New Mexico State University
Department of Astronomy
Las Cruces, New Mexico 88003

This report covers events and activities that occurred during the calendar year 1996.

1. PERSONNEL

The faculty of the Astronomy Department includes Professors Kurt S. Anderson, Reta F. Beebe, Jack O. Burns , Bernard J. McNamara, and William R. Webber; Associate Professor René Walterbos (Dept. Head); Assistant Professors Jon A. Holtzman, Anatoly A. Klypin, and Mark S. Marley; College Assistant Professors Nicholas Devereux, Chris Loken, Tom Harrison, and Michael Ledlow; and Emeritus Professors Herbert A. Beebe and Clyde W. Tombaugh.

Adjunct members of the faculty include Jonathan Brinkman (Apache Point), Roger E. Davis (Science & Technology Corp.), Richard B. Dunn (NSO), Nebojsa Duric (UNM), W. Miller Goss (NRAO), Hunt Guitar (Science & Technology Corp.), Virginia Gulick (NASA, ARC), John J. Keady (LANL), David Kuehn (Pittsburg State Univ.), Donald F. Neidig (NSO), Frazer N. Owen (NRAO), Richard A. Perley (NRAO), Richard R. Radick (NSO), George Simon (NSO, Sac Peak), Raymond N. Smartt (NSO), and John Stocke (Colorado).

The postdoctoral fellows are Paul Mason and Alan Watson. Twenty four graduate students are enrolled for the Fall 1996 semester. They are Mark Bliton, Matthew Carlson, Nancy Chanover, Vanessa Galarza, Christopher Garasi, Marla Geha, Chris Gelino, Percy Gomez, Bruce Greenawalt, Salman Hameed, Charles Hoopes, Nichole King, Andrey Kravtsov, Dawn Leeber, Neal Miller, Jason Peterson, Elizabeth Rizza, Amy Simon, Clay Smith, Denise Stephens, Tom Stephens, Matthew Templeton, David Thilker, Charles Walter.

Observatory and departmental staff include Mendy Fowler, secretary; Laura Maynez, office manager; Dacia Pacheco, accountant; MerriLee Saige, accounting assistant; David Summers, observing specialist; Lyle Huber, programmer analyst; Steven Duran, research assistant.

2. OBSERVATORIES/INSTRUMENTATION

2.1 Apache Point Observatory

New Mexico State University is 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 instrument is the 3.5 meter ARC telescope. The 2.5 meter telescope of the Sloan Digital Sky Survey is presently under construction and an associated 0.6 meter monitoring telescope is now operating at the site. Also, NMSU has installed a new 1.0 meter imaging telescope at Apace Point.

Apache Point Observatory has three Observing Specialists responsible for 3.5 meter operations; Eddie Bergeron, Karen Gloria, and Dan Long. ddie Bergeron left late in the year and will be replaced by Tia Hoyes. Other observatory site staff are Jon Brinkmann, Instrument Scientist; Jon Davis, telescope Engineer; Jim Fowler, Computer Systems Manager; Bruce Gillespie, Site Manager; Mark Klaene, Observatory Engineer; Madonna Reyero, Custodian; and Gretchen Van Doren, Records Specialist. Kurt Anderson is Site Director.

Instrument development and research activities of the ARC facilities at Apache Point Observatory are described in greater detail elsewhere in these Observatory Reports. In brief, the 3.5 meter telescope has been fully operational for over two years, and used for a variety of imaging and spectroscopic investigations at optical and infrared wavelengths. It is noteworthy that most of these observational programs, including several synoptic investigations, have been conducted remotely via INTERNET links. New capabilities and instruments are under development and we are continually upgrading existing systems. Most of the latter efforts address improvements in the pointing, tracking, and image quality of the telescope. The basic mechanical structures of the Sloan telescope were installed last year, the primary mirror is in site awaiting installation, and the instrument will see first light early next year.

