New Mexico State University
Department of Astronomy

Las Cruces, New Mexico 88003

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This report covers events and activities that occurred during the calendar year 2002. More infromation can be found on our web-site `http://astro.nmsu.edu`

1. PERSONNEL

The faculty of the Astronomy Department includes Professors Kurt S. Anderson, Bernard J. McNamara, and René Walterbos (Dept. Head); Associate Professors: Jon A. Holtzman, Anatoly A. Klypin; Assistant Professors: Jim Murphy and Nicole Vogt; College Professors: Reta F. Beebe and William R. Webber; College Assistant Professors: Tom Harrison and Nancy Chanover; Emeritus Professor: Herbert A. Beebe.

Cristina Afonso and Bertrand Goldman are Postdoctoral Fellows; J. Johnson is a research specialist.

Nineteen graduate students are enrolled in 2002. They are Carla Adams, Carrie Anderson, Mark Blackmon, Erica Gerken, Joe Helmboldt, Melinda Kahre, Brandon Lawton, Bhasker Moorthy, Steven Nelli, Hector Noriega, Heather Osborne, Jason Peterson, Tom Stephens, Tanya Tavenner, Takafumi Temma, Nori Takato, Ocatavio Valenzuela, Mayrita Vitvitska, and Robert Zavala.

Observatory and departmental staff include Office Manager - Cheryl Beer; Fiscal Specialist- Lorenza Sanchez; Records Tech - Ofelia Ruiz; Systems Analyst- Lyle Huber; Research Asst - Irma Trejo.

2. OBSERVATORIES/INSTRUMENTATION

2.1 Apache Point Observatory

New Mexico State University is a member of the Sloan Digital Sky Survey. NMSU is also a member of the Astrophysical Research Consortium (ARC) and operates the Apache Point Observatory for the Consortium. Apache Point is located at an elevation of 2800m in the Sacramento Mountains of south-central New Mexico. Its principal instruments are the 3.5 meter ARC telescope and the 2.5 meter telescope of the Sloan Digital Sky Survey. Also, NMSU is operating the 1.0 meter imaging telescope at Apache Point.

Bruce Gillespie is the Site Manager of the Apache Point Observatory. Mark Klaene is Deputy Site Manager. There are four Observing Specialists responsible for 3.5 meter operations; they are John Barentine, Bill Ketzeback, Russett McMillan, and Jack Dembicky. SDSS Observers are Mike Harvanek, Atsuko Kleinman, Scot Kleinman, Jurek Krzesinski, Dan Long, Peter Newman, and Stephanie Snedden. Other observatory site staff are ; Jon Brinkmann, Scientific Instruments Engineer; Jon Davis, Telescope Systems Engineer; Madonna Shatzer, Records Technician; Gretchen Van Doren, Technical Writer; Norm Blythe,Technician; and Dave Woods, Electronics Technician. Craig Loomis is our Computer Systems Manager and Ron Yarger is our Maintenance Technician. On-campus support staff include Lorenza Sanchez and Irma Trejo. Dr. Kurt Anderson is the observatory's Site Director.

Instrument development and research activities of the ARC facilities at Apache Point Observatory are detailed in a separate Observatory Report. Most of the observational programs, including several synoptic investigations, have been conducted remotely and routinely via INTERNET links. New capabilities and instruments are under development. Anderson has used a thermal infrared camera system to characterize the heat environment of the telescopes at Apache Point Observatory. The video rate camera is also an excellent detector of nighttime clouds and it has now been incorporated into an all-sky cloud camera system. This provides observers (and those who access the Apache point Observatory web site) with real time cloud cover images, even on the darkest moonless nights.

NMSUs 1.0 meter telescope at Apache Point is an f/6 Ritchey-Chrtien instrument on an alt-azimuth mounting. It is presently equipped with a CCD camera and filter system at its Nasmyth focus. Jon Holtzman is responsible for the overall supervision and operation of the telescope. The telescope is currently equipped with a CCD camera and offset guider. It is now working in a fully robotic mode, allowing for all operations to be carried out without having an observer present. This has enabled some routine monitoring programs to be implemented on the telescope.

