The University of Toledo
Ritter Astrophysical Research Center
Toledo, Ohio 43606

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This report covers the period 1 July 2000 to 30 June 2001.

1. PERSONNEL

During the report period, D. Pierini joined the Center as a postdoctoral research associate working with Witt. Witt was on sabbatical leave during Fall 2000. Otherwise, the permanent staff and the temporary research staff remained unchanged.

Students involved in astronomical research were: undergraduates Will Fischer, Amanda Gault, Pat Sadowski, Lori Schmetzer, Goldie Summers, and Josh Thomas; and graduate students Jennifer Benson, Boncho Bonev, David Knauth, Don Koglin, Ivaylo Mihaylov, Kaike Pan, Kathy Shan, Tracy Smith, Uma Vijh, John Wisniewski, and János Zsargó. Graduate student Alex Carciofi was a visitor for 2 months, courtesy of a FAPESP grant from the Brazilian government.

Visiting NSF-REU undergraduate students were Gregory Mack (Ohio Wesleyan), Althea Moorhead (Univ. of Arizona), Tom Crenny (Wheeling Jesuit Univ.), and Kevin Croxall (Brigham Young Univ.).

2. OBSERVATORY

The upgraded control system for the Wright Instruments Ltd. CCD cameras on the spectrographs was placed in operation in August 2000, and troubleshooting was largely completed by the end of the report period. Software drivers and hardware interfaces for controlling the CCD's were developed with the assistance of Burmeister, Ambalanath, and Knauth. Upgrades to the telescope control system encoder interface were also developed by Burmeister and Ambalanath.

During the 11 months of operation beginning in August 2000, 743 stellar spectra were obtained with the échelle and 18 with the Low-Dispersion Spectrograph (LDS) on a total of 112 nights used. The échelle observations were made with the standard Hα grating setting, where the spectral coverage consists of 9 disjoint 70-Å regions in the yellow and red, and with a wide slit that yields a spectral resolving power $R \simeq 26{,}000$. During the report period, the Ritter observing team consisted of K. Bjorkman, Fischer, Knauth, Miroshnichenko, Morrison, and Wisniewski.

3. RESEARCH

3.1 Stellar Astrophysics

Ritter Obs. continued its long-term spectroscopic monitoring programs on hot supergiant stars, Herbig Ae/Be stars, and classical Be and shell stars.

Working with Morrison and K. Bjorkman, Croxall studied the accumulated Ritter archival spectra of the Be star κ Dra. He developed templates for the telluric water spectrum at the observatory and cleaned the water lines from the Hα profiles, and he began a time-series analysis of the long-term behavior of Hα in this star. Wisniewski, Morrison, and K. Bjorkman began a study of line-profile variations in Ritter archival spectra of P Cyg taken since 1994.

K. Bjorkman and J. Bjorkman, with K. Wood (Harvard CfA and Univ. St. Andrews, Scotland) continued to develop methods for diagnosing the physical parameters of circumstellar envelopes from spectropolarimetric data, completing a paper on the technique for deriving temperatures. Working with K. Bjorkman, Summers began applying this technique to determining the disk temperatures of several classical Be stars. Gault, working with K. Bjorkman, carried out preliminary studies of whether spectropolarimetry could be used to diagnose inclination angles of such disks.

K. Bjorkman and M. Meade (Univ. Wisconsin) continued to develop an atlas of spectropolarimetry of classical Be stars, based on observations with the HPOL instrument on the 1-m telescope at the Pine Bluff Obs. Analysis of ultraviolet spectropolarimetry data from WUPPE combined with optical data from HPOL continues, with application of the techniques discussed above.

Wisniewski and K. Bjorkman, together with M. Magalhães (Univ. of Sao Paulo, Brazil) have just begun a program to search for disk-like circumstellar envelopes in hot stars in the LMC and SMC, where metallicity effects may make it easier for disks to form. The program will use the imaging polarimeter built by Magalhães to detect wavelength-dependent polarization of stars in LMC/SMC clusters. The initial observations are scheduled for November 2001 at CTIO.

Wisniewski and K. Bjorkman have completed the analysis of the interstellar polarization in the direction of the classical Be star π Aqr. They found that the interstellar polarization contribution is substantially larger than previously published and is at a different position angle. Analysis of the intrinsic polarimetric variability of the star is underway.