NMSUs 1.0 meter telescope is now in place and operational at Apache Point. This 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. The telescope is operated remotely and will eventually be programmed for robotic operation. Current efforts are concentrated on improving its pointing and tracking capabilities. An offset guider and autoguiding system for this telescope are under development. Professor Kurt Anderson has been responsible for the design and construction of this telescope. David Summers, who joined the Department of Astronomy as an Observing Specialist this fall, will eventually assume principal responsibilities for its operation and maintenance. Professor Jon Holtzman is improving the control system software.

2.2 Tortugas Mountain Planetary Observatory

A limited monitoring program is continuing at the Tortugas Mountain Observatory. Multicolor CCD observations obtained with the 0.6 m telescope are reduced, archived and made available to the Planetary community through the Atmospheres Discipline Node of the NASA Planetary Data System, maintained at NMSU. Images collected over the last 29 years are on file and accessible as a climatic data base. Although NASA funding has been reduced, simultaneous observations are obtained when the 3.5 meter Apache Point telescope is scheduled for near-IR observations of Jupiter. Murrell and Chanover are carrying out this program and are archiving the data.

3. RESEARCH ACTIVITIES

3.1 Planetary Science

Simon, Chanover, Beebe and Murrell have continued efforts to sustain a climatological data base containing a multispectral imaging data. This includes aggressive use of Hubble Space Telescope WFPC2 images of both Jupiter and Saturn, near IR imaging with GRIM at Apache Point and .4 to 1.0 micron observations at Tortugas Mountain Observatory.

Chanover continued her periodic near-IR observations of Jupiter made with GRIM, the APache Point facility near-IR camera. In addition, Chanover collaborated with an instrument group at Goddard Space Flight Center and hosted a guest instrument at the Apache Point 3.5 meter telescope. This instrument, a near-IR detector coupled with an acousto-optic tunable filter, was successfully used in May to observe Venus in an effort to spatially map key molecular constituents of the Venusian atmosphere.

A major part of our efforts this year has involved support of the Galileo mission, both probe and orbiter. Our Hubble Space Telescope data provides the global context for interpreting the limited high resolution atmospheric imaging that can be obtained with the Solid State Imaging system and has higher spatial resolution than a major portion of the infrared data. Our access to Voyager and groundbased data provides the temporal framework for interpretation.

A third major thrust has been related to our assumption of operation and improvement of the Atmospheres Discipline Node of the NASA Planetary Data System (DS). Online access to the data sets maintained by the Atmospheres Node is available through http://atmos.nmsu.edu/ or via FTP to the same site. Huber and Duran are maintaining the node and undergraduate assistants Washburn, Chilton and Reinke provide support for ingestion of data and other data handling tasks. This archive includes all atmospheric data that has been obtained with NASA spacecraft as well as some supporting groundbased data. Current data sets that are being prepared for ingestion are the SL-9 data and Galileo Probe data.

In October Beebe assumed the chair of the Atmospheres Working Group of the International Jupiter Watch and will integrate that data source into the PDS Atmospheres Node World Wide Web site. In addition, Beebe served on Jeffery Linsky's working group that was chartered to review all of NASA/OSS data archiving activities. The report was completed in October and is being utilized by OSS.

Marley continued to model the atmospheres of extrasolar giant planets and brown dwarfs. Model temperature profiles derived using a radiative-convective equilibrium code were used to synthesize the spectrum of the brown dwarf Gliese 229 B. Theoretical spectra reproduce the near-infrared observations and constrain the effective temperature and mass of the object. Application of the same atmosphere model to the recently-discovered extrasolar giant planets provides guidance for efforts to detect the new planets directly. Marley was awarded an NSF CAREER grant to expand the studies on the extrasolar giant planets. This work continues in collaboration with W. Hubbard, T. Guillot, J. Lunine, and A. Burrows (U. Arizona), D. Saumon (Vanderbilt), and R. Freedman (NASA/Ames-Sterling Software).

Marley and Walter continue to observe the atmosphere of Uranus in the near-infrared with the ARC 3.5-meter telescope. Atmosphere models of Uranus applied to the data suggest that the number density of stratospheric haze particles has increased substantially since the time of the Voyager encounters.

