagar (Oss. di Arcetri), Kristen Miller (UC Santa Barbara), Laura Woodney (Lowell Observatory), Kip Kuntz (GSFC and U. Maryland Baltimore County), Kartik Sheth (Caltech), and Chin-Fei Lee (National Research Council fellow at Jet Propulsion Lab).

MS degrees were earned by Heather Fleming, Barbara Mattson, Stephanie McLaughlin, Donna Pierce, and Yuxuan Yang.

2. SERVICE AND RECOGNITION

Asteroid 12494 became Doughamilton, joining Asteroids Wellnitz, A'Hearn, McFadden and Orosz (the maiden name of Elizabeth Warner) in being named for department members. Hamilton and Veilleux received NSF five-year CAREER awards, and Associate Research Scientist Wolfire a NASA five-year LTSA award. Veilleux also holds a five-year Cottrell Scholarship from the Research Corporation. Intramural research grants went to Hamilton and Associate Prof. Ostriker. A'Hearn was named a Distinguished University Professor. Instructor Theison was recognized for exceptionally meritorious contributions to students by the University's Parents Association and was also honored as an outstanding teacher by student groups. Associate Research Scientist McFadden was the Barringer Lecturer at Univ. of Arizona and visiting Prof. Trimble the Klopsteg Memorial Lecturer of the American Association of Physics Teachers.

Assistant Prof. McGaugh was selected as a Distinguished Fellow of the Flint Northern Alumni Association, Prof. Kundu a Senior Fellow of the Center for Global Partnership, and Trimble a Foreign Associate of the Royal Astronomical Society. A paper by Prof. Emeritus Wentzel received first prize in the Andean Contest for Technical Translation; research scientist Nixon became a Chartered Physicist; associate research scientist Schmahl shared in a NASA Group Achievement Award to the HESSI Imaging Hardware Team; and Prof. Rose was listed in Who's Who in the World.

Staff member Barbara Scott was elected to the Executive Council of the University Senate and McFadden to the executive committee of the Astronomy Section of the American Association for the Advancement of Science. A'Hearn completed a term as President of Division III (Planetary System Sciences) of the International Astronomical Union and also completed a term as Chair of the Committee on Small Body Nomenclature. Trimble completed a term as Vice President of the Union and was elected President of Division VIII (Galaxies and the Universe). Department members also held offices and served on committees in the American Astronomical Society, the American Physical Society, and other professional organizations.

Prof. Kundu started his 34th year as a member of the editorial board of *Solar Physics*. In other editorial service, Prof. Papadopoulos continued on the plasma physics board for Cambridge University Press; Hamilton helped with *Icarus*, A'Hearn with *Earth, Moon, and Planets* and *International Comet Quarterly*, and Trimble with *Reviews of Modern Physics* and several other journals.

Graduate student Zoe Leinhardt and research assistant Stef McLaughlin gave talks at meetings of the Division for Planetary Sciences of the AAS. Invited talks and colloquium presentations by department members totaled more than 200. Some of the more out-of-the-way locations were Yerevan (Veilleux), Warsaw (Goodrich), Vatican City (McGaugh), Valencia (Trimble), Udaipur (Kundu), Torino (Richardson), Tokyo (Teuben), Taipei (Stone and Harris), Stockholm (Wilson), Ringberg (Mundy, Stone), Korea (Sage), Elmau Castle (Ng), Crete (Papadopoulos), Bologna (Miller), Banff (Stone), and Bad Honef (Vogel), and among the least exotic locales, Cleveland, OH (Hamilton), Newark, DE (Ostriker), and Towson, MD (Wolfire). On the high seas, Theison gave invited talks on board the all-sail warship U.S.S. Constellation and on board the skipjack Minnie V. for the Living Classrooms Foundation. Some of the invitations were not entirely a surprise, because Maryland astronomers also served on the scientific organizing committees for many of the same conferences and others, most out of the way, perhaps, Isla Mujeres (Wilson), St. Petersburg (Sharma), Tubingen (Lanz), and Turku (Trimble).

Virtually every astronomically-oriented NAS/NRC, NSF, and NASA mission or review panel has had at least one Maryland member. A few examples include the relatively recent groups charged with reviewing the status of planetary sciences, plasmas, and space sciences by NAS/NRC (A'Hearn, Stone, and Kundu respectively); the missions Chandra (Young, Arnaud, Wilson), RXTE (Miller, Dave Smith), HST (Harrington), SOFIA and FIRST (Harris), HAAPP (Papadopoulos, Milikh), SEUS (Wilson), and SIRTF (A'Hearn); and peer review panels for the NSF programs in planetary (Hamilton) and extragalactic astronomy (Stone, McGaugh), the interstellar medium (Wolfire), advanced technology and instrumentation (Trimble), and the physics frontier centers (Stone), and for an equally wide range of ground-based observatories and programs, including NRAO (Mundy), ALMA (Vogel, Mundy), NAIC (A'Hearn), La Palma (Veilleux), the AIPS++ consortium (Mundy), the Gruber Foundation (Trimble), and the America-Leiden Friends of Astronomy (Wilson).

The department hosted the Tenth and Eleventh Annual October Astrophysics conferences, jointly organized with Goddard Space Flight Center, on Cosmic Explosions and Young Supernova Remnants, respectively, bringing the series to an end. The prime mover on the GSFC side, sometime Adjunct Prof. Stephen Holt has moved on to Olin College. Most of the work on the Maryland side was done by Prof. Trasco and staff member Susan Lehr. Future conferences on other topics in high energy astrophysics are planned for other locations in the Washington area.

3. EDUCATION AND OUTREACH

About 1300 students each year fulfill a science breadth requirement within the astronomy department. The University Observatory was, as always, open to the public two nights a month, and about 2100 people attended in 2000-01, hearing talks by graduate students, research staff, and teaching faculty, and looking through the 20" and other telescopes when weather permitted. Walker, who is also a member of the public outreach team (headed by McFadden) for the Deep Impact Mission scheduled extra open nights (and days) in association with eclipses and other events visible from the College Park area.

Prof. Emeritus Donat Wentzel continued to coordinate the program of IAU Teaching for Astronomy Development, directing projects in Vietnam, Central America, and Morocco. Instructor Dave Theison was named a Fellow of the Lilly Center for Teaching Excellence, and graduate students Mathew Knight and Kevin Walsh were designated Distinguished Teaching Assistants by the Center.

Hamilton coordinated an online Astronomy Workshop, with interactive tools used by grade schools, high schools, and colleges around the country. His Solar System Collisions page had 50,300 visitors last year. Miller coordinated an astronomy Q&A program for high school students in Pocatello, Idaho, and Lowenstein and other department members located at GSFC participated in their on-going "ask an astronomer" web-based service.

McFadden continued to serve as vice-president of the Explore-It-All mobile science center and to direct the College Park Scholars program in Science, Discovery and the Universe, which now has a component, taught by Warner, in which the honors undergraduates interact with high school freshmen.

McLaughlin, Warner, and Lisse participated in family night at Glenallan Elementary School, and more senior mentors at the K-12 level included Richardson (as part of Project ASTRO), McGaugh (on the use of StarLab Planetariums), Schmahl, Ostriker, and A'Hearn.

Instructors Grace Deming and Dave Theison spoke at the summer 2000 ASP symposium, Cosmos in the Classroom. Theison also served on the organizing committee. Theison was one of three science educators appointed to the Millenium Speakers Bureau of the Maryland Humanities Council and has given over a dozen invited talks throughout the state. Hamilton and Trimble were appointed to the Second Century Speakers Board of the AAS. Members of the department gave public talks in India, Chile, Spain, and the Netherlands, and for more than 50 community and amateur astronomy groups in the US, in cities from Baltimore to Boise and Berkeley.

Maryland astronomers helped communicate science to the public as media advisors, and sometimes performers, at, on, or through AAS press conferences (Wilson), the Osgood File (A'Hearn), Adler Planetarium (Miller), NPR Science Friday (McGaugh), the Discovery Channel, BBC (Papadopoulos), Discovery Canada, and Washington DC radio and TV channels (McLaughlin), PBS, and the Canadian and Australian radio networks (Trimble), and print media from the Prince George's Journal (Ostriker), the front page of the Laurel Leader (Theison), San Jose Mercury, and Danbury News Times, to Science News (Vogel and Miller), Nature, Science, and the New York Times.

4. STUDENT RESEARCH

Fred Berendse is working on instrumentation and data analysis at Goddard Space Flight Center. The instrumentation work is being done with P. J. Serlemitsos and S. M. Owens on a 20- 40 keV bandwidth mirror for balloon flights and he has been predicting and characterizing the performance of the grazing-incidence mirror and its constituent graded multilayer foils. He is also looking for X-ray synchrotron radiation from supernova remnants, including Cas A and RCW 86, using data from the ASCA and RXTE X-ray satellites. Such emission will provide evidence that shocks can accelerate particles to at least TeV energies.

Nicholas Chapman has begun work with Mundy on modelling and analysis of the Herbig-Haro jet HH212. Such objects provide information about the loss of mass and angular momentum from very young stars.

K. W. Flynn and D. C. Richardson have developed a numerical method for efficiently simulating the tumbling motion of arbitrarily shaped asteroids. The asteroids are treated as gravitational aggregates but the constituent particles are ''glued" together into a rigid body. This eliminates the overhead of handling interparticle collisions. The principal application of this technique is for long-term stability studies of binary asteroid systems. Richardson is collaborating with groups in Europe and the United States to understand the origin of asteroid binaries, which now appear to be fairly common in our Solar System.

Woong-Tae Kim's thesis project with Dr. Ostriker is a study of gravitational instability as a mechanism for structure formation in disk galaxies, using both semianalytic methods and time-dependent numerical simulations. They have shown that nonlinear, nonaxisymmetric growth of structure in outer disks is subject to threshold behavior, confirming the long-standing empirical model. Critical values of the Toomre Q parameter for gravitational runaway are found to be similar to observed star formation threshold values. Their work has also shown how gravitational instabilities acting in galactic nuclei where velocity shear is weak are qualitatively quite different from outer-disk instabilities. They also investigated local, gravitational instabilities within magnetized, spiral arms. They found that as a natural consequence of magneto-Jeans instability or swing amplification occurring in compressive and expansive flows in spiral arms, spurs form preferentially in the direction perpendicular to the arm. These spurs undergo fragmentation to form gravitationally bound clumps within arms as well as in interarm regions, possibly evolving into bright arm/interarm HII regions, as seen for example in an optical image of M51.

As part of a collaboration with J. Stone, L. Mundy, and student **C.-F. Lee** on studying the structure and kinematics of protostellar outflows, Ostriker has developed an analytic model for jet-driven outflow shells. This model is consistent with the results of numerical simulations, and explains the spur-like features seen in position-velocity diagrams of observed CO outflows.

Z. M. Leinhardt and D. C. Richardson are using a ''Beowulf'' cluster of PCs to parameterize asteroid collision outcomes with the aim of incorporating the results into planet formation simulations. This will reduce the huge uncertainties of models of asteroid collisions extrapolated from laboratory experiments and will provide a more realistic recipe for planet formation. In earlier work, Leinhardt and Richardson found that accretion of fragmented bodies of comparable size is relatively inefficient at the low collision speeds typical of the early planet-forming environment. This may hamper planetesimal growth somewhat unless the largest bodies grow primarily by sweeping up the very smallest bodies. Work is underway to characterize collision outcomes between bodies of different size in order to quantitatively assess this process.

Lisa Mazzuca's research focuses on star formation in the central inner kiloparsecs of spiral galaxies, especially the starburst properties and evolution of star formation in circumnuclear rings. The goal is to determine the ages of the individual regions that are bright in H-alpha and to determine whether there is an age gradient along the rings.

Donna Pierce is working on a thesis in cometary chemistry and spectroscopy with Prof. A'Hearn. She is currently examining echelle spectra from C/1996 B2 (Hyakutake), looking for evidence of chemical species not previously seen in comets. This is part of a study of chemical reactions in order to examine the possible influence of concave surface topography on cometary jets and chemical species they contribute to the coma. This could impact our understanding of the origin and formation processes of chemical species in comets.

Amanda Proctor is completing a project with Doug Hamilton concerning the orbital evolution of the Jovian moons Amalthea, Thebe and Io. Early in Solar System history, Io was formed closer to Jupiter than it is today; it has slowly moved outward to its present position under the influence of planetary tides. During this outward migration, many of Io's resonances swept across the locations of the small inner satellites Thebe and Amalthea. The team is testing their hypothesis that the current inclinations of these satellites are a signature of these events; if correct, this puts constraints on the initial radial position where Io was formed. Proctor is continuing and extending this work with Hamilton for her senior honors project.

Xi Shao has completed his thesis in the area of space weather. Variations in the density and flow velocity of the solar wind and, most important, the direction of the interplanetary magnetic field cause significant changes in the magnetosphere and ionosphere and on the ground, which can cause disruptions to power distribution systems, wired, and wireless communications. A three-dimensional global magneto-hydrodynamic (MHD) model is used to study the magnetosphere-ionosphere system driven by the solar wind and to predict these changes called space weather.

The code, commonly called LFM (for its developers J. G. Lyon, J. A. Fedder, and C. Mobarry) couples a 3D MDH magnetospheric model with a 2D electrostatic ionospheric model. Information on the solar wind driving comes from satellite data or physics-based models. The overall goal is to improve understanding of the physical properties of the Earth's magnetosphere and its coupling to the ionosphere and to be able to simulate events in real time. Progress has been made in three areas magnetospheric substorms, magnetosphere-ionosphere coupling, and the behavior of the magnetosphere with a steady northward IMF.

Kartik Sheth, Stuart Vogel, Andrew Harris and Peter J. Teuben, in collaboration with colleagues at UC-Berkeley, STScI and NRAO, continued their involvement with the BIMA key project, BIMA SONG. SONG (CO Survey of Nearby Galaxies) is the first, systematic imaging survey of molecular gas kinematics and morphology in the inner disks of 44 nearby spirals at high spatial (300 pc) and velocity (4.1 km/s) resolution. The survey has many scientific objectives including study of disk structures such as spiral arms and bars, relationship between star formation and molecular gas and role of molecular gas in nuclear activity. The preliminary results from this survey have already been presented at various conferences and first papers are being prepared for journal publication.

Sheth continued his thesis research on molecular gas properties of barred spirals under the supervision of Vogel. A study of the molecular gas distribution in barred and unbarred spirals showed that an expected secular evolutionary trend from late to early type bars was not seen in the molecular gas distribution. These results were presented at the ’’Science with ALMA‘‘ conference in October 1999.

Sheth and Vogel, using a subsample of barred spirals from BIMA SONG, have found a systematic azimuthal offset between the stars and the gas in bars. The observations suggest that the bar dust lane is involved in triggering star formation activity, contrary to the widely-help opinion that the bar dust lane is too hostile an environment for star formation. These results were presented at the ’’Galaxy Disks and Disk Galaxies‘‘ conference and at the IAU conference in summer of 2000.

Sheth and Vogel, in collaboration with Christine Wilson (McMaster University) and Thomas M. Dame (Harvard-Smithsonian CfA) compared the giant molecular clouds in the Milky Way and the two nearest spirals, M31 and M33. Their study revealed that the molecular clouds in all three galaxies were similar, indicating that while global distribution of molecular gas may vary dramatically from galaxy to galaxy, the cloud formation and destruction is probably controlled by local physics. These results were presented at a workshop on ’’The Interstellar Medium in M31 and M33‘‘ at Bad Honeff in Germany in summer of 2000.

Yuxuan Yang has completed a project on X-ray imaging and timing of the Seyfert galaxy NGC 4151 using data from the ROSAT High Resolution Imager. He has begun work with A. Wilson analyzing Chandra X-ray data on Seyfert galaxies and radio galaxies, especially the jet of radio galaxy M87.

Ke Zhang is working with Doug Hamilton on the early history of Neptune and Triton. The lack of midsized Neptunian satellites is often attributed to the presence of retrograde Triton, an object that was presumably captured from heliocentric space. They are working analytically and performing numerical integrations to determine the probable fates of an early Neptunian satellite system. Were these objects eaten by Triton, tossed into Neptune, or ejected entirely from the system? Triton's initial capture orbit is hypothesized to be extremely elongated, with the orbit circularizing slowly over time under the actions of planetary tides. They are also seeking to determine the effects of such a captured Triton on very distant satellite, which are themselves probably captured objects. This research will form **Zhang's** second-year project.

5. FACULTY RESEARCH

5.1 Education and Scientometrics

Grace Deming and Beth Hufnagel received funding from the NSF to investigate the reliability and validity of the Astronomy Diagnostic Test (ADT), a 33-question assessment designed for non-science majors taking a course in introductory astronomy. During 2000 and 2001, pre-test results from 5346 students and post-test results from 3842 students were collected as part of the ADT National Project. A wide range of class sizes, different institution types, and classes spread over 30 states are included in this sample. The analysis completed by the Ontario Institute for Studies in Education gave an acceptable degree of internal consistency. Validity was established using results from a pool of 44 experts and analysis of 50 student interviews. Invited talks on the ADT were presented at the Canadian Astronomical Society (BH) and the American Association of Physics Teachers.

Dave Theison has investigated a number of ways of enriching and improving the teaching of non-technical astronomy to both university students and the public. These include the use of science fiction, reading assignments outside the usual framework of textbooks, and astrobiology (especially the Martian environment). With respect to the last, Theison's interactive and multidisciplinary exhibit known as ‘‘The Mars Room’’ continues to attract teachers and students from all disciplines to the Undergraduate Library. A popular open house destination during campus-wide Maryland Day activities, ‘‘The Mars Room’’ was also selected to be one of six Maryland Day activities featured at a Preview Dinner held at the President's Residence.

V. Trimble has examined several topics in the history of astronomy and the astronomical community. Some surprises include (a) the near-constancy for most countries of the ratio of professional astronomers to the Gross Domestic Product (where else do India and Japan look identical, and the two parts of China almost the same?), (b) a sudden increase in the last decade in the fraction of astronomers entering tenure-track jobs (etc.) who were born outside the US from 25% (stable since the middle of the 19th century) to 50%, (c) the very different order in which different kinds of sources were discovered by X-ray, optical, and radio techniques, and (d) a leveling off in the time new professional astronomers (tenure-track faculty and IAU members) have taken to earn their PhDs at six years, after a monotonic rise from four years to nearly seven over many decades.

5.2 Space Plasma Physics and the Sun

5.2.1 Theoretical Space Plasma Physics

K. Papadopoulos, C. C. Goodrich and X. Shao have continued their work on the global modeling research. Over the last few years, they have made very significant advances in the understanding of the Earth's magnetosphere and those of the outer planets. These advances have resulted from three fundamental improvements in their global MHD code, written by their collaborator, J. Lyon (Dartmouth College), including extension of the range of the code to several hundred R_e downstream of the Earth, and implementation of a rotating dipole and semiconducting ionosphere.

The SPP group continued their activity in the Active Aurora Research Program (HAARP). Professor Papadopoulos is the chairman, and Dr. Milikh is the executive secretary of the scientific committee, whose objectives is the study of the scientific uses and of the wide range of applications created by the HAARP project. K. Papadopoulos, G. Milikh and A. Sharma in cooperation with P. Guzdar and N. Gondarenko, from Physics Department of UMD presented a diffraction model of the pattern of ionospheric irregularities detected by the WIND satellite. They also developed a model of the self-focusing instability due to the interaction or powerful radio wave with the ionosphere. R. E. Lopez, M. Wiltberger, J. G. Lyon, C. C. Goodrich, K. Papadopoulos conducted 3-D MHD simulations to investigate the behavior of the high-latitude convection and the polar cap variations during two events characterized by sudden southward IMF turnings. R. L. McNutt, Jr., J. Lyon and C. C. Goodrich conducted simulations of the heliosphere. The interaction of the solar wind with the very local interstellar medium depends strongly on charge exchange between the neutral and ionized hydrogen outside of the heliosphere. A. S. Sharma, M. I. Sitnov, and K. Papadopoulos studied critical behavior of the magnetosphere during substorms. The study of time series data has shown clear evidence of the critical behavior of the magnetosphere. This is of importance for both understanding the underlying physics of substorms and for their practical forecasting using phenomenological data-derived models.

