University of Nebraska
Behlen Observatory
Department of Physics and Astronomy
Lincoln, Nebraska 68588

[S0002-7537(98)03301-0]

1. PERSONNEL

This report covers the period from July 1, 1996 through June 30, 1997. During that interval the staff consisted of Professors. K.C. Leung, E.G. Schmidt, and N.R. Simon, Associate Professor D.J. Taylor, and Visiting Associate Professor C.M. Gaskell.

Graduate students K.M. Lee, S. Snedden, and T. Young worked on thesis research projects. Graduate student C. Hall, and undergraduates M. Hiller and S. Pebley participated in research projects.

Visiting Professor Liande PAN of Shaanxi Astronomical Observatory, Chinese Academy of Sciences, spent six months at the University. She worked with Leung on various aspects of binary stars.

Leung presented an invited paper at the Pacific Rim Conference on Stellar Astrophysics held in Hong Kong, August, 1997. He was also elected to Chair the Pacific Rim Conference Planning Committee. Simon delivered an invited paper at the workshop ''Stellar Ecology.''

2. FACILITIES

Gaskell and Taylor continued to work on the new on-campus undergraduate teaching observatory.

3. RESEARCH

3.1 Variable Stars

Simon and Young completed their study of long-period Cepheids and calibration of the distance scale.

Schmidt and Lee have obtained light curves of the RR Lyrae star V442 Her (P = .44 days) in four separate seasons. The V amplitude was found to vary from about a quarter of a magnitude to nearly a magnitude and a half while the period changed by a part in 10000 from one year to the next. At large amplitude the star exhibits is a typical type ab RR Lyrae light curve while at small amplitude the light curve often does not resemble any type of pulsating star. The period of the modulation is estimated to be about 900 days. If the modulation is due to the Blazhko effect, the long modulation period, large amplitude modulation, unusual changes in the shape of the light curve and large period changes make this the most extreme example of that phenomenon known.

Schmidt has obtained extensive photometry for RR Lyrae stars with periods longer than about 0.6 days. The goal was to investigate the light curve peculiarities exemplified by the stars XZ Cet and BW Com. In a sample of more than 50 stars, only one more, DT Gem, was found to have a light curve of similar type. The new data together with data from the literature are being examined to clarify the significance of the light curve peculiarities.

Lee and Schmidt are continuing their survey of multiperiodicity in RR Lyrae stars. The survey sample consists of 107 stars of type RRab. Observations are presently sufficient for analysis of 73 of our program stars. These were classified in four periodicity categories based on their light curve scatter. They were classified as 51% monoperiodic, 34% multiperiodic, 5% showing excess scatter due to changing periods, and 10% inconclusive. Observations are presently being taken to classify the remaining 34 stars and to obtain complete light curves for those identified as multiperiodic.

3.2 Binary Stars

Leung and D.Q. Zhou of Peking University, China, are continuing their research on two- and three-dimensional mass circulation in contact and very close but detached binary systems.

Goderya, Leung and Schmidt found that the eclipsing binary V719 Her appeared to have an exceptionally large period change. Schmidt has obtained photometry for eight more minima during the past two observing seasons. Combining this data with that obtained previously it was found that the period change was spurious; the period has actually been stable to a part in a million over the past eight years.

Liande PAN completed two papers on period variations of close binary systems. Scott McCarthey of University of Oklahoma had several visits with Leung on research concerning the O'Connel effect among binary systems.

3.3 Active Galaxies

Gaskell began a study in collaboration with W. N. Brandt (Harvard/CfA), C. Otani (Riken, Japan), and Snedden of the X-ray spectra of two extreme narrow-line strong Fe II emitting quasars, Mrk 42 and Mrk 957 (so-called ''narrow-line Seyfert 1s,'' NLS1s). These objects were chosen for study because of their extremely narrow Balmer lines and strong optical Fe II. ROSAT spectra showed that they had very steep soft X-ray spectra, possibly due to a strong soft X-ray excess. X-ray spectra were obtained with ASCA satellite. The goal is to see whether abnormally steep hard X-ray spectra (already found by ASCA in one NLS1) are a common property of NLS1s. Extreme X-ray variability is a common property of NLS1s and both Mrk 42 and Mrk 957 have shown rapid X-ray variability. Both quasars were monitored photometrically from Behlen Observatory during the period of the ASCA observations and optical spectra were obtained with the Multiple-Mirror Telescope. The ASCA spectra are being used to search for X-ray flux and spectral variability and to probe iron K-alpha emission.