3. RESEARCH ACTIVITIES

3.1 Cosmology

Klypin, in collaboration with Yehuda Hoffman, Andrey Kravtsov, Stefan Gottloeber, made cosmological simulations which closely mimic the real Universe within 100Mpc of the Local Group. The simulations, called Constrained Simulations, reproduce the large-scale density field with major nearby structures, including the Local Group, the Coma and Virgo clusters, the Great Attractor, the Perseus-Pisces, and the Local Supercluster, in approximately correct locations. The MARK III survey of peculiar velocities of the observed structures inside 80Mpc/h sphere is used to constrain the initial conditions. Fourier modes on scales larger then 5Mpc/h are dominated by the constraints, while small scale waves are random. The main aim of this paper is the structure of the Local Supercluster (LSC; 30Mpc/h around the Virgo cluster) and the Local Group environment. We find that at the current epoch most of the mass (7.5e14Msun/h) of the LSC is located in a filament roughly centered on the Virgo cluster and extending over 40Mpc/h. The simulated Local Group (LG) is located in an adjacent smaller filament, which is not a part of the main body of the LSC, and has a peculiar velocity of 250kms toward the Virgo cluster. The peculiar velocity field in the LSC region is complicated and is drastically different from the field assumed in the Virgo-centric infall models. The peculiar velocity flow in the vicinity of the LG in the simulation is ‘‘cold’’: the peculiar line-of-sight velocity dispersion within 7Mpc/h of the LG is less than 60km/s, comparable to the observed velocity dispersion of nearby galaxies.

M. Vitvitska (NMSU), A.A. Klypin (NMSU), A.V. Kravtsov (U. Chicago), J.S. Bullock (Ohio State), R.H. Wechsler (UCSC), J.R. Primack (UCSC) propose a new explanation for the origin of angular momentum in galaxies and their dark halos, in which the halos obtain their spin through the cumulative acquisition of angular momentum from satellite accretion. In our model, the build-up of angular momentum is a random walk process associated with the mass assembly history of the halo's major progenitor. We assume no correlation between the angular momenta of accreted objects. Using the extended Press-Schechter approximation, we calculate the growth of mass, angular momentum, and spin parameter λ for many halos. Our random walk model reproduces the key features of the angular momentum of halos found in N-body simulations: a lognormal distribution in λ with an average of $<\lambda>\approx 0.04$, independent of mass and redshift. The evolution of the spin parameter in individual halos in this model is quite different from the steady increase with time of angular momentum in the tidal torque picture.

3.2 Planetary Science

We have completed an analysis of the frequency of dust devil occurrence at the Mars Pathfinder Lander location via analysis of lander meteorology data. At least two such vortices passed by the lander each martian day during its 83 day mission at northern-middle latitudes during northern ;ate summer. A paper has is being submitted to ICARUS. I have completed analyses of thermal wave amplitudes and wavenumbers/frequencies present in martian atmospheric temperature data provided by the engineering Horizon Sensor on-board the Mars Global Surveyor spacecraft. A paper describing these results, as well as the entirety of the MGS Horizon Sensor data set has been submitted to JGR-Planets. I am providing martian atmospheric expertise in an advisory role in support of the ongoing aerobraking activity of the Mars 2001 Odyssey spacecraft which arrived at Mars in late October.

Dr. Nancy Chanover's research in the field of giant planet and satellite atmospheres continued in 2002 with studies of Jupiter, Saturn, and Titan. Near-infrared spectroscopic measurements of Saturn were made in January 2002 at the NASA Infrared Telescope Facility with graduate student Takafumi Temma as part of his dissertation research. Analysis of these data is underway. Visible and very near-infrared imaging of Jupiter and Saturn using a powerful combination of high spectral and spatial resolution was carried out in February 2002, also in collaboration with Temma. The observations were made with an acousto-optic tunable filter camera built at NASA/Goddard Space Flight Center, which was used at the Coude feed of the Maui Space Surveillance System Advanced Electro-Optical System (AEOS) 3.63 meter telescope. This telescope has an adaptive optics system, which enhanced the spatial resolution of our data. Preliminary results from the analysis of this data set were presented at the October 2002 AAS/Division for the Planetary Sciences meeting in Birmingham, AL, and a manuscript is in preparation. Graduate student Melinda Kahre also made use of Mars data acquired with the AEOS telescope and the facility CCD camera. A combination of these data and Mars Global Surveyor's Thermal Emission Spectrometer data yields unique information about albedo changes on the martian surface due to the deposition of dust. Titan's lower troposphere was studied in collaboration with graduate student Carrie Anderson using high spectral resolution imaging of Titan taken at the Mount Wilson Observatory 2.5 meter telescope. Analysis of Titan's limb darkening as a function of wavelength suggests a lower troposphere that has been cleared of haze particles, possibly through rainout (Chanover *et al.*, Icarus, submitted).

