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This report covers activities in the astronomy and astrophysics group at UNLV during the period January 1999 to December 1999.

1 FOREWORD

The astronomy/astrophysics group within the Department of Physics at UNLV is engaged in vigorous programs of research in the areas of active galaxies, large scale structure, stellar atmospheres, and theoretical and laboratory astrophysics related to studies of the interstellar medium. Our small ranks include an HST/STIS Co-Investigator, a former NASA/STScI Hubble Fellow, postdoctoral fellows, and research assistants. The Department is part of the Nevada Space Grant Consortium, the purpose of which is to develop research and educational opportunities in space science in Nevada, with the support of NASA, the State of Nevada, and private organizations. An important goal in our growth is to offer M.S. and Ph. D. degrees in astronomy within the Department of Physics. We anticipate formal approval of this graduate program for Fall 2002. In preparation, we are offering and developing a number of graduate astronomy courses, have succeeded in securing several lines of NASA, HST, and NSF funding, and are exploring telescope partnerships with other institutions. Our vision is to achieve recognized excellence in building a small personal but rigorous graduate astronomy program. In this report, we review activities during the 1999 calendar year.

2 PERSONNEL

UNLV physics staff with astronomical/astrophysical interests are as follows.

2.1 Faculty

- J. Farley, Professor (Ph.D. Columbia 1977) *Laser Spectroscopy of Molecular Ions with applications to Chemistry of Plasmas, Atmospheres, and the Interstellar Medium*
- J. R. King, Assistant Professor (Ph.D. Hawai'i 1993) *Stellar Atmospheres and Interiors, Photospheric Abundances, Galactic Chemical Evolution, Galactic Stellar Populations, Big Bang Nucleosynthesis, High-Resolution Spectroscopy*
- V. Kwong, Professor (Ph.D. Toronto 1977) *Laboratory Studies of Atomic Processes and Structure in Astrophysical Plasmas*
- S. Lepp, Associate Professor (Ph.D. Colorado 1984) *Atomic and Molecular Astrophysics, Theoretical Modelling of the Interstellar Medium, Supernovae, Star Formation Regions, Active Galaxies, and the Early Universe*
- G. Rhee, Associate Professor (Ph.D. Leiden 1989) *Observational Cosmology, Galaxy Clusters, Dark Matter, Galaxy Formation, Gravitational Lensing, N-body Simulations and Structure Formation*

- D. B. Shaffer, Adjunct Professor (Ph.D. Caltech 1974) *Radio Astronomy, Very Long Baseline Interferometry*
- D. Pyper Smith, Associate Professor (Ph.D. UC Santa Cruz 1968) *Stellar Photometry and Spectroscopy, Am Stars, Chemically Peculiar Stars*
- L. Spight, Associate Professor (Ph.D. Nevada, Reno 1969) *Cosmology and Interacting Galaxies*
- D. Weistrop, Professor (Ph.D. Caltech 1971) *Extragalactic Astronomy— Active Galaxies, Starforming Galaxies, BL Lac Objects, Large Scale Structure, UV and Space-based Astronomy*
- B. Zygelman, Associate Professor (Ph.D. CUNY 1983) *Theoretical/Computational Atomic and Molecular Physics with Applications to Astrophysics and Atmospheric Science*

2.2 Postdoctoral Fellows

- C. H. Nelson (Ph.D. Virginia 1994) *Active Galaxies, Starburst Galaxies, Space-based UV Spectroscopy and Photometry*

2.3 Research Staff

- Diane Eggers, Research Assistant (M.S. Nevada, Las Vegas 1998) *Data reduction and analysis of space- and ground-based data on active galaxies*
- John Kilburg (B.S. Computer Science, Nevada, Las Vegas 1993) *Systems manager responsible for the Department's highly stable diverse modern network*

3 FACILITIES

The UNLV astronomy group occupies much of the second floor of the Robert L. Bigelow Physics Building, a 70,000 square foot facility completed in 1994 containing astronomy and physics staff offices, classrooms, and teaching laboratories. We continue to enjoy convenient desk-top access to a highly stable network of Sun Unix and Linux workstations and Windows PCs.