In collaboration with E. Chentsov, S. Ermakov, V. Klochkova, and V. Panchuk (Special Astrophys. Obs., Russia), Miroshnichenko prepared a high-resolution ($R \simeq 15000$, spectral range 4700–6700 Å) atlas of spectra of the super- and hypergiants HD 183143, HD 168607, AS 314 and HD 160529. The atlas contains tables of identified lines and averaged radial velocities for groups of the lines. It also presents typical line profiles and their variability with time.

Miroshnichenko and K. Bjorkman, in collaboration with V. Klochkova and E. Chentsov (Special Astrophys. Obs.), O. Ezhkova (Astron. Inst. of the Uzbekistan Acad. of Sci.), R. Gray (Appalachian State Univ.), P. García-Lario and J. Perea Calderón (ESA, Spain), R. Rudy, D. Lynch, S. Mazuk, and C. Venturini (Aerospace Corp.), and R. Puetter (Univ. of California at San Diego), undertook a study of AS 381, an emission-line star with a large far-IR excess. The study was based on high-resolution optical and near-IR spectroscopy and multicolor optical and near-IR photometry. The spectrum of AS 381 was found to contain features of both a hot and a

cool star. The spectral line profiles indicate that the circumstellar envelope is flattened and is viewed close to pole-on. The high reddening suggests that the system is distant, contains high-luminosity objects, and may be a B[e] supergiant binary, the first one known in the Galaxy.

Miroshnichenko and K. Bjorkman, with V. Krugov (Main Astron. Obs., Ukraine), analyzed high-resolution observations of the Be star γ Cas obtained in 1993–2001 at Ritter Obs. A long-term and a short-term component of the emission-line profile variations were found. The short-term component consists of changes in the mean radial velocity of Hα with a period of 204.9 days, which is most likely related to orbital motion. This finding confirms a recently reported result of Harmanec *et al*. (2000, A&A, 364, L85), although the data suggest a circular orbit rather than the eccentric one derived by them. The behavior of the Hα profile was found to be different from that of non-hydrogen lines. This fact suggests the presence of an additional component in the Hα profile that may originate in the vicinity of the secondary.

The same group, with I. Usenko (Odessa Astron. Obs., Ukraine), undertook a study of more than 2000 high-resolution Hα profiles of about 100 Be stars obtained at Ritter Obs. or published in the literature. The study showed that 50% of the Be stars brighter than 4th mag. have been proved to be binaries. This fraction is smaller for fainter stars, probably because of observational selection. Be stars with strong emission lines and those with complex Hα profiles are most likely binaries.

Miroshnichenko and K. Bjorkman visited the Special Astrophysical Obs. of the Russian Academy of Sciences in June 2001 to work on a joint U.S. Civilian Research and Development Foundation (CRDF) funded project involving the development and creation of a high-resolution spectropolarimeter for the 6-meter telescope with V. Klochkova, V. Panchuk, and E. Chentsov. The preliminary data from a test run of spectropolarimetry using the Prime Focus Echelle Spectrograph (PFES) were examined. The data reduction pipeline and initial interpretation of the data were discussed.

With K. Wood (Univ. St. Andrews), B. Whitney (Space Sciences Institute), Mihaylov, and A. Carciofi (Univ. São Paulo), J. Bjorkman continued developing 3-D radiative transfer techniques using Monte Carlo simulation. As part of his Ph.D. thesis research, Mihaylov has developed techniques for using weighted photons (photon packets with unequal energy) to sample the source function, thereby allowing quick calculation of synthetic images of circumstellar envelopes with complex geometries. He is also investigating the momentum transfer arising from multiple resonance line scattering in stellar winds with complex velocity structures.

Carciofi extended J. Bjorkman's Monte Carlo radiation transfer methods to determine the radiative equilibrium temperatures for dust grains of different size and chemical composition in the winds from both cool and hot stars. These studies show that, under certain conditions, the IR portion of the SED is insensitive to grain size, and also that isotropic scattering can be a poor approximation when calculating the SED of dusty circumstellar envelopes. In particular, the forward-throwing nature of dust grains can significantly increase the UV continuum when it is dominated by the scattered light.

Another application of J. Bjorkman's Monte Carlo radiative equilibrium model is self-consistent calculations of the structure of protostellar disks, which place constraints on theoretical models of such systems. The initial work (in collaboration with K. Wood, B. Whitney, and M. Wolff) finds evidence for dust grain growth—the first step of planet formation—in the young protoplanetary disk of HH30 IRS. They are also investigating (in collaboration with C. Lada) how to use the emergent SED to determine the disk clearing time and the location where the clearing occurs.