M. I. Sitnov, A. S. Sharma, and P. N. Guzdar investigated structure and stability of the magnetotail current sheet. Linear stability of the tearing mode in the collisionless magnetotail current sheet, with finite normal component of the magnetic field, continues to be a subject of persistent debate for more than two decades.

J. Edwards, A. S. Sharma, M. I. Sitnov and Y. Kamide studied average mutual information of geomagnetic indices and magnetometer data and its implication for storm-substorm relationship.

5.2.2 Solar Radio Physics

The solar radio physics group consists of Drs. Kundu, White, and Garaimov and Zhang. Research over the past two years has been concerned with four main areas: (1) small scale energy release on the Sun, (2) quiet Sun, (3) solar flares, and (4) solar active regions. The studies have used the Nobeyama Radio Heliograph (NoRH), VLA and BIMA along with Yohkoh/SXT, SOHO-EIT imaging data and other relevant data.

Small Scale Energy Releases. Using Yohkoh (Japanese satellite) Soft X-ray imaging experiment along with Nancay (France) meterwave imaging data they have detected nonthermal processes (as evidenced by metric type III bursts and type IV continuum bursts) occurring in X-ray bright point flares,X-ray jets and X-ray plasmoid ejections, and studied their properties in the radio domain. They also detected and studied thermal microwave emission (at 17 GHz) from coronal X-ray jets and XBP's.

Quiet Sun. With the availability of high spatial resolution (2'' arc) data (temperature, density) on polar plumes and interplume regions from several SOHO experiments (EIT, UVCS, etc.), they have revisited the question of interpreting the so-far-unexplained radio brightening observed in polar regions in the frequency range 17 - 87 GHz. The combined data set permitted them to make a critical study of the polar microwave brightening and to conclude that the patchy polar emission originates from heights below about 80,000 K layer.

Solar Flares. Using BIMA array at 3mm wavelength they showed for the first time that solar flares of all sizes, that is, regardless of their importance, produce MeV energy electrons. This is because millimeter emission in the impulsive phase of a solar flare is produced by MeV energy electrons, and all flares have millimeter emission associated with them. They mapped several 3 mm flares and found for the first time that the compact flaring regions are bipolar loops. The population of energetic flare electrons seems to be distinct from that producing microwave and hard X-ray emissions.

They have made extensive use of Nobeyama Radio Heliograph(NoRH) data (sometimes along with BIMA imaging data) on solar flares. They have made detailed studies of nonthermal processes of simple solar flares and have shown conclusively that the energetic electron population that emits BIMA 3mm emission does, in fact, extend often to 34 GHz and sometimes to 17 GHz and the emission originates from compact low-lying bipolar loops. They have also studied several possible candidate flares at 17 and 34 GHz (NoRH imaging data) with the objective of providing radio diagnostics of magnetic reconnection in solar flares.

Coronal Magnetic Fields and Abundance of Iron in the Corona. Using EUV observations of Fe lines in the corona (from SOHO/CDS), along with radio continuum measurements of thermal bremsstrahlung from coronal plasma (using VLA), they have made a precise measurement of the absolute abundance of Fe, which is quite different from previously published results.

Using gyroresonance emission mechanism of active region radio emission, they can study very efficiently coronal magnetic fields, currents, and temperature distribution. In particular, they have shown that the effects of magnetic fields induced by coronal currents can be seen directly in radio images, and the property that radio emission in strong coronal fields is optically thick permits them to study temperature distribution better than X-ray/EUV measurements which suffer from line-of-sight integration effects.

5.2.3 Other Solar Research

Dr. E. Schmahl has been working with the NASA/Goddard Solar Branch team developing and analyzing the imaging capabilities of the High Energy Solar Spectroscopic Imager (HESSI). Using a new technique, he has helped confirm and calibrate the X-ray modulation performance of HESSI. He has also developed new methods of imaging that will enhance the scientific analysis of X-ray and gamma-ray flare data when HESSI starts observations in early 2002. In a related project, working with Carol Jo Crannell (GSFC) and Jean Pierre Raulin (Instituto Presbyteriano Mackenzie), Dr. Schmahl has investigated the extent of over resolution in solar flares using the Owens Valley Radio Observatory (OVRO) interferometer. In a sample of $\sim$80 flares from OVRO, it was found that flares are usually over resolved even on the shortest baseline. This means that at low frequencies ($<$2 GHz), where the sources are at their largest, very few flares reported in the literature have had their full extents properly mapped. This is relevent to hard X-ray flares, since it suggests that HESSI may need to use its coarsest imaging elements to see large scale structures such as ''albedo'' sources and ''thin-target'' loops.

The shocks driven by coronal mass ejections (CMEs) generate electromagnetic waves, known as type II radio bursts at the electron plasma frequency, f_{pe} and its harmonic $2f_{pe}$. In order to understand the emission mechanisms, it is essential to know the associated shock parameters, such as the shock normal angle and the magnetosonic Mach number, and the location of the site of type II burst excitation with respect to the shock front. Thejappa Golla and colleagues have studied these issues by analyzing the in situ data of Langmuir waves generated in the vicinity of a large number of interplanetary (IP) shocks observed by the Unified Radio and Plasma Wave (URAP) Experiment on Ulysses spacecraft. The analysis shows that Langmuir waves (1) are observed in only 15% of the IP shocks, (2) occur mostly in the upstream regions, and (3) are produced in the vicinity of both quasi-parallel and quasi-perpendicular shocks and that (4) Langmuir wave producing shocks are supercritical. Since Langmuir waves are the essential ingredients for the solar and interplanetary type II burst excitation, these findings imply that (1) the excitation of type II burst is independent of the shock normal angle, (2) type II bursts are excited in the upstream regions and (3) type II shocks are mostly supercritical with Mach number of approximately 2.

Instead of well defined fundamental and harmonic bands, many type II bursts occur as highly fragmented, where a typical fragment shows a constant drift for $\sim$1 hour, disappears and reappears at a frequency higher or lower than one would expect if it were simply a continuation of the original event. These fragmented events may last for many hours or days. They have found one of the highly fragmented IP type II bursts to be associated with a pair of forward shocks instead of a single IP shock. The association of a pair of shocks indicates that the interaction between the Langmuir waves excited by one of the shocks with the density gradient of the companion shock appears to cause the fragmentation of the type II burst. Based on these and similar observations, they have developed a model for the the clumpiness of the type II bursts in terms of linear coupling of Langmuir waves excited by the shocks with escaping radiation at the sharp density gradients associated with structures like shocks, CMEs or corotating interaction regions (CIRs). They have shown that this process can cause large fluctuations in the efficiency of conversion of Langmuir waves into electromagnetic radiation at the fundamental of the electron plasma frequency f_{pe}, leading to the fragmented emissions. The model predicts that the emission mode of the fragments of type II bursts is the fundamental, which is highly polarized in the sense of O-mode. In order to verify these predictions, we have examined the polarization observations obtained by Trieste Polarimeter at high frequencies. Surprisingly, they have found a highly polarized fragmented type II burst with percentage of polarization of $\sim$70%.

They have analyzed the Ulysses/URAP observations of ion-acoustic waves associated with magnetic clouds and ejecta. The *peak* intensities of these waves, which usually occur inside CMEs when the electron temperature (T_e) is much higher than the ion temperature T_i, are found to be not correlated with heliocentric distance or electron to ion temperature ratio inside the CMEs. Based on these observations, they have concluded that: (1) although ion-acoustic waves occur mostly when $T_e \gg T_i$, their intensity levels do not depend on the magnitude of T_e/T_i probably due to the minimum role of temperatures in the saturation mechanisms, and (2) the peak intensities remain at the same level at different heliocentric distances probably because the consequences of the wave-particle interactions are already relevant by the time the CME reaches 1 AU.

They have found in the Ulysses/URAP data, several occurrences of Langmuir and ion-acoustic waves in the source regions of type III radio bursts, which are the electromagnetic emissions excited by the electron beams propagating radially outward in the solar atmosphere. Bursts of 50-300 Hz (in the spacecraft frame) electric field signals, corresponding to long-wavelength ion-acoustic waves are often observed coincident in time with the most intense Langmuir wave spikes, providing evidence for the electrostatic decay instability. Langmuir waves often occur as envelope solitons, suggesting that strong turbulence processes, such as modulational instability and soliton formation, often coexist with weak turbulence processes, such as electrostatic decay, in some type III burst source regions.

5.3 Solar System

5.3.1 Deep Impact

The Deep Impact project, a NASA Discovery program mission under the direction of M. A'Hearn, continued its development. The major step was completing the Preliminary Design Review and being confirmed by NASA to proceed into the construction phases. This mission will deliver a large, high-speed impactor to the nucleus of comet 9P/Tempel 1 and observe the results of the impact from the flyby spacecraft and from Earth (scheduled launch, July 2004, encounter July 2005). Key scientific achievements during the current year include determining the size of the nucleus using thermal infrared observations from the Keck telescope (effective radius 2.5 km, albedo 4%; effort led by Fernandez, UHawaii) and reanalyzing observations made with IRAS to determine the dust environment for which shielding must be provided. The IRAS observations show that the comet is like several other Jupiter-family comets in having a particle size distribution with a much smaller ratio of small (optical wavelength sized) dust to large (10 microns and larger) dust than do comets 1P/Halley and others known for their dust output (effort led by Lisse, UMD). See http://deepimpact.umd.edu.

McFadden, with support from science team members and Gretchen Walker, addressed the number and wavelengths of filters required to meet science objectives for the Deep Impact mission, and offered an initial in-flight calibration plan for the Earth flyby.

McFadden hired the Education and Public Outreach Team including: Stephanie McLaughlin, Gretchen Walker, Elizabeth Warner, Kathleen Holmay, Gary Emerson and Maura Rountree-Brown. Work continues on developing the EPO plan. Teacher workshops were developed and presented at JPL. Research assistants Warner and McLaughlin spread news about the mission and observing opportunities to amateur astronomer gatherings including club meetings in Virginia and South Carolina and star parties in Texas and Wyoming.

Stephanie McLaughlin started and manages the Small Telescope Science Program and continues the analysis of data recieved from the program's participants. Since March 2000, a network of about 40 amateur and professional astronomers from around the world have been making ground-based, broad-band, photometric CCD observations of comet 9P/Tempel 1, the target of the Deep Impact mission. The network participants will continue to observe the comet through January, 2001, after which they will monitor comets for other space missions until Tempel 1 returns in 2004.

5.3.2 PDS Small Bodies Node

The Small Bodies Node of the Planetary Data System undertook two major activities in the past year. The first was a reorganization of its Earth-based database on small bodies to allow searching for all key properties of any given small body. The second was a peer review of the data from the NEAR mission prior to distributing the final archive (which will be available shortly after this writing). The project continues to work in various ways with all other missions to comets and asteroids. The collaboration with ESA to archive the data from the Rosetta project has been particularly effective and PDS-SBN worked with staff at ESTEC to organize a workshop for the instrument teams to plan the data projects. See: http://pdssbn.astro.umd.edu/.

5.3.3 Comets

A'Hearn continued his collaboration with Lamy, Toth, and Weaver to isolate cometary nuclei from their comae with HST to determine reliable nuclear magnitudes and thus (albedo- dependent) sizes. The program has now studied nuclei from 0.3 to 35 km in effective radius. The actual size distribution, however, is still dominated by small-number statistics so that reliable conclusions can not yet be drawn. Selected comets are also observed at thermal infrared wavelengths, both with ISO and from the ground in various collaborations, to separate the albedo from the size. Ignoring Centaur-comets, albedos range between 2 and 8% although Jupiter- family comets appear to be predominantly in the lower portion of that range.

A'Hearn completed his work on the sulfur dimer in comet Hyakutake, analyzing the excitation of the rotational structure with Kim (Kyong Hee University) and the abundances and source mechanisms with several other collaborators.

A'Hearn and Lisse collaborated with Weaver (Johns Hopkins U.) and others in HST imaging observations of comet LINEAR (1999 S4), the comet that broke into many pieces that rapidly dissipated. There are many puzzles related to this comet, not the least of which is how it could have enough mass to produce the outgassing observed prior to breakup and still dissipate so rapidly after breakup. See http://www.astro.umd.edu/∼ma/.

C. M. Lisse was the lead scientist in the effort that discovered in 1996 that comets are X-ray sources. He has recently, with a number of collaborators, obtained Chandra images and spectra of comet C/LINEAR 1999 S4. These show that the X-ray emission is caused by charge exchange between the solar wind and cometary coma gases. A search for associated far/extreme ultraviolet emission due to charge exchange between solar wind minor ions and cometary gas is underway. He and K. Dennerl (MPE) have also used Chandra to make the first X-ray detection of Venus. Unlike the cometary case, the photons appear to be due to scattering and resonance fluorescence of solar X-rays. He also sought and found, with several groups of collaborators, either Halley-like or very heavy particle dust emission from a number of other comets, separating the dust component from the thermal infrared emitted by the nucleus and making it possible to characterize the dust composition, rotation state and active areas of the comet, and to estimate nuclear sizes and active lifetimes. Comet Hyakutake displayed an unusually high albedo (close to 40%), rotation at close to breakup speed, and anomalously high activity while comet LINEAR 1999 S4 emitted an unusually large amount of icy dust, presumably due to its fragmentation.

5.3.4 Solar System Dynamics

Richardson is using a high-performance parallel N-body gravity code to study various problems in planetesimal dynamics, including planet formation, tidal disruption of comets and asteroids, planetary rings, and granular dynamics. A new 24-node Beowulf cluster has been installed in the department and has achieved a sustained parallel performance of 6 GFlops. The cluster will be used to carry out long-term simulations of planet formation starting with millions of self-gravitating planetesimals. This will be the first direct simulation of the onset of runaway growth in a realistic extended protoplanetary disk. The results will provide the timescale for protoplanet formation along with realistic initial conditions for late-stage planet formation codes.

Barnes, Quinn (both U Washington), and Richardson are performing simulations of close stellar passages to planetesimal disks to see how dramatically the early stellar environment of a planetary system may affect planet growth. Preliminary results indicate that over a star's lifetime in a typical cluster there may be one or two close encounters of sufficient strength to perturb the disk inside 50 AU. This may account for the apparent abrupt truncation of our Kuiper Belt.

The Trojan asteroids are locked in a 1:1 mean motion resonance with Jupiter, leading and trailing the planet by 60 degrees in its orbit about the sun. Because of this close dynamical link the Trojan asteroids may contain critical clues about how Jupiter formed. Doug Hamilton and Steve Kortenkamp have been modeling the origin of the Trojans in the hopes of revealing any such evidence. They are analyzing the effects of; (1) gas drag acting on the Trojan precursors, (2) a gap formed by Jupiter in the gaseous protoplanetary disk, (3) collisions amongst the Trojan precursors, and (4) gravitational perturbations from Saturn and the gaseous disk. All of these effects may be important in the capture and evolution of the Trojan asteroids. Eventually they will incorporate these individual effects into realistic general models and assess the resulting Trojan origin models in the context of the competing scenarios for the formation of Jupiter.

Hamilton and K. Rauch have been collaborating on the development of an efficient new N body symplectic integrator package, which they will apply to solar system problems, particularly its origin. The new integrator is capable of following thousands of planetesimals for several hundred million years. They hope to have a first version available for use and for distribution to the community by the end of 2001.

Doug Hamilton spent much of the summer developing a module to extend the capabilities of the sophisticated code ‘‘HNBody’’ written by Kevin Rauch and Doug Hamilton. The core code follows the orbits of multiple bodies interacting gravitationally. It combines most of the recent advances in symplectic integrators (ability to handle close approaches, new symplectic correctors, regularization of orbits, etc.) into one flexible, easy-to-use package. The code recognizes three classes of particles: heavyweight particles for which all forces are calculated, lightweight particles which affect the heavies but not each other, and zeroweight particles which act as test particles. The new module ‘‘HNdrag’’ allows the user to specify extra non-gravitational forces including: Poynting-Roberston drag, radiation pressure, gas drag, gravitational radiation, and additinal user-specified drag forces. These additions significantly extend the capabilities of the core code. Both codes are being used in projects with Cole Miller, Amanda Proctor, and Ke Zhang.

Hamilton and Miller have investigated the origin of planets orbiting pulsars, of which only one or two cases are known. Their favored mechanism is a neutron star which recoils through a companion star (because of an asymmetric supernova explosion) and captures enough material to form rocky earth-mass objects, even though most of the matter they encounter is hydrogen and helium.

Hamilton is also interested in the dynamics of dust in the solar system and how it affects observations of Mars and Jupiter.

Kortenkamp’s research involves modeling the dynamical evolution of planetary systems at the two far extremes of the mass-accretion rate—the primordial accumulation of planets in protoplanetary disks and the present-day terrestrial influx of interplanetary dust particles (IDPs). Planet formation and IDP accretion, two arguably distinct topics, fall within the realm of the emerging field of astrobiology, with their common bond being a planet’s interaction with the environment of its planetary system. Small bodies on unstable orbits—asteroids, comets, and their precursors—likely play an important role in this interaction from very early on. They are sources of biologically essential chemical materials as well as causes of catastrophic impacts. When sufficiently severe and frequent, such impacts may preclude or interrupt the establishment of a biosphere. When more moderate they can provide an important mechanism for determining the course of evolution. While the continuing threat of such large impacts is recognized today, accretion of much smaller bodies can provide valuable information.

Most collected IDPs and nearly all meteorites come from the asteroid belt. These are currently the only available samples of extraterrestrial material that have preserved a chemical and isotopic record of events that occurred during the formation of our planetary system. Yet asteroid formation models are far too rudimentary for detailed comparison with this meteoritic record. For instance, the idea that Jupiter prevented or interrupted formation of a planet in the asteroid belt is nearly universally regarded as fact. Exactly how this may have occurred, however, has not yet been convincingly demonstrated. For these and other reasons, Kortenkamp plans to continue studying the formation and evolution of terrestrial planets and asteroids in order to better understand not only how our Solar System formed, but what variations we might expect in extra-solar planetary systems.

5.3.5 Asteroids

Lucy McFadden and Dennis Wellnitz participated in the completion of NASA’s NEAR mission to asteroid 433 Eros with the NEAR Science team and engineers at Applied Physics Lab, Laurel, MD. The spacecraft landed on Eros on February 14, 2001 and successfully collected images as the spacecraft approached the surface. It collected data from the X-ray and gamma-ray spectrometer while on the surface.

Wellnitz calculated a slit illumination correction to the Near-Infrared Spectrometer using simultaneously pointed visible imaging and a shape model of the asteroid. With this correction we could measure relative reflectance ratios to an accuracy of 1%. These spectra were analyzed in terms of grain size and compositional variations across the surface which are less than 1-2%. The surface of Eros has a composition that is consistent with undifferentiated low-iron (LL) ordinary chondrite meteorites. The surface is spectrally uniform with respect to olivine and pyroxene chemistry. There is a spectral contribution of both a low-Ca and high-Ca pyroxene. There are variations of a material with a slope of 4% across the surface that cannot be unambiguously identified with existing data.

McFadden, in collaboration with McCoy (Smithsonian), and Trombka and colleagues (GSFC), combined the near-infrared spectra from NEAR with results from the X-ray and gamma-ray spectrometer to constrain composition and evolution of asteroid Eros. Combined data sets support the conclusion that Eros is undifferentiated though there may be compositional evidence for some partial melting.