3.2 High Energy Astrophysics

Harrison and McNamara continued their study of the soft X-ray (7-16keV) studies of gamma-ray bursts (GRBs) using the BATSE Spectroscopy Detectors aboard the Compton Gamma-Ray Observatory. Initial results show that more than 50% of all GRBs detected by the BATSE Large Area Detectors (at higher energies, 40-300 keV) were detected by the Spectroscopy Detectors. This large sample has allowed us to show that the peak flux at soft x-ray energies lags the high energy peak by several seconds. This finding may shed light on the nature of the physical processes at work in the GRB event.

Harrison has published infrared observations of the peculiar cataclysmic variables V605 Aql and CK Vul, objects formerly classified as classical novae. CK Vul was an object that erupted in 1670, and has been called the oldest recovered classical nova. V605 Aql underwent its first outburst in 1917, followed by three more visual maxima during the next six years. The light curves of both objects are unlike any other classical novae, but resemble each other. The new infrared observations show that the spectral energy distributions of both objects are similar, and can be modeled with by a heavily extinguished hot blackbody (presumably the central source) combined with a cooler blackbody (an extended dust shell). V605 Aql can most easily be re-classified as a post-AGB object that exhibited a final helium shell flash. A similar model to explain the nature of CK Vul requires that the central source luminosity of CK Vul to have declined dramatically since the 1670 outburst.

3.3 Normal Galaxies

Hoopes, Walterbos, and Greenawalt published a paper on the diffuse ionized gas in three Sculptor group spirals. Narrow-band imaging in H_α and [SII] show that 30 to 50% of the H_α luminosity is contributed by diffuse ionized gas. A new method was developed to measure this fraction, which addresses the problems of high inclination and a varying brightness level for the diffuse emission. The energy requirements of the DIG in these galaxies favor OB stars as the ionization source. Greenawalt and Walterbos are continuing their study of diffuse ionized gas in nearby spiral galaxies. Long slit spectra from the KPNO 4-m telescope of diffuse ionized gas in M31 shows that the observed line ratios of [OII], [OIII], and [SII] to H_α are consistent with photo ionization models in which radiation from OB stars is the source of ionization. Analysis has also begun on narrow-band H-alpha and [SII] images obtained for several nearby spirals including M33, NGC 628, NGC 925, NGC 2366, and NGC 2403. Hoopes and Walterbos have begun a project that tries

to further test the photo ionization model for diffuse ionized gas. The project utilizes HST UV and optical images of fields in M31 and M33 to determine the the ionizing luminosity of stars in HII regions and in DIG, to determine whether field OB stars can ionize the DIG, or if ionizing photons can leak out of HII regions. As part of this project we are also analyzing UIT images of these galaxies to investigate the ionization on a more global scale. That analysis is in collaboration with Bothun (University of Oregon), Schommer (CTIO) and Smith (NASA/GSFC).

Walterbos, Hoopes, and Greenawalt are continuing their study of the FIR emission in galaxies. They developed a model which computes the likely contribution to the FIR emission from dust heated by the interstellar radiation field. The model has now been applied to a large sample of nearby galaxies, and the results confirm the initial finding that the interstellar radiation field can play a significant role in heating the dust. They are now studying the relation between their model predictions and the H_α luminosity in galaxies.

Galarza, Walterbos, and Braun (NFRA) are analyzing optical spectra of M31 supernova remnants, using candidates from the Braun & Walterbos (1994) survey, and of HII Regions in M31. Preliminary results include discovery of three Wolf-Rayet candidates and corroborating evidence for a previously known Wolf-Rayet star in M31. The goal is also to study the abundance gradient in M31 using the spectra of more than 30 HII Regions covering a range in radial distances in the NE arm of the galaxy. Walterbos, King, and Braun (NFRA) are using the ARC 3.5-m telescope to obtain data on a sample of massive stars with high mass loss rates in M31, that they discovered from an earlier emission-line imaging survey. Five new LBV or B[e] stars have been found so far, which more than doubles the number known previously. Plans are made to expand the study to nearby galaxies.