In addition to radiative equilibrium calculations, J. Bjorkman is developing methods for calculating the two-dimensional ionization structure of circumstellar disks, in collaboration with B. Abbott (Amer. Museum of Nat. Hist.) and J. MacFarlane (Prism Computational Sciences). They have now produced piecewise spherical models and have applied them to investigate line formation in rotating stellar winds. Their initial studies indicate that B star mass-loss rates may be a factor of 5–10 higher than previously thought. Future work involves incorporating Monte Carlo techniques in the calculation of the radiation transfer, which will allow a proper treatment of the three-dimensional velocity fields in the rotating wind.

The dynamics of these winds is being investigated by Moorhead in collaboration with J. Bjorkman. They have been studying the 1-D equatorial solutions of a rotating stellar wind and now have added the effects of both rotation and the finite solid angle of the stellar radiation source. In general, they find that the finite disk effect doubles the number of critical points in the wind. Furthermore, at high rotation rates, the inner critical point disappears and a new set of critical points appears at large radii. It appears that both the inner and outer critical point solutions may exist simultaneously, potentially offering a mechanism for the wind to switch discontinuously between high and low mass-loss states. To investigate this possibility, Moorhead is now performing time-dependent computational fluid dynamics simulations of the rapidly rotating wind.

J. Bjorkman has begun developing methods for using gravitational microlensing as a tool for exploring the structure of extended circumstellar envelopes. In collaboration with R. Ignace (Univ. Iowa) and J. Simmons (Univ. Glasgow), he is investigating the polarization signal produced by the microlensing event. They find that simultaneous observations of the polarization and flux amplification can be used to determine all the parameters of the microlens. Determining the mass and distance of the lens is especially important for studies of the dark matter component of the galaxy.

3.2 Solar Astronomy

B. Bonev and K. Penev (Caltech) examined the long-term trends in the solar variability that can be deduced from both indirect data and optical records. They applied a rigorous Monte Carlo technique in order to distinguish quasi-periodicities with probable physical origin from the random components in their periodograms. The variability of the differential amplitudes and of the average periods of the domi-

nant cycles was then traced with a fine time step. The present secular trend of solar activity is downward, because of the declining phases of both the Gleissberg and the quasi-two century solar cycles. With B. Komitov (Inst. of Astronomy, Bulgarian Acad. of Sciences), Bonev has pointed out that the violation of the Gnevyshev-Ohl rule in the current 11-year solar maximum is one of the indicators that a minimum in the long-term solar variability will occur in the 21st century. This minimum is expected to be significantly *less deep* than the Maunder and Spörer minima, and the 11-year maxima are expected to continue quasi-regularly.

3.3 Interstellar Matter

Knauth, under the direction of Federman and in collaboration with Lambert (Univ. Texas), completed the research for his Ph.D. thesis. He is studying the ^{7}Li/^{6}Li ratio in interstellar space through ultra-high resolution ($R = 360{,}000$), high signal-to-noise spectra acquired at McDonald Obs. For interstellar clouds in the solar neighborhood, the typical lithium isotope ratio is similar to the solar system value of about 12. The line of sight to *o* Per remains special; the ^{7}Li/^{6}Li ratio in one of the clouds toward the star is about 2, the value expected from spallation of interstellar C, N, and O nuclei by Galactic cosmic ray protons. If the original isotope ratio were 12 and is now 2, a significant enhancement in the elemental abundance of Li would be expected, but the Li/H abundance is the same as in other directions, as is the K/Li elemental abundance ratio. The latter ratio is a useful measure because K and Li have different production pathways. Another interesting line of sight is the one toward 20 Aql; here the Li isotope ratio is ''normal,'' as is the K/H ratio, but the K/Li ratio is twice the value for the other directions in the sample. This sight line passes near a supernova remnant containing 10^6 K gas. It is suggested that many of the fragile Li nuclei in this sight line were destroyed in the hot gas.

Knauth also used his survey to help constrain the stellar source for ^{7}Li. About 10% of the current elemental Li abundance came from Big Bang nucleosynthesis, and a similar amount is thought to come from Galactic cosmic ray spallation. The remaining fraction involves some stellar source; potential sources include AGB stars, RGB stars, and neutrino spallation during supernova explosions upon the death of a massive star. While he could not pinpoint the source, his analysis shows that the stellar contribution to the ^{7}Li abundance is constant in the solar neighborhood. This result suggests that one or at most two stellar sources are operating.