5.4 Stellar Astrophysics

Grundahl(Aarhus), VandenBerg (Victoria), Bell, Andersen (Oulu) and Stetson (DAO) have used deep Stromgren photometry to determine the age of the very metal poor globular cluster M92 from the $(v\text{-}y)_0$, c_0 diagram. The observational data, when presented in this diagram, are independent of distance and insensitive to the adopted reddening, since this is small, but the model data are dependent on the accuracy of isochrones and synthetic colors. The age of M92 is found to lie in the range 12 -17 Gyrs, making allowance for errors in the isochrones and synthetic colors. These latter quantities have been checked by comparing synthetic colors for very metal poor field stars, including the metal deficient subgiant HD 140283, with observation. The field star colors have also been compared with those of the M92 stars. These comparisons show that M92 and the field stars are coeval to within 1 Gyr and M92 has an age $\geqslant$ 16 Gyr.

Houdashelt, Bell, Sweigart (NASA-GSFC) and Wing (Ohio State) have calculated MARCS stellar atmosphere models and SSG synthetic spectra of M giants. Using the spectral type, temperature relation of Dyck *et al.*, models of appropriate temperature match the K band spectral types of Kleinmann and Hall (1986). The oscillator strengths of the TiO bands have been adjusted to best reproduce spectral types based on TiO band data.

Spectral types estimated from the strengths of the TiO bands and the depth of the bandhead of CO near 2.3 μm quantitatively confirm that the synthetic spectra are good representations of those of field M giants. The broad-band colors of the models are found to match the field relations of K and early-M giants very well; for late-M giants, differences between the field-star and synthetic colors are probably caused by the omission of spectral lines of VO and H_2O in the spectrum synthesis calculations. Four grids of K-band bolometric corrections and colors are presented – Johnson U−V and B−V; Cousins V−R and V−I; Johnson-Glass V−K, J–K and H–K; and CIT/CTIO V–K, J–K, H–K and CO – for models having 3000 K $\leqslant$ teff $\leqslant$ 4000 K and –0.5 $\leqslant$ log g $\leqslant$ 1.5. These grids, which have $[Fe/H] = +0.25$, 0.0, –0.5 and –1.0, extend and supplement the color-temperature relations of hotter stars presented in a companion paper.

These models are intended for use in modelling elliptical galaxies.

In 1998, Balachandran and Bell found that it was necessary to increase the UV continuous opacity in the solar atmosphere if the solar oxygen abundance derived from the A-X system of OH was to match that derived from the OH vibration-rotation lines. They suggested that this opacity increase might be caused by FeI. Following this result, Bell, Balachandran and Bautista used Bautista's FeI continuous opacity calculations to study their effect on the solar continuous spectrum. This opacity source was found to be very important at shorter wavelengths, e.g. 2400 A, but unimportant beyond 4000 A. The observed solar continuous spectrum was derived from observations of the solar flux by Woods *et al.*, corrected for line absorption using line absorption data from Kitt Peak solar atlas. The best agreement between this observed continuous flux and the MARCS model flux was found when Bautista's data were increased by a factor of two, a change consistent with the error limits of his calculations.

Radio emission by means of synchrotron radiation is a characteristic property of young supernova remnants. There is strong evidence that electrons are accelerated to highly relativisitc energies as collisionless supernova shocks propagate through circumstellar and interstellar gas surrounding a supernova outburst. Recently, W. K. Rose has interpreted the radio observations of SN 1993J and suggested that electron acceleration occurs in young supernova remnants because plasma turbulence leads to the generation of Langmuir solitons. Such localized, oscillatory electric fields can accelerate electrons to relativistic energies and explain radio emission from supernova remnants and also the electron component of cosmic rays. W. K. Rose is currently extending this research to interpret Chandra observations of radio hotspots.

The second phase of WITS ''The WEB Infrared Tool Shed'' came on-line. This WEB based modeling and analysis tool was developed by Drs. M. Wolfire, L. Mundy, M. Pound, and S. Lord (IPAC) and now includes the Dust InfraRed Toolbox (DIRT) and the PhotoDissociation Region Toolbox (PDRT). These toolboxes provide an extensive grid of PDR and dust continuum models. The PDR toolbox (PDRT) provides emission diagnostics based on the models of Kaufman, Wolfire, *et al.* 1999, ApJ, 527, 795. Using the observed IR line fluxes and line ratios, users can determine the PDR gas density and temperature, and the incident far-ultraviolet radiation field strength. The Dust Infrared Toolbox (DIRT) is geared toward modeling the dust continuum from envelopes of young and evolved stars. Users can automatically fit their data by searching grids of pre-calculated models. Model outputs include the dust temperature and density distributions, and the flux as a function of wavelength and beamsize. Over 300,000 models are currently stored and available in the DIRT model database. The WEB page was developed under a NASA ADP grant (PI Wolfire) and can be accessed through the URL http://dustem.astro.umd.edu and http://wits.ipac.caltech.edu.

J. P. Harrington has continued to work on planetary and proto-planetary nebulae in collaboration with K. J. Borkowski (North Carolina State). The work centers on observations made with several instruments on the Hubble Space Telescope. They are in the process of modeling the morphology and polarization and in analyzing spectra to determine the density, temperature, and shock speed structure in the high-velocity, highly-collimated jets of the protoplanetary He 3- 1275. Harrington realized recently that there have been very few tests of photoionization codes for PNe against real data. He has been awarded time in Cycle 10 to get HST STIS spectra of the smooth, high excitation PN NGC 2610 to provide a benchmark for comparison with his own computer models and others.

5.5 Millimeter Astronomy, Star Formation, and Interstellar Material

5.5.1 The Laboratory for Millimeter Astronomy

The University of Maryland owns and operates the BIMA millimeter-wave interferometric array telescope in partnership with the University of California (Berkeley) and the University of Illinois. The BIMA array, located in Hat Creek, California, operates in the 1 millimeter, 3 millimeter and 1 centimeter wavelength bands. With a longest baseline of 1.9 kilometers, an angular resolution as high as 0.1'' can be achieved in the 1 mm band. The BIMA array has the best angular resolution and image-forming capability of any millimeter-wave telescope. The telescope provides unique observations of a wide range of objects including molecular clouds, star-forming regions, protoplanetary and circumstellar disks, the Galactic center, evolved stellar envelopes, the molecular interstellar medium in galaxies, active galactic nuclei, Sunyaev-Zeldovich absorption by clusters, comets, planetary atmospheres and surfaces, and solar flares.

The University of Maryland has a 2/7 share of the BIMA array; a corresponding share of the observing time is available to student and faculty researchers at the University of Maryland. The Laboratory for Millimeter-wave Astronomy (LMA) is the organization set up by the University of Maryland to manage its participation in the BIMA project. The LMA is part of the Astronomy Department; faculty associated with the LMA include S. Vogel (director), A. Harris, M. Kundu, L. Mundy, and W. Erickson (emeritus). Also associated with the LMA are Research Scientists M. Pound, P. Teuben, S. White, M. Wolfire, and postdoctoral fellows F. Wyrowski, M. Das, and A. Gibb. Graduate students doing work with the array included Raquel Fraga-Encinas, Kayhan Kultekin, Chin-Fei Lee, Kartik Sheth, Nikolaus Volgenau, and Sally Watt. Sheth completed his Ph.D. and assumed a postdoctoral fellowship at the California Institute of Technology with the Owens Valley Radio Observatory. J. M. Hollis was a sabbatical visitor. A BIMA summer school is held most years at the observatory in Hat Creek for interested students and postdocs; typically several students from Maryland attend. Further information on BIMA and the LMA can be obtained at the BIMA web site, http://bima.astro.umd.edu.

5.5.2 Instrumentation

Development of wideband spectrometers for heterodyne astronomical and atmospheric observations continues under the direction of Dr. A. Harris. Research areas include:

- Submillimeter observations of active galactic nuclei with the Caltech Submillimeter observatory. This is a collaborative project with J. Zmuidzinas' group at Caltech.
- Provision of the spectrometer package for the CASIMIR instrument that will fly on the SOFIA airborne observatory.
- Design of millimeter-wave heterodyne spectrometers with 30% fractional bandwidths to search for high-redshift objects. This is a collaborative project involving the Max Planck Institutes for Extraterrestrial Physics and Radio Astronomy, in Garching and Bonn, Germany; the Institute for Radio Astronomy at Millimeter Wavelengths in Grenoble, France; and NASA's JPL.
- Atmospheric phase correction for the BIMA and CARMA millimeter-wave interferometers. Techniques developed in this research are also important for the ALMA interferometer. The group involved in this work includes M. Pound, A. Gibb, P. Teuben, N. Volgenau, C. Frank, K. Gultekin, L. Mundy, and A. Harris.
- Development of ultra-wideband (15 GHz) correlation spectrometers. A custom-designed monolithic microwave integrated circuit has been designed; testing at Maryland will follow fabrication. Others involved in this project are S. Maas (Nonlinear Technology, Inc.) and S. Weinreb (NASA JPL).

5.5.3 Star Formation

There is continuing work studying the formation of stars and evolution of young circumstellar disks. A three year study of molecular outflows from young stars was just completed (C.-F. Lee's PhD thesis work in collaboration with E. Ostriker, J. Stone, and L. Mundy). The study utilizes BIMA CO images of the ten outflows and numerical hydrodynamic simulations to test the viability of the jet model and wide-angle wind model for outflows. We find that neither model is entirely satisfactory to explain the range of observed structures. The data point to either a hybrid two-wind model or perhaps a wandering jet model. Mundy, in collaboration with L. Looney at MPE Munich and Dr. Welch at UC Berkeley, is extending their high resolution studies of disks around young stars. Recent observations at 1.4 mm wavelength with the BIMA array are providing 0.25 arcsecond resolution (35AU linear resolution) images of the disks around HL Tauri and DG Tauri. These new data confirm that the disks are of order 100 AU in extent and that the surface density decreases roughly as one over the radius. Wyrowski, Gibb, and Mundy are also involved in the study of massive star formation regions utilizing the high resolution capability of the BIMA array. Looking to the future, Mundy and graduate student, N. Volgenau, have begun BIMA observations to complement a SIRTF Legacy project (''From Cores to Stars,'' PI N. Evans II at Univ. of Texas, Co-I Mundy).

In an ongoing effort to establish an evolutionary sequence of high-mass star-formation, Friedrich Wyrowski and colleagues used the BIMA array in several complementary projects:

Dense, collapsing condensations within a new population of infrared dark clouds, identified during the MSX mid-infrared survey of the galactic plane, were observed for the first time with high angular resolution. In all three observed sources compact, slightly resolved (in some cases multiple) 3mm continuum cores were detected. These detections lead together with SCUBA data to constraints of the dust properties of the cores and allow proper estimates of their sizes, masses and density structures. N_2H^+ was used as a molecular line tracer and the resulting maps show an impressive correspondence with the MSX mid-infrared absorption and SCUBA imaging. This allows for the first time the study of the kinematical properties of these these cold and massive prestellar cores in detail.

Immediate precursors of ultracompact HII regions (UCHIIs) were observed, detected and mostly resolved with the BIMA array. They were selected by (1) searching for sources with infrared colors similar to UCHIIs but without detectable HII regions and by (2) selecting recently observed submillimeter peaks in the neighborhood of UCHIIs. The high angular resolution data obtained are used to determine the density and temperature structure of the presumedly still accreting environments of these massive (proto) stars.

Four hot core/ultracompact HII regions were studied with BIMA at 1.3mm in continuum and line emission with subarcsecond resolution. In three cases the dust continuum is clearly offset from the UCHII regions and coincident with maser and hot core emission. Evidence for outflows from embedded massive (proto) stars were found, suggesting an evolutionary state prior to the onset of a visible UCHII region. In G10.47, the two densest UCHIIs are embeeded in the dust emission, hence young UCHII regions have already emerged in the hot core.

5.5.4 Interstellar Gas

In May of 2000, Dr. Jan M. Hollis (NASA/GSFC and UMd) and colleagues used the NRAO 12 Meter telescope to discover interstellar glycolaldehyde, the first sugar detected in interstellar clouds. Since sugars are associated with some of the most basic aspects of life like metabolism and reproduction, this discovery is biologically significant, and increases the likelihood that life may exist elsewhere in our galaxy. Observations to determine the distribution of glycolaldehyde have been obtained with the BIMA array.

Weiner (OCIW), Vogel, and Williams (Rutgers) have completed a survey of ultra-faint, diffuse optical emission lines from 20 high velocity clouds and the Magellanic Stream using the Maryland Fabry-Perot on the Las Campanas Dupont 2.5 m telescope. Models for the origin of high velocity clouds range from gas from the galactic fountain to the accreting remnants of the formation of the Local Group. The key to resolving their nature is determination of their distances. Although a few large-angular size clouds are known to be within a few kpc, distances for almost all clouds are unknown. Hα emission is found to be much brighter than if the clouds were ionized by metagalactic ionizing radiation. The observed distribution of brightnesses is inconsistent with galactic fountain models. The range of brightness is less than a factor of 100, which is difficult to explain in those models which place the clouds at a range of distances from a few kpc to several 100 kpc or even more than a Mpc. Ionization sources in addition to photoionization by Local Group galaxies are required.

Using Hα observations of the Haynes-Giovanelli cloud obtained with the Maryland Fabry-Perot at Las Campanas Observatory, Vogel, Veilleux, and Weymann (OCIW) have placed the tightest limits yet on the value of the metagalactic ionizing radiation at zero redshift. The results constrain models for the emissivity of AGN and starbursts and absorption models for the IGM, and have implications for the fraction of baryonic gas in ionized form.

Vogel, Helfer (Arizona) *et al.* have completed a 62-field mosaic at 6'' resolution of CO emission from the grand-design spiral galaxy M51 using the BIMA array. CO is imaged along the entire length of each spiral arm, extending to the companion galaxy (which is also imaged). CO is seen to lie along the inner edge of the arms along most of their length. The kinematics of the gas are consistent with inflow driven by tidal interaction with the companion.

Most of the research efforts of L. Sage center around the study of gas (molecular and atomic) in other galaxies, with the goal of understanding the evolution and cycling of the interstellar medium. Sage has completed a survey of CO and HI in a volume-limited sample of lenticular galaxies; the results are being written up.

M. Das has been studying the kinematics of molecular hydrogen gas in the centers of the barred galaxies observed in the BIMA survey of nearby galaxies (SONG). This is a collaborative project with Peter Teuben and Stuart Vogel. They have determined the velocity field and inner CO rotation curves of 23 of the 29 barred galaxies observed; the remaining few did not have enough gas to determine a rotation curve. The CO rotation curve is one of the most accurate means of determining the dynamical mass distribution in the centers of galaxies. Das has also used the optical data in the BIMA SONG data to determine the ellipticities of the bars. Preliminary results show that the ellipticities of the bars decreases with increasing dynamical mass concentrations in barred galaxies. Thus bars may dissolve out as mass accumulates in the centers of galaxies.

5.6 Theoretical and High Energy Astrophysics

5.6.1 Theoretical Astrophysics: Compact Objects, Disks and Accretion

The extreme nature of neutron stars and black holes means that they can be used as unique probes of strong gravity and dense matter. The advent of a new generation of high energy resolution X-ray satellites such as Chandra and XMM-Newton, plus planned high-energy missions such as Constellation-X, means that with careful modeling and comparison with these new data we will be able, for the first time, to make quantitative tests of general relativity in strong gravity. We will also be able to place strong constraints on the equation of state of matter beyond nuclear density. In anticipation of these data Cole Miller is beginning a program of modeling and simulation in collaboration with scientists at Goddard Space Flight Center and elsewhere. He is concentrating on the kilohertz oscillations in the brightness of neutron-star low-mass X-ray binaries, both in their persistent, accretion-powered emission and in their bursting, thermonuclear-powered emission.

Miller is investigating the impact of a population of primordial compact objects (such as black holes) on the angular power spectrum of the cosmic microwave background. Miller and Eve Ostriker are also examining the effects such compact objects would have on the formation of the first nonlinear structures in the universe, at redshifts z=10-20. Ionization produced by accretion onto early compact objects could delay the formation of globular clusters and could introduce significant extra entropy into group- and cluster-scale mass accumulations. This may produce signatures observable by future satellites such as the Microwave Anisotropy Probe and the Next Generation Space Telescope.

E. Ostriker, in collaboration with J. Stone and C. Gammie (U.Illinois), has continued investigations of the structure and dynamics of molecular clouds. The emphasis of recent work has been on developing diagnostics, using snapshots of large-scale numerical simulations of clouds, for interpreting observations of clouds. These investigations have included, for example, analyses of hierarchical and non-hierarchical mass spectra of density and column density concentrations in simulated clouds, for comparison to observed clump mass spectra from data cubes of CO line emission and maps of mm-continuum emission. These investigations have also included comparisons of the accuracy of various magnetic field estimators related to the Chandrasekhar-Fermi method.

With student W.-T. Kim, Ostriker has engaged in investigations of the self-gravitational instabilities that can form gaseous condensations in magnetized models of galactic disks. This work was focused on (1) distinguishing the two different types of localized instabilities that occur in inner and outer galactic disks (the magneto-Jeans and swing instabilities, respectively), and (2) assessing the threshold criterion, in terms of the Toomre Q parameter, for nonlinear instability to lead to self-gravitational runaway. The threshold Q value determined by this study is in the range 1.2-1.4 (depending on magnetic field strength), consistent with empirical results for the thresholds for active star formation in disk galaxies from Kennicutt and coworkers.

With collaborator M. van Putten (MIT), Ostriker has developed a simple model for the dynamics of the central engine in gamma-ray burst sources, in order to interpret the bimodal distribution of burst durations. In this model, the burst duration is determined by the lifetime of the disk or torus surrounding the central black hole; this disk evolves in response to large-scale magnetic torques from a wind and, potentially, a rapidly-spinning black hole. This work proposes that short bursts are associated with states of hyperaccretion onto a slowly-spinning black hole, and long-bursts are associated with states of suspended-accretion around a rapidly-spinning black hole. The ratio in typical burst durations for the two cases is expected to be comparable to mass ratio for the black hole to disk; the observed bimodality thus arises as a consequence of a large mass ratio.

With M.C. Miller, Ostriker has considered the effects of accretion onto primordial black holes on the thermal and ionization evolution in the universe. This work shows that even a relatively low level of accretion (requiring only a very small fraction of the closure density in black holes) can heat the universe sufficiently to delay the onset of collapse for the first baryonic objects from, e.g., $z=10$ to $z=5$ for 1-sigma perturbations.

Because the mass of the collapsed objects increases as the 3/2 power of the temperature, the corresponding masses of the first collapsed objects would also be larger by, e.g., more than three orders of magnitude for 1-sigma perturbations. Since the ionization boost at high redshift may be relatively low, detection of the signature of such a process in the CMB power spectrum will require the high sensitivity of the upcoming MAP and Planck experiments.

In Spring 2000, Ostriker co-coordinated, with E. Zweibel (U. Colorado), a Workshop and Conference on Astrophysical Turbulence at the Institute for Theoretical Physics at U.C. Santa Barbara.

J. Stone, in collaboration with graduate students T. Fleming, C. Lee, and R. Piontek, and postdoctoral research associates N. Turner and T. Sano, continues to study the dynamics of interstellar gas in a wide variety of contexts. Fleming and Sano are studying the nonlinear stage of the magnetorotational instability (MRI) in protostellar accretion disks to understand the conditions for grain growth and planet formation. Lee is comparing numerical simulations of the dynamics of protostellar winds and jets to high-resolution observations made with the BIMA. Turner is studying the saturation of the MRI in radiation dominated accretion disks around black holes and neutron stars. Piontek has begun a numerical study of the efficacy of ram pressure stripping of HI gas from spiral galaxies in clusters of galaxies. All of these studies utilize large scale simulations on massively parallel supercomputers available at the national centers.

Using the Chandra X-ray Observatory Wilson, Young and Shopbell observed the X-ray counterparts to radio ‘‘hot spots’’ at the termini of extragalactic jets in Pictor A and Cygnus A. The mechanism responsible for particle acceleration in the hot spots was found to be qualitatively different between galaxies. The observation of Pictor A also revealed a spectacular X-ray jet, and this will be the subject of a follow-up observation in the next Chandra cycle. [These also generated NASA press releases, see http://chandra.harvard.edu/photo/cycle1/pictor/index.html and http://chandra.harvard.edu/photo/cycle1/0216/index.html].

