

University of Kansas
Lawrence, Kansas 66045

I. PERSONNEL

Faculty involved in astronomy and space physics at Kansas were Professors T. P. Armstrong, D. B. Beard, D. J. Bord (Adjunct), J. P. Davidson, S. J. Shawl, and, from August 1980, R. B. Phillips (Visiting).

II. RESEARCH

A. Stellar and Galactic Studies

Bord and Davidson, with the assistance of graduate student Richard Desko, are continuing their investigations of the Hg-Mn stars κ Cnc and ι CrB using the method of wavelength coincidence statistics (WCS). Studies of the long-wavelength (1960–3230 Å) IUE spectrum of κ Cnc have confirmed the presence of Cr, Mn, and Fe, as well as evidence to support the identifications of Hg and Os. Differential abundance analysis yields a value of 5.5 ± 1.0 dex for Os; the solar abundance of Os is 0.9 dex. This is the first reported determination for Os in κ Cnc, and taken together with overabundances of Pt and Hg, may indicate that overabundances of heavy elements in κ Cnc have occurred through the r -process, as in the case of HR 465 (Cowley *et al.*, Ap.J. 183, 127, 1973). No statistical evidence to support the identification of Au in the region 1960–3230 Å in κ Cnc has been found in the studies, and a line-by-line examination of all coincidences between measured stellar features and laboratory lines of Au I, Au II, and Au III has provided no reason to doubt the result of our statistical analysis. Our result leaves unsubstantiated the reported discovery of Au in κ Cnc by Leckrone and Heacox (Publ. ASP, 90, 492, 1978), and, hence, also leaves unanswered the question of whether or not there exists a violation of the even-odd effect in the elemental sequence Pt-Au-Hg in this star. These and more detailed results are discussed in a recent paper submitted to *The Astrophysical Journal*. Similar searches for heavy elements of $74 < Z < 81$ in the short-wavelength (1230–2121 Å) IUE spectrum of ι CrB have offered little that is new in element identifications.

Currently, Bord and Davidson are extending their element search in κ Cnc to include medium- Z elements in the range $12 < Z < 40$ in an attempt to confirm previously reported violations of the even-odd effect involving P and Ga (Cowley and Aikman, Ap.J. 196, 521, 1975). Preliminary WCS results provide evidence to support the identification of the even- Z elements Mg, Si, Ca, Sr, and Zr, as well as the odd- Z element Cl. The latter result confirms a previous report by Leckrone and Heacox (1978) of Cl in κ Cnc, and, in the absence of a detection of S and Ar, may indicate a violation of the even-odd effect in the sequence S-Cl-Ar. Work is continuing in this area (funded by grants from the AAS and The Research Corporation to Bord, and The University of Kansas to Davidson) in an attempt to deter-

mine whether nuclear or non-nuclear processes provide the better explanation for the abundance patterns observed in this star and others like it. It is anticipated that the Department's new VAX computing system will double the rate at which the WCS analyses of IUE data can be carried out, and allow elements of interest to be isolated and then studied with more traditional methods.

Two large projects are moving close to completion under funding from the NSF to S. J. Shawl. With enthusiastic assistance from undergraduate James Meyer, Shawl and J. E. Hesser (DAO) have analyzed 32 000 individual line measurements from about 800 Cerro Tololo image-tube spectra of IAU standard radial velocity stars. The project was undertaken because the properties of this instrument have not been fully calibrated for radial velocity determination. A systematic declination dependence was found which they believe can be traced to the magnetically focused spectrograph coming close to the pier of the 1-m telescope at high southerly declinations. Details of the measurements and preliminary correction tables were presented at IAU colloquium No. 68 in Schenectady, N.Y., to be published in the meeting proceedings.

The study of globular cluster shapes, orientations, and galactic coordinates by Shawl and White (Steward Observatory) is also progressing well under funding from the NSF. Currently, 116 globulars have been scanned with the KPNO PDS; these scans have been blurred. Eighty-eight among these have been analyzed with the IPPS, while 93 have had the necessary measurements made for determination of the cluster center and orientation in equatorial coordinates. Work still in progress includes detailed analysis of the systematic errors in the reduction technique, and the influence of vignetting on the off-axis clusters on wide-field Schmidt plates.

Shawl and Martin (DDO) have completed one phase of their polarimetric study of the magnetic field of M31. They find general agreement with previous optical studies, but there is some disagreement for a few globular clusters. The data are generally consistent with a circular magnetic field in the galactic plane. They find the measured polarization to be low, even for large reddening, and attribute this to poor alignment and/or randomly oriented field lines along the line of sight.