Pan, Federman, and Welty (Univ. Chicago) found evidence for small-scale structure in gas density from observations of the multiple star systems HD 206267 and HD 217035. Federman and Zsargó (JHU) attempted to derive a self-consistent set of oscillator strengths for C I lines below 1200 Å from high-quality observations with *HST*.

In collaboration with, mainly, C.C. Popescu (Obs. Carnegie), R.J. Tuffs (MPIK, Heidelberg, Germany) and H.J. Voelk (MPIK, Heidelberg, Germany), Pierini presented photometry of 63 Virgo cluster galaxies later than S0 and brighter than $B_T = 16.8$, derived from deep diffraction-limited far-IR strip maps obtained with ISOPHOT in bands centered at 60, 100 and 170 μm. The analysis of the spectral energy distributions of 30 out of the 38 galaxies detected at all three wavelengths reveals the presence of emission from cold (i.e., $10 < T < 20$ K) dust. This result applies to all morphological types, from early giant spirals to blue compact dwarfs.

Pierini and Witt analyzed long-slit spectra of the Evil Eye galaxy (NGC 4826), obtained by T. A. Boroson (NOAO) on the 4-m Mayall reflector at KPNO. The prominent, asymmetrically placed dust lane, crossing the bright bulge of this galaxy, provided a geometry ideally suited for investigating the wavelength dependence of the dust attenuation and the presence of extended red emission (ERE) in an extragalactic system. The observed attenuation was well matched by radiative transfer models including a clumpy dust structure with scattering. Excess red emission in the 580 nm - 910 nm spectral range was found and identified as ERE, with characteristics similar to those of ERE in Galactic environments with high radiation densities.

Gordon (Univ. Arizona) and Witt continued their investigations of radiative transfer through clumpy, scattering media. They were joined by collaborators K.A. Misselt (NASA-GSFC) and G.C. Clayton (LSU). The existing radiative transfer code was expanded to incorporate the capability to predict the linear polarization of the outgoing light as a function of position in extended sources with arbitrary distributions of stars and of dust. In addition to absorption and scattering, the model self-consistently computes the equilibrium and the non-equilibrium thermal emission and the aromatic features emission. As a first large-scale computing project, the radiative transfer through a bulge/disk galactic system with a doubly-exponential, clumpy dust distribution was completed. The analysis of the model results is in progress.

Witt, R.K. Smith (CfA), and E. Dwek (NASA-GSFC) completed their analysis of the X-ray scattering halo around Nova Cygni 1992. The results confirmed the need to extend the interstellar grain size distribution to and possibly beyond 2μm. This result is consistent with findings by interplanetary spacecraft (*Ulysses* and *Galileo*), which have detected a substantial flux of interstellar grains with diameters as large as 2 μm entering the solar system.

Witt and Vijh began an investigation of the colors of Lyman-break galaxies with redshifts ~ 3, with data kindly provided by C. Steidel (Caltech). It is their aim to investigate the reddening and attenuation by internal dust, the optical characteristics of the high-*z* dust, and the structure of the dust distribution. This investigation is a continuation of a study begun with Mack during summer 2000.

3.4 Planetary System Astrophysics

James is a Participating Scientist for Mars Global Surveyor and is a member of the MOC (Mars Orbiter Camera) Team. He has been selected as a co-I for the 2005 *Mars Reconnaissance* payload. His principal interest during the past year has been the seasonal behaviors of the Martian caps; he has used data acquired by the MOC wide-angle and narrow angle cameras in this effort. In a collaborative study of polar meteorology with J. Hollingsworth (NASA Ames), he is also analyzing MOC observations of Martian clouds in the polar regions.

The large interannual variability in the amount of dust activity on Mars presumably influences the seasonal condensate cycles on the planet. The effects of atmospheric dust on the seasonal cycle of the CO_2 polar caps is the subject of a theoretical study being undertaken by Bonev by means of J. Bjorkman's radiative equilibrium models. The goals are to determine the backwarming of the Martian polar caps by dust in the atmosphere, including the effect of dust on the sublimation rate of the polar caps, and to obtain improved understanding of interannual variability in seasonal cycles on Mars. The fact that one MOC year has included a major storm while the other has not provides an unusual opportunity to compare theory with observations.

