OBSERVATIONS OF SPECTROSCOPIC BINARIES WITH A SOLID-STATE DETECTOR

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The recent installation of a solid-state 1024-element silicon photodiode array detector (Reticon) at the coude focus of the 2.7 m McDonald Observatory reflector has greatly extended its limits of observation for binary and multiple systems which have weak and/or broad-lined components. This detector can produce extremely high signal-to-noise ratio observations and has high quantum efficiency over the wavelength region 3000-11000Å. The observational programs of three users of this device are described below.

1. RETICON OBSERVATIONS OF ECLIPSING BINARIES BY J. TOMKIN

Secondaries of Algol-type eclipsing binaries are being observed by J. Tomkin. Most of the stars in his program have evolved secondaries although a few main-sequence pairs are also included. The sensitivity of the Reticon in the red and near-infrared--where the secondaries are relatively brighter than in the photographic part of the spectrum and blending problems are less severe--are advantages. The outstanding advantage, however, is the large signal-to-noise ratio that can be obtained. This is particularly true of bright objects. The detection of the NaD lines of the secondary of Algol (Fig.1) is an example.

Studies of δ Lib, Algol and U Sge have been published. A preliminary analysis of U Cep gives a K_2 of 200 km s^{-1}. Batten had suggested a tentative value of 180. The secondaries of RZ Cas, S Cnc, U CrB, Alpha CrB, AI Dra and EK Cep, have also been detected and further observations of these systems are underway.

J. Tomkin, D. Lambert and M. Parthasarathy are studying abundances in eclipsing binaries. An investigation of the metal abundances of the secondary of U Cep shows that they are not significantly different from solar. A preliminary analysis of the secondary of U Sge shows that it also has solar metal abundances. These results do not support the conclusions of earlier investigations by narrow-band photometry which had indicated large metal-deficiencies in evolved Algol-type secondaries. An investigation of carbon, nitrogen and oxygen abundances in primaries and secondaries is planned.

M. J. Plavec, D. M. Popper and R. K. Ulrich (eds.), Close Binary Stars: Observations and Interpretation, 53–57.

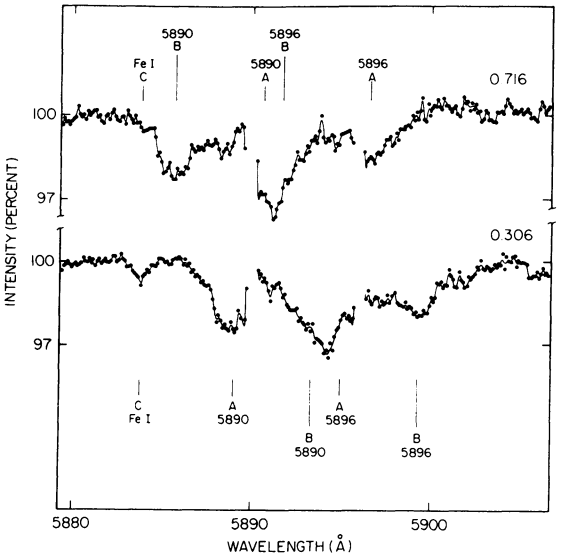

Figure 1. Two spectra of NaD lines in Algol are plotted on an expanded intensity scale. At phase 0.716 the 5890 Å NaD line of Algol B is resolved and the 5896 Å line is blended with the 5890 Å NaD line of Algol A. At phase 0.306 the situation is reversed. Lines from Algol C are also weakly present.

2. ECLIPSING BINARY PROGRAM OF CLAUD LACY AND DAVID EVANS

This program is restricted mainly (but not exclusively) to those systems which already have accurate photometric elements, but lack double-lined RV curves. Prime targets (listed in Table 1) are bright systems with large light-ratios and fainter systems with light-ratios nearer unity. The ultimate goal is to obtain accurate RV curves, and thus masses and absolute dimensions for these systems.

TABLE 1. ECLIPSING SYSTEMS IN WHICH MEASURABLE LINES OF SECONDARY HAVE BEEN OBSERVED.

*	Sp	V	l_1/l_2	Remarks
KP Aql	A2(K)	9.7pg	1	Sp looks like F-stars.
CW CMa	A4	8.58	1	
YZ Cas	AZV + F5V	5.65	9(Red)	Blue light ratio is 15.
V442 Cyg	F4	10.0pg	1	Period is double that of GCVS.
TT Hya	A3e + (G5)	7.5pg	8(Blue)	Si II broad, Fe I sharp.
FL Lyr	G5	9.30	2	
EE Peg	A4mV + FV	6.97	9(Blue)	
IQ Per	B7V + AZV	7.72	10(Blue)	Detection tentative.
V906 Sco	B9V + B9V	5.96	1	Triple-lined system.
TX UMa	B8V + gF2	7.06	4(Yellow)	Broad sec. lines ~1% deep.