Young, Wilson and Shopbell obtained a Chandra X-ray observation of the archetypal Seyfert 2 galaxy NGC 1068. The X-ray image has a wonderful spiral morphology, and immediately shows that the starburst is not the dominant source of the spatially extended X-rays. The extended emission is spectroscopically complex, most likely a combination of photo-ionized and collisionally-ionized gas.

A joint Chandra and RXTE study of the nucleus of Cygnus A by Young, Wilson, Terashima, Arnaud, and Smith was used to study in detail the nature of the buried nucleus, finding it to be more AGN-like than quasar-like, and also revealed the presence of a bi-polar scattering nebula.

5.6.2 High Energy Astrophysics and the Goddard Connection

The most important thing K. Arnaud has done in the last year has been the continued enhancement, maintenance, and support of the XSPEC software package. This is the world-standard for the analysis of X-ray spectroscopic data and has a market penetration that Bill Gates would envy. At a recent international X-ray astronomy conference in Yokohama, $\sim$ 75% of the talks presented showed plots produced using XSPEC. His work on XSPEC encompasses astrophysics, computational methods, and statistics. Recent improvements have been driven by the wonderful new data available from the Chandra and XMM-Newton satellites. These have required new statistical techniques, improved capabilities for high resolution spectra, and more physically realistic theoretical models. The first two of these he developed on his own while the last has lead to a number of collaborative projects.

Arnaud was a co-I on two successful major proposals this year. The proposed SMEX mission, Joule, was one of eight selected by NASA HQ for phase A development. This was proposed as a recovery mission after the loss of Astro-E, which failed to make orbit when its Japanese launcher failed. Japanese collaborators have now received funding to build a copy (Astro-E2), and the team is waiting for approval from

NASA HQ to convert SMEX to a revitalized collaborative program. Arnaud was also the lead editor on the HEASARC Senior Review proposal. This was rated very highly by the review and ensured continued funding at the current level (the best result possible as it turned out).

He has also worked on Chandra observations of the X-ray background, ASCA observations of the Galactic ridge emission and the SNR 3c397, RXTE observations of the cluster Abell 496, and ASCA and ROSAT observations of a large sample of local clusters. The work with Chandra led him to develop new data analysis techniques and in particular a new statistical approach which combined ideas from two papers published over 20 years ago.

M. Lowenstein has focussed on data analysis, interpretation, and theoretical modeling of X-ray emission from early-type galaxies and clusters of galaxies. Together with Valia and Mushotsky, he identified a new, extended hard X-ray component in the emission from elliptical galaxies and placed strong limits on the X-ray luminosity associated with supermassive black holes at the centers of these galaxies. He has also helped to uncover some anomalous chemical abundances and structural features in intracluster gas and attempted to explain them with reference to the first generation of stars to form in the universe.

C. K. Ng is studying the amplification of interplanetary Alven waves by streaming energetic protons and the consequences in solar energetic particle events. With D. V. Reames (GSFC) and A. J. Tylka (NRL) he has confirmed aspects of the time variability of SEP events and correlations of intensity, anistropy, and composition.

I. G. Richardson is engaged in analysis of energetic data from the GSFC cosmic ray experiments on the ISEE-E, IMP-8, and Helios-1 and -2 spacecraft. Results include new information on the correlations of the GCRs that reach us with solar wind and solar cycle. There is, for instance, a 22 year cycle in the cosmic ray modulation as well as an 11-year one. There is also a 153 day periodicity in the interplanetary magnetic field intensity at 1 AU, which he has related to a similar period in solar energetic phenomena during the 1979-82 solar maximum. It may again be present in the current solar cycle.

D. Chornay has participated in the reduction and analysis of data returned from the Low Energy Neutral Atom (LENA) imaging director, which is part of the Image spacecraft; in the design, testing, and calibration or an electron analyzer and detector for the Plasmag instrument on the Triana mission (the only spacecraft ever invented by a politician; it is the ‘‘Gore mission’’); and in instrumentation for a future Solar Probe mission.

F. H. Finkbeiner has had responsibility for coordinating detector characterization and detector fabrication in the Detector Development Laboratory, especially the development of Transition- Edge Sensor (TES) calorimeters that will be needed for the future X-ray mission, Constellation- X. He has also performed magnetic field simulations for Adiabatic Demagnetization Refrigerators that will be needed as cold platforms for TES operation.

C. A. Nixon is part of the science/operations team of the CIRS instrument, carried on the Cassini spacecraft. Most recently, he was involved in the implementation of the decision to make observations during the Jupiter gravitational slingshot maneuver at the end of 2000. He will be using tools developed at GSFC and Oxford to analyze planetary spectra for variations in atmospheric composition to produce maps of gaseous abundances.

T. M. Lanz continues to center his activities on modeling the atmospheres of hot objects and on radiation transport theory. The non-LTE code he developed with I. Hubney (NOAO and GSFC) incorporates about 10 million atomic lines of 45 ions. It has been applied to O stars observed with STIS, to hot horizontal branch stars, and to several hot white dwarfs. The code (Tlusty) and the associated spectrum synthesis code (Synspec) are used at about 80 sites worldwide. They can be accessed from http://tlusty.gsfc.nasa.gov. He has also been involved in efforts to measure stellar ages and magnetic fields and wrote the main article on Stellar Atmospheres for the new Encyclopedia of Astronomy and Astrophysics (Institute of Physics, 2001).

5.7 Extragalactic Astronomy

Veilleux, D. B. Sanders (Univ. of Hawaii), and D. C. Kim (ASIAA) are continuing their ground-based optical and near-infrared imaging survey of a large sample of ultraluminous ($\log[L_{IR}/L_{\odot}] > 12$) IRAS galaxies. The spectroscopic portion of this survey was published last year in the Astrophysical Journal. The main effort now focusses on completing the analysis of the imaging data and combining these data with the results of the spectroscopic analysis to look for a possible evolutionary link between these objects and optical quasars.

In collaboration with J. Bland-Hawthorn (AAO), G. N. Cecil (Univ. of North Carolina), S. T. Miller (Univ. of Maryland), R. B. Tully (Univ. of Hawaii), and S. Vogel (Univ. of Maryland), Veilleux is carrying out a comprehensive study of the warm ionized medium on the outskirts of nearby disk galaxies. The physical state, distribution, and velocity structure of this material are relevant for understanding large-scale galactic winds (‘‘superwinds’’) and fountains in active and normal galaxies, quasar absorption-line systems, the baryonic content of the universe, the formation and evolution of galaxies, and measuring the mass and distribution of dark matter in galaxies. The distribution of the line-emitting gas in a complete sample of nearby galaxies is being mapped down to unprecedented flux levels using state-of-the-art optical Fabry-Perot interferometers and recently developed observational techniques. Recent results from this survey were presented at the ‘‘Imaging the Universe in Three Dimensions’’ conference in Walnut Creek, California and at the ‘‘Environments of Galaxies’’ workshop in Birmingham, England. The portion of this survey on normal disk galaxies will constitute Miller’s Ph.D. thesis at Maryland.

A. S. Wilson, in collaboration with postdocs P. L. Shopbell, A. J. Young, D. A. Smith, and Y. Terashima and graduate student Y. Yang, initiated a study of active galaxies with the Chandra X-ray Observatory. Bi-polar or jet-related X-ray nebulosities were found in all objects studied, although the emission process differs for different classes of object. In low luminosity active galactic nuclei (LLAGN), such as M51 and NGC 4258, the gas is collisionally ionized by mass outflows from the nucleus, and detailed associations are found between regions of high velocity (identified in optical emission lines) gas and high temperature X-ray emitting gas. In NGC 4258, the well known ''anomalous arms'' are prominent X-ray emitters and apparently represent gas in the galactic disk which has been shock-heated by the out-of-plane radio jets. In high luminosity Seyfert galaxies (e.g. NGC 1068, NGC 4151 and the Circinus galaxy), the X-ray emitting gas is photoionized by the nucleus and is closely correlated with the high excitation gas seen in optical emission lines. It is shown that electron scattering is a negligible contributor to the extended X-ray emission of NGC 4151. Their results on NGC 1068, when taken together with the XMM-Newton RGS spectrum, suggest photoionization and fluorescence by radiation from the Seyfert nucleus to several kpc from it. Non-thermal X-ray emission has been detected from the jets and/or hot spots of the radio galaxies Cygnus A, Pictor A and M87. In Cygnus A, the spectra of the hot spots are in excellent agreement with synchrotron self-Compton models, showing that the magnetic field strength is close to equipartition. In Pictor A and M87, synchrotron self-Compton or external Compton models require improbable conditions, leading the authors to favor a synchrotron model. The presence of such high energy electrons in nearby radio galaxies lends support to the notion that high energy cosmic rays may come from this class of object.

N. Nagar, Wilson and H. Falcke (MPIfR) have continued a program of high resolution radio studies of LLAGN. The main results are i) compact, flat spectrum radio cores are found (with the VLA) in at least 50% of LLAGN (Seyferts and LINERs). The highly inverted spectra predicted by ADAF models are rarely found. ii) studies with the VLBA at milli arc second (pc scale) resolution detected all of a sample of 16 LLAGN, confirming that the radio emission is powered by accreting black holes. iii) the radio-brightest nuclei have pc-scale jets. These results favor an origin of the radio emission in jets rather than in the accretion flow itself.

Wilson prepared reviews of the capabilities of DARWIN (a planned ESA infrared space interferometer) in the area of galactic nuclei, and the contributions of HST to our knowledge about gas in active galaxies for the STScI spring 2000 symposium ''A Decade of HST Science.''

The active nuclei which lie at the centers of many galaxies are powered by accretion onto massive black holes. The accretion may be driven by the magneto-rotational or Balbus-Hawley instability. During the past year, N. Turner and J. Stone showed by numerical simulations that in the inner, radiation-pressure dominated parts of the disks, the axisymmetric form of the instability grows at the rate predicted by linear analysis. Under conditions where turbulence develops, and radiation can diffuse across the most-unstable wavelength in about one orbit, large radiation pressure leads to stronger fluctuations in the density. Working with E. Agol and J. Krolik at Johns Hopkins University, they showed also using axisymmetric radiation hydrodynamical calculations that the predicted thermal instability of radiation-dominated disks is quenched by changes in the convective flux in response to changes in the dissipation rate.

Stacy McGaugh has been engaged in a major study of the dynamics of faint and low surface brightness galaxies. Together with collaborators Jim Schombert, Greg Bothun (U.Oregon), and Erwin de Blok (ATNF), McGaugh has extended the Tully-Fisher relation to very faint galaxies, in the process showing that the disk mass (stars plus gas) is the more fundamental quantity in this relation than the stars alone. Detailed studies of the rotation curves of low surface brightness galaxies with collaborators de Blok, Vera Rubin (DTM), and Honors thesis student Mike Barker are nearing fruition. These data provide strong tests of the predictions of cold dark matter models, with which they are strongly inconsistent. In an effort to check whether the dynamical data were correct in indicating the non-existence of cold dark matter, McGaugh posed a test based on the amplitude of the second peak in the angular power spectrum of fluctuations in the microwave background radiation. His prediction for the purely baryonic case was subsequently confirmed by the BOOMERanG and Maxima-1 experiments.

Mosumi Das has been studying the kinematics of molecular hydrogen gas in the centers of the barred galaxies observed in the BIMA survey of nearby galaxies (SONG). This is a collaborative project with mainly Peter Teuben and Stuart Vogel. They have determined the velocity field and inner CO rotation curves of 23 of the 29 barred galaxies observed; the remaining few did not have enough gas to determine a rotation curve. The CO rotation curve is one of the most accurate means of determining the dynamical mass distribution in the centers of galaxies. M. Das has also used the optical data in the BIMA SONG data to determine the ellipticities of the bars. Preliminary results show that the ellipticities of bars decreases with increasing dynamical mass concentrations in barred galaxies. Thus bars may dissolve out as mass accumulates in the centers of galaxies.

PUBLICATIONS

Graduate Student Publications

Berendse, F., Holt, S. S., Petre, R., and Hwang, U., 2001, ''X-ray Synchrotron in the Forward Shock of Cassiopeia A,'' in Young Supernova Remnants, 11th Astrophysics Conference, College Park, MD 2000, Stephen S. Holt and Una Hwang, Eds., AIP Conf. Proc. 565 pp. 399-402.

Boeker,T., Van der Marel, R.P., **Mazzuca, L.**, Rix, H., Rudnick, G., Ho, L., Shields, J., ''A Young Stellar Cluster in the Nucleus of NGC 4449,'' ApJ 121,1473-1481, 2001.

Castelaz, M. W., Luttermoser, D. G., Caton, D. B., **Piontek, R. A.**, ''Phase-dependent Spectroscopy of Mira Variable Stars,'' AJ, 120, 2627, 2000.

Castelaz, M. W., Luttermoser, D. G., **Piontek, R. A.**, ''Vanadium Oxide in the Spectra of Mira Variables,'' ApJ, 538, 341, 2000.

Cecil, G., Greenhill, L. J., DePree, C. G., **Nagar, N.**, Wilson, A. S., Dopita, M. A., Perez-Fournon, I., Argon, A. L., and Moran, J. M., 2000, ''The Active Jet in NGC 4258 and its Associated Shocks,'' ApJ, 536, 675.

Durda, D. D., Bottke, W. F., Jr., Asphaug, E., Richardson, D. C., **Leinhardt, Z. M.**, Merline, W. J., and Flynn, K. W., 2001, ''Numerical Models of the Formation of Asteroid Satellites,'' Asteroids 2001 from Piazzi to the 3rd millenium (Palermo, Italy, Jun 11-15, 2001, pp. 88-89).

Ebeling, H., Jones, L. R., Perlman, E., Scharf, C., **Horner, D.**, Wegner, G., Malkan, M., Fairley, B. W., Mullis, C. R., ''The WARPS Survey. III. The Discovery of an X-Ray Luminous Galaxy Cluster at z=0.833 and the Impact of X-Ray Substructure on Cluster Abundance Measurements,'' AJ, 534, Issue 1, pp.133-145.

Ebeling, H., Jones, L. R., Fairley, B. W., Perlman, E., Scharf, C., **Horner, D.**, ''Discovery of a Very X-Ray Luminous Galaxy Cluster at Z=0.89 in the Wide Angle ROSAT Pointed Survey,'' AJ, 548, Issue 1, pp. L23-L27.

Fairley, B. W., Jones, L. R., Scharf, C., Ebeling, H., Perlman, E., **Horner, D.**, Wegner, G., Malkan, M., ''The WARPS survey - IV. The X-ray luminosity-temperature relation of high-redshift galaxy clusters,'' MNRAS, 315, Issue 4, pp. 669-678.

Falcke, H., Lehar, J., Barvainis, R., **Nagar, N. M.**, & Wilson, A. S., 2000, ''Radio- Variability in Radio-Quiet Quasars and Low-Luminosity AGN,'' in ''Probing the Physics of Active Galactic Nuclei by Multiwavelength Monitoring,'' ASP Conf. Series Vol. 224, 265, Eds. B. M. Peterson, R. S. Polidan & R. W. Pogge.

Falcke, H., **Nagar, N. M.**, Wilson, A. S., and Ulvestad, J. S., 2000, ''Radio Sources in Low-Luminosity Active Galactic Nuclei. II. VLBI Detections of Compact Radio Cores and Jets in a Sample of LINERs,'' ApJ, 542, 197.

Fernandez, Y. R., Lisse, C. M., Kaufl, H. U., Peschke, S. B., Weaver, H. A., A'Hearn, M. F., Lamy, P. P., Livengood, T. A., and Kostiuk, T., ''Physical Properties of the Nucleus of Comet 2P/Encke,'' Icarus, 147, 145-160.

Guzdar, P. N., **Shao, X.**, Wiltberger, M., Goodrich, C. C., Papadopoulos, K., and Lyon, J. G., ''Three-dimensional MHD simulations of the steady-state magnetosphere with northward interplanetary magnetic field,'' J. Geophy. Res., 106, 275, 2001.

Horner, Donald J., Mushotzky, R. F., Scharf, C. A., ''Observational Tests of the Mass-Temperature Relation for Galaxy Clusters,'' AJ, 520, Issue 1, pp.78-86.

Kim, W.-T., & Ostriker, E. C., 2000, ''Magnetohydrodynamic Instabilities in Shearing, Rotating, Stratified Winds and Disk,'' ApJ, 540, 372.

Kim, W.-T., & Ostriker, E. C., 2001, ''Amplification, Saturation, and Q Thresholds for Runaway: Growth of Self-Gravitating Structures in Models of Magnetized Galactic Gas Disks,'' ApJ, 559, 70.

Lee, C.-F., Mundy, L.G., Reipurth, B., Ostriker, E.C., & Stone, J.M., 2000, ''CO Outflows from Young Stars: Confronting the Jet and Wind Models,'' ApJ, 542, 925.

Lee, C.-F., Stone, J.M., Ostriker, E.C., & Mundy, L.G., 2001, ''Hydrodynamical Simulations of Jet- and Wind-driven Protostellar Outflows,'' ApJ, 557, 429.

Leinhardt, Z. M., and Richardson, D. C., 2001, ''The Effect of the Internal Configuration of Rubble Piles on Collision Outcome,'' LPSC, 32, 1400.

Leinhardt, Z. M., and Richardson, D. C., 2001, ''Planetesimal Evolution: A Mass Ratio Study of Rubble Pile Collisions,'' Asteroids 2001 from Piazzi to the 3rd millenium (Palermo, Italy, Jun 11-15, 2001, p. 99).

Leinhardt, Z., M., Richardson, D. C., and Quinn, T., 2000, ''Direct N-body Simulations of Rubble Pile Collisions,'' Icarus, vol. 146, 133-151.

Leinhardt, Z. M., Richardson, D. C., and Quinn, T., 2000, ''When Rubble Piles Collide,'' LPSC, 31, 1274.

Leinhardt, Z. M., Richardson, D. C., and Quinn, T., 2000, ''Size Distribution Dependence in Rubble-pile Collisions and Implications for (216) Kleopatra,'' BAAS, 32, 1017.

Lisse, C. M., **Fernandez, Y. R.**, A'Hearn, M. F., *et al.*, 1999, ''Infrared Observations of the Dust Emitted By Comet Hale-Bopp,'' Earth, Moon, and Planets, 78:1-3, 251-257.

Lisse, C. M., A'Hearn, M. F., **Fernandez, Y. R.**, and Peschke, S. B., 2001, ''A Search for Trends in Cometary Dust Emission,'' IAU Symposium 181, in press.

Mazzuca, L.M., Knapen, J.H., Regan, M.W., Boeker, T., ''High-Resolution Imaging of Stars, Dust, and Star Formation in Nuclear Rings in Galaxies,'' ASP Conference Series, accepted June 2001.

Milikh, G. M., Dimant, Y. S., **Shao, X.**, Guzdar, P. N., Sharma, A. S., Papadopoulos, K., Burns, E. M., Goodrich, C. C., Rosenberg, T. J., Weatherwax, A. T., Wilberger, M. J., Lyon, J. G., and Fedder, J. A., 2001, ''Modeling Riometer Observations of Ionospheric Absorption During Substorms,'' Geophy. Res. L., 28, 487.

Miller, K., and Stone, J. M., 2000, ''The Formation and Structure of a Strongly Magnetized Corona Above Weakly Magnetized Accretion Disks,'' ApJ, 534, 398.

Miller, S. T., and Veilleux, S., 1999, ''A Deep Multi-Line Imaging Survey of Edge-On Spiral Galaxies,'' AAO Newsletter No. 88, 4.