Thilker, Braun (NFRA), and Walterbos continued development of an automated technique for the systematic detection and characterization of expanding gaseous shells in HI data cubes of spiral galaxies. The method produces statistically robust expanding shell catalogs. The algorithm is equally suited to optical emission-line data obtained using Fabry-Perot imaging spectrometers. They are able to determine catalog completeness as a function of shell size and expansion velocity. In collaboration with Mashchenko (National Academy of Sciences of Ukraine), they have started incorporating realistic hydrodynamic numerical models to derive predicted observational supershell signatures. A first paper, presenting the method and results for the spiral galaxy NGC 2403, was submitted for publication to Astronomy and Astrophysics.

Thilker, Walterbos, and Norman (STScI) begun analysis of archival HST WFPC2 broad-band multi-color optical images of regions coinciding with expanding HI shells in M101 and M81. The goal is to test if the embedded stellar populations are consistent with model predictions for the massive stars needed to form the shells. This pilot project will be increased in scope as more observations become available and as additional shell catalogs are compiled for other galaxies in the sample. Wang (NWU), Walterbos, and Thilker obtained a very deep (180-ksec) ROSAT HRI observation of M101. This X-ray data will be used to look for general correspondence between the observed spatial distribution of hot gas and the distribution predicted in relation to M101's HI supershell population.

Observing from KPNO and APO, Thilker and Walterbos obtained wide-field emission line images and long-slit spectroscopy of the superwind outflow in M82, the canonical starburst galaxy. Sensitive H_α images suggest the presence of previously undiscovered portions in the NW outflow cone, extending to a projected distance of 10 kpc from the starburst nucleus. Optical spectroscopy confirms the anticipated line-of-sight velocity for this ionized gas and argues against the possibility of a chance projection.

Devereux, Duric (Univ. of New Mexico) and Scowen (Arizona State Univ.) have analyzed H_α, far infrared and thermal radio continuum images of the nearby late-type spiral galaxy M33. The $H\alpha$ image is compared with the 6cm thermal radio continuum image to determine the extinction to the ionized gas. The H_α image is also compared with a high resolution far infrared image to constrain the contribution of O and B stars to the far infrared luminosity measured by the Infrared Astronomical Satellite (IRAS). The results, to be published in the January 1997 Astronomical Journal, indicate that the extinction is high locally, but low globally, and that at least 70% of the far infrared luminosity is generated by O and B stars.

Devereux & Hameed have compiled reliable IRAS fluxes for galaxies in the Nearby Galaxies Catalog (NBG). The large database, which includes approximately 2000 galaxies, has been used to quantify massive star formation rates for nearby galaxies of different Hubble Type. The results, to be published in the February 1997 Astronomical Journal, indicate that both the present day massive star formation rates, and the ratio of present to past star formation, is independent of spiral type, at least for the Sa's, the Sb's and the Sc's.

Devereux, Ford (Johns Hopkins Univ.) and Jacoby (NOAO) imaged the central 1 kpc of the nearest Seyfert 1 galaxy; M81. The images reveal a small, 100 pc, disk of ionized gas and sinuous dust lanes that wind into a very bright and unresolved nucleus. An Cycle 7 HST proposal, written in collaboration with Tsvetanov (Johns Hopkins Univ.), is pending to measure the disk kinematics with STIS in order to constrain the mass of the black hole that presumably lies at the center of M81.

Watson continued collaboration with Hofner (NAIC), Shepherd (Caltech), and Churchwell (University of Wisconsin) to investigate ultracompact HII regions and candidate massive YSOs in the near infrared. Their observations have yielded an direct constraint on the evolutionary state of the O star ionizing the ultracompact HII region G29.96 - 0.02 which suggests that massive stars begin their lives already somewhat evolved, in agreement with recent theoretical models.

They have also detected what appears to be a bow shock from a jet from the massive outflow source G192.16 - 3.82. If confirmed by planned molecular imaging, this would be the first detection of a highly collimated jet, as opposed to a less collimated outflow, that could be securely identified with a massive YSO.