Chanover and Anderson (in collaboration with Slanger, Cosby and Huestid of SRI International) used the echelle spectrograph on the 3.5 meter ARC telescope to successfully detect the Venus dark side nightglow in the 5577 line of atomic oxygen and in the Herzberg II band system near 5500. Ground based monitoring of these variable features continues. The aim is to better understand the processes of the Venerian atmosphere. We propose to extend these nightglow emission studies to Mars (where the OH emission should be prominent) and to Venus with HST and further 3.5 meter spectroscopy.

The Atmospheres Discipline Node of the NASA Planetary Data System (PDS) continues to provide online access to atmospheric data sets through `http: //atmos.nmsu.edu` or via FTP to the same site. Huber and Trejo are maintaining the node and undergraduate assistants provide support for ingestion of data and other data handling tasks. This archive includes atmospheric data that have been obtained with NASA interplanetary spacecraft as well as some supporting ground-based data. Current data sets that are being prepared for ingestion include Galileo Probe and Orbiter data, Mars Global Surveyor data, NASA IRTF data and other ground-based data.

3.3 Stars

Anderson, with Tsuenori Takato, Scot Kleinman, and Atsuko Kleinman is using the Sloan database to search for and characterize a large sample of white dwarf stars. SDSS spectroscopy for many of these is acquired since some are identified as potential QSO candidates and selected for followup spectroscopy.

Harrison continues to collaborate with F. Benedict and B. McArthur (U. of Texas) on measuring the parallaxes to cataclysmic variables and other objects using the Fine Guidance Sensors on the Hubble Space Telescope. Recently, we have determined the parallax to the ''intermediate polar'' cataclysmic variable EX Hydrae (with K. Beuermann Universitats-Sternwarte, Goettingen, Germany), and to the fundamental distance calibrators RR Lyrae and Delta Cephei. By early 2003, the distances to three more cataclysmic variables (WZ Sagittae, YZ Cancri, and RU Pegasi) will be known.

Harrison, with graduate student Osborne, continue their program of investigating the nature of the secondary stars in cataclysmic variables. Infrared spectroscopy of a dozen cataclysmic variables has been completed using spectrographs at the Infrared Telescope Facility and at Cerro Tololo Inter-American Observatory. These new infrared spectra reveal that the secondary stars of cataclysmic variables have unusual abundance patterns. The majority of the secondary stars show a deficiency in ^{12}C, and enhanced levels of ^{13}C. This suggests that nuclear processed material from the CNO tri-cycle is finding its way into the atmospheres of these stars. In addition, we have found enhancements and/or deficits in such elements as sodium, calcium, silicon, titanium, and magnesium. These results suggest that the standard model for the evolutionary history of cataclysmic variables may need substantial revision.

3.4 High Energy Astrophysics

W. Webber, with collaborators, has employed the modified weighted slab technique along with recent values of the relevant cross sections to compute primary to secondary ratios including B/C and sub-Fe/Fe for different Galactic propagation models. The models that we have considered are the disk-halo diffusion model, the dynamical halo wind model, the turbulent diffusion model, and a model with minimal reacceleration. The modified weighted slab technique will be briefly discussed and a more detailed description of the models will be given. We will also discuss the impact that the various models have on the problem of anisotropy at high energy and discuss what properties of a particular model bear on this issue.

