University of Virginia

Department of Astronomy
Leander McCormick Observatory

Charlottesville, Virginia, 22903-0818

This report covers the period 1 September 2001 to 31 August 2002.

1 Personnel

During this time the departmental faculty consisted of Steven A. Balbus, Roger A. Chevalier, John F. Hawley, Zhi-Yun Li, Steven R. Majewski, Edward M. Murphy Robert W. O'Connell, Richard J. Patterson, Mercedes T. Richards, Robert T. Rood, Craig L. Sarazin, William C. Saslaw, P. Kenneth Seidelmann, Michael F. Skrutskie, Trinh X. Thuan, Charles R. Tolbert, D. Mark Whittle, and Kiriaki M. Xilouris.

Robert E. Johnson from Materials Science has his research group in planetary astronomy located within the department. Richard F. Bradley and J. Richard Fisher from the National Radio Astronomy Observatory have an instrumentation lab in the department. In retirement both Laurence W. Fredrick and Philip A. Ianna remained active members of the Department.

Anne J. Verbiscer and Gregory J. Black joined the Department in November and August respectively as a Research Scientists. Wesley N. Colley began a position as Lecturer in August. David A. McDavid started as an observatory support research scientist in July. Mercedes Richards left the Department in August taking a position at Penn State.

Postdocs in residence included Elizabeth L. Blanton, Jean-Pierre de Villiers, Nicholas Gruel, Yutaka Fujita, Robert Link, Kristen Menou, Thomas H. Reiprich, Jaehyon Rhee & Motokazu Takizawa. Mary Kutty Michael from Robert Johnson's planetary astronomy group was also in residence. Blanton was a Chandra Fellow. Fujita & Takizawa both held Overseas Researcher Fellowships from the Japanese Ministry of Science and were working with Sarazin. Menou, Rocha-Pinto & Reiprich all received support from the Celerity Foundation.

Other personnel included Data Analyst Cameron Hummels, Instrument Maker Charles Lam, Electronics Design Technician James Barr, Office Manager Barbara Nicholson, & Secretary Jacquelynn Harding.

There were 20 enrolled graduate students at the end of this period. Joshua Kempner, James Ostheimer, & Wayne Winters completed their Ph.D.s during the year.

Long term visitors included Yuri Izotov, Bill Kunkel, John Papaloizou, and Valery Shematovich.

The Virginia Institute for Theoretical Astronomy (VITA) continued operations during this period with support from the University of Virginia and NASA's Astrophysical Theory, Long Term Space Astrophysics, Origins of Solar Systems, and XMM programs, JPL, Chandra, Space Telescope Science Institute, and the NSF Stars/Stellar Systems and Gravitational Physics Programs.

2 Facilities

The Leander McCormick Observatory with its 26-in Clark refractor on Mount Jefferson is now used exclusively for education and public outreach. It is heavily used for both our graduate and undergraduate courses. The Public Night program has been expanded. Several rooms in the observatory have been remodeled and converted into a museum.

The 0.7-m and the 1-m reflectors on Fan Mountain were used during the year for our undergraduate majors and graduate observational astronomy courses. The auto-guider and 1024x1024 CCD camera were in routine use and a new 2048x2048 camera has recently been installed.

A gift from the Celerity Foundation of Frank and Wynnette Levinson has made it possible for the Department to initiate several programs. Skrutskie heads a program in optical/IR instrumentation, and John Wilson from Cornell has recently joined that effort. During the year lab space was renovated for use by this program and a radio astronomy instrumentation program led by Bradley and Fisher. The Department has recently joined the Large Binocular Telescope consortium and Steward Observatory in an agreement made through the Research Corporation.

3 Research

3.1 Stars and Stellar Evolution

Balbus, DeVilliers, and graduate student S. Fromang (IAP, Université de Paris) have developed a three-dimensional magnetohydrodynamics code including self-gravity to study the collapse of self-gravitating cylinders. The aim is to investigate the development of the magnetorotational instability in star formation processes, and to elucidate the conditions under which differential rotation is enhanced by angular momentum transport, and when it is eliminated.

Balbus and Hawley continue to investigate, through combined analytical and numerical studies, the nature of the angular momentum transport mechanisms, MHD turbulence, and global dynamics of astrophysical disk systems, including protoplanetary systems.

Chevalier, J. Oishi (graduate student), and J. Blondin (NCSU) are carrying out simulations of the early evolution of supernova remnants, taking into account the mass loss processes leading up to the supernova. In par-

ticular, they are investigating wind interaction models for the bright remnant Cas A. From 3-dimensional simulations, they are finding that instabilities during the deceleration of the supernova ejecta can account for much of the structure that is observed in the remnant.

Chevalier and R. Mellon (graduate student) are calculating models for the initial evolution of pulsar wind nebulae in supernova ejecta in order to provide a context for the many new observations in this area. Points to be addressed are whether correct identifications of nebulae with historical supernovae have been made, whether energy equipartition applies to the wind nebulae, and whether the pulsars may have been born rotating much more rapidly than their current rate. The indications are that 3C 58 may be older than SN 1181, but that the identification of G11.2–0.3 with SN 386 is plausible. Also, there is evidence that a number of pulsar wind nebulae have considerably more energy in particles than in magnetic field.

Chevalier and Li are continuing their investigation of whether the afterglow emission from gamma-ray bursts (GRBs) indicates that they are interacting with the winds from massive stars. This issue is crucial for the question of GRB progenitors. A problem for massive star models is that some GRBs have afterglows that indicate interaction with a constant density medium. It has been suggested that such a medium could be produced by a shocked stellar wind flow. However, Chevalier and Li have found that the required medium is difficult to produce by mass loss. This suggests that not all the long duration GRBs have massive star progenitors.

Chevalier and Fransson (Stockholm) are investigating the infrared dust emission from supernovae. Possible sites of dust emission are a dust echo from circumstellar dust, circumstellar dust that is collisionally heated by the fast shock wave, dust possibly formed in a radiative reverse shock wave, and dust formed in the freely expanding supernova ejecta. It appears that a variety of mechanisms are relevant in different supernovae.

Hawley and postdoc Jean-Pierre deVilliers are working on developing the next generation of general relativistic simulation code. They have added the magnetic terms to the already-deployed relativistic hydrodynamics code, and carried out an extensive set of test problems.

Hawley and J. Stone (Maryland) continue a collaborative effort to develop an astrophysics simulation code as a successor to the popular ZEUS code.

Hawley and J. Krolik (Johns Hopkins University) continued their detailed study of the inner regions of black hole accretion disks with an emphasis on the stress produced at the marginally stable orbit (modeled by the pseudo-Newtonian potential). Several high resolution simulations were analyzed in depth, and the observational implications of these results for the inner regions of disks were investigated.

Li started a new project on the structure of magnetically supported circumstellar disks expected to form around protostars, with an eye on forming substellar companions. He estimated that the disk could become self-gravitating during the early rapidly accreting, "Class 0" phase of star formation. The self-gravitating disk could fragment into pieces of substellar masses, which may collapse into brown dwarfs and possibly massive planets.