Shan completed a study of the seasonal variation of clouds in the Tharsis region of Mars using the MOC mapping images from the first (terrestrial) year. Benson and Koglin are extending Shan's work to include all of the recent MOC data on condensate clouds in equatorial and midlatitude regions.

HST continued to observe Mars during the most recent year. The STIS UV spectra and WFPC2 images will be used to determine the amounts of ozone, dust, and condensate clouds in the Martian atmosphere. Because of the STIS down time during 2001, some of these observations have been moved into Cycle 10 and occurred during the recent dust storm.

3.5 Laboratory Astrophysics

Curtis collaborated with Z. Zhiguo, T. Brage, H. Lundberg, and I. Martinson (Univ. of Lund) in high-precision measurements and theoretical calculations of lifetimes of the $5d^9 6p$ levels in Au II. The measurements were made by means of laser-induced fluorescence techniques, and the calculations used fully relativistic MCDHF methods. These results confirmed earlier beam-foil measurements, resolved earlier discrepancies with nonrelativistic calculations, and indicated the importance of a fully relativistic treatment of the Au II system (in contrast to Ag II, for which nonrelativistic calculations have been shown to be adequate).

Witt and Smith continued laboratory investigations of the photoluminescence properties of a wide variety of interstellar dust analogs containing silicon and carbon. Their objective was the identification of candidates for the carrier of the extended red emission (ERE), which is widely observed in individual reflection, planetary, and emission nebulae, as well as in the diffuse interstellar medium. Silicon nanoparticles are the only laboratory analog found so far that matches the spectral characteristics and quantum yield of the interstellar ERE carrier.

Smith and Witt completed a major study of the photophysics of the ERE carrier, showing that the strong variability of the ERE quantum yield as a function of the interstellar environment is regulated by photoionization of the carrier particles. The ERE spectral variations, in particular the shift of the ERE peak emission toward longer wavelengths in denser UV radiation fields, was explained through a process of photofragmentation of the smaller carrier particles through a combination of Coulomb instability, induced by multiple ionization, and stochastic heating by single energetic photons.

4. INSTRUCTION

4.1 Academic

Zsargó received the Ph.D. in physics and is now a Postdoctoral Fellow at Johns Hopkins Univ. Smith completed her Ph.D. thesis and took up a postdoctoral position at the Louisiana State Univ. Shan received the M.S. in physics and took a teaching position.

Approval was received for a new B. A. degree program in astronomy.

In 1997 September, The University of Toledo changed from a quarter to a semester academic calendar. Therefore, for comparison with earlier enrollment figures, the following numbers should be multiplied by 1.5. Undergraduate astronomy enrollments for the summer quarter and the two semesters covered by the report period were as follows. In our general education courses, the annual total was 1215 for the three introductory lecture courses and 93 for the laboratory. The more advanced general-education courses had a total enrollment of 136. In graduate courses, the total enrollment was 13.

4.2 Public

Jeffery S. Potter filled the newly created position of Planetarium Education Specialist.

Undergraduate Assistants to Anderson, Mak and Potter at the Ritter Planetarium-Brooks Obs. for public education were Will Fischer, Meredith Gray, Beth Stelneki, Erin Durant, Kelly Smith, and Lori Schmetzer. Dawn Mulliss continues to maintain the Planetarium's web pages (″www.rpbo.utoledo.edu″).

Duringthe report period, Ritter Planetarium presented thirteen unique public planetarium programs. Nine of them were from our library, one was supplied by another planetarium, and three were new in-house productions (author/producer in parentheses): *New Worlds Around Distant Suns* (Gray, Mak and Potter); *Old Lights for a New Millenium* (Mak); and *Where Have all the Martians Gone* (Potter).

When weather permitted, we continued our normal program of monthly public observing nights with the Ritter 1-meter telescope and weekend evening viewings with the facilities of the Brooks Obs. Approximately 5,000 people toured at least one of our observatories.

During the report period, we continued to upgrade our library of K–12 programs, and we developed a new program, similar to our Boy Scout program, to meet the needs of the younger Cub Scouts. The Boy Scouts' Astronomy Merit Badge program and the Girl Scouts' Space Exploration Ribbon program were completed by approximately 425 and 225 scouts, respectively, each a significant increase from previous years.