Shawl and Martin have also completed their search for optical polarization from dark patches in globular clusters. They have produced a simple model which shows circumstances under which polarization of light scattered from small particles will occur. Their search for such polarization patches in M3, M13, and M15 provided a tentative detection in M15 ($0.26\% \pm 0.06\%$).

B. Extragalactic Studies

Phillips, R. L. Mutel (Univ. of Iowa), and H. D. Aller (Univ. of Michigan) have been making an intensive series of

VLBI maps of BL Lacertae to follow its milliarcsecond structure as the source evolves from the violent 1980 outburst. The comprehensive data on daily flux measurements made at Michigan allow the most detailed analysis yet of how structure changes might relate to flux variations. The milliarcsecond maps made at 10.6 GHz between December 1980 and October 1981 show that BL Lac is probably a member of the "superluminal" club of radio sources which appear to show internal expansions faster than c , but that BL Lac also varies its structure even more rapidly than superluminals like 3C 273 and 3C 345. Thus, it is difficult to make an unambiguous case for a straightforward expansion as has been done for those objects. BL Lac appears to have multiple components, both moving *and* fading out within one year. Since observations can only be scheduled every 4–6 months, no model can be presented as a final answer. However, the best working model to date features a fixed core at the north end of the source, from which "blobs" are ejected at about $15c$, and which fade with half-lives of a few months. This model, although quite untested, offers the advantage of identifying the emergence of *each* blob seen to date with a characteristic "signature" in the day-to-day flux records. VLBI mapping will continue as often as can be scheduled, and the investigators hope a clear answer will emerge.

Phillips and Mutel continued a program to enlarge the sample of compact radio sources whose structure is well known at centimeter wavelengths. A new class of widely separated, compact double radio sources has been discovered as a result of this work, and now comprises roughly 15%–20% of all compact sources. This discovery showed that not all compact sources are highly asymmetric objects whose appearance is strongly molded by relativistic beaming effects, as was first thought from early VLBI investigation. These compact doubles almost certainly represent a missing link between "classical" radio doubles 1 arcsec or more in size and the active, variable compact objects often observed with VLBI. They believe they can identify compact double "candidates" through their radio spectra, and will make studies of a sample chosen by spectra alone to test this hypothesis.

Phillips and Mutel also isolated the source region responsible for slow flux variations in the unidentified source NRAO 150 over the period 1974–1978. Maps of NRAO 150 at six frequencies from 1.7 to 22 GHz show it is an unusual compact source, 200 times smaller at 22 GHz than at 1.7 GHz.

Phillips and D. B. Shaffer (Phoenix Corporation) have mapped a group of six strong sources at 2.3 GHz, a little-used frequency for astronomy in recent years. The maps have allowed detailed comparison with maps made at nearby frequencies for structure and spectra. As a result, remote measurements of some basic physical quantities have been made, and some models for source processes have been rejected, both goals of VLBI as it matures from its pioneering days.

S. C. Unwin (CIT), Phillips, Mutel, and R. P. Linfield (CIT) pooled maps at three frequencies to present the most reliable review of the radio structure of NGC 1275 (3C 84).

The nucleus of this galaxy, itself of disputed type, is quite complex and changes on time scales of about one year. Unwin's careful interpretation of the latest maps indicates that VLBI practitioners cannot begin to analyze this extremely bright *and* complex source without large numbers of antennas in the VLB array and the latest in mapping methods. Hence, comparison with early model maps cannot be performed usefully. The authors also showed that the inverse Compton x-ray emission of the milliarcsecond radio processes observed can account for the unresolved component of x-ray emission from the whole Perseus cluster.

III. SOLAR SYSTEM STUDIES

Beard was the recipient of NASA grants to model (1) the magnetic field of Jupiter and (2) shocks, Type I comet tail rays, and cometary atmospheres.

Beard successfully represented a compressed planetary magnetic field in the antisolar region near the planet, by means of cylindrical harmonics. The region is important as a source of the aurora, magnetic storm activity, and much geophysical activity, but the old representation using spherical harmonics was greatly in error.

Beard parametrized the planetary dipole strengths of both Saturn and Mercury as well as their dipole direction and position, to fit magnetospheric calculations of Earth's magnetic field to space flight measurements near Mercury and Saturn to obtain rms fits of 9 for Mercury and for Saturn.