Watson ported his parallel Monte-Carlo radiation transfer code to the massively parallel T3D supercomputer. Watson, Burrows (STScI), Krist (STScI), and Stapelfeldt (JPL) used this code to model the circumstellar disk seen in WFPC2 observations of the low-mass YSO HH30. This effort was able to constrain the properties of both the disk and the dust.

Watson and Holtzman published their analysis of the massive stellar clusters found in the nearby starburst galaxy NGC 253. Analysis of sub-arcsecond UV, optical, infrared, and radio images of the starburst galaxy NGC 2903 is continuing. Watson gave an invited review of observations of superstar clusters at conference entitled ''AGN, Dense Stellar Systems, and Galactic Environments.''

Holtzman continued to work primarily with data from the Hubble Space Telescope as a member of the Investigation Definition Team for the Wide Field Planetary Camera 2. A sample of two interacting galaxies and four cooling flow galaxies were studied to look for the presence of young compact massive star clusters. Such clusters were found in both interacting galaxies, NGC 3597 and NGC 6052, but only in one of the cooling flow galaxies, and even in this galaxy, it is unclear how compact and massive the clusters are. These data strongly support the hypothesis that compact clusters can be formed in interacting systems, and probably reject the hypothesis that they are related to cooling flows. The clusters in NGC 3597 were studied in detail to determine their physical size, and results indicate that they are comparable in size to Galactic globular clusters.

A study of the morphology of dust in the cooling flow galaxies was undertaken by Jason Pinkney with Holtzman. The images of the central galaxy in Abell 1795 show a remarkable correpondence between the location of dust in the center of the galaxy and the nuclear radio jet. The existence of dust at all is somewhat of a puzzle because of the high gas temperatures found in the center of the cluster. Analysis of the images determined that the total mass in dust in this galaxy is comparable to that found in other ellipticals, and the extinction law is consistent with the Galactic extinction law.

Deep WFPC2 observations were obtained of the central regions of NGC 1275 to measure the luminosity function of the young clusters present in this galaxy. Analysis of these observations will comprise a significant part of Matt Carlson's Ph.D thesis. The data show a clear split in color between a population of young clusters and a population of older clusters, suggesting that the young clusters formed within a short period of time. Analysis is underway to estimate the total number of clusters formed and how this event affected the specific frequency of globulars in this galaxy. Carlson hopes to extend such studies to other galaxies with young clusters as well.

Detailed analysis of photometry of several fields in the Large Magellanic Cloud was performed by Holtzman in collaboration with J. Gallagher (U. Wisc.) J. Mould (MSSO), Marla Geha (NMSU), and others. The width of the upper main seqeuence in these fields suggests a roughly constant star formation rate in the LMC over the past few Gyr, although one field shows evidence of a mild ''burst'' in star formation about 2 Gyr ago. The luminosity function of the lower main sequence was analyzed to infer an initial mass function, and the derived slope of the IMF is consistent with that found in the solar neighborhood, though preferred values are slightly steeper. Assuming a solar neighborhood IMF, it was found that the data are inconsistent with a picture of the LMC as being totally dominated by young stars. Instead, a star formation history was derived which has a roughly constant star formation rate for 10 Gyr, then an increase in star formation rate of about a factor of 3 during the past 2 Gyr. However, a predominantly young population would be allowed if the IMF were steeper than the solar neighborhood value.

Holtzman continued his project to study the effects of dust in spiral galaxies, in collaboration with S. Courteau (NOAO), although there was little progress in the past year.

3.4 Active Galaxies

Anderson, as part of a large collaborative effort, as been monitoring the temporal behavior of the broad-lined radio galaxy 3C390.3. Images in Gunn g and r, plus low resolution (7) blue and red spectra, have been obtained at intervals of roughly 10 days throughout the year. These observations were made using the double imaging spectrograph on the ARC 3.5 meter telescope at Apache Point Observatory. The same approach will be used to monitor the Seyfert 1 galaxy Markarian 335 in 1977. The intention is to use reverberation mapping techniques to understand the spatial and kinematic geometry of the broad emission line regions.

