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A Preliminary Speckle Orbit of the Old Disk Population Star HR 1071

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1. INTRODUCTION

The F7V star HR 1071 has attracted little individual attention in the literature. Eggen (1972, 1973) included HR 1071 among some 250 metal-deficient stars, of which 20 are halo population objects, in a photometric calibration of their absolute magnitudes. HR 1071 stands out in Eggen's sample as a disk population star of extreme space velocity compared with stars of similar moderate metal deficiency, having (U, V, W) = (−60, −39, +8) km s^{-1}. Kinematically, HR 1071 would be considered an old disk population star although this classification would be strengthened if the metallicity were lower. More recently, Balachandran (1990, hereafter BAL) took Eggen's (1973) sample as a basis for studying the possible effects of rotational breaking on Li depletion in old-disk population F stars. HR 1071 possesses the fifth lowest Li abundance (the Li λ6707 Å equivalent width was less than 1 mÅ) and the third lowest observed rotational velocity of 5 km s^{-1} in BAL's sample.

A companion to HR 1071 with an angular separation generally less than $0''\!.1$ was discovered in 1985 in a speckle interferometric survey for duplicity among high-velocity stars carried out by Lu *et al.* (1987) using the CHARA speckle camera system at the KPNO 4-m telescope. Subsequent observations covering a span of six years now provide a total of seven epochs through which the system has shown very significant orbital motion. While these data cannot yet give a truly definitive orbit, the combination of their high accuracy and favorable orbital coverage provide a solid starting point for discussion.

2. SPECKLE OBSERVATIONS AND ORBIT

The close system which comprises HR 1071 was discovered in November 1985 at an angular separation of $0''\!.102$ and has revolved through nearly 230° of position angle to the time of its most recently measured geometry on 1991.8937. The system has been designated as CHARA 117 in our continuing list of binary star discoveries. The seven speckle measurements of the HR 1071 system are recorded in Table 1 along with the residuals from the newly determined orbit. The orbit solution, the results of which are presented in Table 2, was carried out using a least-squares algorithm described by Hartkopf *et al.* (1989). The rms dispersions of the residuals in ρ and θ are $\pm0''\!.0024$ and $\pm0''\!.0017$, respectively. The orbital fit to the observations is shown in Figure 1 where it is apparent that the new orbit indeed fits these data very well. Because the observations do not yet cover a full 360° of mean anomaly, the orbit cannot yet be considered definitive. However, it seems unlikely that the orbital elements will change significantly as future observations are accumulated.

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TABLE 1 (left). Speckle Observations and Residuals for HR 1071.
TABLE 2 (right). Speckle Orbital Elements for HR 1071.

Date -1900.	θ_{obs} °	ρ_{obs} mas	θ_{calc} °	ρ_{calc} mas	$\Delta\theta$ °	$\Delta\rho$ mas
85.8433	155.3	102	154.9	101	0.4	1
86.8862	180.5	96	180.0	98	0.5	-3
87.7654	201.0	97	201.7	98	-0.7	-1
88.6608	224.8	92	224.8	93	0.0	-1
89.7067	257.5	74	260.4	73	-2.9	1
90.7551	326.9	63	325.5	58	1.4	5
91.8937	23.4	87	23.1	87	0.3	-0

$P = 13.76$ y	$\pm$	0.14 y
$a = 0''.116$	$\pm$	$0''.001$
$i = 44^\circ.1$	$\pm$	$0^\circ.1$
$\Omega = 234^\circ.4$	$\pm$	$0^\circ.5$
$T = 1990.18$	$\pm$	0.01
$e = 0.331$	$\pm$	0.002
$\omega = 59^\circ.6$	$\pm$	$0^\circ.5$

3. HR 1071 AS A SPECTROSCOPIC BINARY

Although we cannot yet accurately determine Δm for HR 1071, we can provide a qualitative argument to support our impression that Δm must be rather small. We estimate a Δm ~0.2 mag, based on a comparison of the directed vector–autocorrelation (DVA) of speckle data for HR 1071 with data for two binaries with Δm's of 0.0 and 0.4 mag. For late F types stars, such a Δm is equivalent to about one spectral subclass. HR 1071 therefore offers some promise towards its detection as a double–lined spectroscopic binary. If such detection did occur, and the velocity amplitudes of the radial velocity orbits of both components were determinable, then the individual masses of the components as well as the distance to the system would become known. This would provide an important opportunity to determine masses and luminosities for older disk population stars that have evolved well away from the zero–age main sequence.