The planetarium presented a series of workshops to about 300 area Head Start teachers, as well as our annual ''How to Buy a Telescope'' workshop. The planetarium staff collaborated on several special events with other area organizations such as COSI-Toledo and the Stranahan Arboretum. The

planetarium staff continued to attend local, state, and regional conferences. Potter presented ''Spread the Word: Increasing Attendance and/or Revenue'' at the Joint Conference of the Southeastern Planetarium Association and the Great Lakes Planetarium Association.

The total attendance for all programming conducted under the auspices of Ritter Planetarium and Brooks Obs. was 28,250. This figure represents an increase of nearly 9% from last year and marks the busiest year in our history.

Bopp was a UT Science Content expert in connection with the U. Toledo College of Education TAPESTRIES program during the summers of 2000 and 2001, working with elementary school teachers to develop and practice classroom science activities. He was also a member of the advisory board for the JASON project, a web-based science education effort coordinated by the Toledo Lucas County Public Library. Bopp was guest speaker at the spring 2001 meeting of the Toledo Area Phi Beta Kappa Association, May 6, 2001, on the topic ''Cosmic Fellowship or Cosmic Loneliness: The Search for Extraterrestrial Intelligence.''

K. Bjorkman participated in Project ASTRO and gave several talks to school groups and local organizations.

5. MISCELLANEOUS

5.1 Participation in Meetings

Posters at the Meeting of the Ohio Section of the American Physical Society that was held at the Univ. of Toledo were presented by Zsargó and Federman and by Mihaylov and J. Bjorkman. Bonev presented a poster at the 2000 annual DPS meeting in Pasadena. Poster papers were presented at the 197th AAS meeting in San Diego, CA (Jan. 2001) by: K. Bjorkman and Miroshnichenko; J. Bjorkman; ; and Mihaylov; and at the 198th meeting in Pasadena, CA (Jun. 2001) by Fischer and by Pierini and Witt, in collaboration with A. Majeed and T.A. Boroson (NOAO).

Witt presented invited lectures: ''Grains in Astronomy - An Overview'' at the Joint Discussion 1 on ''Atomic and Molecular Data for Astrophysics: New Developments, Case Studies, and Future Needs'' at the XXIVth General Assembly of the IAU in Manchester, UK; ''The Chemical Composition of the Interstellar Medium'' at the Royal Society Meeting on ''Origin and Early Evolution of Solid Matter in the Solar System'' in London, UK; and ''Interstellar Silicon Nanoparticles'' at the International Workshop on ''Origin and Evolution of Interstellar Silicates'' at the Lorentz Center, Univ. of Leiden, NL. Federman attended the IAU General Assembly in Manchester, England, and presented a poster at Joint Discussion 1.

5.2 Visiting Lectureships

Miroshnichenko and K. Bjorkman presented colloquia at the Main Astronomical Obs. of the Russian Academy of Sciences at Pulkovo and at the Special Astrophysical Obs. of the Russian Academy of Sciences. J. Bjorkman presented colloquia at the Univ. of Iowa and the Univ. of Georgia.

Witt presented invited colloquia at the Univ. of Hertfordshire, Hatfield, UK; at KPNO/Univ. of Arizona, Tucson, AZ; at NASA-GSFC, Greenbelt, MD; at the Friedrich Schiller Univ., Jena, Germany (Nov. 2000 and June 2001); and at the Technical Univ., Chemnitz, Germany (Nov. 2000 and June 2001).

5.3 Service

Morrison continued to serve on the V. M. Slipher Committee on Public Education in Astronomy, and J. Bjorkman continued to serve on the Organizing Committee of the IAU Working Group on Active B stars. Federman continued as chair of the *FUSE* Observers' Advisory Committee and was selected to serve on the Executive Committee for Commission 14 (Atomic and Molecular Data) of the IAU.

5.4 Awards and Research Support

K. Bjorkman received the 2001 Sigma Xi/Dion D. Raftopolous Award for Outstanding Research at the University of Toledo. J. Amar (U. Toledo), J. Bjorkman, and C. E. Theodosiou (U. Toledo) received a grant from the Ohio Supercomputer Center to support acquisition of a Beowulf computer cluster.

K. Bjorkman is a Cottrell Scholar of the Research Corporation, and gratefully acknowledges their support.

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Witt also acknowledges generous support from the Forscher Gruppe Laboratory Astrophysics at the Universities in Jena and Chemnitz, Germany, which provided for two long-term visits to those institutions in Nov. 2000 and June 2001.

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