A related program, based upon optical imaging and spectroscopy of samples of Seyfert galaxies and broad-lined radio galaxies, attempts to describe and understand both the great similarities and large differences between these two classes of AGN.

Anderson, in collaboration with W. Baggett (Computer Sciences Corporation) and S. Baggett (STScI)has completed an imaging study for a large sample of disk and lenticular galaxies. Images of a large and homogeneous sample of galaxies have been examined and their surface brightness profiles in V represented by the superposition of a de Vaucouleurs law bulge and an inner-truncated exponential disk. Surprisingly, this succeeds for more than 94% of the 659 disk and lenticular galaxies in the sample. There seem to be no significant trends in fittability with morphological type or inclination. At least 25% of disk profiles are best fit with an inner-truncated exponential, suggesting that such truncations are both real and relatively common. Preliminary indications are that the incidence of inner truncations is at least a factor of four higher among barred systems than among unbarred systems. These results strengthen earlier conclusions which were based upon a much smaller and less homogeneous sample of galaxies.

Ledlow, F. Owen (NRAO), and W. Keel (Alabama) have recently submitted a paper to the Astrophysical Journal on the detection of possibly the first powerful FR I radio source in a disk or spiral galaxy. This object was the only one of its kind out of a survey of greater than 500 Abell clusters with the VLA. It has been an accepted fact for some time that these types of radio sources are only found in elliptical galaxy hosts. The paper describes an analysis of VLA radio

imaging, optical B and R-band images, near-infrared J and K imaging and optical spectroscopy. Limits are placed on the contribution of starburst or AGN-like activity from the galaxy nucleus. The data clearly show that this galaxy is a disk system, with a measured rotation curve. Higher resolution VLA imaging is underway, and a proposal was submitted to HST to resolve the morphology and properties of the circumnuclear environment.

Loken and Burns, along with colleagues at the National Center for Supercomputing Applications (NCSA), ran the highest-resolution simulation to date of the disruption of a 3D equilibrium jet. The entrainment and stability properties were investigated and compared with previous, lower resolution simulations. They also began a self-convergence study of entrainment rates in an effort to determine the resolution required to properly characterize turbulent entrainment by jets.

Owen and Ledlow have published (January 1997, ApJS) the final radio maps from their VLA 20cm survey of >500 Abell clusters of galaxies. These are VLA snapshot observations made with a combination of different array configurations to map the sources at all interesting spatial scales. New maps are presented for 200 radio sources located within the centers of Abell clusters with $z<0.25$, including a statistically complete sample of clusters with $z<0.09$.

Bliton, Rizza, Burns, Owen, and Ledlow have analyzed the morphological and kinematic properties of a sample of 17 Abell clusters containing 26 Narrow-Angle Tail (NAT) radio galaxies with archival ROSAT PSPC observations. They found that NAT radio sources are preferentially located in unrelaxed clusters, based on the presence of X-ray substructure in these systems. As compared to a control sample of radio-quiet clusters, 88% of the NAT clusters, and only 23% of the control sample showed significant substructure. Additionally, from the distribution of NAT galaxy velocities relative to their cluster velocity dispersions it was determined that NAT galaxies do not preferentially have high peculiar velocities. This result, and the alignment of the radio tails with local X-ray substructure in the cluster implies that the local ICM, possibly form bulk flows produced in cluster-cluster mergers (rather than the galaxy's motion), plays an important role in shaping the radio tails.

Ledlow, Owen, J. Hill (Steward), Rizza, and Burns, are studying the optical spectra of radio galaxies identified in several distant ($z>0.2$) Abell clusters from deep VLA imaging. These clusters are interesting, in that many of these clusters have factors of 3-5 more radio galaxies than lower redshift clusters of the same optical richness. Optical imaging and spectroscopy are used to discern the nature of the host galaxies (starbursts, post-starburst, AGN, old stellar population) in order to understand the high frequency of radio emission from these cluster galaxies, and possible correlations with the Butcher-Oemler effect, cluster-cluster merging, and models of radio source evolution.