Gaskell and Snedden continued their participation in the International AGN Watch (IAW). The demise of the International Ultraviolet Explorer (IUE) in 1996 brought an end to the ultra-violet observational phase of the IAW, but analysis of the IUE observations continues. The last two quasars

monitored with the IUE were 3C 390.3, the prototypical quasar showing multiple peaks in the broad-line region profiles, and the low luminosity object NGC 7469.

For 3C 390.3 a good X-ray light was obtained from 90 ROSAT HRI observations. The soft X-ray flux varied by a factor of four. The optical continuum light curve, obtained from observations by Francis, Gaskell, Hiller, Pebley and Snedden at Behlen Observatory, and by others elsewhere, showed a delay of 5 days relative to the soft X-ray light curve, but unfortunately the uncertainty in the delay is also about 5 days, so zero phase lag could not be ruled out. The UV light curve was similar to the soft X-ray light curve. The IUE observations confirmed the relatively large size of the high-ionization region emitting the UV lines, but the most interesting emission line result was that the Balmer lines responded two or three times faster than the high-ionization UV lines. This supports the idea that the optical lines come from a different region than the UV lines. The new optical and UV variability data provide important contraints on the origin of structure in quasar broad line profiles.

NGC 7469 was chosen for study because of its low luminosity and known variability. It was monitored continuously by the IUE from 1996 June 10 to July 29. As expected, the variability of the UV lines yielded small sizes (about two light days). The most remarkable results were the detection, at a high level of significance, of delays in the continuum response that increase through the IUE bands into the optical region monitored from Behlen Observatory and elsewhere. These delays suggest reprocessing of the continuum close to the central energy source. It is not clear why similar delays were not seen in the earlier monitoring of NGC 4151, another low luminosity AGN.

The Infrared Space Observatory (ISO) was used to monitor Mrk 279. The campaign has been successfully concluded with a total of 16 observations obtained between 1996 February 5 and 1997 February 13.

Snedden and Gaskell continued their major study of the line profiles of broad emission lines in quasars observed with the *HST*. They are using the *HST* data to do detailed analyses using both optical and UV spectra in the same objects. Snedden has been using the photoionization code CLOUDY to deduce physical conditions as a function of velocity. She has generated large grids of models to match to the data. For the high-ionization lines there is little variation in density and ionization parameter with velocity. The use of abundances much greater than solar brings the densities deduced from photoionization models into better agreement with the results of reverberation mapping. The physical conditions deduced from the UV lines seem irreconcilable with the conditions necessary to produce the Balmer decrements and the Lyman to Balmer ratio. At least two separate components seem to be required.

3.4 Large Scale Structure of the Universe

Hall and Gaskell continued their study of the distribution of quasars as a means of probing the large-scale structure of the universe at moderate and high redshifts. Previously published studies of quasar clustering had given contradictory results. Hall and Gaskell found that only a few regions of the sky are well enough surveyed to produce useful results. They are concentrating on pencil beams in the best-surveyed regions of the sky. They are studying the variance of quasar counts in cells, which gives a volume average of the correlation function. If there is quasar clustering, it is at best only weak. Hall and Gaskell have noted some effects which might have artificially raised estimates of the degree of clustering in earlier studies.

Crenshaw, D. M. … Gaskell, C. M., *et al.,* ‘‘Multiwavelength Observations of Short Time-Scale Variability in NGC 4151. I. Ultraviolet Observations’’ ApJ, 470, 322

Dietrich, M. … Francis, O. … Gaskell, C. M. … Pebley, S. P. … Snedden, S. A., *et al.* ‘‘Steps Toward Detemination of the Size and Structure of the Broad-Line Region in Active Galactic Nuclei. XII. Ground-Based Monitoring of 3C 390.3,’’ ApJS in press

Edelson, R. A. … Gaskell, C. M., *et al.,* ‘‘Multiwavelength Observations of Short Time-Scale Variability in NGC 4151. IV. Analysis of Multiwavelength Continuum Variability,’’ ApJ, 470, 364

Gaskell, C. M. & Snedden, S. A. 1997, ‘‘The Nature and Origin of Structure in Broad Emission Line Profiles,’’ in Emission Lines in Active Galaxies: New Methods and Techniques, ed. B. M. Peterson, F.-Z. Cheng, & A. S. Wilson, 193