Adopting $\Delta m = +0.2$ mag gives approximate V magnitudes for the components of 7.0 and 7.2 mag. These coupled with the two M_V estimates yield distances of 76 and 52 pc. The distance to the system can easily be combined with the visual orbital elements to predict the amplitude of the radial velocity curve for the system.

At the next periastron passage, predicted for late 2003, the two components will be separated in radial velocity by nearly 15 km s^{-1}. This corresponds to a line doubling separation of 275 mÅ at λ5500 Å, a value which should clearly show doubling in the line cores of the sharp absorption spectrum features of this slowly rotating star. A somewhat less favorable, but certainly worthwhile, phase regime is being entered into now and includes the period 1992.5 through 1994.5 when the differential radial velocity between the components will be approximately 10 km s^{-1}, giving line separations of 180 mÅ.

The low rotational velocity of the system enhances the chances of detecting line doubling. The velocity amplitude, and hence the line doubling separation, scales directly with the distance of the system. Even if the star is as close as 50 pc, HR 1071 still offers a challenging opportunity to spectroscopists. Its resolution as a double–lined spectroscopic binary will provide the necessary complementary information to the speckle observations to determine the component masses and to geometrically determine the system's distance. Masses and luminosities for such an old disk population will make a valuable addition to the collection of fundamental stellar paremeters.

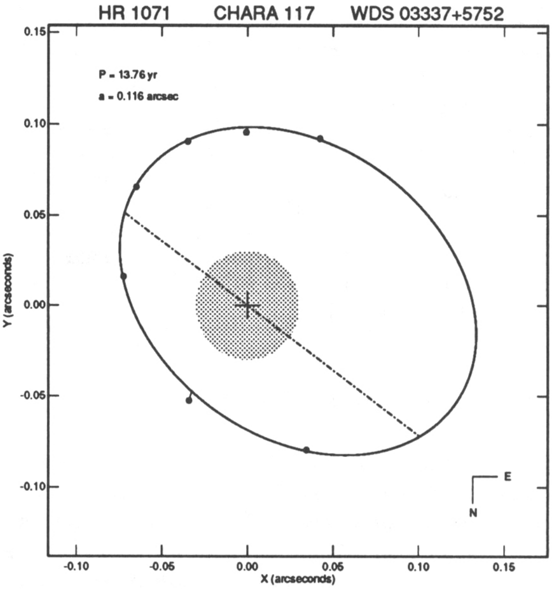

FIGURE 1. Seven speckle measurements of HR 1071 are plotted against the newly determined visual orbit of the system. Each point is connected to the orbit by an $O-C$ line; the broken line is the line of nodes. The hatched circular region represents the $0\farcs03$ limit of resolution by speckle interferometry at the 4-m KPNO telescope.

4. CONCLUSION

We have shown that this old disk population star presents an excellent opportunity to spectroscopists to acquire the missing information necessary to determine component masses and distance to the system. The geometrically–determined distance then leads to a fundamental determination of the absolute magnitudes of the components, independent of any spectrophotometric calibration.

Because of its kinematically inferred age, its moderately low metallicity, its truly low rotational velocity (not likely the result of projection), its extremely low lithium content, and its existence as a detached binary system whose component masses and luminosities are likely to be determined, HR 1071 is a system worthy of further scrutiny. Such efforts may also shed more light on the role duplicity appears to play in reducing the Li abundance in F type stars.

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