Departmental facilities include a 16-inch computer-operated student training telescope mounted on the roof of the Bigelow building and numerous computer workstations dedicated to digital image processing. The Department is also part of a four-college consortium that operates the 30-inch Automated Photometric Telescope at the Fairborn Observatory site at Washington Camp near Nogales, AZ. Additionally, the Department is a member of the National Undergraduate Research Observatory which shares 60% of the observing time on Lowell Observatory's 31-inch telescope on Anderson Mesa near Flagstaff, AZ. The Department also houses the W.M. Keck Computational Physics Laboratory, a cluster of multiple and single CPU computers with a peak performance of ~ 8 GFLOPs; the software environment includes a wide variety of compilers, Internet tools, network authentication and notification, data reduction

packages, and custom-written software. This powerful system enables UNLV researchers to attack grand challenge problems in astrophysics.

4 RESEARCH

Donna **Weistrop** is a Co-Investigator on the team which developed the Space Telescope Imaging Spectrograph (STIS), installed on HST in 1997. She is participating in several investigations using STIS and HST. Research Associate Dr. Charles **Nelson** has been working with Weistrop and other STIS team members to determine the physical conditions in the narrow line region of the Seyfert galaxy NGC 4151. They are also analyzing STIS spectra to ascertain whether there is a black hole at the center of galaxy NGC 7332.

Graduate students M. **Hancock**, K. **Plaks**, and A. **Stone** and Research Assistant D. **Eggers** are using HST ultraviolet and visible wavelength imaging and spectroscopy to investigate the young stellar populations in galaxies NGC 3991, 3994, and 3995; NGC 4194; and NGC 3395 and 3396. Undergraduate students R. **Bachilla** and J. **Yates** are analyzing groundbased spectra of these galaxies to support and extend the HST observations to the entire galaxy environment. Weistrop's work is supported by a continuing contract for the STIS team and a grant from the Nevada Space Grant Consortium.

Pyper-Smith is continuing studies of stellar evolution through investigations of CP variable stars. She is using Four College automatic telescope photometric data to determine the periods of chemically peculiar (CP) stars in clusters as an indicator of magnetic rotational braking. In collaboration with T. Ryabchikova (Russ. Acad. Sci), S. Plachinda and I. Savenov (Crim. Ap. Obs.) and R. Kuschnig (U. Vienna) she determined an abrupt shift in the period of the short-period CP star CU Vir. This phenomenon has never before been observed in this type of star and the discovery has already led to several theoretical studies. With REU summer student L. Schwendiman, Pyper-Smith examined the photometric data for another short-period CP star, V1093 Ori, but no evidence of a period shift was found. She is continuing to collect data on several very long-period CP stars and several stars that show evidence of changes in the shapes of their light curves or period shifts.

King continued numerous investigations into stellar photospheric abundances. In collaboration with D. Soderblom (STScI), B. Jones and D. Fischer (UCSC/Lick Obs.), he carried out a study of the activity, rotation, lithium, and metal abundances of a sample of solar-type PMS stars in NGC 2264. Surprising findings included the generally low rotational velocities, ionization-dependent differences in metal-abundances, and possible evidence for star-to-star Li scatter.

In collaboration with B. Schaefer (Yale U.) and C. Deliyannis (Indiana U.), King investigated the prevalence of superflares on ordinary solar-type stars. This work suggested that such (possibly life-impeding) flares may occur on time scales of every several centuries in such stars' adolescence.

King, in collaboration with A. Krishnamurthi (JILA) and M. Pinsonneault (Ohio State U.) completed a reanalysis of

lithium and activity data in the Pleiades. The results may suggest a needed revision in the perceived source of Li scatter in this cluster. The Li scatter, in contrast with scatter in heavier metals such as Ca, appears to correlate well with activity; this may suggest that incomplete photospheric/chromospheric modeling produces illusory scatter.

King also completed a reanalysis in the [O/Fe] and [C/Fe] ratios of metal-poor dwarfs in light of new NLTE stellar parameters. This work suggests that there is no dwarf-giant or [O I] λ 6300-UV/OH O abundance discrepancies, and implies continually but gently increasing [O/Fe] with declining [Fe/H].

King, in collaboration with D. Soderblom, initiated a study of 5000 nearby solar-type stars selected from the *Hipparcos* catalog. The goal of this study is to deduce these stars activity, abundances, and kinematics as part of the NASA/NSF Nearby-Stars initiatives. King also continues work on: a) open cluster Be abundances from Keck/HIRES data in collaboration with A. Boesgaard (U. Hawai'i) b) open cluster Li and Fe abundances as part of the *WYN Open Cluster Study* in collaboration with S. Margheim (Indiana U.) and C. Deliyannis c) Cu abundances in metal-poor dwarfs from Keck/HIRES data in collaboration with F. Primas (ESO) and C. Sneden and E. Brugameyer (U. Texas), and d) metal abundances in little evolved stars in the globular clusters M71 and M13 from Keck/HIRES data in collaboration with A. Boesgaard and C. Deliyannis.

