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PHOTOMETRY OF THE HD 187123 FIELD

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The star HD 187123 = GSC 2664_550 was found to have an orbiting planet with a period of $3^{\rm d}.097$ and a semi-amplitude of 72 m/s (Butler et al. 1998). Anticipating that the star might experience transits of the planet we began photometric observations. The star IRAS 19450+3416 (Beichman et al. 1988) = USNO 1200–13176787 (Monet et al. 1996) was also in the field.

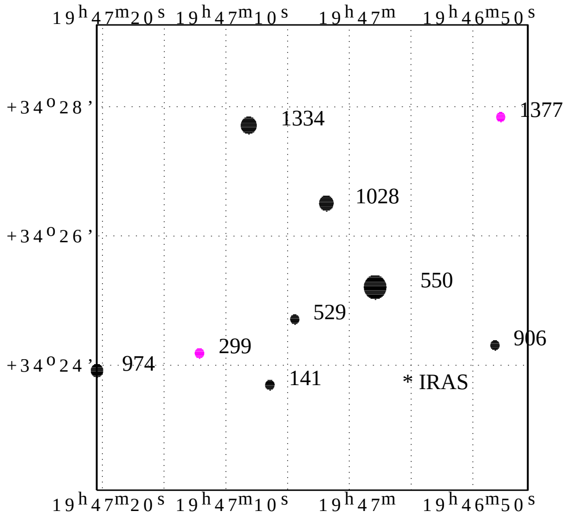

Figure 1. Finder chart labeled with the GSC numbers and an '∗' for IRAS19450+3416

Plotted in Figure 1 is the field of stars observed with the automated 0.5-m telescope and reduced in a fashion nearly identical to that described in Robb and Greimel (1999). Due to the brightness of HD 187123 the telescope was left slightly out of focus and 8 arc second star apertures were used. During the 47 nights a total of 8323 frames were observed each with an exposure time of 42 seconds.

Tabulated in Table 1 are the stars' identification numbers, coordinates (J2000) and magnitudes from the Hubble Space Telescope Guide Star Catalog (GSC) (Jenkner et al. 1990). The most precise photometry requires that all parameters be kept constant during a night, from night to night, from run to run and from year to year. Our data divide

Table 1: Stars observed in the field of HD 187123 in 1998

GSC No.	R.A. J2000	Dec. J2000	GSC Mag.	ΔR Mag.	Std Dev Between	Std Dev Within
2664_550	$19^h46^m58^s$	$+34°25'12''$	7.5	−2.137	0.001	0.002
2664_1334	$19^h47^m08^s$	$+34°27'43''$	9.6	—	—	—
2664_1028	$19^h47^m02^s$	$+34°26'30''$	10.1	0.415	0.003	0.003
2664_974	$19^h47^m20^s$	$+34°23'55''$	10.8	0.947	0.002	0.004
2664_299	$19^h47^m12^s$	$+34°24'11''$	11.8	2.488	0.002	0.008
2664_529	$19^h47^m04^s$	$+34°24'43''$	11.9	2.070	0.003	0.008
2664_141	$19^h47^m06^s$	$+34°23'42''$	11.8	2.506	0.003	0.010
IRAS 19450+3416	$19^h46^m55^s$	$+34°23'35''$	12.7	2.209	0.052	0.008
2664_906	$19^h46^m48^s$	$+34°24'18''$	11.9	2.335	0.004	0.009

naturally into three runs, fall 1998, summer 1999 and fall 1999. A different flat field was used for each run and it was found that there were constant offsets from run to run of about 0.01 magnitudes. Due to this offset we present in Table 1 the results for the fall 1998 data, which had a smaller standard deviation from night to night but a larger standard deviation during each night. Our differential ΔR magnitudes are calculated in the sense of the star minus GSC 2664_1334. Brightness variations during a night were measured by the standard deviation of the differential magnitudes during a night. The best night is tabulated in Table 1 as "Std Dev Within". For each star the mean of the nightly means is shown as ΔR in Table 1. The standard deviation of the nightly means is a measure of the night to night variations and is called "Std Dev Between" in Table 1. The star IRAS 19450+3416 had obvious variations from night to night and is therefore a new variable star.

Since star spots or pulsations could cause the observed velocity variations, we initially observed HD 187123 at all orbital phases. From Table 1 and the 1999 data we can see that any such variations must be less than a millimagnitude and are not likely to be significant.

During some of the nights there remained a trend of about 0.01 magnitudes from sunset to sunrise, which we attribute to the telescope focus changing as a function of hour angle. The trend was removed by subtracting a straight line fit from that night's data. To increase clarity of the light curve, nine points were then averaged to make a normal point. In Figure 2 we have plotted the normal points near the expected phase of transit with their errors in the mean and the phases calculated from the period $3\overset{d}{.}096571$ and and epoch of Julian Date 2451268.76416 (Marcy 1999). A line has been added to show the approximate phase, depth and duration of a transit of a planet of the expected radius. From this plot we can see that there is no transit of a depth greater than about 0.002 magnitudes, depending on the assumed duration and phase of the transit. Thus the orbital inclination must be less than 84°, which does not significantly restrict the estimate of the planet's mass.

The variations of the star IRAS 19450+3416 were not evident during a night so the data were combined into nightly means. Since we observed only three maxima, there is a little ambiguity in the determination of a photometric period of IRAS 19450+3416, but the best light curve as estimated by eye was found using the ephemeris:

$$\text{HJD of Maxima} = 2451006\overset{d}{.}(5) + 118\overset{d}{.}(5) \times E.$$

An estimate of the uncertainties in the final digit are given in brackets.