Mundy, L. G., Wyrowski, F., and **Watt, S.**, 2001, ''The Circumstellar Environment of Embedded Massive Stars,'' Proceeding of IAU General Assembly: Joint Discussion 3, ed. Conti, P. and Churchwell, E.

Nagar, N. M., and Wilson, A. S., 1999, ''The Relative Orientations of Nuclear Accretion and Galaxy Stellar Disks in Seyfert Galaxies,'' ApJ, 516, 97.

Nagar, N. M., Falcke, H., Wilson, A. S., and Ho, L. C., 2000, ''Radio Sources in Low- Luminosity Active Galactic Nuclei. I. VLA Dectections of Compact, Flat-Spectrum Cores,'' ApJ, 542, 186.

Nagar, N. M., Wilson, A. S., Mulchaey, J. S., and Gallimore, J. F., 1999, ''Radio Structures of Seyfert Galaxies VIII. A Distance and Magnitude Limited Sample of Early-Type Galaxies,'' ApJ Supp., 120, 209.

Nagar, N. M., Wilson, A. S., *et al.*, 2001, ''Gigahertz-peaked Spectrum Radio Sources in Nearby Galaxies,'' in ''Issues in Unification of AGNs,'' (Eds.) R. Maiolino, A. Marconi, & N. Nagar, ASP Conf. Series, in press.

Nagar, N. M., Wilson, A. S., & Falcke, H., 2001, ''Evidence for Jet Domination of the Nuclear Radio Emission in Low-luminosity Active Galactic Nuclei,'' ApJL, 559, L87.

Ogasaka, Y., Tamura, K., Haga, K., Okajima, T., Ichimaru, S., Takahashi, S., Goto, A., Kito, H., Fukuda, S., Kunieda, H., Tawara, Y., Yamashita, K., Tsusaka, Y., Serlemitsos, P. J., Soong, Y., Chan, K. W., Owens, S. M., **Berendse, F.**, and Tueller, J., 2000, ''Development of a balloonborne hard x-ray telescope using a Pt/C multilayer supermirror,'' in X-ray Optics, Instruments, and Missions III, Joachim

E. Truemper and Bernd Aschenbach, Eds., Proc. SPIE Vol. 2012 pp. 294-305.

Ostriker, E.C., **Lee, C.-F.**, Stone, J.M., & Mundy, L.G., 2001, ‘‘A Ballistic Bow Shock Model for Jet-driven Protostellar Outflow Shells,’’ ApJ, 557, 443.

Owens, S. M., Okajima, T., Ogasaka, Y., **Berendse, F.**, and Serlemitsos, P. J., 2000, ‘‘Multilayer coated thin foil mirrors for InFOCuS,’’ in X-ray Optics, Instruments, and Missions III, Joachim E. Truemper and Bernd Aschenbach, Eds., Proc. SPIE Vol. 2012 pp. 619-625.

Regan, M. W., **Sheth, K.**, & Vogel, S. N., 1999, ‘‘Molecular Gas Kinematics in Barred Spiral Galaxies,’’ ApJ, 526, 97.

Regan, M.W., Thornley, M. D., Helfer, T. T., **Sheth, K.**, Wong, T., Vogel, S. N., Blitz, L., and Bock, D. C.-J., 2001, ‘‘The BIMA Survey of Nearby Galaxies: I. The Radial Distribution of CO Emission in Spiral Galaxies,’’ ApJ, in press.

Richardson, D. C., **Flynn, K. W.**, & **Leinhardt, Z. M.**, 2001, ‘‘Rubble Piles in the Solar System: Evidence and Dynamics,’’ Asteroids 2001 from Piazzi to the 3rd millenium (Palermo, Italy, Jun 11-15, 2001, p. 255).

Shao, X., Guzdar, P. N., Papadopoulos, K., Goodrich, C. C., Sharma, A. S., Milikh, G. M., Wiltberger, M. J., and Lyon, J. G., ‘‘Three-dimensional MHD simulations of the Earth’s magnetosphere on Feb 9-10 1995 for northward interplanetary magnetic field and comparison of the lobe field with Geotail observations,’’ in press, Geophy. Res. Lett., 2001.

Shao, X., Guzdar, P. N., Milikh, G. M., Papadopoulos, K., Goodrich, C. C., Sharma, A. S., *et al.*, 2001, ‘‘Comparing Ground Magnetic Field Perturbations from Global MHD Simulations with Magnetometer Data for Jan. 10, 1997 Magnetic Storm Event,’’ J. Geophys. Res., in press.

Sheth, K., Vogel, S.N., Harris, A.I., Regan, M.W., Thornley, M.D., Helfer, T.T., Wong, T., Blitz, L., Bock, D.C.-J., 2001, ‘‘Molecular Gas and Star formation in BIMA SONG Bars,’’ ASP Conf. Ser. 230: Galaxy Disks and Disk Galaxies, 383.

Sheth, K., Vogel, S. N., Wilson, C. D., & Dame, T. M., 2000, ‘‘Comparing giant molecular clouds in M31, M33 & the Milky Way,’’ Proceedings 232, WE-Heraeus Seminar, 22-25 May 2000, Bad Honnef, Germany, Edited by Elly M. Berkhuijsen, Rainer Beck, and Rene A. M. Walterbos, Shaker, Aachen, 2000, p. 37-40, 37.

Sheth, K., Regan, M. W., Vogel, S. N., & Teuben, P. J., 2000, ‘‘Molecular Gas, Dust, and Star Formation in the Barred Spiral NGC 5383,’’ ApJ, 532, 221.

Sheth, K., & Teuben, P. J. Teuben, ‘‘Stress Drives Gas into a Black Hole,’’ 1999, Nature, 397, 298.

Sheth, K. *et al.*, 1999, ‘‘The BIMA Survey Of Nearby Spiral Galaxies (BIMA SONG),’’ Science with the Atacama Large Millimeter Array (ALMA), Associated Universities, Inc., held October 6-8, 1999 at Carnegie Institution of Washington, E59.

Snyder, L. E., Veal, J. M., **Woodney, L. M.**, Wright, M. C. H., Palmer, P., A’Hearn, M. F., Kuan, Y.-J., de Pater, I., and Forster, J. R., 2001, ‘‘BIMA Array Photodissociation Measurements of HCN and CS in Comet Hale-Bopp (C/1995 O1),’’ AJ, 121, 1447-1154.

Veal, J. M., Snyder, L. E., Wright, M. C. H., **Woodney, L. M.**, Palmer, P., Forster, J. R., de Pater, I., A’Hearn, M. F., and Kuan, Y.-J., 2000, ‘‘An Interferometric Study of HCN in Comet Hale-Bopp (C/1995 O1),’’ AJ, 119, 1498-1511.

Veilleux, S., Bland-Hawthorn, J., Cecil, G., Tully, R. B., and **Miller, S. T.**, 1999, ‘‘Galactic-Scale Outflow and Supersonic Ram-Pressure Stripping in the Virgo Cluster Galaxy NGC 4388,’’ ApJ, 520, 111.

Veilleux, S., Shopbell, P. L., and **Miller, S. T.**, 2000, ‘‘The Biconical Outflow in the Seyfert Galaxy NGC 2992,’’ AJ, 121, 198.

Wilson, A. S., **Yang, Y.**, and Cecil, G., 2001, ‘‘Chandra Observations and the Nature of the Anomalous Arms of NGC 4258 (M 106),’’ ApJ, 560, in press.

Woodney, L. M., A’Hearn, M. F., McMullin, J., and Samarasinha, N. 1997, ‘‘ Sulfur Chemistry at Millimeter Wavelengths in C/Hale-Bopp,’’ Earth, Moon, and Planets, 78, 69-70.

Wright, M. C. H., de Pater, I., Forster, J. R., Palmer, P., Snyder, L. E., Veal, J. M., A’Hearn, M. F., **Woodney, L. M.**, Jackson, W. L., Kuan, Y.-J., and Lovell, A. J., 1998, ‘‘Mosaiced Images and Spectra of J=1-0 HCN and HCO+ emission from Comet Hale-Bopp (1995 O1),’’ AJ, 116, 3018-3028.

Yang, Y., Wilson, A. S., & Ferruit, P., 2001, ‘‘Chandra X-ray Observations of NGC 4151,’’ ApJ, in press.

Zhang, J., White, S. M., & Kundu, M. R., 1999, ‘‘Two-Temperature Coronal Models from SOHO/EIT Observations,’’ ApJ, 527, 977.

Zhang, J., Kundu, M. R., and White, S. M., 2001, ‘‘Spatial Distribution and Temporal Evolution of Coronal Bright Points,’’ Solar Physics, 198, 347.

Zhang, J., Dere, K. P., Howard, R. A., Kundu, M. R., & White, S. M., 2001, ‘‘On the Temporal Relationship Between Coronal Mass Ejections and Flares,’’ ApJ, in press.

Zhang, J., Kundu, M. R., White, S. M., and Dere, K. P., 2001, ‘‘Reconcile the EUV & Radio Observations of the Sun’s Corona,’’ ApJ, in press.

6. FACULTY PUBLICATIONS

Agol, E., Krolik, J. H., Turner, N. J., & Stone, J. M., 2001, ‘‘Two-Dimensional Hydrodynamic Simulations of Convection in Radiation-Dominated Accretion Disks,’’ ApJ, in press.

A’Hearn, M. F., 2000, ‘‘The Comet No One Saw,’’ Nature, 405, 285-287.

A’Hearn, M. F., 2000, ‘‘Pluto: A Planet or a Trans-Neptunian Object?,’’ Trans. IAU, XXIVB, in press.

A’Hearn, M. F., Meech, K. J., Belton, M. J. S., Delamere, A., Klaasen, K., Kissel, J., McFadden, L. A., *et al.*, 2000, ‘‘Deep Impact Exploring the Interior of a Comet,’’ in Bio-Astronomy 1999, Conf. Proceedings.

Allen, S. W., Fabian, A. C., Johnstone, R. M., Arnaud, K. A., & Nulsen, P. E. J., 2001, ‘‘ASCA and ROSAT Observations of Nearby Cluster Cooling Flows,’’ MNRAS, 322, 589.

Aoki, K., Kosugi, G., Wilson, A. S., & Yoshida, M., 1999, ‘‘The Radio Emission of the Seyfert Galaxy NGC 7319,’’ ApJ, 521, 565.

Balachandran, S. C., Carr, J. S. & Carney, B. W., 2001, ''Oxygen Abundances from infrared OH lines,'' New Astronomy Reports, 45, 529.

Balachandran, S. C., Fekel, F. C., Henry, G. W., Uitenbroek, H., 2000, ''Two K Giants with Supermeteoritic Lithium Abundances: HDE 233517 & HD 9746,''ApJ, 542, 978.

Bell, R. A., Balachandran, S. C. & Bautista, M., 2001, ''The Importance of Fe I as a Continuous Opacity Source in the Solar Atmosphere,'' ApJ, 546, L65.

Biersdorfer, P., Lisse, C. M., *et al.*, 2001, ''X-Ray Velocimetry of Solar Wind Ion Impact on Comets,'' ApJ, 549, L147.

Boldt, E., and Loewenstein, M., 2000, ''Cosmic Ray Generation by Quasar Remnants: Constraints and Implications,'' MNRAS, 316, L29.

Borkowski, K. J., and Harrington, J. P., 2001, ''Kinematics of 1200 km/s Jets in He 3-1475,'' ApJ, 550, 778.

Burns, J.A., Hamilton, D. P., and Showalter, M. S., ''Dusty planetary rings,'' in Interplanetary Dust, (S.F. Dermott, H. Fechtig, E. Grün and B.A.S. Gustafson, Eds.), Springer Verlag, in press.

Bus, S. J., A'Hearn, M. F., Bowell, E., & Stern, S. A., 2001, ''Chiron: Evidence for Activity Near Aphelion,'' AJ, 150, 94-103.

Cane, H. V., Richardson, I. G., & St. Cyr, O. C., 2000, ''CMEs, Ejecta and Geomagnetic Storms,'' Geophys. Res. Lett., 27, 3591.

Carr, J. S., Sellgren, K., & Balachandran S. C., 2000, ''The First Stellar Abundance Measurements in the Galactic Center: The M Supergiant IRS 7,''ApJ, 530, 307.

Charbonnel, C., & Balachandran, S. C., 2000, ''The Nature of the lithium rich giants. Mising episodes in the early-AGB,'' A&A, 359, 563.

Cecil, G., Veilleux, S., Bland-Hawthorn, J., Filippenko, A. V., 2001, ''Jet- and Wind-Driven Ionized Outflows in the Superbubble and Star-Forming Disk of NGC 3079,'' ApJ, in press.

Cecil, G., Bland-Hawthorn, J., & Veilleux, S. 2000, ''The Lives of Quasars'' in Scientific American: Book of the Cosmos, Chap. 2, pp. 49–56 (Macmillan: New York), ed. D. Levy.

Chen, T. C., Finkbeiner, F. M., *et al.*, 1999, ''Molybdenum-Gold Proximity Bilayers as Transition Edge Sensors for Microcalorimeters and Bolometers,'' Proc. International Superconductive Electronics Conf. '99, IEEE Supercond. Sci. Technol., 12, 840-842.

Cheng, E. S., Hill, R. J., Mackenty, J., Cawley, L., Knezek, P., Kutina, R., Lisse, C. M., *et al.*, 2000, ''Wide-Field Camera 3 for the Hubble Space Telescope,'' in Proc. SPIE 4013, 367-373, UV, Optical, and IR Space Telescopes and Instruments, J.B. Breckinridge and P. Jakobsen, Eds.

Clark, P. E., and McFadden, L. A. 2000, ''New Results and Implications for Lunar Crustal Iron Distribution Using Sensor Data Fusion Techniques,'' J. Geophys. Res. 105, E2, 4291 - 4316.

Colina, L., Alberdi, A., Torrelles, J. M., Panagia, N., & Wilson, A. S., 2001, ''Discovery of a Bright Radio Supernova in the Circumstellar Starburst of the Luminous Seyfert Galaxy NGC 7469,'' ApJL, 553, L19.

Collier, M. R., Moore, T. E., Ogilvie, K. W., Chornay, D., *et al.*, 2001, ''Observations of Neutral Atoms from the Solar Wind,'' J. Geophys. Res., in press.

Cooke, A. J., Baldwin, J. A., Ferland, G. J., Netzer, H., & Wilson, A. S., 2000, ''The Narrow Line Region in the Seyfert 2 Galaxy NGC 3393,'' ApJS, 129, 517.

Cooray, A. R., Quashnock, J. M., and Miller, M. C., 1999, ''Gravitational Lensing and the Hubble Deep Field,'' in After the Dark Ages: When Galaxies Were Young, proc. of the 9th Annual October Astrophysics Conference, eds. S. S. Holt and E. P. Smith, pp. 180-183.

Dermott S.F., Grogan K., Durda D.D., Jayaraman S., Kehoe T.J.J., Kortenkamp S.J., Wyatt M.C., 2001, ''Orbital evolution of interplanetary dust,'' in Interplanetary Dust, Grun E., Gustafson B.A.S., Dermott S.F., and Fechtig H., Eds., Springer-Verlag, Berlin.

Dupke, R. A., and Arnaud, K. A., 2001, ''Central Element Abundance Ratios in Perseus Cluster: Not Resonant Scattering But SNIa Enrichment,'' ApJ, 545, 922.

Fabian, A.C., Iwasawa, K., Reynolds, C.S., & Young, A.J., 2000, ''Broad Iron Lines in Active Galactic Nuclei,'' PASP, 112, 1145.

Falcke, H., Wilson, A. S., Henkel, C., Brunthaler, A., & Braatz, J., 2000, ''Hubble Space Telescope and Very Large Array Observations of the H_2O Gigamaser Galaxy TXS2226-184,'' ApJL, 530, L13.

Falcke, H., Henkel, C., Wilson, A. S., and Braatz, J. A., 2001, ''Host Galaxies and Nuclear Structure of AGN with H2O Megamasers as Seen with HST,'' Proceedings of Grenada Conference on Host Galaxies of Active Galactic Nuclei, in press.

Farley, D. R., Estabrook, K. G., Glendinning, S. F., Glenzer, S. H., Remington, B. A., Shigemori, K., Stone, J. M., *et al.*, ''A Radiative Jet of Astrophysical Interest Produced at the Nova Laser Facility,'' Physical Review Letters, 83, 1982.

Farnham, T. L., Schleicher, D. G., & A'Hearn, M. F., 2000, ''The HB Narrowband Comet Filters: Standard Stars and Calibrations,'' Icarus, 147, 180-204.

Ferruit, P., Wilson, A. S., Falcke, H., Simpson, C., Pécontal, E., & Durret, F., 1999, ''The Extended Emission Line Region of the Seyfert Galaxy Markarian 573,'' MNRAS, 309, 1.

Ferruit, P., Wilson, A. S., *et al.*, 1999, ''HST/FOS Spectroscopy of Spatially Resolved Narrow Line Regions in Seyfert Galaxies,'' ApJ, 523, 147.

Ferruit, P., Wilson, A. S., & Mulchaey, J. S., 2000, ''HST/WFPC2 Imaging of a Sample of Early-Type Seyfert Galaxies,'' ApJS, 128, 139.

Ferruit, P., Pécontal, E., & Wilson, A. S., 2000, ''3D Observations of Nearby Active Galaxies with the IFU TIGER,'' in ''Imaging the Universe in Three Dimensions: Astrophysics with Advanced Multi-Wavelength Imaging Devices,'' ASP Conference Series 195, Eds. W. van Breugel & J. Bland-Hawthorn, p 289.

Finkbeiner, F. M., Chen, T. C., *et al.*, 1999, ''Fabrication of Superconducting Bilayer Transition Edge Thermometers and Their Application for Spaceborne X-ray Microcalorimetry,'' Proc. Applied Supconductivity Conf. '98, IEEE

Trans. Appl. Supercond., vol. 9, 2, 2940-2942.

Fleming, H.J., and Hamilton, D. P., ''On the origin of the Trojan asteroids: Effects of Jupiter's mass accretion and radial migration,'' Icarus, 148, 479-493.

Fleming, T. P., Stone, J. M., & Hawley, J. F., 2000, ''The Effect of Resistivity on the Nonlinear Stage of the Magnetorotational Instability in Accretion Disks,'' ApJ, 530, 464.

Gondarenko, N. A., Guzdar, P. N., Milikh, G. M., Sharma, A. S., Papadopoulos, K., & Ossakow, S. L., 1999, ''Spatio-temporal Development of Filaments Due to the Thermal Self- focusing Instability Near the Critical Surface in Ionospheric Plasmas,'' Radio Sci. Quantum Elect., 42, 670.

Gondarenko, N. A., Papadopoulos, K., Milikh, G., Sharma, A. S., *et al.*, 2000, ''Diffraction Model of Ionospheric Irregularity-induced Heater-wave Pattern Detected on the WIND Satellite,'' Geophys. Res. Lett., 27, 3, 317-320.

Goodrich, C. C., Wiltberger, M., Lopez, R. E., Papadopoulos, K., & Lyon, J. G., 1999, ''Global MHD Simulation of Actual Magnetospheric Substorm Events,'' in Proc. International Conf. on Substorms, S. Kokubun (ed.), 645-649.

Grun, E., Hanner, M. S., Peschke, S. B., Muller, T., Bohnhardt, H., Brooke, T. Y., Campins, H., Crovisier, J., Delahodde, C., Heinrichsen, I., Keller, H. U., Knacke, R. F., Kruger, H., Lamy, P., Leinert, Ch., Lemke, D., Lisse, C. M., *et al.*, 2001, ''Broadband Infrared Photometry of Comet Hale-Bopp with ISOPHOT,'' A&A, accepted.

Grundahl, F., VandenBerg, D. A., Bell, R. A. *et al.*, 2000, ''A Distance-Independent Age for the Globular Cluster M92,'' AJ, in press.

Gurevich, A. V., and Milikh, G. M., 1999, ''Generation of X-rays Due to Multiple Runaway Breakdown Inside Thunderclouds,'' Phys. Lett. A., 262, 457-463.