3.5 Galaxy Clustering and Cosmology

Ledlow, Loken, Burns, Hill, and R.White(NASA/ GSFC) have produced a volume-limited, statistical sample of 49 poor galaxy clusters as part of an X-ray / Dynamical study of poor cluster environments. An analysis of the optical properties, dynamics, and environments of these clusters was presented to study the role of poor clusters in hierarchical models of cluster formation. It was found that a large fraction of the clusters show evidence for being in a non-relaxed dynamical state, and most are imbedded within larger galaxy condensations.

From the poor cluster sample in Ledlow *et al.* (1996), Burns, Ledlow, Loken, Klypin, W. Voges (MPE, Germany), G. Bryan (NCSA), M. Norman (NSCA), and White, have constructed the first X-ray luminosity function for poor galaxy clusters. The X-ray luminosities were measured from the ROSAT All-Sky-Survey (RASS). From the poor and rich-cluster XLF, the Gas Mass function was derived and compared to different cosmological models. These data extended the XLF for galaxy clusters an order of magnitude lower than previously determined. The slope and amplitude of the XLF was found to be continuous down to these lower luminosity levels, suggesting that poor clusters share a continuum of properties with rich clusters, at the low-end of the mass-function.

Gomez, Pinkney, Burns, Wang (NRAO), Owen, and Voges presented new ROSAT PSPC pointed observations of 9 Abell clusters which contain wide-angle-tailed (WAT) radio galaxies. They found that 90% of the clusters have X-ray substructure, mostly with elongations between the radio tails. This is consistent with their hydro/N-body simulations of clusters which are in the process of merging with subclusters. The bending of the radio tails results from ram pressure produced by bulk motion of the intracluster medium during the merger event.

Rizza, Burns, Ledlow, Owen, and Voges have analyzed ROSAT HRI images for 11 distant ($0.15<z<0.3$) Abell clusters. Also included are archival ROSAT PSPC and ASCA X-ray spectra for approximately half of the sample. This sample is being used to examine the frequency of substructure and cooling flows, the luminosity/temperature relationships, and gas mass and baryon fractions for rich, optically selected galaxy clusters over an epoch in which evolution in cluster properties may be important. From this fairly small sample, they have found $>70\%$ of the clusters show evidence for significant substructure and/or cooling flows. This subsample is part of a much larger sample to study the statistics of these properties, which can possibly be used to constrain cosmological models and Ω. A paper is nearing submission.

Voges, Ledlow, Owen, Burns, and Smith have recently analyzed ROSAT All-Sky-Survey X-ray images of the 294 Abell clusters from our statistically complete VLA survey. They found an approximate 65% X-ray detection rate for the clusters. These data are being used (in a series of 4 papers) to construct a low-redshift X-ray luminosity function for comparison to higher redshift samples, a correlation of optical cluster properties, relationship to radio emission from cluster galaxies, and frequency of substructure in comparison to an $\Omega=1$ cosmological simulation of the X-ray properties of rich clusters at this redshift (Loken *et al.* 1997).

Loken, Burns and Klypin completed a detailed analysis of the structure and evolution of X-ray clusters in a high-

resolution 3D simulation of a CHDM universe with 2 neutrinos. Slight positive evolution was observed in the cluster X-ray luminosity function while the temperature function showed negative evolution. Both of these results are in agreement with theoretical predictions which assume purely adiabatic gas physics. In addition, the evolution of individual clusters was followed in order to estimate merger rates, to assess the importance of mergers on the development of substructure and to estimate the prevalence of substructure at various epochs.

Klypin, Loken, and Burns were awarded a NASA Astrophysics Theory grant to numerically investigate the evolution of the cluster X-ray luminosity function. The simulations will employ an advanced adaptive-mesh refinement code and include additional physics such as radiative cooling and galaxy feedback. The goal of the research is to resolve the discrepancy between theoretical predictions and observational results concerning the evolution of the X-ray luminosity function.