John W. **Farley** has been conducting laboratory studies of the spectrum of molecular ions, including both positive and negative ions. Molecular ions are very reactive, and tend to dominate the chemistry of media in which they occur, including the upper atmosphere, comet tails, and molecular clouds in the interstellar medium. Such clouds can have as much as a million solar masses, and are believed to be the site of star formation. Reactions between ions and neutral molecules plays a very important role in such clouds. Farley is particularly interested in negative ions, which are more difficult to study, but less well explored than positive ions. The Farley laboratory is well equipped for the experimental study of molecular ions, with a large array of modern lasers.

5 INSTRUCTION

The Department's two introductory astronomy courses aimed at non-science majors had 651 enrolled students during the 1999 calendar year. The optional introductory laboratory course enrolled 353 students. An honors and associated laboratory course with a 50% astronomy component contained 34 students.

Four graduate courses on introductory astrophysics, observational techniques, active galaxies, and cosmology enrolled a total of 13 students. Students in Weistrop's Observational Astronomy Techniques class observed variable stars at the NURO 31-inch optical telescope and calculated the stellar periods from these data. In previous years, UNLV students have used data from NURO to study quasar variability and photometry of galaxies.

King is introducing innovations in the introductory solar system astronomy course. These include pre- and post-concept testing, development and employment of collabora-

tive learning exercises during lecture, utilizing a suite of classroom assessment techniques, instituting homework exercises with a specific focus on critical thinking and logic via quantitative reasoning, and development of numerous web-based resources to facilitate student learning in the course.

6 MISCELLANEOUS

6.1 Meeting Participation

Weistrop, Nelson, and King presented a total of 5 poster papers at the 193rd and 194th meetings of the American Astronomical Society in Austin and Chicago. Farley presented two papers on his negative ion work at the International Symposium on Molecular Spectroscopy in Columbus and at the centennial meeting of the American Physical Society in Atlanta. **Zygelman** presented a paper at the 1999 NASA/JPL International Conference on Fundamental Physics in Space in Washington DC.

6.2 Invited Talks

Farley, King, Nelson, **Rhee**, and Zygelman made a total of 10 colloquium/seminar presentations to UC Santa Cruz, Goddard Space Flight Center, Middle Tennessee State U., Wesleyan U., U. Notre Dame, UNLV, DOE, and the Japan Institute of Space and Astronautical Science (ISAS).

6.3 Grants and Proposals

The astronomy/astrophysics group vigorously pursued a number of grant opportunities during 1999. Farley, **Kwong**, **Lepp**, Nelson, Pyper-Smith, and Rhee were PI or Co-I on newly funded grants totalling some \$347,000 from NASA, NSF, and internal UNLV resources. Farley, Kwong, King, Lepp, Nelson, Pyper-Smith, and Zygelman were PI or Co-Is on submitted grants to NASA, NSF, DOE, and the AAS requesting over \$2,100,000. As will be reported in next year's contribution, many of these proposals were successful. 1999 proved a fruitful year in supplementing existing astronomy/astrophysics-related grants of some \$1,260,000 within the Department.

King, Rhee, and Weistrop were PI or Co-Is on observing proposals for ground-based telescopes at the ESO, Keck, KPNO, CTIO, MDM, and Mt. Laguna Observatories. Despite rigorous competition, a majority of the requested nights were awarded overall. King, Nelson, **Spight**, and Weistrop were PI or Co-Is on Hubble Space Telescope proposals requesting a total of 137 orbits.

6.4 Professional Service

Weistrop serves as Chair (1999-2001) of the National Undergraduate Research Observatory (NURO) Steering Committee. NURO is a consortium of several colleges and universities, which, together with Lowell Observatory, operate a 31-inch telescope at Anderson Mesa southeast of Flagstaff, AZ. As a member of NURO, UNLV is guaranteed several nights of observing time each year. NURO membership provides UNLV students with the opportunity to observe with a research class telescope at a dark site.

