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A literature search was performed for the probable magnetic properties of 15 Algol-type binaries. The properties examined included detection of Calcium, Hydrogen and Potassium emission, the x-ray luminosity determined from x-ray flares, detection of radio emission and type of polarization, evidence of variations in the brightness of the cool secondary and changes in the orbital periods of the binary which can be linked to changes in the polarity of the magnetic field of the cool star. The technique of Doppler Tomography was used in an attempt to isolate the source of the emission seen in the Hydrogen alpha difference profiles of Algol. The Doppler images indicate that most of the emission is not associated with the cool star but with the mass transfer process and, in particular, with gas found between the two stars.

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Progress Report for AFOSR Grant F49620-92-J-0024

Principal Investigator: Mercedes T. Richards

Project Title: Chromospheric Activity in Algol Binaries

Project Period: 10-01-91 to 09-30-94

Current Date: August 10, 1992

I. Summary of Scientific Progress to date

The cool G- to K-type secondaries in short-period Algol-type binaries are expected to be magnetically-active because of their rapid rotation and outer convective layers. However, magnetic activity is not usually associated with these binaries because the secondaries are faint relative to the luminous B5 – A5 V primaries at visible wavelengths. Nevertheless, the detections of both stellar flares and starspots in these binaries have provided evidence of magnetic activity associated with the cool secondary. The P.I. has shown that Algol secondaries are similar to the doubly-active RS CVn binaries and display magnetic properties which include weak CaII H and K emission; brightness variations in the light curve of $\lesssim 0.1$ mag. indicative of the motions of starspots; coronal X-ray emission; weak radio flares; nonthermal gyrosynchrotron radio emission; ultraviolet and infrared excesses; and alternate increases and decreases in the orbital period of the binary (see Richards 1990 and references therein).

The P.I. performed a literature search for the probable magnetic properties of 15 Algol-type binaries (Richards 1992a; Richards and Albright 1992). The systems chosen had orbital periods typically less than 6 days since short-period rapid rotators are more likely to display magnetic activity than their long-period counterparts. The properties examined included possible detections of CaII H and K emission and hydrogen Balmer line emission, the x-ray luminosity determined from x-ray flares, detections of radio emission and type of polarization detected, evidence of variations in the brightness of the cool secondary, and changes on the order of $\sim 10^{-5}P$ in the orbital period of the binary which can be linked to changes in the polarity of the magnetic field of the cool star. The survey showed that although six of the chosen binaries displayed evidence of variations in the brightness of the secondary, β Persei is the only Algol binary for which there was strong evidence of starspot activity. In this case, the evidence was obtained by the P.I. (Richards 1990) from a study of the 1.2 μm light curves of that system. It is clear that similar work needs to be done to examine starspot activity in other members of the group. Furthermore, there is an urgent need for a systematic study of the x-ray, visual, and radio observations of these systems.

Hα Balmer line emission from Algol binaries has been investigated even more than starspot activity because these binaries have traditionally been associated with mass transfer resulting from Roche lobe overflow. The P.I. is now determining the influence of chromospheric Hα emission on what was formerly assumed to be emission from circumstellar gas. In the study of β Persei, the P.I. (Richards 1992b; 1992c) assumed that the chromospheric Hα emission from the K2 IV secondary would be insignificant compared to that from the circumstellar material associated with the B8 V primary. However, some of the Hα "difference profiles" profiles seen during primary eclipse could have been produced by either a transient accretion disk or a chromospheric flare (Richards 1992b), even though the disk explanation is more likely. In principle, it should be possible to distinguish between the two sources of Hα emission (*e.g.*, using the technique of Doppler imaging) but this is not a trivial exercise because both forms of emission are weak relative to the combined continuum flux of the binary. One approach is to use values of Ca II H & K and Hα emission line strengths obtained from studies of F6 - M2 stars in single and binary systems (Strassmeier *et al.* 1990), and in short-period RS CVn binaries (Barden 1985) to estimate the chromospheric Hα line strengths in the short-period Algols.

The P.I. and undergraduate student Robert D. Jones have used the technique of Doppler Tomography (Marsh and Horne 1988) in an attempt to isolate the source of the emission seen in the Hα difference profiles of Algol (Jones and Richards 1992). The Doppler images suggest that most of the Hα emission is not associated with the cool star but with the mass transfer process, and in particular with gas found between the two stars (Richards and Jones 1992). This result merely confirms that the chromospheric contribution is weak.

The P.I. and graduate student Geary E. Albright are applying for observing time to use the infrared photometers on the 1.3m telescope at Kitt Peak National Observatory in Tucson, Arizona, and the 1.5m Carlos Sanchez Telescope at Tenerife in the Canary Islands. We expect to obtain infrared light curves of up to 15 short period Algols beginning with β Per, TX UMa, RW Tau, δ Lib, and U CrB. This work will be a major part of Mr. Albright's Ph.D. thesis research. We anticipate that observations will begin in Spring 1993.

II. Education and Human Resource Development

The P.I. is currently an Assistant professor at the University of Virginia. In Fall 1991, she taught a third-year undergraduate course on "Observational Astronomy" to astronomy majors, and in the Spring, she taught a new graduate course on "Binary Stars". Her research experience enabled her to present an advanced and mature approach to the study of binary stars, so that the graduate students who attended her course benefited from that experience.

Since September 1991, the P.I.'s AFOSR grant has supported one undergraduate Summer student who worked on Doppler imaging, and a full-time Ph.D. student will be supported starting in October 1992.

III. Research papers resulting from AFOSR grant F49620-92-J-0024

1. Richards, M. T. 1992a, Magnetic activity in Algol-type binaries, in *Cool Stars, Stellar Systems and the Sun*, ed. M. Giampapa and J. Bookbinder, ASP Conference Series **26**, 367.

2. Richards, M. T., and Albright, G. E. 1992, Magnetic activity in short-period Algol binaries, in preparation.

3. Richards, M. T., and Jones, R. D. 1992, Doppler tomography of non-photospheric gas in β Persei, in preparation.

Other References

1. Barden, S. C. 1985, *Ap. J.*, **295**, 162.

2. Jones, R. D., and Richards, M. T. 1992, *Bull. AAS*, **24**, 768.

3. Marsh, T. R., and Horne, K. 1988, *M.N.R.A.S*, **235**, 269.

4. Richards, M. T. 1990, *Ap. J.*, **350**, 372.

5. Richards, M. T. 1992b, *Ap. J.*, **387**, 329.

6. Richards, M. T. 1992c, *Ap. J. Suppl.*, in press.

7. Strassmeier, K. G., Fekel, F. C., Bopp, B. W., Dempsey, R. C., and Henry, G. W. 1990, *Ap. J. Suppl.*, **72**, 191.