Li continued his study of the collapse of magnetized, singular isothermal toroids with and without rotation, in collaboration with F. Shu (NTHU, Taiwan) and A. Allen (ASIAA, Taiwan). They confirmed the formation of the so-called "pseudo-disk" during the collapse of non-rotating clouds, and found that the structure of the pseudo-disk can be substantially modified by rotation and the associated magnetic braking. The braking produces under the assumption of ideal MHD an low-speed outflow, which carries away a substantial fraction of the angular momentum of the collapsing material. The outflow could play a role in the formation of circumstellar Keplerian disks, out of which planets are thought to form.

Li continued his long-term program with F. Nakamura (UC Berkeley and Niigata University, Japan) on the fragmentation of magnetic clouds leading to the formation of stellar systems. They showed that a non-axisymmetric $m = 2$ mode of perturbation of modest amplitude can grow nonlinearly during the magnetically supercritical phase of cloud evolution into an elongated bar. The bar collapses into a opaque, needle-like structure, which could break up into fragments for a fast enough rotation. In the presence of higher order mode or random perturbations, the cloud can break up directly into multiple fragments, each of which is well on its way to form a single star or stellar system.

Li continued his collaboration with a research group in Moscow led by V. Shematovich in developing a coupled dynamical and chemical model for starless cores of molecular clouds, which are sites for isolated low-mass star formation. They carried out a model update, and a parameter exploration aimed at explaining the velocity field and pattern of chemical differentiation observed in the well-studied starless core L1544. They found that the available data on L1544 are consistent with the standard scenario for isolated low-mass star formation, in which the core forms out of a strongly magnetized cloud due to ambipolar diffusion over several dynamical times.

Li and Anderson started a systematic investigation of the structure of axisymmetric magnetocentrifugal outflows launched from accretion disks, together with R. Krasnopolsky (UIUC) and R. Blandford (CalTech). They focused on the effects of mass loading rate on the outflow structure. It was shown that, for a given field distribution on the disk, increasing the mass loading rate enhances the toroidal field in the outflow, which leads to a better collimation. Above a certain rate, the outflow becomes unsteady, for reasons not completely understood. The heavily loaded outflow has a predominantly toroidal magnetic field, which may cause the outflow to become unstable, particularly in 3D.

Majewski and Patterson's group, including Rhee (postdoc), C. Hummels (data analyst), A. Polak (grad-

uate student), J. Crane (graduate student) and collaborators continued the Grid Giant Star Survey (GGSS). The GGSS is designed to find stars needed for the Astrometric Grid of SIM, with a strategy to identify the most distant, $V < 13$, giants in 1302 "bricks" each covering ~ 0.5 deg^2, distributed over the entire sky. To date, photometric observations with the Washington M, T_2 and the (gravity sensitive) $DDO51$ filters have been performed in 99% of these bricks at the Las Campanas 1-m telescope, the 0.8-m telescope of McDonald Observatory, and the WIYN 0.9-m telescope. Reduction pipelines have been refined to generate a sample of giant candidates, along with photometric parallaxes and metallicities derived from the three-filter system. To date, 765 bricks (59%) have been completely reduced, and 96% of these fields contain at least one candidate with a photometric distance > 1 kpc. The best SIM candidate for each brick has a median distances of ~ 4 kpc and metallicity of [Fe/H] ~ -1. Low-resolution spectroscopic follow-up observations on the LCO 1-m of over 3200 Grid giant candidates have been carried out to verify the luminosity class and determine spectroscopic abundances and radial velocities. Polak continued to develop a dynamic web database for the GGSS data. The database is used extensively by GGSS and SIM Grid followup observers and will assist in scientific analysis of the data. It will be provided to the community upon completion of the Grid Survey and will be useful for scientific studies with GGSS before SIM launch.

Majewski, Polak, Rhee and A. Kundu (MSU), with the UVa GGSS team, have reported first science results from the GGSS. Based on the multifiber spectroscopy of several hundred stars in 11 fields selected from the GGSS, in the combination with photometrically determined parameters, they have found a group of 8 giants for which spatial, kinematical, and abundance characteristics are coherent, but for which these properties differ from those of the main populations in the fields. Comparison with models of debris from the Sgr dSph suggest that the peculiar stars are associated with a leading trail from Sgr.

M. Garvin & Frinchaboy (graduate students), with Majewski, Patterson and Kunkel (LCO), has been analyzing radial velocity data from spectra of GGSS candidate giants taken from the Hydra spectrograph at CTIO and KPNO. Using the radial velocity data as well as GGSS photometry, he has looked for giant stars in the Sagittarius tidal streams.

Using extant astrometric catalogs, Polak obtained proper motions for a subset of GGSS candidates. These will be combined with the radial velocities of the stars to study the kinematics of bright giant stars in GGSS fields.

J. Ostheimer (graduate student), Rhee, Majewski, Patterson, and R. Gray (Appalachian State) have produced a new grid of synthetic spectra using the SPECTRUM code of Gray with Kurucz's convective overshoot model atmospheres, and then computed synthetic Washington M, T_2, and $DDO51$ colors of giant and dwarf stars over the Yonsei-Yale isochrones. They have found good agreement between their synthetic color-magnitude isochrones and empirically defined giant branches, and no significant age effect in ($M - T_2$, $M - DDO51$) space. This result strongly supports the methodology (which is being employed for the GGSS) to estimate metallicities and distances of field stars from the three filter system.

S. Sohn (graduate student), M. Siegel (STScI), C. Palma (PSU), Majewski and Patterson have performed observations with the KPNO 4-m + Mosaic camera to extend their spatial coverage of the dSph galaxies Leo I, Leo II, and Ursa Minor. A complete M, T_2, and $DDO51$ photometric catalog to $M \sim 22.5$ and $T_2 \sim 21.5$ now exists for a 4.5 deg^2 field centered on Leo I. Using this catalog, Sohn confirmed his preliminary results showing clear evidence of extratidal giant stars of Leo I. He is currently analyzing the data to understand the overall structure better. Spectroscopic follow-ups are planned for both Leo I and Leo II.

C. Palma, Majewski, and J. Kuhn (Hawaii) have obtained Keck HIRES spectra for approximately 50 candidate giant star members of the Ursa Minor dwarf spheroidal. Preliminary results indicate that a number of these stars have radial velocities consistent with membership in this dSph galaxy, even though they are found well outside the nominal tidal radius of the dSph.

Majewski, Dinescu (Yale), P. Frinchaboy, Kunkel (Las Campanas), V. Smith (UT), Patterson, Ostheimer, Rhee, and Palma (PSU) have been studying internal stellar population and kinematic properties of the Galactic globular cluster omega Centauri. The catalog includes photometry, proper motion, radial velocity, and abundance data. Photometric metallicities were also derived using a technique adapted by J. Rhee. The metallicity distribution function (MDF) of omega Centauri was determined through the use of the Washington M,T_2 and $DDO51$ photometry to derive photometric metallicities. The photometric metallicities were calibrated with spectroscopic metallicities and by using proper motion and radial velocity membership we were able to construct the MDF. The data reveal the omega Centauri has four metallicity peaks, this combined with published work on the age spread in omega Centauri lend support to the idea that this globular may actually be the nucleus of a massively disrupted dwarf galaxy.