3.5 Galaxies

Anatoly Klypin, HongSheng Zhao, and Rachel S. Somerville proposed new models for the Milky Way and M31 galaxies. The resulting models score remarkably well when confronted with the broad range of observational data available for the Milky Way and M31 galaxies, giving a Milky Way virial mass of $1-2\times10^{12}M_{\odot}$ and concentration C=12-17. We consider two types of models, in which: (A) baryons conserve angular momentum and (B) some of the angular momentum of the baryons are transferred to the dark matter. Type-A models produce good agreement with observed rotation curves and obey constraints in the solar neighborhood, but may have too much dark matter in the center to allow a fast rotating bar. The type-B models with angular momentum transport have a slightly more massive disk and less dark matter in the central part, allowing a fast rotating bar to persist.

Nicole Vogt's research efforts are focused on understanding the evolution of galaxies over the history of the Universe. Her current focus extends from the present to redshift z $\sim$ 1.5, where the latest instrumentation (HST, Keck, VLT, & Gemini) enables a rich, detailed set of observations for a significant fraction of the total galaxy population. One of the grandest challenges of modern cosmology is to understand the evolution of galaxies over the history of the Universe. Her focus extends from the present to redshift z$\sim$1.5, where the latest instruments enable a rich, detailed set of observations for a significant fraction of the total galaxy population. This program can be described with four interwoven themes.
Disentangling the effects of environment from time-dependent evolution. Local spirals around clusters exhibit accelerated evolution due to the extreme environment. A clear progression can be traced from the infalling population through violent interactions with the hot gas, tidal forces, and galaxy-galaxy harassment, leading to a gas-stripped disk which forms no new stars and slowly fades to join the cluster lenticulars. By studying the effects of a dense environment on star formation histories, we can separate the observed evolution in the distant galaxy population due to individual galaxy evolution and to the growth of large structures (e.g., clustering)
Understanding the evolution and star formation history of spiral galaxies to $z = 1$. Detailed observations of mass, luminosity, morphology and structure reveal the growth of old and young stellar populations in spiral bulges and disks. One key result is that a significant fraction (85%) of elongated galaxies have properties analogous to those of local spirals; the exceptions are compact, high surface-brightness galaxies undergoing bursts of star formation, or morphologically disturbed systems with a superficial similarity to edge-on disks.
Integrating observational surveys and theoretical model ensembles. Galaxy evolution is differential, occurring at varied rates within different types of galaxies. We thus need to incorporate observational selection biases at every stage of analysis. Modern processors allow model analyses with sufficient resolution and speed to examine critical parameters (e.g., star formation processes, satellite and gas infall) in depth within a generated ensemble of halo potentials. We can thus model the underlying galaxy population, apply actual redshift-dependent survey selection criteria (e.g., surface brightness selection functions), and then compare the results with those found for observed samples of galaxies. This enables us to identify the propagation of biases which take the form of apparent galaxy evolution.
Studying disk formation between $z = 1$ and 2. Disk morphology appears to become less common and less regular beyond a redshift of 1, but optical passbands are dominated by UV flux, key star formation indicators are difficult to observe, and even spectral redshifts are sparse. Are local spiral analogs vanishing, to be replaced by turbulent disks in the throes of successive infall, just as observational samples become increasingly biased towards irregular, blue galaxies with extreme star formation? Large infrared-optimized telescopes and instruments are of critical importance for exploration of this critical regime, where both observations and theory suggest the formation of the first large disk systems occurred.

Holtzman continued to work on stellar populations in Local Group galaxies. Full star formation histories were derived for the Phoenix dwarf galaxy, and similar work is underway on the WLM dwarf; the latter work is in collaboration with graduate students H. Noriega and G. Smith (UCO/Lick). Both galaxies show evidence for star formation extended over most of the lifetime of the galaxy. Holtzman, with collaborators, presented a systematic and homogeneous analysis of population gradients for a large number of Local Group dwarf spheroidals; significant population gradients are found in most objects. In some galaxies, metallicity is the driver for the gradient; in others, it appears to be age.

To help understand the reliability of reconstructed star formation histories from the distribution of stars in color magnitude diagrams, Holtzman participated in a controlled experiment in which multiple groups attempted to recover the star formation history of a field in the LMC bar using the same dataset. Initial results were presented at a workshop in spring 2001 in Coimbra, and additional work continues.