Beard obtained a convenient representation of the magnetic field of the Jovian equatorial current sheet which completes the calculation of the Jovian magnetic field.

Beard derived a credible theory of the generation of ionized gas tails of comets and has been deriving isophotes for both neutral gas atmospheres in cometary comas and tails near the comet itself. Work continues on all of these projects.

IV. TEACHING AND PUBLIC SERVICE

Doctoral degrees were awarded to Patrick Briggs and Joe Nonnast in space physics. Shawl's innovative use of outstanding undergraduates as peer-tutors in the introductory astronomy courses has continued, much to the benefit of the tutors themselves and the astronomy program.

In October 1980, the KU Observatory was officially renamed the Clyde W. Tombaugh Observatory, in honor of the discover of Pluto and recipient of bachelor's and master's degrees at the University in 1934 and 1939. The renaming of the Observatory and the dedication of the Daus-Preston telescope were the highlights of Astronomy Week, which featured talks by Phillips on "Radio Sources," Shawl on "Extraterrestrial Intelligence," and a reminiscence with Professor Tombaugh before a packed house at the Kansas Union. The 14-in. Daus-Preston telescope is the latest acquisition of the Observatory, and is the gift of June and Floyd Preston and Mrs. Paul H. Daus, to whom we express our everlasting thanks.

V. VISITORS AND MISCELLANEOUS

We were pleased to have the following visitors who gave colloquia during the past year: D. Gurnett (Univ. of Iowa), R. Mutel (Univ. of Iowa), and R. Robinson (Univ. of Texas).

Phillips was an invited participant at a Workshop on Jets in Radio Sources sponsored by the University of New Mexico in Albuquerque. Bord, Davidson, Phillips, and Shawl attended the 157th meeting of the AAS and all gave papers. Phillips gave colloquia at Benedictine College, Kansas, and Wichita State. Shawl presented the results of two large projects described above, at IAU Colloquium No. 68 on Globular Clusters, held at Schenectady, N.Y.

VI. PUBLICATIONS

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- Beard, D. B. (1981). "The photosphere," *Encyclopedia of Physics*, edited by Lerner and Trigg.
- Bord, D. J., and Davidson, J. P. (1980). "Element identification in the ultraviolet spectrum of Cancri," *Bull. Am. Astron. Soc.* **12**, 798.
- Bord, D. J., and Davidson, J. P. (1981). "An application of the method of wavelength coincidence statistics to the ultraviolet spectrum of Cancri," submitted to *Astrophys. J.*
- Davidson, J. P., and Bord, D. J. (1981). "The search for heavy metals in CP stars—Iota Corona Borealis," *Trans. Kansas Acad. Sci.* **84**, 155.
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- Mutel, R. L., and Phillips, R. B. (1980). "Temporal variation in the compact radio structure of NRAO 150 at 1671 MHz," *Astrophys. J.* **241**, L73.
- Mutel, R. L., Phillips, R. B., and Skuppin, R. (1981). "The structure of DA 344 at 167 GHz," *Astron. J.* **86**, 1600.
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- Phillips, R. B., Mutel, R. L., and Shaffer, D. B. (1980). "VLBI maps of compact double radio sources," *Bull. Am. Astron. Soc.* **12**, 804.
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- Phillips, R. B., and Mutel, R. L. (1981). "Superluminal behavior in BL Lacertae," *Bull. Am. Astron. Soc.* **13**, 842.
- Shawl, S. J., and White, R. E. (1980). "Accurate equatorial positions for the centers of six x-ray globular clusters," *Astrophys. J.* **239**, L61.

R. B. PHILLIPS

Data Survey

- (1) No. of faculty/staff: tenured or tenure-track 1 (M), 0 (F); post-doc 0 (M), 0 (F); res. assoc. 0 (M), 0 (F); other Ph.D.'s 1 (M), 0 (F).
- (2) No. of graduate students: first year 0 (M), 0 (F); total 0 (M), 0 (F).
- (3) No. of degrees awarded: terminal Master 0 (M), 1 (F); Ph.D. 2 (M), 0 (F).
- (4) Employment of those in (3): post-doc 1 (M), 0 (F); res. assoc. 0 (M), 0 (F); tenure-track 1 (M), 0 (F); FFRDC 0 (M), 0 (F); govt. lab 0 (M), 1 (F); industry 0 (M), 0 (F); foreign 0 (M), 0 (F); other 0 (M), 0 (F).