Crane (graduate student), Majewski, Patterson and J. Bahcall (IAS) continued work on determining the amount of local dark matter in the Galactic disk (the Oort limit). To this end, Crane assembled a photometric sample of candidate disk giant stars using M, T_2, and $DDO51$ imaging data covering almost 200 square degrees at the North Galactic Pole. Followup medium resolution spectra of 326 candidates have been collected using the KPNO 2.1-m + GoldCam spectrograph. Data reduction is underway.

Using 2MASS data, Majewski, Skrutskie and D. Law (undergraduate student) searched for tidal tails around the globular cluster ω Centauri, and studied the potential metallicity spread in NGC 6388 and NGC 6441. Re-

sults suggest that previous studies of these clusters are subject to subtle biases due to differential reddening, and that these particular Galactic globular clusters may not be cores of disrupted dwarf satellite galaxies, as has been recently proposed.

Law and Majewski analyzed the results of numerical simulations of the tidal destruction of dwarf satellites by the Milky Way Galaxy, using the models of K. Johnston (Wesleyan University). The virial theorem and other methods were used to calculate possible inflation of derived mass-to-light ratios for these simulated stellar systems.

Polak worked on a project to study the kinematics of stars at the North Galactic Pole. Using deep BVI CCD photometry in conjunction with proper motions derived from photographic plates, space velocities were found for a sample of stars. Multivariate analysis of the data is being undertaken to understand chemo-dynamics of Galactic stellar populations.

Majewski, Kunkel, Patterson and Ostheimer have continued spectroscopic observations and analysis of giant stars in the periphery of the Magellanic Clouds. Significant halo substructure has been found in the dataset of several hundred K-giant spectra located in 29 fields around the Magellanic Clouds. However, no certain tidal debris from the Clouds have been identified.

Majewski, Siegel (STScI), Sohn, C. Gallart (Instituto de Astrofísica de Canarias) and R. Braun (NFRA) completed a search for giant stars in compact high velocity clouds (CHVC's). While they did not detect any giant stars, which allows limits to be placed on either the distance or stellar content of the CHVC's, some evidence of extinction by CHVC's was found – indicating the presence of dust in these objects.

H. Rocha-Pinto (postdoc) and Majewski are studying stellar streams in the halo and the Galactic structure above the disk, specially developing statistical methods for the identification of stellar streams from enhancements in spatial density, metallicity and velocity distributions. The research has been mainly focused in the analysis of an extensive proper motion, radial velocity and photometric catalogue of stars near the North Galactic Pole field SA 57. Rocha-Pinto has found evidence of substantial velocity clustering among giant stars, confirming previous work reported by Majewski for dwarf stars. So far, the analysis of stars situated at about 3 kpc, in the direction of SA 57, has confirmed previous claims of their research group for a retrograde halo and for the existence of a large number of stars falling into the disk.

Garvin, Kunkel and Frinchaboy are also working on improved methods of precise radial velocity measurement from low S/N, medium resolution spectra. Garvin is developing an algorithm that can accurately distinguish between CCD cosmetic features (or cosmic rays) and important spectral features. The ultimate goal of this project is to produce an efficient pipeline for obtaining high-precision radial velocity measurements.

Frinchaboy, Majewski, Skrutskie, Kunkel (Las Campanas), and R. Phelps (CSU Sacramento) have begun a project to determine the orbits and of a number of Galactic clusters using absolute proper motions and radial velocities. This will yield cluster orbits that can be used as a probe of Galactic disk dynamics with "test particles" of known ages and distances. These data will be used to investigate the outer Galactic rotation curve and the Galactic abundance gradient.

Majewski, Patterson, Siegel, Frinchaboy, K. Westfall (Wisconsin), and Kunkel, are conducting a spectroscopic follow-up of various extratidal giant candidates around the Leo II, Carina and Sculptor dwarf galaxies, using the Hydra spectrograph at KPNO and CTIO. Extratidal stars are also being sought around globular clusters. Majewski, Patterson, Frinchaboy and Siegel are exploring the distribution of giant stars around the globular cluster Arp 2, and around the cluster N288 with A. Forestell (UT).

Frinchaboy and Phelps completed their work on the Saurer et al. open star clusters. These clusters are similar in appearance to the Berkeley open clusters and are believed to be old. Results show that one of these clusters one of the most distant open clusters ever discovered, with $R_{gc} = 19$ kpc, and and age of 7-8 Gyr.

Rhee and T.C. Beers (Michigan S.) have initiated medium-resolution spectroscopy follow-up to identify extremely metal-poor giant stars with [Fe/H] ≤ -2.0 in the HK-II survey, using KPNO 2.1-m and CTIO 1.5-m telescopes and 6dF facility on the UK Schmidt telescope. Preliminary results have shown that some new 80 extremely metal-deficient giants with [Fe/H] ≤ -2.0 are discovered successfully, with detection efficiency of 30–50 % as a function of galactic latitude (i.e., higher yield at higher latitude). They also continued large international spectroscopic follow-up of metal-poor stars and Carbon stars selected from the Hamburg/ESO survey in collaboration with N. Christlieb (Hamburg) and M. Bessell (Australian N.). Metallicities and radial velocities determined from the medium-resolution spectroscopy, combined with proper motions from ongoing and future astrometric surveys (such as the Yale/San-Juan SPM, USNO survey, and SIM), will provide full space motions for numerous extremely old stars. This effort will also furnish a large sample of giant candidates to be searched for stars with highly enhanced r-process elements by high-resolution spectroscopic follow-up with VLT, KECK, and SUBARU. The results will help unravel the chemical and dynamical history of the Milky Way.

Rhee and T. Beers (Michigan S.) have shown the presence of a rapidly rotating disklike popluation of stars selected without proper motion bias from the Luminous Stars Extension survey of Drilling & Bergeron, even at quite low metallicity. The distribution of orbital eccentricity of the giants as a function of [Fe/H] indicated that relatively high fraction ($30\% - 40\%$) of local metal-poor stars within 1 kpc from the Sun may be associated with the metal-weak thick disk and may extend to metallicites below [Fe/H] $= -1.6$, much lower than previously

claimed.

Richards, Waltman (Naval Research Lab), and Ghigo (NRAO) continued their study of radio flares from binary systems. They analyzed 2.3 GHz (S band) and 8.3 GHz (X band) radio continuum observations collected with the NRAO-Green Bank Interferometer nearly continuously over 2096 days (5.7 years). Two RS CVn binaries (V711 Tau and UX Ari) and two Algol-type binaries (β Per and δ Lib) were studied. Flare events were unique. Most began with a strong initial rise, with weaker peaks along the exponential tail of the event. Other flares had the weaker peaks at nearly constant flux. The intensity dips in the flare profile can be explained either by the eclipse of the flare region or by the intermittent production of nonthermal particles as the flare decayed. For the four systems, flares took (20–50) hours to rise and decayed over (10–40) days. On the Sun, flare eruptions occur within 100 seconds and decay over a few hours. The duration of the flares in the four systems was correlated with the total energy output during the flare event. The spectral index was positive during flares for all four systems, which suggests that the flares arise from a partially opaque gyrosynchrotron source. The flaring behavior of UX Ari was similar to that of V711 Tau, but its flares were weaker than those of V711 Tau. More flares were detected from β Per than from V711 Tau over the same time interval, but the flares on V711 Tau were typically stronger than those on β Per. Flare strength at 8.3 GHz was as high as 1.17 Jy in β Per, 1.44 Jy in V711 Tau, and 0.82 Jy in UX Ari. Only two flares were detected from δ Lib during the survey, with maximum 8.3 GHz flux of only 0.034 Jy. A preliminary analysis suggests that the strongest flares in the RS CVn binaries tend to occur near $\phi = 0.5$ or 1.0, with more flares visible near $\phi = 0.5$ when the more active K star is toward the observer. The strongest flares in the Algols were seen near $\phi = 0.0$ when the active cooler star was toward the observer.