King, Lepp, Rhee, and Zygelman served as reviewers for manuscripts submitted to *A&A*, *ApJ*, *ApJ Letters*, *Nature*, and *New Astronomy*.

Zygelman served as a member of the Information Technology Research panel of the National Science Foundation, and served as a proposal reviewer for DOE and the UK's PPARC.

6.5 Outreach and Community Service

Weistrop described some of her STIS team's results in a public lecture presented to the Las Vegas Astronomical Society. She also was a member of the Nevada Rhodes Scholarship Committee of Selection. In recognition of important issues, discussions, and changes in the astronomical community concerning gender and science education/careers, Weistrop was also a contributing source for a *Christian Science Monitor* article on the Shuttle Mission commanded by Eileen Collins.

Pyper-Smith hosted several telescope viewing sessions for elementary school groups and taught a heliostat lab for National Science and Technology Day.

Rhee led outings to Mt. Carlestone and the Grand Canyon for UNLV undergraduate and Continuing Education students.

Farley organized a group of local high school physics teachers, and ran the NSF-funded Research Experience for Teachers (and Research Experience for Undergraduates) program.

6.6 Textbook Authorship

Pyper-Smith's astronomy laboratory text "A Guide to Astronomy," 3rd edition (Kendall-Hunt Publishing) was published. Rhee is currently working on a text on cosmology.

PUBLICATIONS

The publication list includes all astrophysics-related papers published during the 1999 calendar year by Department members. Our strong contingent of publications submitted or "in press" by the end of the 1999 calendar year will appear in next year's contribution.

Balakrishnan, N., Vieira, M., Babb, J.F., Dalgarno, A., Forrey, R.C., & **Lepp, S.** 1999, "Rate Coefficients for Rovibrational Transitions in H₂ Due to Collisions with He," *ApJ*, 542, 1122

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Boesgaard, A.M., Deliyannis, C.P., **King, J.R.**, Ryan, S.G., Vogt, S.S., & Beers, T.C. 1999, "Beryllium Abundances in Halo Stars from Keck/HIRES Observations," *AJ*, 117, 1549

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- Gredel, R., Tine, S., **Lepp, S.**, & Dalgarno, A. 1999, "The Excitation of Molecular Hydrogen in XDRs" in *Millimeter-Wave Astronomy: Molecular Chemistry & Physics in Space*, eds. W.F. Wall, A. Carramiana, & L. Carrasco, (Dordrecht: Kluwer Academic Publishers)
- Hutchings, J.B., Crenshaw, D.M., Danks, A.C., Gull, T.R., Kraemer, S.B., **Nelson, C.H.**, **Weistrop, D.**, Kaiser, M.E., & Joseph, C.J. 1999, "High Velocity Line Emission in the NLR of NGC 4151," *AJ*, 118, 2101
- Jackson, N., Roland, J., Bremer, M., & **Rhee, G.** 1999, "VLA Observations of a 4C Equatorial Sample II," *A&AS*, 134, 401
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- King, J.R.** 1999, "Abundances in the Metal-Poor Common Proper Motion Star BD+00 2058A," *PASP*, 111, 817
- Marvel, K.B., Shukla, H., & **Rhee, G.** 1999, "A VLA Search for Head-Tail Radio Sources in Abell Clusters," *ApJS*, 120, 147
- Nelson, C.H.** & Whittle, M. 1999, "Stellar And Gaseous Kinematics in Seyfert Galaxies," in *Galaxy Dynamics*, eds. D. Merritt, J.A. Sellwood & M. Valluri, ASP Conference Series, 182, 53
- Nelson, C.H.** & Whittle 1999, "Stellar Absorption Lines in the Spectra of Seyfert Galaxies," in *Advances in Space Research*, proceedings of The AGN/Host Galaxy Connection, Scientific Assembly of COSPAR
- Pyper, D.M.**, Ryabschikova, T., Malanushenko, V., Kuschnig, R., Plachinda, S., & Savenov, I. 1999, "Evidence for an Abrupt Change in the Period of the CP Star CU Virginis," *A&AS*, 339, 822
- Soderblom, D.R., **King, J.R.**, Siess, L., Jones, B.F., & Fischer, D. 1999, "The Evolution of the Lithium Abundance of Solar Type Stars IX. High-Resolution Spectroscopy of Low-Mass Stars in NGC 2264," *AJ*, 118, 1301
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Jeremy King