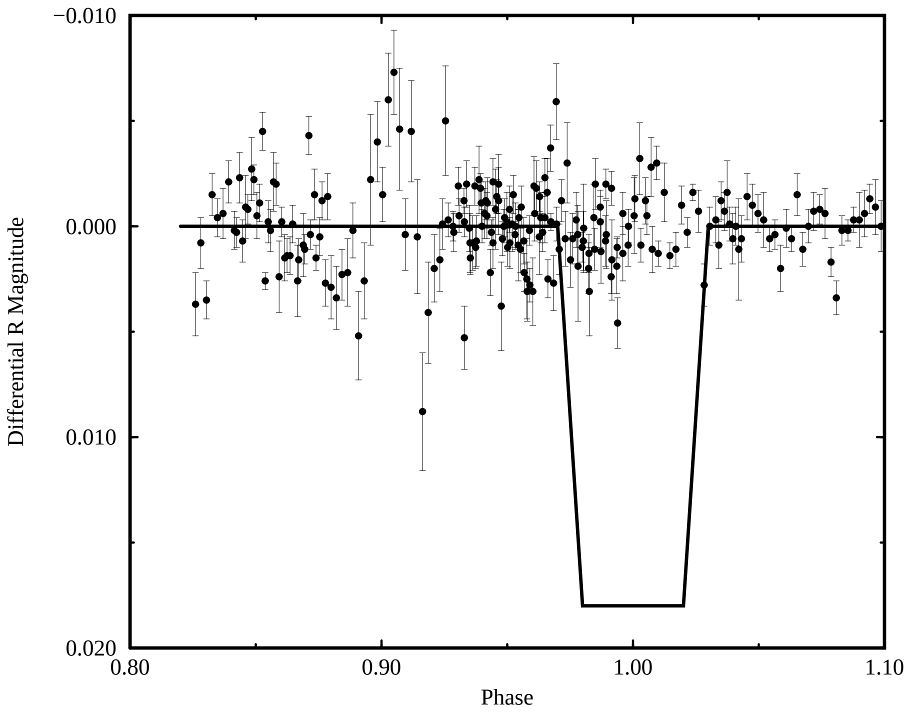

Figure 2. *R* band normal points of HD 187123 showing a prediction of a planetary transit

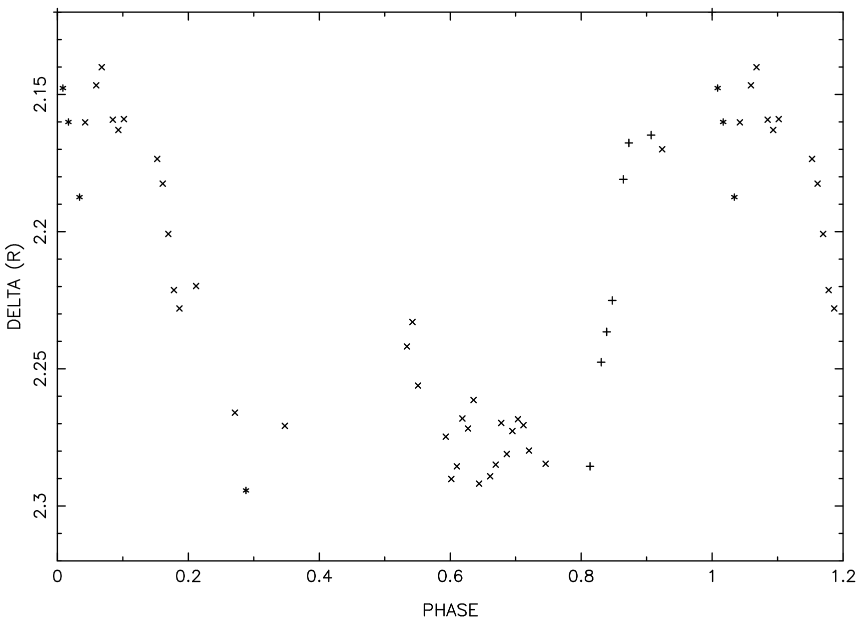

Figure 3. Nightly means of *R* band differential magnitudes of star IRAS 19450+3416

The differential (IRAS 19450+3416 − GSC 2664_1334) R magnitudes phased at this period are plotted in Figure 3 with $+$'s and $*$'s for 1998 and $\times$'s for the 1999 data. The small run offsets have been ignored for this plot.

The USNO Catalog (Monet et al. 1996) gives a $(b-r) = 2.3$ for IRAS 19450+3416 suggesting that this is a very cool star. On one night a few frames of this field were observed through the V and I filters. Assuming that HD 187123 has $V = 7.925$ and $V - I = 0.72$ (ESA 1997), the star IRAS 19450+3416 has a $V = 14.3$, $(V-R)_c = 2.3$ and a $(V-I)_c = 4.5$ with an uncertainty of 0.1 from photon counting errors and as a consequence of the star's extreme redness at least 0.5 magnitudes for transformation errors. Ignoring reddening these colors do not match a dwarf star but are correct for an M8 giant (Thé et al. 1990) at a distance of 3600 pc. Garnavich et al. (1994) find $M_I \simeq -2.7$ for M giants of about solar metallicity, giving a distance of 3100 ± 1000 pc.

The star HD 187123 is a star constant in brightness. IRAS 19450+3416 is a late-type variable star with a period of 118 days and an amplitude of 0.13 magnitudes. Its very red color, small amplitude, short period and low galactic latitude hint that it could be a very interesting star. Spectroscopic classification and photometric observations would be valuable to learn the temperature and to look for variations in the period and morphology of the light curve.

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