Richards, Waltman, and Ghigo found that β Per, V711 Tau, and UX Ari have predictable flaring cycles. They used Power Spectrum analysis and the Phase Dispersion Minimization technique to determine the periodicity of flaring activity from data collected continuously over a total of 4.6 years. From 1995 January to 2000 October, flares on β Per had a periodicity of (48.9 ± 1.7) days. In the RS CVn group, the significant periodicities were (120.7 ± 3.4) days and (80.8 ± 2.5) days for V711 Tau, with (141.4 ± 4.5) days and (52.6 ± 0.7) days for UX Ari. So strong flares occurred roughly every 17 orbital cycles on β Per, every 28.5 and 42.5 orbits on V711 Tau, and every 8 and 22 orbits on UX Ari. No periodicities were found from the δ Lib data. Both V711 Tau and β Per display long-term cycles of apparently alternating active and quiescent flaring activity which seem to last for more than 500 days. However, the survey was not long enough for the period-search analysis to confirm these long-term cycles to any level of confidence. These results were presented at the AAS Meeting in June 2002.

Tiffany Soinski (undergraduate student) and Richards used the 5-year database of radio flares from V711 Tau, UX Ari, and β Per. They studied the profiles of individual radio flares and discovered that no two were exactly alike. While the timescales of flaring activing may be predictable, the shape of the flare is quite variable. These results were presented at the AAS Meeting in June 2002.

Helio Rocha-Pinto is continuing the analysis of a sample of late-type dwarfs that he used to study the chemical enrichment and the star formation history of the local Galaxy, during his former PhD research in São Paulo, Brazil. With J. Scalo (Texas), C. Flynn and J. Hänninen (Tuorla Obs.), he studies the age–velocity dispersion and the radial variation of the star formation history and metallicity distributions.

The metallicity distribution is also the main topic of two lines of research presently conducted by Rocha-Pinto. With C. Chiappini (Trieste) and J. Scalo,the metallicity distribution of the solar neighborhood at past times was reconstructed, using chromospheric stellar ages and photometric metallicities. The other project, done with the collaboration of G. Porto de Mello (Rio de Janeiro) and W. Maciel (São Paulo), consists in the determination of spectroscopic abundances and radial velocities for a large survey (325 stars) of southern hemisphere nearby G dwarfs. The observations were completed in the end of 2001 and are presently being reduced. The survey is expected to yield important information about the evolution of the solar neighborhood, since the G-dwarf metallicity distribution is considered one of the best discriminating constraints to the chemical evolution. An extension of this survey to the northern hemisphere is being planned by Rocha-Pinto, J. Shi (München) and Porto de Mello.

Rood, Ferraro, and others from Bologna continue work on globular cluster stars. Current projects include blue stragglers, putative central black holes, and hot horizontal branch stars.

Skrutskie has been investigating the Galactic distribution of giants and asymptotic giant branch stars in the Milky Way disk and halo based on the reliable color-selection of candidates from the Two Micron All Sky Survey (2MASS). Using a sample of late-type 2MASS M-giants Skrutskie, Majewski and Weinberg (UMass) have isolated an all-sky sample of halo giants which delineate the Sagittarius dwarf galaxy and its tidal streams. Work continues to match the distribution and kinematics of these tracers with dynamical models of the Sagittarius/Milky Way system. Skrutskie, Weinberg, and Reber (Amherst College) have similarly isolated a population of 30,000 disk carbon star candidates in the plane of the Milky Way. Distance estimates derived from simple assumptions about the uniform luminosity vs. color of these object yield a 3-dimensional distribution of Milky Way carbon stars which reveals the complete stellar bar and delineate the outer extent of the entire Milky Way disk.

Winters, Balbus, and Hawley completed a study of the formal chaos properties of magnetized differential ro-

tation. The Lyapunov exponents of model flows were determined and the hallmark chaos features of extreme sensitivity to initial conditions and unpredictability explicitly demonstrated. Of some practical importance was the finding that very long averaging baselines are required to give any statistical significance to the ensemble average of the Reynolds and Maxwell stresses.

Lorimer (Jodrell Bank), Camilo (Columbia University) and Xilouris, have used high precision timing observations with the Arecibo 300-m radiotelescope, to obtain phase-coherent timing solutions for the first time for 17 pulsars discovered at Arecibo by Hulse & Taylor (1975) in a 430-MHz survey of the Galactic plane. In addition to the timing solutions scatter-broadening measurements for two pulsars were presented as well as the pulse nulling and mode-changing properties of two others.

During the latter stages of the Arecibo upgrade a systematic drift-scan survey carried out by two collaborations (Fruchter, Lorimer, Xilouris, STScI/NAIC) and (Arzoumanian, Backer, Cordes, Lommen, McLaughlin, Berkeley/Cornell) has so far revealed 7 new pulsars. The data acquisition system used is the Penn State Pulsar Machine (PSPM)—a fast-sampling filterbank spectrometer, nominally capable of detecting pulsars with submillisecond periods. Data covering 450 square degrees have been analyzed so far at Jodrell Bank while intensive processing continues. Among the new discoveries are two likely recycled pulsars with periods of 5.79 and 55.6 ms. On going Arecibo high precision timing observations will provide a more accurate measure of the spin and astrometric parameters of the newly discovered pulsars and give insight to the nature of these pulsars.

Following the installation of a new auxiliary guider on the 1-m astrometric reflector at Fan Mt, long CCD exposures became possible. Deep narrow-band CCD imaging is used to investigate the mechanism responsible for the present shaping of planetary nebulae with large angular size. Using the Fan Mountain 1-m telescope, Martin, Xilouris and Soker (UVA/University of Haifa) detected an Hα emission-line structure in the upstream side of the planetary nebula NGC 40. This structure was earlier predicted by numerical simulations, and is attributed to Rayleigh-Taylor instability. Such a Rayleigh-Taylor instability is expected to occur at early stages of the interaction process between the interstellar medium and a fast moving planetary nebula, as is the case for NGC 40. The investigation continues with deep imaging of extended nebulosities.

3.2 Interstellar Medium

R. Johnson & postdoc, E. Bringa, have used a molecular dynamics model of a solid to simulate heavy cosmic ray ion-induced desorption of mantel material from a grain in cold regions of the interstellar medium. These simulations were used to test the earlier models for desorption by Leger and co-workers and Hasegawa and Herbst. These models were based on treating the evolution of the energy deposited by a fast heavy ion in a small grain by thermal evaporation from a transient heat spike. Both of these models were shown to fail. The new calculations were then compared to extrapolations of laboratory data on energetic ion induced erosion and expressions were given for application to energetic particle-induced desorption in a variety of radiation environments.