Gurevich, A. V., Carlson, H. C., Milikh, G. M., & Zybin, K., 2000, ''Suprathermal Electrons Generated in the Ionosphere Modified by Powerful Radio Waves,'' Geophys. Res. Lett., 27, 2461-2464.

Guzdar, P. N., Gondarenko, N. A., Papadopoulos, K., Milikh, G. M., Sharma, A. S., *et al.*, 2000, ''Diffraction Model of Ionospheric Irregularity-induced Heater-wave Pattern Detected on the WIND Satellite,'' Geophys. Res. Lett., 26, 317.

Guzdar, P. N., Gondarenko, N. A., Papadopoulos, K., Milikh, G. M., Sharma, A. S., *et al.*, 1999, ''Diffraction Model of Ionospheric Irregularity-induced Heater-wave Pattern Detected on the WIND Satellite,'' Radiophysics Quantum Electronics, 42, 589-600.

Hamilton, D. P., 2001, ''Saturn: Saturated with satellites,'' Nature, in press.

Harrington, J. P., 2000, ''Planetary Nebula Central Star Mass Loss/Winds,'' in the Grove ''Encyclopedia of Astronomy and Astrophysics,'' Institute of Physics Publishing.

Harrington, J. P., and Borkowski, K. J., 2000, ''Searching for Jets in Asymmetrical Nebulae with the Hubble Space Telescope,'' in Asymmetrical Planetary Nebulae II: From Origins to Microstructures, eds. J. H. Kastner, N. Soker, S. Rappaport, APS Conference Series, Vol. 199, pp. 383-386.

Harris, A. I., ''Wideband Lag Correlator for Heterodyne Spectroscopy,'' in From X-rays to X- Band: Astrophysical Detectors and Detector Technology, STScI Proceedings, ed. C. Blades.

Harris, A. I., and Zmuidzinas, J., ''Wideband Lag Correlator for Heterodyne Spectroscopy,'' Rev. of Scientific Instruments, in press.

Hashimshony, D., Cohen, C., Zigler, A., & Papadopoulos, K., 1999, ''Generation of Tunable FIR Radiation by the Interaction of a Superluminous Ionizing Front with an Electrically Based Photoconductor,'' Applied Phys. Lett., 72, 12, 1669-1671.

Hashimshony, D., Zigler, A., & Papadopoulos, K., 2000, ''Minature Photoconducting Capacitor Array as a Source for Tunable THz Radiation.''

Hashimshony, D., Zigler, A., & Papadopoulos, K., 2000, ''Conversion of Electrostatic to Electromagnetic Waves by Super-luminous Ionization Fronts,'' Phys. Rev. Lett., in press.

Heap, S. R., Lindler, D. J., Lanz, T., *et al.*, 2000, ''STIS Coronographic Observations of β Pictoris,'' ApJ, 539, 435-444.

Hofner, P., Wyrowski, F., Walmsley, C. M.and Churchwell, E., 2000, ApJ, 536, 393.

Hollis, J. M., Lovas, F. J., & Jewell, P. R., 2000, ''Interstellar Glycolaldehyde: The First Sugar,'' ApJL, 540, L107.

Hollis, J. M., Pedelty, J. A., Forster, J. R., White, S. M., Boboltz, D. A., and Alcolea, J., 2000, ''R-Aquarii: Constraints on the Rotational Period of Long-Period Variable,'' ApJL, 543, L81.

Hollis, J. M., and Churchwell, E., 2001, ''Functional Molecular Groups on Interstellar Grains,'' ApJ, 551, 803.

Hollis, J. M., Boboltz, D. A., Pedelty, J. A., White, S. M., & Forster, J. R., 2001, ''R Aquarii: Evidence for Differential Rotation of the SiO Maser Shell,'' ApJL, in press.

Hollis, J. M., Vogel, S. N., Snyder, L. E., Jewell, P. R., & Lovas, F. J., 2001, ''The Spatial Scale of Glycolaldehyde in the Galactic Center,'' ApJL, 554, L81.

Houdashelt, M. L., Bell, R. A., & Sweigart, A. V., 2000, ''Improved Color-Temperature Relations for Cool Stars,'' AJ, 119, 1448.

Houdashelt, M. L., Bell, R. A., Sweigart, A. V., & Wing, R. F., 2000, ''Synthetic Spectra and Color-Temperature Relations of M Giants,'' AJ, 119, 1424.

Hudson, J. K., Elkington, S. R., Lyon, J. G., Goodrich, C. C., & Rosenberg, T. J., 1999, ''Simulation of the Radiation Connections,'' J. L. Burch *et al.* (eds.), Geophysical Monograph, 109, 171-182.

Hudson, M. K., Elkington, S. R., Lyon, J. G., & Goodrich, C. C., 2000, ''Increase in Relativistic Electron Flux in the Inner Magnetosphere: ULF Wave Mode Structure,'' Adv. Space Res., in press.

Hufnagel, B., Slater, T., Deming, G. L., Adams, J., Adrian, R., Brick, C., and Zeilik, M., 2000, ''Pre-Course Results from the Astronomy Diagnostics Test,'' Publications of the Astronomical Society of Australia, 17, 2.

Hurley, K., Kouveliotou, C., Cline, T., Cole, D., Miller, M. C., Harmon, A., Fishman, G., Briggs, M., van Paradijs, J., Kommers, J, and Lewin, W., 2000, ''Precise Interplanetary Network Localization of the Bursting Pulsar GRO J1744−28,'' ApJ, 537, 953-957.

Huettemeister, S., Aalto, S., Das, M., Wall, W. F., 2000, ''Changing Molecular Gas Properties in the Bar and Center of NGC 7479,'' A&A, in press.

Izenberg, N. R., Bell, J. F., III, Warren, J. W., Murchie, S. L., Peacock, K., Darlington, E. H., Carcich, B., Chapman, C., Clark, B. E., Harch, A., Heyler, G., Joseph, J., Martin, P., McFadden, L., Merline, B., Robinson, M., Veverka, J., Wellnitz, D., 2000, ''In-flight Calibration of the Near Earth Asteroid Rendezvous Mission's Near Infrared Spectrometer. I. Initial Calibrations,'' Icarus, Vol.148, No.2, p. 550-71.

Kaufman, M. J., Wolfire, M. G., Hollenbach, D. J., & Luhman, M. L., 1999, ''Far-Infrared and Submillimeter Emission from Galactic and Extragalactic Photodissociation Regions,'' ApJ, 527, 795.

Kaufman, M., Brinks, E., Elmegreen, B. G., Elmegreen, D. M., Klarić, M., Struck, C., Thomasson, M., & Vogel, S., 1999, ''The Interacting Galaxies NGC 5394/5395: A Post-Ocular Galaxy and Its Ring/Spiral Companion,'' AJ, 118, 1577.

Keller, John W., Chornay, D. J., *et al.*, 1999, ''A Gated Time-of-Flight Tophat Plasma Composition Analyzer for Space Physics Rsearch,'' Rev. Sci. Inst., 70, 3167.

Kortenkamp, S.J., Wetherill, G.W., Inaba, S., 2001, ''Runaway growth of planetary embryos facilitated by massive bodies in a protoplanetary disk,'' Science 293, 1127-1129.

Kortenkamp, S.J., Dermott, S.F., Fogle, D., Grogan, K., 2001, ''Sources and orbital evolution of interplanetary dust accreted by Earth,'' in Accretion of Extraterrestrial Matter Throughout Earth's Histor, Peucker-Ehrenbrink, B. and Schmitz, B., Eds., Kluwer, Dordrecht.

Kortenkamp, S.J., Kokubo, E., Weidenschilling, S., 2000, ''Formation of planetary embryos,'' in Origin of the Earth and Moon, Canup, R. and Righter, K., Eds. pp. 85-100, Univ. of Ariz. Press, Tucson.

Kortenkamp, S.J. and Wetherill, G.W., 2000, ''Terrestrial planet and asteroid formation in the presence of giant planets I. Relative velocities of planetesimals subject to Jupiter and Saturn perturbations,'' Icarus, 143, 60-73.

Krisha Swamy, K. S., and A'Hearn, M. F., 2000, ''On SO in Comets,'' Earth, Moon, and Planets, 84, 109-113.

Krüger, H., Grün, E., Landgraf, M., Baguhl, M., Dermott, S., Fechtig, H., Gustafson, B. A., Hamilton, D. P., *et al.*, 1995, ''Three years of Ulysses dust data: II. 1993 to 1995,'' Planet. Space Sci., 47, 363-383.

Krüger, H., Grün, E., Graps, A., Bindschadler, D., Dermott, S., Fechtig, H., Gustafson, B. A., Hamilton, D. P., *et al.*, ''One year of Galileo dust data from the Jovian system: 1996,'' Planet. Space Sci., in press.

Krüger, H., Grün, E., Landgraf, M., Dermott, S., Fechtig, H., Gustafson, B. A., Hamilton, D. P., *et al.*, ''Four years of Ulysses dust data: 1996 to 1999,'' Planet. Space Sci., in press.

Kundu, M. R., 1999, ''Radio Observations of Weak Coronal Transients,'' in Solar Physics with Radio Observations, eds. T. S. Bastian, N. Gopalswamy & K. Shibasaki, Nobeyama Radio Observatory, p. 111.

Kundu, M. R., White, S. M., Shabasaki, K., & Sakurai, T., 2000, ''Nonthermal Flare Emission from MeV-energy Electrons at 17, 34 and 86 GHz,'' ApJ, 545, 1084.

Kundu, M. R., White, S. M., Shabasaki, K., & Sakurai, T., 2000, ''Nonthermal Flare Emission from MeV-energy Electrons at 17, 34 and 86 GHz,'' in High Energy Solar Physics: Anticipating HESSI, eds. R. Ramaty & N. Mandzhavidze, ASP Conference Series (San Francisco), p. 307.

Kundu, M. R., and Grechnev, V. V., 2001, ''Seemingly Intersecting Flaring Loops in Microwaves: Possible Radio Evidence for Reconnection,'' Earth, Planets and Space, 53, 585.

Kundu, M. R., Nindos, A., White, S. M., & Grechnev, V. V., 2001, ''A Multiwavelength Study of Three Solar Flares,'' ApJ, 557, 880.

Kundu, M. R., Nindos, A., Vilmer, N., Klein, K.-L., Shibata, K., & Ohyama, M., 2001, ''Metric Radio Emission Associated With X-Ray Plasmoid Ejections,'' ApJ, 559, 443.

Kundu, M. R., White, S. M., Shibasaki, K., Sakurai, T., & Grechnev, V. V., 2001, ''Spatial Structure of Simple Spiky Bursts at Microwave/Millimeter Wavelengths,'' ApJ, 547, 1090.

Kundu, M. R., White, S. M., Shibasaki, K., & Raulin, J.-P., 2001, ''A Radio Study of the Evolution of Spatial Structure of an Active Region and Flare Productivity,'' ApJS, 133, 467.

Kundu, M. R., Grechnev, V. V., Garaimov, V. I., & White, S. M., 2001, ''Double Loop Configuration of a Flaring Region from Microwave, EUV and X-ray Imaging Data,'' ApJ, in press.

Kundu, M. R., 2001, ''Radio Observations of High Energy Solar Flares,'' IAU Trans., JD-7, in press.

Lake, G., Quinn, T., Richardson, D. C., and Stadel, J., 2000, ''Speedup to Virtual Petaflops Using Adaptive Potential Solvers and Integrators for Gravitational Systems,'' SPEEDUP, 12, 53-60.

Lake, G., Quinn, T., Richardson, D. C., and Stadel, J., 1999, ''Virtual Petaflops to Simulate Solar System Formation,'' High Performance Computing 1999: Grand Challenges in Computer Simulation Proceedings of the 1999 Advanced Simulation Technologies Conference (San Diego, CA, Apr 11-15,1999, pp. 128-131.

Lamb, F. K., Miller, M. C., and Psaltis, D., ''The Origin of Kilohertz QPOs and Implications for Neutron Stars,'' in Neutron Stars and Pulsars: Thirty Years After the Discovery, ed. N. Shibazaki *et al.*, (Tokyo: University Academy Press), p. 89.

Lamb, F. K., Miller, M. C., and D. Psaltis, 1998, ''Constraints on Neutron Star Matter From Kilohertz QPOs,'' in Nuclear Astrophysics, Proc. International Workshop XXVI on Gross Properties of Nuclei and Nuclear Excitations, ed. M. Buballa, W. Norenberg, J. Wambach, & A. Wirzba (GSI: Darmstadt), 114.

Lamb, F. K., Miller, M. C., and D. Psaltis, ''Rapid X-ray Variability of Neutron Stars in Binary Systems,'' in The Active X-ray Sky, eds. L. Scarsi, H. Bradt, P. Giommi, and F. Fiore (Amsterdam: Elsevier), p. 113.

Lamb, F. K., and Miller, M. C., ''Changing Frequency Separation of Kilohertz Quasi-Periodic Oscillations in the Sonic-Point Beat-Frequency Model,'' Astrophys. J. Lett., accepted.

Lanz, T., 2000, ''Stellar Atmospheres,'' The Encyclopedia of Astronomy and Astrophysics, Inst. of Physics Publ. & McMillan Publ.

Lee, J., White, S. M., Kundu, M. R., & Mikić, 1999, ''Active Region Emissions and Coronal Field Extrapolations,'' in Solar Physics with Radio Observations, eds. T. S. Bastian, N. Gopalswamy & K. Shibasaki, Nobeyama Radio Observatory, p. 59.

Lisse, C. M., Bingham, B., *et al.*, 1999, ''X-Ray Emission From Comet Hale-Bopp,'' Earth, Moon, and Planets, 77, No. 3, 283-291.

Lisse, C. M., Christian, D., *et al.*,1999, ''X-ray and Extreme Ultraviolet Emission from Comet 2P/Encke 1997,'' Icarus, 141, No. 2, 316-330.

Lisse, C. M., Christian, D. J., Dennerl, K., Meech, K., Petre, R., Weaver, H. A., & Wolk, A. J., 2001, ''First Detection of Cometary Charge Exchange Emission Lines from Comet C/LINEAR 1999 S4,'' Science, 292, 1343.

Loewenstein, M., Valinia, A., & Mushotzky, R., 2000, ''RXTE Investigation into Extended Hard X-ray Emission from Elliptical Galaxies,'' ApJ, 547, 722.

Loewenstein, M., 2000, ''Heating of Intergalactic Gas and Cluster Scaling Relations,'' ApJ, 532, 17.

Loewenstein, M., and White III, R. E., 1999, ''Prevalence and Properties of Dark Matter in Elliptical Galaxies,'' ApJ, 518, 50.

Loewenstein, M., Hayshida, K., Toneri, T, & Davis, D. S., 1998, ''On the Nature of the X-ray Emission from M32,'' ApJ, 497, 681.

Looney, L. W., Mundy, L. G., & Welch, W. J., 2000, ''Unveiling the Envelope and Disk: A Sub-arcsecond Survey,'' ApJ, 579, 477.

Looney, L. W., Mundy, L. G., & Welch, W. J., 2000, ''Unveiling the Envelope and Disk: A Sub-arcsecond Survey of Circumstellar Structure,'' ApJ, 529, 477.

Lopez, R. E., Goodrich, C. C., Lyon, J. G., & Papadopoulos, K., 1999, ''MHD Simulations of the Response of High-latitude Potential Patterns and Polar Cap Boundaries to Sudden Southward Turnings of the Interplanetary Magnetic Field,'' Geophys. Res. Lett., 26, 967-970.

Lopez, R. E., Goodrich, C., Wiltberger, M., & Lyon, J., 2000, ''Solar Wind - Magnetosphere Energy Coupling Under Extreme Interplanetary Conditions: MHD Simulations,'' J. Atm. Solar Terr. Physics, 865.

Main, D. S., Smith, D. M., Heindl, W.A., Swank, J., Leventhal, Mirabel, I. F.,and L.F.Rodriguez, 1999, ''Long-Term X-Ray Monitoring of 1E 1740.7-2942 and GRS 1758-258,'' ApJ, 525, 901-908.

Martel, A. R., Turner, N. J., Sparks, W. B., & Baum, S. A., 2000, ''Nuclear Gas and Dust Disks in Nearby 3CR Elliptical Galaxies,'' ApJS, 130, 267.

Mathys, G., Stehl, C., Brillant, S., & Lanz, T., 2000, ''The Physical Foundation of Stellar Magnetic Field Diagnosis from Polarimetric Observations of Hydrogen Lines,'' A&A, 358, 1151-1156.

McGaugh, S. S., 2000, ''BOOMERanG Data Suggest a Purely Baryonic Universe,'' ApJ, 541, L33-36.

McGaugh, S. S., Schombert, J. M., Bothun, G. D., & de Blok, W. J. G., 2000, ''The Baryonic Tully-Fisher Relation,'' ApJ, 533, L99-102.

McGaugh, S. S., and Schulman, E., 2000, ''Modified Newtonian Dynamics,'' Mercury, 29 (2), 8.

McGaugh, S. S., 2001, Galaxy Dynamics and the Second Peak: Col Dark Matter?,'' International Journal of Modern Physics A, in press.

McGaugh, S. S., 2001, ''Baryonic Tully-Fisher Relations,'' in Galaxy Disks and Disk Galaxies, eds. Funes, J. G., & Corsini, E. M., in press.

McLaughlin, S., 2000, Letter to the Editor: Call for CCD Observations of Comet 9P/Tempel 1. International Comet Quarterly, Vol. 22, No. 2, 35.

McLaughlin, S., 2000, Small Telescope Science Program, NASA Deep Impact Mission. 196th Meeting of the AAS, Pro-Am Collaborations Session, June 5, 2000.

McMullin, J. P., Mundy, L. G., *et al.*, 2000, ''A Spectral Line Study of the Serpens S68 FIRS1 Region,'' ApJ, 536, 845.

McNutt, R. L., Lyon, J., & Goodrich, C. C., 1999, ''Simulation of the Heliosphere: Generalized Charge-Exchange Cross Sections,,'' J. Geophys. Res., 104, 14,803-14,810.

Milikh, G. M., Papadopoulos, K., McCarrick, M., & Preston, J., 1999, ''ELF Emission Generated by the HAARP HF-Heater Using Varying Frequency and Polarization,'' Radiophysics & Quantum Electrons, 42, 639-646.

Miller, M. C., 2001, ''Small-Scale Structure Deduced from X-and γ-ray Timing Measurements,'' Pub. Astr. Soc. Pacific, in press.

Miller, M. C., ''Beat-Frequency Models of Kilohertz QPOs,'' Astrophysical Letters and Communications, accepted.

Miller, M. C., 2000, ''Reionization Constraints on the Contribution of Primordial Compact Objects to Dark Matter,'' ApJ, 544, 43-48.

Miller, M. C., 2000, ''Attenuation of Beaming Oscillations Near Neutron Stars,'' ApJ, 537, 342-350.

Miller, M. C., 2000, ''A Characterization of the Brightness Oscillations During Thermonuclear Bursts from 4U 1636−536,'' ApJ, 531, 458-466.

Miller, M.C., and Hamilton, D. P., 2001, ''Implications of the PSR+12 Planetary System for Isolated Millisecond Pulsars,'' ApJ, 550, 863-870.

Miller, M.C., & Ostriker, E.C., 2001, ''Suppression of Gravitational Structure Formation by Cosmological Accretion Heating,'' ApJ, in press.

Moore, T. E., Chornay, D., *et al.*, 2000, ''The Low Energy Neutral Atom Imager for the IMAGE Mission,'' Space Sci. Rev., 91, 155-195.

Moore, T. E., Collier, M. R., Burch, J. L., Chornay, D. J., *et al.*, 2001, ''Low Energy Neutral Atoms in the Magnetosphere,'' Geophys. Res. Lett., in press.