Goderya, S., Leung, K.C., & Schmidt, E.G. 1996, ‘‘Photometric Investigation of the Short Period Eclipsing Binary Star V719 HER,’’ Astrophysics and Space Science, 243, 315-328

Goderya, S., Leung, K.C., & Schmidt, E.G., 1997, ‘‘ Photometric Investigation of the Evolved Contact System DN AUR,’’ Astrophysics and Space Science, 246, 291-298 (1997)

Goderya, S., Leung, K.C., & Schmidt, E.G. 1997, ‘‘Selected Zero-age Contact and Evolved Case B Contact Systems,’’ in Recent Development on Binary Star Research, ed. by K. C. Leung (Provo: Astrono. Society of the Pacific, 1997), p 219-222.

Goderya, S.N., Leung, K.C., & Schmidt, E.G. 1997, ‘‘Photometric Study of Selected Zero-Age Contact and Evolved Binary Systems,’’ presented at the Third Pacific Rim Conference on Recent Developments in Binary Star Research. Proceedings ed by K.C. Leung (Provo: ASP, 1997), p 219.

Kereszturi, A., Sarneczky, K., Tepliczky, I., Jennsikens, P., & Gaskell, C. M. 1996, ‘‘Perseid Meteors 1996,’’ IAUC, 6450.

Leung, K.C. 1997, ‘‘Ancient Astronomical Instruments in China’’ in Oriental Astronomy from Guo Shoujing to King Sejong (Yonsei University Press 1997) ed. by I.S. Nha & F.R. Stephenson, p 221-228.

Leung, K.C., & Lu, Y. ‘‘The Tian Yuan Fa Wei By Bao Yulong’’ in Oriental Astronomy from Guo Shoujing to King Sejong (Yonsei University Press 1997) ed. by I.S. Nha & F.R. Stephenson, p 355-356.

Leung, K.C. 1997, ‘‘The 1995 Total Solar Eclipse Expedition of the Third Pacific Rim Conference on Binary Star’’ in Recent Development on Binary Star Research, ed. by K. C. Leung (Provo: Astrono. Society of the Pacific, 1997), p 327-338.

Leung, K.C. ‘‘Recent Development on Binary Star Research,’’ (Provo: Astrono. Society of the Pacific, 1997) editor.

Rodriguez-Pascual, P. M, … Gaskell, C. M., *et al.* 1997, ‘‘Steps toward Determination of the Size and Structure of the Broad-Line Region in Active Galactic Nuclei. IX. Ultraviolet Observations of Fairall 9,’’ ApJS, 110, 9

Schmidt, E.G. 1996, ‘‘Stars Classified as Constant in the General Catalogue of Variable Stars’’ PASP 108, 1105

Schmidt, E.G. 1996, ‘‘Variable Star Research at Behlen Observatory,’’ a paper presented at the meeting entitled ‘‘The Role of Small Telescopes in Astronomy’’ at Lowell Observatory, Flagstaff, AZ, October 1996

Schmidt, E.G. & Seth, A. 1996, ‘‘The Behlen Observatory Variable Star Survey IV,’’ AJ 112, 2769

Snedden, S. A. & Gaskell, C. M., ‘‘An Analysis of Broad Emission Line Profiles from HST Data,’’ in Emission Lines in Active Galaxies: New Methods and Techniques, ed. B. M. Peterson, F.-Z. Cheng, & A. S. Wilson, 195

Wanders, I. … Gaskell, C. M. … Snedden, S. A., *et al.* 1997, ‘‘Steps toward Determination of the Size and Structure of the Broad-Line Region in Active Galactic Nuclei. XI. Intensive Monitoring of the Ultraviolet Spectrum of NGC 7469’’ ApJS, 113, 69

Zhou, D.Q. & Leung, K.C. 1997, ‘‘Temperature Inhomogeneity on Surface of Detached Close Binary Star due to Irradiation’’ in Recent Development on Binary Star Research, ed by K. C. Leung (Provo: Astron. Society of the Pacific, 1997), p 69-74.

Zhou, D.Q. & Leung, K.C. 1997, ‘‘ A 2-D Numerical Simulation of the Circulation in the Envelope of a Contact Binary System, an Update’’ in Recent Development on Binary Star Research, ed. by K. C. Leung (Provo: Astrono. Society of the Pacific, 1997), P 95-101.

Donald J. Taylor, Observatory Director