Murphy, B. Otte (JHU), J. C. Howk (San Diego), Q. D. Wang (UMass), W. R. Oegerle (NASA/GSFC), and K. R. Sembach (STScI) have obtained additional observations of the halos of NGC 4631 and NGC 891 with the Far Ultraviolet Spectroscopic Explorer. They have detected O VI in emission in the halo of NGC 4631, but find no emission from the halo of NGC 891. Toward NGC 4631, the total O VI luminosity is equal to the soft X-ray luminosity. The O VI appears to be co-rotating with the disk gas and is therefore likely to be cooling galactic fountain material. The total cooling mass flux in NGC 4631 is 1–3 solar masses per year depending on whether the fountain is a single large bubble or a galaxy wide fountain. The non-detection toward NGC 891 implies that the cooling mass flux is less than 1 solar mass per year in that galaxy if the O VI halo has the same extent as the soft X-ray halo.

Graduate student Quireza Campos (Sao Paolo) and Rood are using high precision radio recombination line and continuum data to determine electron temperatures of a very large sample of Galactic H II regions. This will lead to an estimate of metallicity. The large sample scattered throughout the Galaxy can show for example whether abundance trends are azimuthally symmetric.

3.3 Galaxies and Active Galactic Nuclei

Hawley and Balbus continue their work on non-radiative accretion flows around black holes. Such flows were modeled with large scale simulations of full three-dimensional global accretion disks. The simulation results were adapted to to the Galactic center source Sgr A* using some simple radiative properties of the flow In MHD simulations disk stress is produced self-consistently.

Balbus and Hawley conducted a study of angular momentum transport in the linear stages of a rotationally and convectively unstable magnetized fluid. This was motivated by models of black hole accretion flows in which convective disturbances transported angular momentum inward, the opposite of the usual sense in accretion flows. It was found in the studied example that inward angular momentum transport generally required large adverse entropy gradients and long wavelengths, modes that are largely unaffected by magnetic tension. It was argued that not only was standard outward transport possible, it was required for self-consistency.

With undergraduate student M. Kunz, Balbus is computing the radiation properties of three-dimensional MHD black hole accretion flow simulations. The spectrum includes synchro-Compton and thermal bremsstrahlung processes. The Galactic Center source is of particular interest because it is so unexpectedly faint. Ground based radio, millimeter, and submillimeter ob-

servations have recently been augmented by a Chandra X-ray detection. A good spectral fit seems to require an electron population substantially cooler than the ions, a result also found by other investigators working with different accretion geometries.

Ostheimer, Majewski, Patterson, and R. Link (postdoc) have studied the halo of M31 both spatially and chemically. They find that M31's halo shows evidence for substructure and have constrained the halo to be metal-rich with a metal-poor tail. Additionally, they have studied the Andromeda companion dSph galaxies And I, And II, and And III and have found that And I shows a significant correlation of spatial distribution to metallicity with the most metal-poor stars being less centrally concentrated and elliptically distributed, while the metal-rich stars are more centrally concentrated and circularly distributed.

Frinchaboy, Kunkel, S. Demers (U Montreal), and P. Battinelli (INAF) are working on a project to obtain the radial velocities of carbon stars around the local group galaxies to derive rotation curves and study their mass distributions. Observations have been conducted on NGC 6822 using the hydra spectrograph at CTIO.

O'Connell, Rood, and S. Sohn (graduate student) have obtained deep HST far-ultraviolet photometry of the metal rich globular cluster system of the elliptical galaxy M87 using the STIS/FAR-UV MAMA camera. They are using time-tagged data analysis to eliminate periods of brighter orbital UV sky background. In a preliminary reduction, 38 clusters in three fields are detected to a limit of $m(FUV) \sim 23$. These exhibit a 2.5 mag range in FUV−V color and appear to fall into two color groups, possibly associated with the two known cluster subsystems in M87.

O'Connell, Sarazin, and R. White (UAl) extended their analysis of Chandra X-ray Observatory images of the nearby elliptical galaxy M32. M32's core is the densest known stellar system, which makes it an obvious candidate for nuclear activity. However, no evidence of an AGN has ever been found associated with the core. The CXO observations were the deepest yet attempted in X-rays of M32, and reach point sources with $L_x \sim 10^{35}$ erg/s. The images resolve the previously known single X-ray source near the center of M32 into 3 discrete sources within 15″ of the nucleus. Corrected astrometry for the nucleus from 2MASS shows that one of these sources is coincident with the nucleus (0.6″ distant). This source has $L_x \sim 2 \times 10^{36}$ erg/s, making it the lowest luminosity AGN yet detected. There is also evidence for low-level, diffuse X-ray emission around M32.

O'Connell, with Rood and B. Dorman (GSFC) completed a study of the usefulness of mid-UV spectra and colors (between 2500 and 4000 Å) for reducing the serious "age-metallicity degeneracy" encountered at longer wavelengths in analyzing the integrated light of old stellar populations. They find that the mid-UV improves resolution in $\log t$, $\log Z$ space by about a factor of 3 for a given observational precision. Most of the spectral information on old populations resides below 4000 Å. They also find that contamination of mid-UV light by hot, post-He-flash evolutionary phases can reach over 80% in objects with large hot populations. However, this is straightforward to remove as long as far-UV measurements are available. They show that a 4 Gyr, solar abundance model based on empirical spectra for nearby stars provides an excellent fit to the mid-UV spectrum of the Local Group elliptical galaxy M32. This indicates that the poorer results obtained by several groups from theoretical spectra probably arise from limitations of the synthesis models for individual stars.

The X-ray group at U.Va. has an ongoing project to image X-ray-bright early-type galaxies to study the physics of the hot interstellar gas. S. Randall (graduate student), Sarazin, and J. Irwin (U. Michigan) have analyzed the Chandra observation of the X-ray bright elliptical galaxy NGC 4649. This galaxy has a large number of Low Mass X-ray Binaries (LMXBs), and very bright X-ray emission by interstellar gas. The gas emission shows radial fingers which my be due to convection. They are also analyzing an XMM/Newton observation of the same galaxy. J. Carlin (graduate student) and Sarazin are working on a Chandra observations of NGC 533 and NGC 1600. Sarazin is reducing an XMM/Newton observation of NGC 5846. Cycle 2 XMM/Newton observations of NGC 4552 and NGC 4125 are scheduled as well.

The LMXB populations and hot gas in X-ray-faint early-type galaxies are being studied by the X-ray group at U.Va. G. Sivakoff (grad student), Sarazin, and Irwin have studied the LMXB populations in two X-ray faint early-type galaxies (NGC 4365 and NGC 4382) with Chandra observations. Chandra observations of NGC 5866 are scheduled.

The X-ray group at U.Va. has a project to determine the properties of the LMXB populations and hot gas in a complete sample of Virgo cluster ellipticals. Sivakoff, Sarazin, Irwin, P. Coté, and L. Ferrarese (Rutgers) are using both archive and new Chandra observations. Coté is the PI of an HST large project to image all these galaxies with the ACS, and this will provide globular cluster (GC) populations to compare to the LMXBs.