Mundell, C. G., Wilson, A. S., Ulvestad, J. S., & Roy, A. L., 2000, ''Parsec-Scale Images of Flat-Spectrum Radio Sources in Seyfert Galaxies,'' ApJ, 529, 816.

Mundell, C. G., Wilson, A. S., Ulvestad, J. S., & Roy, A. L., 2001, ''The Nature of Flat- Spectrum Nuclear Radio Emission in Seyfert Galaxies,'' in ''Galaxies and their Constituents at the Highest Angular Resolutions,'' IAU

Symposium No. 205, Eds. R. Schilizzi, S. Vogel, F. Paresce & M. Elvis, ASP Conf. Series, in press.

Mushotzky, R. F., Cowie, L. L., Barger, A. J., & Arnaud, K. A., 1999, ''Resolving the Extragalactic Hard X-ray Background,'' Nature, 404, 459.

Neugebauer, M., Cravens, T. E., Lisse, C. M., *et al.*, 2000, ''Time Variabilities of Solar Wind Ion Fluxes and of X-ray and EUV Emissions From Comet Hyakutake,'' JGR, 105, 20949-20955.

Ng, C. K., Reames, D. V., & Tylka, A. J., 1999a, ''Effect of Proton-amplified Waves on the Evolution of Solar Energetic Particle Composition in Gradual Events,'' Geophys. Res. Letters, 26, 2145-2148.

Ng, C. K., Reames, D. V., & Tylka, A. J., 1999b, ''A Model for the Evolution of the Elemental Abundances of Solar Energetic Particles,'' Proc. 26th Int. Cosmic Ray Conf., Salt Lake City, 6, 151-154.

Ng, C. K., Reames, D. V., & Tylka, A. J., 2000, ''Effects of Wave Generation on the Evolution of Elemental Abundances,'' in High Energy Astrophysics Anticipating HESSI, eds. R. Ramaty & N. Mandzhavidze, ASP, p. 162.

Nindos, A., Kundu, M. R., Raulin, J.-P., Shibasaki, K., White, S. M., Nitta, N., Shibata, K., & Shimojo, M., 1999, ''A Microwave Study of Coronal and Chromospheric Ejecta,'' in Solar Physics with Radio Observations, eds. T. S. Bastian, N. Gopalswamy & K. Shibasaki, Nobeyama Radio Observatory, p.135.

Nindos, A., Kundu, M. R., White, S. M., Gary, D. E., Shibasaki, K., & Dere, K., 1999, ''Microwave and Extreme Ultraviolet Observations of Solar Polar Regions,'' ApJ., 527, 415.

Nindos, A., Kundu, M. R., & White, S. M., 2000, ''Soft X-ray and Gyroresonance Emission Above Sunspots,'' ApJS, 130, 485.

Nindos, A., Kundu, M. R., & White, S. M., 2000, ''Soft X–ray and Gyroresonance Emission Above Sunspots,'' in High Energy Solar Physics: Anticipating HESSI, eds. R. Ramaty & N. Mandzhavidze, ASP Conference Series (San Francisco), p. 359.

Nindos, A., White, S. M., Kundu, M. R., & Gary, D. E., 2000, ''Observations and Models of a Flaring Loop,'' ApJ, 533, 1053.

Nindos, A., White, S. M., Kundu, M. R., & Gary, D. E., 2000, ASP Conf. Series 206: High Energy Solar Physics Workshop - Anticipating HESS!, 359.

Nixon, C. A., Irwin, P. G. J., Calcutt, S. B., Taylor, F. W., & Carlson, R. W., 2000, ''Atmospheric Compositon and Cloud Structure in Jovian 5 μm Hotspots from Analysis of Galileo NIMS Measurements,'' Icarus, in press.

Ogilvie, K. W., Burlaga, L. F., Chornay, D. J., & Fitzenreiter, R. J., 1999, ''Sources of the Solar Wind Electron Strahl in 1995, '' Journal of Geophysical Research, 104, 22389.

O'Neil, K., Verheijen, M. A. W., & McGaugh, S. S., 2000, ''Star Formation and Tidal Encounters with the Low Surface Brightness Galaxy UGC 12695 and Companions,'' AJ, 119, 2154-2165.

Orgel, L., A'Hearn, M., Bada, J., *et al.*, 2000, Adv. Space Res., 25, 239-248.

Orr, A., Barr, P., Guainazzi, M., Parmar, A.N., & Young, A.J., 2001, ''BeppoSAX Spectroscopy of MR 2251-178: A Test for Ionized Reflection in Radio Quiet QSOs,'' A&A, in press.

Ostriker, E. C., Gammie, C. F., & Stone, J. M., 1999, ''Kinetic and Structural Evolution of Self-Gravitating, Magnetized Clouds: 2.5-Dimensional Simulations of Decaying Turbulence,'' ApJ, 513, 259.

Ostriker, E. C., Stone, J. M., & Gammie, C. F., 2001, ''Density, Velocity, and Magnetic Field Structure in Turbulent Molecular Cloud Models,'' ApJ, 546, 980-1005.

Papadopoulos, K., Goodrich, C. C., Wiltberger, M., Lopez, R. E., & Lyon, J. G., 1999, ''The Physics of Substorms as Revealed by the ISTP,'' Physics & Chemistry of the Earth, 24, 1-3, 189-202.

Peschke, S. B., Gruen, E., Bohnhardt, H., Campins, H., Osip, D. J., Hanner, M. S., Heinrichsen, I., Knacke, R., Leinert, Ch., Lemke, D., Lisse, C. M., *et al.*, 1999, ''ISOPHOT Observations of Comet Hale-Bopp,'' Earth, Moon, and Planets, 78:1-3, 299-304.

Phillips, R. R., Gibb, A. G., Little, L. T., 2001, "Dense Cores in L1630 Molecular Cloud: Discovering New Protostars with SCUBA," MNRAS, 326, 927.

Proga, D., Stone, J. M., & Drew, J. E., 1999, ''Line-driven Disk Wind Models with an Improved Line Force,'' MNRAS, 310, 476.

Proga, D., Stone, J. M., & Kallman, T., 2000, ''Dynamics of line-driven disk winds in Active Galactic Nuclei,,'' ApJ, 543, 686.

Psaltis, D., Wijnands, R., Homan, J., Jonker, P. G., van der Klis, M., Miller, M. C., Lamb, F. K., Kuulkers, E., van Paradijs, J., and Lewin, W. H. G., 1999, ''On the Magnetospheric Beat-Frequency and Lense-Thirring Interpretations of the Horizontal Branch Oscillations in Z Sources,'' ApJ, 520, 763-775.

Ramirez, S. V., Sellgren, K., Carr, J. S., Balachandran, S. C., Blum, R., Terndrup, D. M., & Steed, A., 2000, ''Stellar Iron Abundances at the Galactic Center,''ApJ, 537, 205.

Randich, S., Pallavicini, R., Meola, G., Stauffer, J. R., & Balachandran, S. C., 2001, ''Membership, lithium and metallicity in the young open clusters IC2602 and IC 2391: Enlarging the sample,''A&A, 372, 862.

Reames, D. V., Ng, C. K., & Tylka, A. J., 1999, ''Energy-dependent Ionization States of Shock- accelerated Particles,'' Geophys. Res. Letters, 26, 3585-3588.

Reames, D. V., Ng., C. K., & Tylka, A. J., 2000, ''Heavy Ion Abundances and Spectra and the Large Gradual Solar Energetic Particle Event of 2000 July 14,'' ApJ, 548, L233.

Reames, D. V., Ng, C. K., & Tylka, A. J., 2001, ''Initial Time Dependence of Abundances in Solar Energetic Particle Events,'' ApJ, 531, L83.

Reames, D. V., Ng, C. K., & Berdichevsky, D., 2001, ''Angular Distributions of Solar Energetic Particles,'' in press.

Richardson, D. C., 2001, ''Giants in the Asteroid Belt,'' Nature, 411, 899-900.

Richardson, D. C., Quinn, T., Stadel, J., and Lake, G., 2000, ''Direct Large-scale N-body Simulations of Planetesimal Dynamics,'' Icarus, 143, 45-59.

Richardson, I. G., *et al.*, 2000, ''Bidirectional Particle Flows at Cosmic Ray and Lower ($\sim$ 1 MeV) Energies, and

Their Association with Interplanetary CMEs/Ejecta,'' J. Geophys. Res., 105, 12,579.

Richardson, I. G., Cliver, E. W., & Cane, H. V., 2000, ''Sources of Geomagnetic Activity Over the Solar Cycle: Relative Importance of CMEs, High-speed Streams, and Slow Solar Wind,'' J. Geophys. Res., 105, 18,203.

Richardson, I. G., *et al.*, 2000, ''Solar-cycle Variation of Low Density Solar Wind during More Than Three Solar Cycles,'' Geophys. Res. Lett., 2, 3761.

Riess, A. G., Veilleux, S., *et al.* 2001, ''The Farthest Known Supernova. Support for an Accelerating Universe and a Glimpse of the Epoch of Deceleration, ApJ, in press.

Roettiger, K., Stone, J. M., & Burns, J. O., 1999, ''Magnetic Field Evolution in Merging Clusters of Galaxies,'' ApJ, 518, 594.

Roettiger, K., Burns, J. O., & Stone, J. M., 1999, ''A Cluster Merger and the Origin of the Extended Radio Emission in A3667,'' ApJ, 518, 603.

Roos-Serote, M., Vasavada, A. R., Kamp, L., Drossart, P., Irwin, P., Nixon, C., & Carlson, R. W., 2000, ''Proximate Humid and Dry Regions in Jupiter's Atmosphere Indicate Complex Local Meteorology,'' Nature, 405, 158-160.

Rosa, R. R., Sharma, A. S., & Valdivia, J. A., 1999, ''Characterizations of Asymmetric Fragmentation Patterns in Spatially Extended Systems,'' Intern. J. Mod. Phys. C, 10, 147.

Rose, W. K. 2000, in Cosmic Explosions, edited by S. S. Holt and W. W. Zhang (AIP: Woodbury), p. 169.

Rose, W. K. 2001, in Young Supernova Remnants, edited by S. S. Holt and U. Hwang (AIP: Melville), in press.

Roy, A. L., Ulvestad, J. S., Wilson, A. S., Colbert, E. J. M., *et al.*, 1999, ''Free-free Absorption on Parsec Scales in Seyfert Galaxies,'' in ''Perspectives in Radio Astronomy: Imperatives at cm and m Wavelengths,'' p173, Ed M.P. van Haarlem, (Dwingeloo: NFRA).

Roy, A. L., Ulvestad, J. S., Wilson, A. S., Colbert, E. J. M., 2001, ''Slow Jets in Seyfert Galaxies: NGC 1068,'' in Proc. of the 5th EVN Symposium, Ed. J. E. Conway, in press.

Roy, A. L., Wrobel, J. M., Wilson, A. S., *et al.* 2001, ''Parsec Scale Jets and Tori in Seyfert Galaxies,'' in ''Galaxies and their Constituents at the Highest Angular Resolutions,'' IAU Symposium No. 205, Eds. R. Schilizzi, S. Vogel, F. Paresce, & M. Elvis, ASP Conf. Ser., in press.

Safi-Harb, S., Petre, R., Arnaud, K. A., Keohane, J. W., Borkowski, K. J., Dyer, K. K., Reynolds, S. P., and Hughes, J. P., ''A Broadbrand X-ray Study of the Young SNR 3C397,''ApJ, 545, 922.

Sage, L. J., 1999, ''Second Light: Remarkable Increase in the Sun's Magnetic Field,'' JRASC, 93, 167.

Sage, L. J., 1999, ''Second Light: Measuring Galactic Distances,'' JRASC, 93, 214.

Sage, L. J.,1999, ''Second Light: Moons of Asteroids,'' JRASC, 93, 260.

Sage, L. J., 2000, ''Second Light: Detecting Other Planets,'' JRASC, 94, 19.

Sage, L. J., 2000, ''Second Light: Thunderstorms on Jupiter,'' JRASC, 94, 54.

Sage, L. J., 2000, ''Second Light: X-ray Background Explained,'' JRASC, 94, 93.

Sage, L. J., 2000, ''The Stellar Fuel,'' Nature, 404, 717.

Schilizzi, R. T., Vogel, S. N., Paresce, F., and Elvis, M. S., 2001, (editors) Galaxies and their Constituents at the Highest Angular Resolutions, IAU Symposium No. 205, Astronomical Society of the Pacific, in press.

Schilke, P., Menten, K. M., Wyrowski, F. and Walmsley, C. M., 2000, ''Astrochemistry: from Molecular Clouds to Planetary Systems,'' IAU Symposium No. 197, eds. Y. C. Minh and E. F. van Dishoeck, Sogwipo, Korea, p. 125-133.

Schlegel, E. M., Petre, R., & Loewenstein, M., 1998, ''ROSAT Observations of X-ray Faint SO Galaxies: NGC 1380,'' AJ, 115, 524.

Sharma, A. S., Sitnov, M. I., & Papadopoulos, K., 2001, ''Substorms as Nonequilibrium Transitions of the Magnetosphere,'' J. Atmos. Solar Terr. Phys., in press.

Shopbell, P. L., Veilleux, S., and Bland-Hawthorn, J., 1999, ''A Very Extended Ionized Nebula around the Quasar MR2251-178,'' proceedings from the Walnut Creek meeting on Imaging the Universe in Three Dimensions, eds. W. van Breugel and J. Bland-Hawthorn, p. 404.

Shu, F.H., Allen, A., Shang, H., Ostriker, E.C., & Li, Z.-Y. 1999, ''Low-Mass Star Formation: Theory,'' in The Origin of Stars and Planetary Systems, eds. C. J. Lada & N.D. Kylafis (Dordrecht: Kluwer), pp. 193-223.

Sitnov, M. I., Malova, H. V., & Sharma, A. S., 1999, ''Linear Stability of a Tearing Mode in a Quasineutral Plasma,'' Plasma Physics Reports, 25, 277.

Sitnov, M. I., Sharma, A. S., Papadopoulos, K., Vassiliadis, D., *et al.*, 2000, ''Phase Transition- like Behavior of Magnetospheric Substorms,'' J. Geophys. Res., 105, 12,955.

Sitnov, M. I., Zelenyi, L. M., Malova, H. V., & Sharma, A. S., 2000, ''Thin Current Sheet Embedded within a Thicker Plasma Sheet: Self-consistent Theory,'' J. Geophys. Res., 105, 13,029.

Smith, D. A., Georgantopoulos, I., & Warwick, R. S., ''Variable X-ray Absorption in the Seyfert 2 Galaxy Mrk 348,'' ApJ, 550, 635, 2001.

Smith, D. A., & Wilson, A. S., 2001, ''A *Chandra* Observation of the Circinus Galaxy,'' ApJ, 557, 180.

Smith, D. A., Wilson, A. S., Arnaud, K. A., Tersashima, Y., & Young, A. J., 2001, ''A Chandra X-ray Study of Cygnus A - III. The Cluster of Galaxies,'' ApJ, in press.

Sridharan, T. K., Menten, K. M., Wyrowski, F. and Schilke, P., 1999, ''Star Formation 1999,'' in Proceedings of Star Formation 1999, held in Nagoya, Japan, June 21 - 25, 1999, ed. T. Nakamoto, Nobeyama Radio Observatory, p. 183-184, 183.

Stadel, J., Wadsley, J., and Richardson, D. C., 2001, ''High Performance Computational Astrophysics with PKDGRAV/GASOLINE,'' in High Performance Computing Systems and Applications 2000, Kluwer Academic Publishers, in press.

Staguhn, J., Harris, A. I., & Mundy, L. G., ''A Wideband Multicannel Radiometer for Phase Delay Correction,'' in Imaging at Radio through Submillimeter Wavelengths, Ed. J. Mangum, ASP Conf. Series.

Stahle, C. K., Finkbeiner, F. M., *et al.*, 2000, ''First Results from Mo/Au Transition-Edge Sensor X-ray Calorimeters,,'' Nucl. Instr. Methods Sec. A, 444, 224-227.

Stern, S. A., Slater, D. C., Festou, M. C., Parker, J. Wm., Gladstone, G.-R., A'Hearn, M. F., &Wilkinson, E., 2000, ''The Discovery of Argon in Comet C/1995 O1 (Hale-Bopp),'' ApJ, 544, L169-L172.

Stone, J. M., 1999, ''The ZEUS Code for Astrophysical Magnetohydrodynamics: New Extensions and Applications,'' Journal of Computational and Applied Mathematics, 109, 261.

Stone, J. M., Pringle, J. E., & Begelman, M. C., 1999, ''Hydrodynamic Non-Radiative Accretion Flows in Two-Dimensions,'' MNRAS, 310, 1002.

Stone, J. M., 1999, ''Simulations of MHD Turbulence in Giant Molecular Clouds,'' in Numerical Astrophysics, Astrophysics and Space Science Library Vol. 240, ed. by S. Miyama, K. Tomisaka, & T. Hanawa (Kluwer: Dordrecht), p. 99.

Stone, J. M., Gammie, C. F., Balbus, S. A., & Hawley, J. F., 2000, ''Transport Processes in Protostellar Disks,'' in Protostars and Planets IV, ed. by V. Mannings, A. Boss, & S. Russell, (Tucson: U. of Arizona Press), p. 589.

Stone, J. M., and Hardee, P. E., 2000, ''MHD Models of Axisymmetric Protostellar Jets,'' ApJ, 540, 192.

Stone, J. M., Turner, N., Estabrook, K., Remington, B., Farley, D., Glendinning, S. G., & Glenzer, S., 2000, ''Testing Astrophysical Radiation Hydrodynamics Codes with Hypervelocity Jet Experiments on the Nova Laser,'' ApJS, 127, 497.

Terashima, Y., and Wilson, A. S., 2001, ''A Chandra Observation of M51: Active Nucleus and Nuclear Outflows,'' ApJ, in press.

Terashima, Y., and Wilson, A. S., 2001, ''A Chandra Observation of M51: Nucleus, Nuclear Outflows, and X-ray Source Populations,'' in Yokohama Conf. on X-ray Astronomy, in press.

Theison, D., 2000, ''The Mars Room': A Campus-Wide Bioastronomy Project,'' in Bioastronomy '99: A New Era in Bioastronomy, ASP.

Theison, D., 2000, ''Reader Dialouge Sheets: Encouraging Student Interaction with Required Reading Assignments,'' Cosmos in the Classroom 2000, Ed. Andrew Fraknoi, ASP.

Theison, D., 2000, ''The Cultural Significance of Astronomy: An Interdisciplinary Course,'' Cosmos in the Classroom 2000, Ed. Andrew Fraknoi, ASP.

Theison, D., 2000, ''Astrobiology Bibliography: An Annotated List of Recent Books (1990 - present) on Extraterrestrial Life and Intelligence,'' Cosmos in the Classroom 2000, Ed. Andrew Fraknoi, ASP.

Theison, D., 2000, ''An Upper Level Astrobiology Class with Discussion Sections,'' Cosmos in the Classroom 2000, Ed. Andrew Fraknoi, ASP.

Thejappa, G., and MacDowall, R. J., 2000, ''Langmuir Waves in the Vicinity Of Interplanetary Shocks and Consequences for Type II Burst Models,'' ApJ, 544, L163-L167.

Thejappa, G., and MacDowall, R. J., 2000, ''Ulysses observations of nonlinear wave-wave interactions in the source regions of type III solar radio bursts, '' J. Astrophys. Astron., 21, 447.

Thejappa, G., and MacDowall, R. J., 2001, ''Fragmented structure of interplanetary type II bursts,'' J. Geophys. Res., Vol. 106, (in press).

Thejappa, G., and MacDowall, R. J., 2001, ''In Situ Wave Phenomena Associated with Magnetic Clouds and Other Ejects,'' Space Sci. Rev., (in press).

Trimble, V., 1999, ''White Dwarfs in the 1990s,'' BASI, 27, 549.

Trimble, V., 1999, ''A Century of Drivers of Astronomical Progress,'' J. Ast. Hist. & Heritage, 2, 81.