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A pair of representative spectra are shown below:

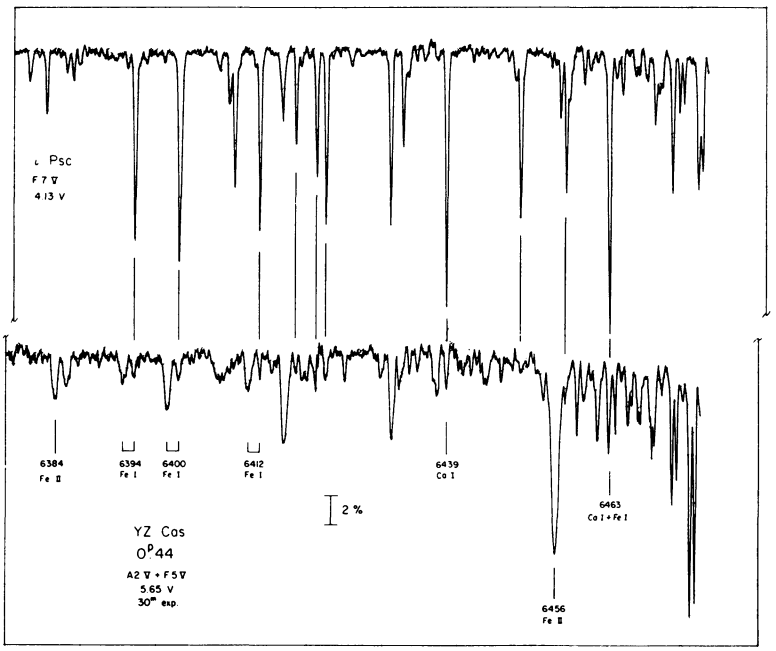

Figure 2--YZ Cas and ι Psc in the red. The upper comparison spectrum has been aligned with features due to the faint secondary in the lower spectrum. The strongest unblended lines have been marked. Some doubled lines are indicated. The strongest features of the secondary are ∿ 2% deep. The signal-to-noise ratio of this spectrum is about 500 to 1. The light-ratio is 9 to 1.

3. MULTIPLE STAR PROGRAM OF F. FEKEL

For the past several years Francis Fekel has obtained Reticon observations of short period ($P \leq 20$ years) visual binaries, one or both of whose components are short period spectographic binaries, making the systems triple or quadruple. These spectroscopic observations, combined with visual and speckle interferometric data, enable the parallax and individual masses to be determined.

Masses have already been determined for the Ψ Sgr system which contains an early F III and a G 5III component. In collaboration with A. Batten, C. Morley and J. Tomkin, observations of HD 165590 have been completed. Work will shortly be completed on HD 203345 after it passes through nodal passage in its 6 year visual orbit later this year. It had been suggested that this system might contain a neutron star. Reticon observations showed the third

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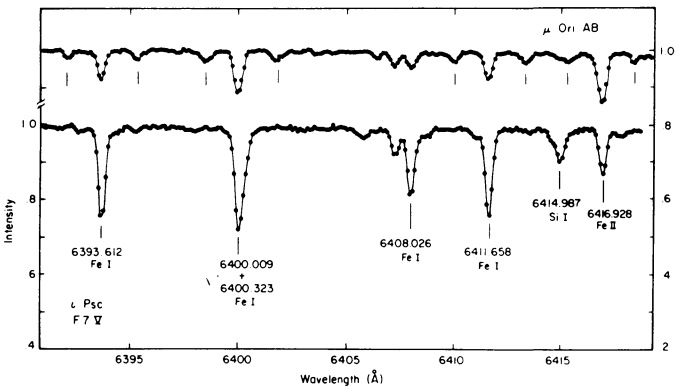
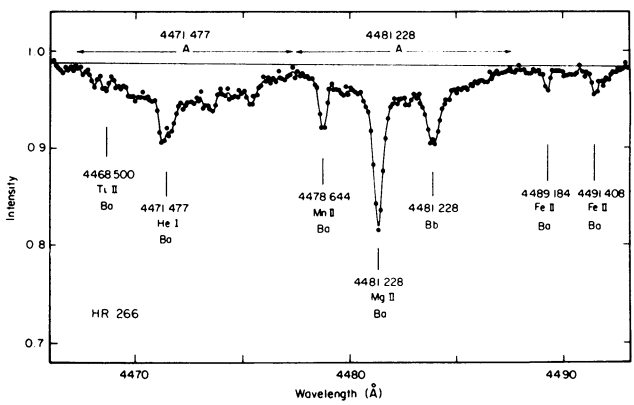
component to be an early K dwarf. The visual secondary of μ Ori was thought to violate the mass-luminosity relation. Reticon observations (below) showed that the secondary is not a single star but a double-lined binary, thus solving this problem.



Weak broad-lined features can also be detected in the blue. Examples of this are HR 2130 and HR 266 (below). The broad



lines of HeI and MgII were not detected on well exposed IIaO plates but are obvious in the Reticon observations. Finally, in collaboration with George O'Brien, the mass ratio and rotational velocity of Capella A, B are being redetermined because of the very broad-lined nature of Capella B.

From the systems presently observed with the Reticon it appears the mid and late type systems can be detected as double-lined binaries if they have mass functions $\gtrsim 0.1\ M_{\odot}$. These systems have mass ratios as small as 0.6.

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DISCUSSION FOLLOWING FEKEL, LACY AND TOMKIN

Popper: If I were much younger and was considering going into this field with the facilities now available to me, I would withdraw in favor of the superior capabilities of techniques such as that employed at McDonald. I hope adequate observing time will be made available for this fundamental work.

Budding: Does your list of stars include R CMa? It would be interesting to have independent confirmation of the existence of a definite class of "underluminous subgiants".

Lacy: I believe Joc Tomkin has it on his list.

Mayo: You have shown us some very impressive detections of the lines of faint components in binary and triple systems. Although Cygnus X-1 is usually considered as a binary system containing a black hole, the alternative hypothesis of replacing the black hole by a 'normal' star with a neutron star in orbit around it cannot be unambiguously ruled out. The question is: have you tried looking for lines of the unseen star? If not I strongly recommend doing so.

Fekel: To the best of my knowledge no one at Texas has looked at Cygnus X-1 with the coudé Reticon system. If lines of a possible third component are at least several percent deep they might be detected with our system.

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