Sarazin, Sivakoff, E. Blanton (post doc), Randall, A. Kundu (MSU), and Irwin have studied the connection between LMXBs and globular clusters (GCs) in a sample of four early-type galaxies observed with Chandra. A significant fraction of the LMXBs are located in GCs, and the fraction appears to increase along the Hubble sequence from spiral bulges to S0s to gEs to cD galaxies. The LMXBs are preferentially associated with the optically most luminous and the reddest GCs. Sarazin, Irwin, and J. Bregman (U. Mich.) observed the very X-ray faint S0 galaxy NGC 3115 with Chandra to determine the nature of its LMXB population, and to try to understand why it is fainter than similar elliptical galaxies. Along with A. Athey (U. Mich.), and Bregman, Sarazin & Irwin, have studied the X-ray spectral properties of a large sample of LMXBs observed in 15 nearby early-type galaxies with Chandra.

Thuan and Gruel, in collaboration with Hammer (Meudon) and Flores (Meudon) are studying the population of Luminous Infrared Galaxies (LIRGs) seen by ISO (L(IR) $\geq 2 \times 10^{11}\, L_{\odot}$) and which are among the main contributors to the star formation activity of the universe at redshifts between 0.5 and 1. They have undertaken VLT slit optical spectroscopic studies of the LIRGs. They found that the LIRGs have large extinction with A_V varying between 1.5 mag and more than 3 mag. Corrections for these large extinction give the LIRGs large star formation rates, between 20 and 100 $M_{\odot}$ yr^{-1}. Their gas metal abundances are about solar, and their absorption spectra can be synthesized with a mix of a few Gyr old and relatively metal-rich (solar to oversolar values) stellar population and a younger stellar population ($\leq 5 \times 10^8$ yr) having a metal abundance similar to that of the gas. They argue that the LIRGs are the progenitors of present-day spiral bulges. The gas needed to feed the observed star formation is likely to be falling in from the outskirts of the LIRG, being tidally pulled out from interacting companion galaxies. They have obtained HST images which show that most that the LIRGs are disks and that nearly half of them are found in interacting/merging systems.

Thuan in collaboration with Hunt (Arcetri, Italy) and Izotov (Kiev) has obtained deep JHK UKIRT images of IZw18, the most metal-deficient Blue Compact Dwarf (BCD) galaxy known, and has analyzed them in conjunction with archival HST/WFPC2 optical images. They found that the data show no evidence for stellar populations in IZw18 older than $\sim$ 500 Myr, so that IZw18 is a good candidate for being a young galaxy in the local universe. The colors of the young and intermediate-age stellar populations are significantly affected by widespread and inhomogeneously distributed ionized gas and dust. Our conclusions disagree with previous work based mostly on color-magnitude diagrams which have found evidence for stars older than 1 Gyr in IZw18. They attribute the disagreement primarily to the lack of consideration of the effects of ionized gas and dust extinction.

Whittle (PI), Rosario (graduate student), Nelson (U. Nevada), and Wilson (U. Maryland) have continued to work on HST STIS observations of Seyfert galaxies which show strong jet-gas interactions. Having fully reduced and analysed the first dataset, they focussed on identifying the ionization mechanisms occurring in the region. Using CLOUDY, they extended the class of models which combine optically thin and thick components, and using recent results from MAPPINGS III they extended earlier treatments of fast autoionizing shocks. Initial results confirm the dominance of nuclear source photoionization, in part because of the absence of correlations beween ionization degree and kinematic state of the gas. A second dataset covering a further 6 Seyferts has been acquired and analysis of this has just begun. A first paper has been accepted for publication, while another is in preparation.

A third HST project (Whittle, PI) focusses on the origin of extended blue wings in the line profiles of two Seyferts. Broad band and emission line imaging, combined with STIS spectroscopy has been used to investiate the distribution and acceleration mechanisms acting on this high velocity component. The region has been spatially resolved, and from the distribution of dust, it seems the gas is driven in an outflow by a fast nuclear wind.

3.4 Clusters of Galaxies

Blanton, Sarazin, and B. McNamara (Ohio U.) are using a Chandra image to study the cooling flow cluster Abell 2052. The X-ray image shows that the radio source is blowing bubbles in the X-ray gas. They are currently working on Chandra observations of Abell 262 and Abell 2626, both of which show evidence for radio/cooling flow interactions. M. Takizawa (postdoc), Sarazin, Blanton, and G. Taylor (NRAO) are studying the Chandra image of the cooling flow cluster Abell 3112, which also shows a strong interaction between the radio source and the cooling flow gas. M. Chatzikos (graduate student), Sarazin, and Blanton are also analyzing a Chandra archive observation of the cooling flow clusters 2A0335+096. XMM/Newton observations of Abell 2626 and Abell 2063 are being obtained by Blanton, Sarazin, and McNamara to study the X-ray spectra of the radio bubbles detected with Chandra.

Blanton, Sarazin, and N. Soker (Univ. Haifa) have studied the possible effects of thermal conduction on cluster cooling flows.

Blanton, Sarazin, D. Helfand (Columbia), M. Gregg (IGPP), and R. Becker (UC Davis) are observing possible distant clusters with Chandra and XMM/Newton. The clusters were first selected by searching the FIRST radio survey for distorted radio galaxies, and have been confirmed with optical/IR observations.

J. Kempner (graduate student), Sarazin, and P. Ricker (U. Illinois) studied Abell 85 using observations from the Chandra X-ray Observatory. The cluster has a significant cooling flow, but also shows interesting structure associated with the merger of two small subclusters with the main cluster, one of which also has a radio relic. The observations will provide information about thermal and nonthermal effects in the merger process and about the effect of mergers on cooling flows.

Kempner, Sarazin, M. Markevitch (CfA), and Ricker are observing the clusters Abell 2034 and Abell 2065 in X-rays with Chandra. These are merging clusters with radio relics, one newly discovered by Kempner and Sarazin. The Chandra observation provides interesting constraints on the northern merger, while the southern "subcluster" appears to actually be a background, moderate redshift cluster. They are also observing the merging clusters Abell 3395, Abell 1240, and Abell 725 with XMM-Newton. They will obtain high resolution temperature and entropy maps of the clusters, as well as providing kinematic information about the mergers.

Kempner, Sarazin, and L. Rudnick (U. Minnesota) are making follow-up observations of three newly dis-

covered radio relics using the VLA. They have gotten high resolution total intensity maps of the relics at multiple frequencies which allows measurements of the cluster magnetic fields and the spectral aging of this population of cosmic ray particles, and polarization maps which provide details about the magnetic field structure and shock amplification of the field. Comparison with X-ray observations would also provide an opportunity to study the efficiency of shock acceleration of relativistic electrons and the contributions of nonthermal effects to pressure support in the ICM.

Randall and Sarazin are using merger trees to determine the effects of cluster mergers on the thermal and nonthermal properties of clusters of galaxies. They are hoping to understand the empirical correlations between radio halos and the X-ray properties of clusters.

Reiprich, Sarazin, and Kempner are analyzing XMM-Newton data of the merging galaxy cluster Abell 1644. Despite the very disturbed appearance in the X-ray surface brightness preliminary results indicate that the temperature distribution of the hot intergalactic gas of the two main subclusters resembles that of very relaxed clusters. This suggests that the dense cluster cores are not strongly affected by the merging process.