Holtzman completed some work on measuring sizes of marginally resolved clusters using HST/WFPC2 data; this work was initiated several years ago by former graduate student Matt Carlson. Results were obtained for young clusters in NGC 1275 and NGC 3597 that suggest that these young clusters are comparable in structural parameters to Galactic globular clusters.

Holtzman continued his project to study structural parameters in spiral galaxies in collaboration with S. Courteau and L. McArthur (UBC). Results on bulge-disk decompositions were presented in a workshop in fall 2001. A project to study the nature of bulges by looking for line strength gradients using spectroscopy was continued at APO; graduate student B. Moorthy continues to work on the analysis of these data.

Helmbold, Walterbos, Bothun (Oregon), de Blok (CSIRO), and O'Neil (Arecibo) continued study of the star formation properties of low surface brightness galaxies and dwarfs through Halpha and broadband observations of an HI selected (HIPASS) selected sample of galaxies in the southern hemisphere. About 70 of these HIPASS galaxies have been imaged. The sample is dominated by late-type, dwarf disks with exponential disk scalelengths around 1 kpc or less. The overall sample properties were compared with an optically selected sample to determine how much of the star formation in the local universe might be missed in such surveys. Results will be published in two papers.

Walterbos, Gerken, and Oey (Lowell Observatory) are studying the radiation and mechanical energy output of massive stars in the Magellanic Clouds, to test models of the ionization of the diffuse ionized medium, and of shell creation by supernova explosions. Hoopes (JHU) and Walterbos are continuing studies of the ionization of DIG in nearby spirals through optical spectroscopy. New data were obtained in 2002 for M33 and M81.

Walterbos, Braun (NFRA), Corbelli (Arcetri Observatory), and Thilker (NRAO) obtained a new HI survey of the nearby spiral M31 with the Westerbork Radio Telescope out to unprecedented radial distances and sensitivity levels. The goal is to look for faint outer disk HI and extend the rotation curve to larger radial distances. They also obtained new GBT data of M33 and M31 and their environments.

Walterbos, Chiappini (Trieste), Kennicutt (Steward Observatory) and Thilker (NRAO) obtained abundances of HII regions at very large distances from the centers in M81 and M31 using the ARC 3.5-m and MMT 6.5-m telescopes. Two more spirals were added in collaboration with Cuisinier (Rio de Janeiro). In addition, a beginning was made in obtaining abundances of Planetary Nebulae in the outer disk of the MW with the ARC 3.5-m telescope. The overall goal of these projects is to improve our knowledge of abundance gradients and star formation thresholds in outer disks.

Anderson, in collaboration with W. Baggett and S. Baggett, has completed the second phase of a project on disk morphology. A high incidence (at leat 28%) of Fremman Type II profiles is found for a large and uniform sample of disk and lenticular galaxies. While the incidence is much higher among barred systems, the presence of a bar is neither a necessary nor sufficient condition for the inner truncation characterizing Type II surface brightness profiles.

Anderson and Stephanie Snedden are gathering line profile statistics for AGN using the SDSS spectroscopic database. This is part of an ongoing study of the statistics and kinematics of broad line regions in AGN and quasistellar objects.

4. EDUCATION

The Sunspot Visitor and Astronomy Center is a collaborative venture of the NMSU Department of Astronomy, Apache Point Observatory, the Sacramento Peak Solar Observatory, and the United States Forest Service. Adjacent to the National Solar Observatory facilities at Sunspot, NM, and to Apache Point Observatory, the Center serves as a visitor center for the growing complex of astronomical facilities in the Sacramento Mountains. Approximately half of the 5000 square foot area of the main building is an exhibit area, devoted to instructional and interactive exhibits with astronomical themes. Emphasis is on the instruments and research at Apache Point and Sacramento Peak. An auditorium or meeting room/auditorium area is of comparable size. Office space and other visitor facilities occupy the remainder of the area. A system of walking trails joins the Center building to the telescopes and other features of the observatories.

The Sunspot Astronomy Center is funded by a combination of grants from the New Mexico State Legislature and matching funds from the Federal Highway Administrations ISTEA program. Kurt Anderson represents the Department of Astronomy and Apache Point Observatory in this venture.

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A. Klypin