Garasi, Loken and Burns completed a numerical study of the evolution of rotating, cluster cooling flows. Spherically-symmetric, steady-state cooling flows with varying mass drop-out rates were perturbed by imposing rotation profiles of differing shape and strength. Thin, dense, cold disks were shown to form on time-scales inversely related to the mass drop-out rate. The combined effect of Kelvin-Helmholtz and thermal instabilites resulted in dense, cool knots of gas forming in models with little mass drop-out. The same problem is now being investigated in 3D; removal of the axisymmetry constraint will allow for shear in the ϕ-direction and likely result in more substructure.

Roettiger (NASA/GSFC), Burns and Loken completed a series of papers on hybrid hydro+N-body simulations of merging clusters of galaxies. They conducted a series of simulations with varying cluster masses and gas densities and investigated their observational signatures. Significant temperature inhomogeneities and supersonic bulk flows of gas were found in the simulations; these were demonstrated to account for various X-ray and radio observations of clusters.

4. EDUCATION

The Sunspot Astronomy Center a is a collaborative venture of the NMSU Department of Astronomy, Apache Point Observatory, the Sacramento Peak Solar Observatory, and the United States Forest Service. This facility is on the solar observatory campus at Sunspot, N.M., adjacent to Apache point Observatory. It will serve 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. The Center building, with its roads and parking areas, are in place and the building will be ready for occupancy by years end. A formal opening of the facility is planned for the spring of 1997.

Reta Beebe co-chaired a NASA/OSS working group that was charged with formulating the OSS Education/Public Outreach Implementation Plan. The report was completed in October and is available at http: //www. hq.nasa.gov/office/oss/edu/imp_plan.html and should be read and considered in conjunction wth the OSS Education/Public Outreach Strategy which can be found at http://www.hq.nasa.gov/office/oss/ edu/educov.html

5. SAMPLE OF PUBLICATIONS

Andersen, K., Baggett, W., & Baggett, S.M. ''Inner Truncated Disks - Are They Tied to Bars?,'' in Barred Galaxies, IAU Colloquium 157, R. Buta, D.A. Crocker, and B.G. Elmegreen, editors. Astronomical Society of the Pacific Conference Series, 91, 91 (1996)

Andersen, K., Horan, S. Denny, M.S., & Fowler, J.R. ''Real-Time Control of Remote Sites: Using the ACTS with the Apache Point Observatory,'' ACTS Conference Proceedings,(1996).

Andersen, K., Baggett, W.E. & Baggett, S.M. ''Bulge-Disk Decomposition of 659 Spiral and Lenticular Galaxy Brightness Profiles,'' ApJ, submitted.

Beebe, R.F. 1996, ''Growth and Dispersion of the Shoema ker-Levy 9 Impact Features from HST Imaging'' in ''The Collision of Comet Shoemaker-Levy 9 and Jupiter,'' IAU Colloquium 156 ed. K.S. Noll, H.A. Weaver and P.D. Feldman, Cambridge University Press, 307 328.

Beebe, R.F., A.A. Simon, L.F. Huber 1996, ''Comparison of Galileo Probe and Earth-Based Translation Rates of Jupiter's Equatorial Clouds,'' Science 272, 841.

Burns, J.O, Ledlow, M.J., Loken, C., Klypin, A., Voges, W., Bryan, G., Norman, M., & White, R.A. 1996, ''The X-ray Luminosity Function and Gas Mass Function For Optically Selected Poor and Rich Clusters of Galaxies ,'' ApJ, 467, L49.

Burrows, C., J., Stapelfeldt, K. R., Watson, A. M., Krist, J. E., *et al.* 1996, ApJ, December ''HST Observations of the Disk and Jet of HH30''

Chanover, N. J. *et al.* 1996, ''Absolute Reflectivity Spectra of Jupiter: 0.25 -3.5 Micrometers,'' Icarus 121, 351-360.

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A. Klypin