Reiprich, Sarazin, Blanton, Randall, and Böhringer, Schuecker (MPE), and Ikebe (GSFC) started a project to analyze in detail a statistical sample of the 63 X-ray brightest galaxy clusters in the sky with Chandra and XMM-Newton data, primarily based on data from public archives. In addition Chandra will observe nine clusters proposed by them in the next cycle. The main aim is to reduce systematic uncertainties which dominate the overall uncertainty in the use of clusters as cosmological probes.

Reiprich initiated an international collaboration between UVa and MPE involving 16 people (including individuals from CfA, ESO, and STScI) to investigate the multiwavelength properties of a statistical sample of about 800 galaxy clusters selected from the ROSAT All-Sky Survey. The collaboration is based on the telescope time available to UVa through the agreement with the University of Arizona made possible by the Celerity foundation. The first observing run using a telescope of the University of Arizona at Kitt Peak has been carried out successfully in January.

Sarazin, Takizawa, and Y. Fujita (NAO, Japan) have developed a theoretical model for the turbulent acceleration of relativistic particles during cluster mergers.

Sarazin, Kempner, Fujita, H. Andernach (U. de Guanajuato), M. Ehle (XMM-Newton SOC), A. Roy (MPIfR), Rudnick, and B. Slee (ATNF) are observing the cluster Abell 133 with XMM/Newton. Previously, they observed this cluster with Chandra.

Sarazin, M. Wise, J. Houck, D. Davis (MIT), and McNamara are using the Chandra spectrum of the distant cooling flow cluster MS2137.3-2353 to study the origin of excess soft X-ray absorption in the spectra of cooling flows. Sarazin, McNamara, Wise, P. Nulsen, and L. David (CfA) have observed the moderate redshift cluster MS0839.9+2938, which may be a cooling flow cluster in formation.

4 Cosmology

De Villiers continues studies of the gravitational scattering of cosmic strings He is currently collaborating with Valeri Frolov, and graduate student Martin Snajdr (University of Alberta) to extend work on the interaction of cosmic strings with Schwarzschild black holes to the case of rotating (Kerr) black holes. This work represents one of the simplest models for the study of the interaction of an extended body with a black hole. Although cosmic strings are exotic objects for which evidence of existence is still lacking, the analytic and numerical techniques developed in this study could see a much broader range of applicability.

Skrutskie, Kashlinsky (GSFC), Mather (GSFC), Odenwald (GSFC), and Cutri (IPAC) are analyzing deep integrations obtained from hundreds of repeated observations of 2MASS calibration fields to derive the spatial power spectrum of the diffuse extragalactic infrared background. This background, predicted to arise from galaxies and galaxy clusters with redshifts $\sim$1, is detected in these observations with the anticipated power law slope vs. spatial frequency but at an absolute level several times greater than predicted by standard models of the star formation history of the universe.

Thuan and Lecavelier (Institut d'Astrophysique de Paris) and Izotov (Kiev) is engaged in a long-range program to obtain FUSE far-UV absorption spectra of metal-deficient Blue compact dwarf (BCD) galaxies to study element abundances in their neutral HI envelopes. Three BCDS have been analyzed thus far: Mrk 59 with an ionized gas abundance of 12% that of the Sun, SBS 0335-052, the second lowest metallicity BCD known with an ionized gas abundance of 2.5% that of the Sun, and IZw18, the lowest metallicity BCD known with an ionized gas abundance of 2% that of the Sun. They found that the metallicities of the neutral and ionized gas are unrelated, and that the neutral component of all three BCDs appears to have been enriched to a constant level of log (O/H)$\sim$–5 (1% solar). Interestingly, this is also about the same oxygen abundance as that derived for the intergalactic medium from absorption lines in the Lyα forest absorbers. This suggests that the intergalactic neutral gas has been enriched to an universal level of log (O/H) ~ -5 by population III stars.

4.1 Astrometry

Bartlett (graduate student), Ianna, and Begam completed a time-series analysis of eight fields from the southern hemisphere parallax program. In six cases, they found no evidence of any companions. On the basis of their Lomb periodograms, LHS 288 and LHS 2813 were selected for further study.

Ianna and Begam completed the observational portion of the CCD parallax work at the Mount Stromlo and Siding Spring Observatories using the 1-m reflector. Ianna, T. Henry (GSU), and R. Mendez (ESO) are

into the fourth year of a parallax program at CTIO on the 0.9-m and 1.5-m telescopes through a NOAO Survey award. The observing, about six nights per month, began in August 1999. The aims of this program are similar to the Australian program: to identify new nearby star candidates in new southern proper motion catalogs through photometry as well as other sources and to obtain parallaxes of those objects likely to be within 20 pc. So far, they have discovered 12 new stars within 10 parsecs and 63 new stars within 25 parsecs of our Sun.

Seidelman and S. Howard (USNO) have begun work as editors of the "Explanatory Supplement to the Astronomical Almanac," to be completed in 2003.

Seidelman and J. Kovalevsky (USNO) completed the book "Fundamentals of Astrometry" and sent it to Cambridge University Press for publication.

4.2 Astronomical Instrumentation

Crane completed the design for a fiber-fed spectrograph for the Fan Mountain Observatory 40-inch telescope and construction is underway, with completion expected this winter. Crane has also designed a weather and telescope environment monitoring and control system for the Fan Mountain Observatory. This system is currently being assembled.

Skrutskie is leading the development of a laboratory for the design and fabrication of near-infrared cameras and spectrographs. Renovations are in progress and development of a 1024x1024 HgCdTe imager/grism spectrograph will begin in the Fall. The CorMass NICMOS3-based cross-disperssed near-infrared spectrograph, currently in operation at the Palomar 60-inch telescope is being prepared for test observations at the 1.8m Vatican Observatory telescope at Mt. Graham.

4.3 Space Astronomy

Ianna is a co-investigator with a MASSIF Effort to Determine the Mass-Luminosity Relation for Stars of Various Ages, Metallicities, and Evolution States, which is a key project for the NASA's Space Interferometry Mission (SIM). MASSIF seeks precise mass measurements for stellar and substellar using astrometry and spectroscopy. SIM is currently scheduled for launch in 2009.

Seidelman has continued in the efforts toward solving the FAME technical problems of production of CCDs and specifying the requirements of the optical system, so that a reduced and realistic schedule and budget can be developed, despite NASA decision in January 2002 not to fund phase C of the FAME midex project. CCDs have been produced and are being prepared for testing to determine the effectiveness of charge injection as a means of mitigating the charge transfer inefficiency effects of radiation. The minimum requirements for the optical design are being developed.

C. Slesnick (Caltech), Rhee, Patterson, and G. Benedict (U.T. Austin) have determined luminosity classes for reference stars used in the determination of a parallax for the distance scale calibrator δ Cephei, obtained with the Fine Guidance Sensor interferometer on the Hubble Space Telescope.

4.4 Solar System

Johnson et al. have shown that the processing of the surfaces of Europa, Ganymede and Callisto by the energetic trapped particle radiation appears to determine all of the observed species seen in reflectance by Voyager, Galileo and HST. The one possible exception is the sodium atmosphere observed at Europa. Although it is produced by the incident radiation its ultimate source may be the putative subsurface ocean.