Trimble, V., 1999, ''99 Things About the Last 100 Years of Astronomy,'' Mercury, 28, No. 6, 16.

Trimble, V., 1999, ''The Gunn-Peterson Effect,'' ApJ, 525, 1C, 1073.

Trimble, V., 1999, ''C-to-Z Physics,'' BeamLine, 29, No. 2, 34.

Trimble, V., 1999, ''Astrophysics Faces the Millennium: part I,'' BeamLine, 29, No. 3, 28.

Trimble, V., 2000, ''Looking Backward,'' Sky & Telescope, 99, No. 1, 50.

Trimble, V., 2000, ''A Year of Discovery: Astronomy Highlights of 1999,'' Sky & Telescope, 99, No. 2, 28.

Trimble, V., 2000, ''The First Explosions,'' in Cosmic Explosions, S. S. Holt & W. W. Zhang (eds.), AIP Conf. Ser. 522, 3.

Trimble, V., 2000, ''The Immutability of the Heavens,'' PASP, 112, 1.

Trimble, V., 2000, ''Some Characteristics of Young vs. Established Astronomers, Entering the New Century,'' Scientometrics, 48, 403.

Trimble, V., 2000, ''The Stained and Spotted Heavens (Astrophysics Faces the Millennium, Part II),'' BeamLine, 30, No. 1, 26.

Trimble, V., 2000, ''The Ratios of Small Whole Numbers: Misadventures in Astronomical Quantization (Ap/Millennium, Part III),'' BeamLine, 30, No. 2, 49.

Trimble, V., 2001, ''Stellar, Stellar Bang Bang (AP/Millennium, Part IV),'' BeamLine, 31, No. 1, 28.

Trimble, V., 2001, ''A Year of Discovery: Astronomy Highlights of 2000,'' Sky & Telescope, 101, No. 2, 50.

Trimble, V., 2001, ''Astrophysics Faces the Millennium,'' Johns Hopkins Applied Physics Laboratory Technical Digest, 22, No. 1, 59.

Trimble, V., 2001, ''Chemical Evolution Tomorrow,'' in Origin of Elements in the Solar System, Ed. O. K. Manuel, Kluwer/Plenum, p. 175.

Trimble, V., 2001, ''The First Lenses,'' in Gravitational Lensing: Recent Progress and Future Prospects, T. G. Brainerd & C. A. Kochanek (Eds.), ASP Conf. Ser., in press.

Trimble, V., 2001, ''Eschatology of Stellar Collisions,'' in Stellar Collisions and Mergers, M. Shara (ed.), ASP Conf. Ser., in press.

Trimble, V., 2001, ''Pineapples and Crabs: When Young SNRs were Even Younger,'' in Young Supernova Remnants, S. S. Holt & U. Hwang (Eds.), AIP Conf. Proc. 565, 3.

Trimble, V., 2001, ''Cecilia Payne-Gaposchkin and the Rest of the Universe,'' in The Starry Universe, O. Gingerich (ed.), L. Davis Press, in press.

Trimble, V., 2001, ''The Quest for the Edge of the Universe,'' in Historical Development of Modern Cosmology, V. Martinez *et al.* (Eds.), ASP Conf. Ser., in press.

Trimble, V., 2001, ''Binary Stars: Overview,'' in IOP Encyclopedia of Astronomy and Astrophysics, Vol. 1, 180-185.

Trimble, V., and Aschwanden, M., 2000, ''Astrophysics in 1999,'' PASP, 112, 434.

Trimble, V., and Aschwanden, M., 2001, ''Astrophysics in 2000,'' PASP, 113, 1025.

Trimble, V., and Hoskin, M. A., 2001, ''Astronomical Societies and Publications,'' in IOP Encyclopedia of Astronomy and Astrophysics, Vol. 1, 120-124.

Turner, N. J., and Smith, G. H., 1999, ''300-580 nm Long-Slit Spectroscopy of Comet Tabur (1996Q1),'' AJ, 118, 3039.

Turner, N. J., & Stone, J. M., 2001, ''A Module for Radiation Hydrodynamic Calculations in ZEUS-2D using Flux-Limited Diffusion,'' ApJS, 135, 95.

Tylka, A. J., Boberg, P. R., McGuire, R. E., Ng, C. K., & Reames, D. V., 2000, ''Temporal Evolution in the Spectra of Gradual Solar Energetic Particle Events,'' in Acceleration and Transport of Energetic Particles Observed in the Heliosphere,'' eds. R. A. Mewaldt, J. R. Jokipii, M. A. Lee, E. Mobius, & T. H. Zurbuchen, New York: New York, p. 147.

Ulvestad, J. S., Wrobel, J. M., Roy, A. L., Wilson, A. S., Falcke, H., & Krichbaum, T. P., 1999, ''Sub-Relativistic Radio Jets and Parsec-Scale Absorption in Two Seyfert Galaxies,'' ApJL, 517, L81.

Unger, S. J., Clegg, P. E., Stacey, G. J., Cox, P., Fischer, J., Greenhouse, M., Lord, S. D., Luhman, M. L., Satyapal, S., Smith, H. A, Spinoglio, L., & Wolfire, M., 2000, ''ISO-LWS Spectroscopy of Centaurus A: Extended Star Formation,'' 2000, A&A, 355, 885.

Valdivia, J. A., Vassiliadis, D., Klimas, A. J., Sharma, A. S., & Papadopoulous, K., 1999, ''The Spatio-temporal Structure of Magnetic Storms,'' J. Geophys. Res., 104, 12,239.

Valdivia, J. A., Vassiliadis, D., Klimas, A. J., & Sharma, A. S., 1999, ''Modeling the Spatial Structure of the High Latitude Magnetic Perturbations and the Related Current Systems,'' Phys. Plasmas, 6, 4185.

Valdivia, A., Vassiliadis, D., Klimas, A. J., & Sharma, A. S., 2001, ''Near Real Time Prediction of the High Latitude Magnetic Perturbations (HLMP),'' J. Geophys. Res., 106, in press.

Valinia, A., Tatischeff, V., Arnaud, K., Ebisawa, K., & Ramaty, R., ''On the Origin of the Iron K Line in the Spectrum of the Galactic X-ray Background,'' ApJ, 543, 733.

Valinia, A., Arnaud, K., Loewenstein, M., Mushotzky, R.F., & Kelley, R., 2000, ''Hard X-ray Observations of Abell 496,'' ApJ, 541, 550.

Valinia, A., Henriksen, M. J., Loewenstein, M., Roettiger, K., Mushotzky, R. F., & Madejski, G., 1999, ''Rossi X-ray Timing Explorer Hard X-Ray Observations of A754: Constraining the Hottest Temperature Component and the Intracluster Magnetic Field,'' ApJ, 515, 42.

van Putten, M.H.P.M, & Ostriker, E. C., 2001, ''Hyper- and suspended-accretion states of rotating black holes and the durations of gamma-ray bursts,'' ApJL, 552, L31-L34.

Vázquez-Semadeni, E., Ostriker, E., Passot, T., Gammie, C., & Stone, J. 2000, ''Compressible MHD turbulence and the ISM: Implications for Molecular Cloud and Star Formation,'' in Protostars and Planets IV, eds. V. Mannings, A. Boss, & S. Russell, Tucson: The University of Arizona Press, pp.3-28.

Veilleux, S., 1999, ''Highlights: Optical/NIR Spectroscopy of Ultraluminous Infrared Galaxies,'' review presented at the Ringberg Meeting on Ultraluminous Infrared Galaxies: Monsters or Babies?, Ap&SS, 67-72.

Veilleux, S., 1999, ''Fabry-Perot Imaging Spectroscopy of Starburst an AGN Winds,'' review presented at the Walnut Creek meeting on Imaging the Universe in Three Dimensions, eds. W. van Breugel and J. Bland-Hawthorn, p. 277.

Veilleux, S., Bland-Hawthorn, J., & Cecil, G. 1999, ''A Kinematic Link between Boxy Bulges, Stellar Bars, and Nuclear Activity in NGC 3079 and NGC 4388,'' A. J., 118, 2108.

Veilleux, S., 2000, ''The Starburst-AGN Connection,'' proceedings of the Ringberg Meeting on Starburst Galaxies: Near and Far held in September 2000, in press.

Veilleux, S., Cecil, G., Bland-Hawthorn, J., & Shopbell, P. L., 2001, ''New Results from a Survey of Galactic Winds in Nearby Active Galactic Nuclei,'' proceedings of the international workshop on ''Line Emission from Jet Flows'' held on Isla Mujeres in November 2000, in press.

Veilleux, S., 2001, ''The QSO - Ultraluminous Infrared Galaxies Connection,'' proceedings of the international workshop on ''QSO Hosts and their Environments'' held in Granada, Spain in January 2001.

Veilleux, S., 1999, ''Turbulence in a Nearby Twin,'' Sky and Telescope, Vol. 98, No. 3, 56.

Veilleux, S., 2001, ''Spectroscopic Diagnostics for IR-Selected AGNs'', proceedings of IAU Colloquium 184, Byurakan, Armenia. (invited review)

Veilleux, S., Cecil, G.N., & Bland-Hawthorn, J. 2000, ''Colossal Galactic Explosions,'' in Scientific American: Book of the Cosmos, Chap. 3, pp. 83–90 (Macmillan: New York), ed. D. Levy.

Vennes, S., Polomski, E., Thorstensen, J. R., Lanz, T., Chayer, P., & Gull, T., 2000, ''Hubble Space Telescope STIS Observations of the Hot White Dwarf in the Close Binary Feige 24,'' ApJ, 544, 423-436.

Veverka, J., Robinson, M., Thomas, P., Murchie, S., Bell, J. F., III, Izenberg, N., Chapman, C., Harch, A., Bell, M., Carcich, B., Cheng, A., Clark, B., Domingue, D., Dunham, D., Farquhar, R., Gaffey, M. J., Hawkins, E., Joseph, J., Kirk, R., Li, H., Lucey, P., Matin, M., Martin, P., McFadden, L., Merline, W. J., Miller, J. K., Owen, W. M., Jr., Peterson, C., Prockter, L., Warren, J., Wellnitz, D., Williams, B.G., Yeomans, D. K., 2000, ''NEAR at Eros: Imaging and Spectral Results,'' Science, Vol. 289, No. 5487 p. 2088-97.

Veverka, J., Thomas, P.C., Robinson, M., Murchie, S., Chapman, C., Bell, M., Harch, A., Merline, W. J., Bell, J. F., III, Bussey, B., Carcich, B., Cheng, A., Clark, B., Domingue, D., Dunham, D., Farquhar, R., Gaffey, M. J., Hawkins, E., Izenberg, N., Joseph, J., Kirk, R., Li, H., Lucey, P., Malin, M., McFadden, L., Miller, J. K., Owen, W. M., Jr., Peterson, C., Prokter, L., Warren, J., Wellnitz, D., Williams, B.G., Yeomans, D. K., 2001, ''Imaging of Small-scale Features on 433 Eros from NEAR: Evidence for a Complex Regolith,'' Science, Vol. 292, No. 5516, p. 484-8.

Vogel, S. N. *et al.*, 1999, ''A 62-field Mosaic of CO Emission from the Grand Design Spiral M51,'' Science with the Atacama Large Millimeter Array (ALMA), Associated Universities, Inc., held October 6-8, 1999 at Carnegie Institution of Washington, E66.

Weaver, K. A., Wilson, A. S., Henkel, C., & Braatz, J. A., 1999, ''X-ray Emission from the Prototypical LINER Galaxy NGC 1052,'' ApJ, 520, 130.

Weinberg, N., Miller, M. C., and Lamb, D. Q., 2000, ''Extracting Neutron Star Properties from X-ray Burst Oscillations,'' in Cosmic Explosions, proc. of the 10th Annual October Astrophysics Conference, eds. S. S. Holt and W. Zhang, pp. 371-374.

Weinberg, N., Miller, M. C., and Lamb, D. Q., 2001, ''Oscillation Waveforms and Amplitudes from Hot Spots on Neutron Stars,'' ApJ, 546, 1098-1106.

Weiner, B. J., Vogel, S. N., and Williams, T., 2001, ''Distance Constraints for High Velocity Clouds from Optical Emission Lines,in Gas and Galaxy Evolution,'' (eds) Hibbard, J., Rupen, M., and van Gorkom, J.H., VASP Conference Series Vol. 240, in press.

Welch, G. A., and Sage, L. J., 2000, ''Missing Atomic Hydrogen in M32,'' ApJ, submitted.

Wentzel, D., 1999, ''National Strategies for Science Development'' in Teaching of Astronomy in Asian-Pacific Region, ed. S. Isobe, Bulletin 16, p. 4-10.

White, S. M., 1999, ''Millimeter Interferometer Observations of Solar Flares,'' in Solar Physics with Radio Observations, eds. T. S. Bastian, N. Gopalswamy & K. Shibasaki, Nobeyama Radio Observatory, p. 223.

White, S. M., 2000, ''Radio Versus EUV/X–Ray Observations of the Solar Atmosphere,'' Solar Physics, 190, 309.

White, S. M., 2000, ''The Contributions of the VLA to the Study of Radio Stars,'' in Radio Interferometry: The Saga and the Science, eds. D. G. Finley & W. M. Goss, Associated Universities Inc. (NRAO Workshop 27), p. 86.

White, S. M., Janardhan, P., & Kundu, M. R., 2000, ''Radio Detection of a Rapid Disturbance Launched by a Solar Flare,,'' ApJL, 533, L167.

White, S. M., & Kundu, M. R., 2000, ''Millimeter-Interferometer Observations of Flares in Conjunction with HESSI,'' in High Energy Solar Physics: Anticipating HESSI, eds. R. Ramaty & N. Mandzhavidze, ASP Conference Series (San Francisco), p. 335.

White, S. M., Lee, J., Kundu, M. R., & the MDI Team, 1999, ''The Emergence of a Solar Active Region'' in Three-Dimensional Structure of Solar Active Regions, eds. C. Alissandrakis & B. Schmieder, Astron. Soc. Pac. Conf. Series 155, p.130.

White, S. M., Janardhan, P., & Kundu, M. R., 2000, ''Radio Detection of a Rapid Disturbance Launched by a Solar Flare,'' ApJL, 533, L167.

White, S. M., Thomas, R. J., Brosius, J. W., & Kundu, M. R., 2000, ''The Absolute Abundance of Iron in the Solar Corona,'' ApJL, 534, L203.

White, S. M., Thomas, R. J., Brosius, J. W., & Kundu, M. R., 2001, ''The Absolute Abundance of Iron in the Solar Corona,'' in Cool Stars, Stellar Systems and the Sun XI: Challenges for the New Millennium, eds. R. J. García López, R. Rebolo & M. R. Zapatero Osorio, ASP Conference Series (San Francisco), CD-1361.

White, S. M., 2001, ''Observations of Solar Coronal Magnetic Fields,'' in Magnetic Fields Across the Hertzsprung–Russell Diagram, eds. G. Mathys, S. K. Solanki and D. T. Wickramasinghe, ASP Conference Series (San Francisco), in press.

Wibberenz, G., Cane, H. V., Richardson, I. G., & von Rosenvinge, T. T., 2001, ''The Influence of Tilt Angle and Magnetic Field Variations on Cosmic Ray Modulation,'' Space Sci. Rev., in press.

Wilson, A. S., and Raymond, J. C., 1999, ''Do Jet-Driven Shocks Ionize the Narrow Line Regions of Seyfert Galaxies?,'' ApJL, 513, L115.

Wilson, A.S., Young, A.J., and Shopbell, P. L., 2000, ''Chandra Observations of Cygnus A: Magnetic Field Strengths in the Hot Spots of a Radio Galaxy,'' ApJL, 544, 27.

Wilson, A. S., 2000, ''Studies of Galactic Nuclei with Darwin,'' In Proceedings of the Conference ''Darwin and Astronomy - The Infrared Space Interferometer,'' p 91, (European Space Agency ESA SP-451).

Wilson, A. S., Shopbell, P. L., Simpson, C., *et al.*, 2000, ''Hubble Space Telescope Imaging of the Circinus Galaxy,'' AJ, 120, 1325.

Wilson, A.S., Young, A.J., and Shopbell, P.L., 2000, ''Chandra X-Ray Observations of Cygnus A: Magnetic Field Strengths in the Hot Spots of a Radio Galaxy,''ApJL, 544, L27.

Wilson, A.S., Young, A.J., and Shopbell, P.L., 2001, ''Chandra X-Ray Observations of Pictor A: High-Energy Cosmic Rays in a Radio Galaxy,'' ApJ, 547, 740.

Wilson, A. S., Young, A.J., and Shopbell, P.L., 2001, ''Chandra X-Ray Observations of Cygnus A and Pictor A,'' in ''Particles and Fields in Radio Galaxies,'' Eds. R. A. Laing and K. M. Blundell, ASP Conf. Series, in press.

Wiltberger, M., Papadopoulos, K., Lopez, R. E., Goodrich, C. C., & Lyon, J. G., 1999, ''Effects of Northward Turnings on the Initiation of Substorms in Global MHD Simulations,'' in Proc. International Conf. on Substorms, S. Kokubun (ed.), 287-290.

Wiltberger, M., Pulkkinen, T. I., Lyon, J. G., & Goodrich, C. C., 2000, ''MHD Simulation of the Magnetotail During the December 10, 1996 Substorm,'' J. Geophys. Res., 105, 27649.

Winge, C., Storchi-Bergmann, T., Ward, M. J., & Wilson, A. S., 2000, ''Extended Gas in Seyfert Galaxies: Near Infrared Observations of 15 Active Nuclei,'' MNRAS, 316, 1.

Wright, M. C., Coil, A., Ho, P. T. P., McGary, R. S., &

Harris, A. I., 2001, ‘‘Molecular Tracers of Infall into the Galactic Center,’’ ApJ, in press.

Wyrowski, F., Walmsley, C. M., Goss, W. M. and Tielens, A. G. G. M., 2000, ApJ, 543, in press.

Xu, J., Hardee, P. E., & Stone, J. M., 2000, ‘‘The Stability of Radiatively Cooled Jets in Three Dimensions,’’ ApJ, 543, 161.

Yi, S., Brown, T. M., Heap, S. R., Hubeny, I., Landsman, W., Lanz, T., Sweigart, A., 2000, ‘‘On the Age Estimation of LBDS 53W091,’’ ApJ, 533, 670-681.

Young, A.J., Fabian, A.C., Ross, R.R., and Tanaka, Y., 2001, ‘‘A Complete Relativistic Ionized Accretion Disc in Cygnus X-1,’’ MNRAS, 325, 1045.

Young, A.J., Wilson, A.S., and Shopbell, P.L., 2001, ‘‘A Chandra X-Ray Study of NGC 1068. I. Observations of Extended Emission,’’ ApJ, 556, 6.

Young, A. J., Wilson, A. S., Terashima, Y., Arnaud, K. A., & Smith, D. A., 2001, ‘‘A Chandra X-ray Study of Cygnus A-II. The Nucleus,’’ ApJ, in press.

Young-Owl, R. C., Meixner, M. M., Wolfire, M. G., Tielens, A. G. G. M., & Tauber, J., 2000, ‘‘HCN and HCO^+ Images of the Orion Bar Photodissociation Region,’’ ApJ, 540, 886.

Zelenyi, L. M., Sitnov, M. I., Malova, H. V., & Sharma, A. S., 2000, ‘‘Thin and Superthin Ion Current Sheet: Quasiadiabatic and Nonadiabatic Models,’’ Nonlinear Proc. Geophys., 7, 127.

Zlotnik, E. Ya., White, S. M., & Kundu, M. R., 1999, ‘‘The Solar Atmosphere Above a Sunspot’’ in Three-Dimensional Structure of Solar Active Regions, eds. C. Alissandrakis & B. Schmieder, Astron. Soc. Pac. Conf. Series 155, p. 135.

Virginia Trimble and Susan Lehr