In collaboration with colleagues at the Space Telescope Science Institute and MIT, Johnson has modeled the dust, gas and plasma interactions in Saturn's inner magnetosphere. In doing this they have shown that the HST observations of the OH neutral torus at Saturn imply that there is much more surface area in this region than is seen telescopically. This is likely in the form of icy grains produced, possibly, by small unseen colliding satellites or an active surface on Enceladus.

Verbiscer is studying the photometric properties of Saturnian satellites Mimas, Enceladus, Tethys, Dione, and Rhea using UVBRI HST WFPC2 data in collaboration with R. French and C. McGhee (Wellesley). Solar phase curves in the range 0.26 to 6.4 degrees reveal the first observation of steep, narrow opposition effects of Mimas and Enceladus at visible wavelengths and necessitate an increase on the order of 20% in their currently accepted geometric albedos. Fits to the Hapke (Icarus, 157, 523 2002) photometric equation enable the distinction between the shadow-hiding and coherent backscatter opposition effects as well as other regolith properties including the single scattering albedo, macroscopic roughness, and the single particle phase function. Comparisons between derived photometric parameters for each satellite suggest the degree to which location—either interior (Mimas and Enceladus) or exterior (Tethys, Dione, and Rhea) to the densest point in the E-ring—affects the physical properties of regolith particles. Mimas and Enceladus have brighter trailing hemispheres, while Tethys, Dione, and Rhea display the opposite hemispherical albedo dichotomy. Multiple observations during a single HST orbit provide a series of measurements of the brightness of a satellite at constant phase angle, longitude, and latitude in each UVBRI filter, occasionally spanning a broader range from 255–1042nm. These spectral data indicate the satellite's color and demonstrate wavelength dependence on albedo.

5 Education and Public Outreach

Murphy, R. Bell (U. Virginia School of Education), and Gauthier (graduate student) organized a two-week workshop "Space Science for Teachers" for in-service teachers in July 2002. Twenty-seven educators in grades 3-9 from the Commonwealth of Virginia participated in the workshop to learn basic astronomy using hands-on, inquiry-based instruction, including a significant amount of work with small telescopes at night. Each teacher was

provided with the materials necessary to incorporate the methods into their curriculum. The project was funded under the federal Dwight D. Eisenhower Development Program.

6 Miscellany

Balbus was a visitor for four weeks at the Institut d'Astrophysique de Paris. He was also an invited participant to a conference on Astrophysical Fluid Dynamics, held in in Durham, England.

Bartlett (graduate student) completed a year as Visiting Assistant Professor of Physics and Astronomy at Hampden-Sydney College.

Chevalier served on the NRC/NAS Committee on Astronomy and Astrophysics, the AURA/NOAO Observatories Visiting Committee, the USRA Board of Trustees, and the AAS Heineman Prize Committee. He was on the Scientific Organizing Committees for the COSPAR meeting on High Energy Emission from Supernova Remnants and Neutron Stars (October 2002), IAU Colloquium 192 on Supernovae (April 2003), and IAU Symposium 218 on Young Neutron Stars and Their Environments (July 2003).

In Fall 2001, Crane was awarded a Grant-in-Aid of Research from the National Academy of Sciences, administered by Sigma Xi. In Spring 2002, Crane was awarded an Aerospace Graduate Research Fellowship, administered by the Virginia Space Grant Consortium.

Frinchaboy and Patterson have continued as Cooperative Observers for the National Weather Service Station that has operated continuously at McCormick Observatory since the 1890's.

Hawley collaborated with staff at the American Museum of Natural History on the scientific content of the Hayden Planetarium's new show "The Search for Life: Are We Alone?" Hawley created a time-dependent simulation of an protoplanetary disk which was a component of an animation showing the birth of a star and the creation of a solar system. He also served on the National Computational Science Alliance (NCSA) User Advisory Committee.

Ianna is serving as a rotator in the Stars and Stellar Astrophysics section of the NSF. He also serves as a technical consultant to CSICOP, a member of the Executive Board of the International Dark-Sky Association, the chair of the Virginia Section of IDA, on the Scientific Working Group of the NASA NStars Project, on the Outdoor Environmental Lighting Committee of the IESNA, on the IAU Working Group on Extrasolar Planets, and on the Roadway Lighting Design Study Advisory Committee for VDOT.

Majewski was named a Mead Honored Faculty at the University of Virginia.

O'Connell is chair of the Scientific Oversight Committee for the Hubble Space Telescope Wide Field Camera 3, a two-channel UV-visible-infrared imager scheduled for installation during the 2004 servicing mission. He also served as a member of the stellar populations panel for the Giant Segmented Mirror Telescope project (NOAO), the UV/Optical Detector Working Group (NASA HQ), and the Committee of Visitors for the Division of Astronomical Sciences at NSF.

Reiprich is chair of the Local Organizing Committee of the international conference "The Riddle of Cooling Flows in Galaxies and Clusters of Galaxies" to be held in June 2003 in Charlottesville.

Richards is a member of the Scientific Organizing Committee for IAU Joint Discussion No. 9 on "Astrotomography," to be held at the IAU General Assembly XXV, in Sydney, Australia, July 17, 2003. Richards was a member of the Scientific Organizing Committee for the conference titled "3-D Stellar Structure" that was held at UC Davis and Lawrence Livermore National Laboratory in July 2002. She gave an invited lecture on "An Assessment of National Resources for Stellar Astronomy" at the special session on The Future of Stellar Astrophysics at the AAS Meeting in January 2002. She had a press release on her study of flaring cycles in binary star systems at the AAS Meeting in June 2002 (www.aoc.nrao.edu/epo/pr/2002/algol/). Richards also attended the Annual Southeast Michigan Junior Science and Humanities Symposium for high school students, held at Wayne State University, Detroit, Michigan, March 7–8, 2002. At that symposium, Richards gave the main after dinner lecture on "Tomography and Other Adventures."

Sarazin was a member of the Astronomy and Space Physics Council of Universities for Space Research Association, and the scientific organizing committees for the The Future of Extreme Ultraviolet Astronomy workshop in Albuquerque, NM, the Soft X-ray Emission from Clusters of Galaxies and Related Phenomena meeting in Huntsville, VA, and the meeting of the Southeastern Section of the American Physical Society in Auburn, AL.

Seidelmann continues as president of the Celestial Mechanics Institute, the organization responsible for the scientific oversight of the Celestial Mechanics and Dynamical Astronomy journal. He and R.E. Schmidt have begun preparations for a star map that will lie at the feet of a statue of Einstein, similar to the ones in Washington and Jerusalem, currently in preparation for the American Museaum of Natural History in New York city.

Skrutskie is leading the Two Micron All-Sky Survey science team in the analysis and evaluation of the Survey's data products in preparation for the final distribution of catalogs and images from 100% of the celestial sphere in late 2002. The final data release catalogs are expected to include 450 million point source and 1.5 million extended source extractions. Sources not dominated by noise will have photometry precise to 0.03 mag in three near-infrared bands and astrometry precise to 100 milliarcseconds. Accompanying the source catalogs will be approximately 10 terabytes of image data of the entire sky with 1" pixels.

Tolbert, Fredrick, and Rood all served as AAS Shapley Lecturers.

7 Prizes and Awards

Rhee received a Small Research Grant of the American Astronomical Society (AAS) in support of his research entitled "New Metal-Poor Giants and Horizontal-Branch Stars from the HK-II Survey."

8 Support

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