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Harold A. McAlister and William I. Hartkopf (eds.)

The Very Low–Mass Companion to BD+6° 398

P. A. IANNA
Department of Astronomy, University of Virginia,
Charlottesville VA 22903-0818, USA

ABSTRACT: **New parallax and orbital period estimates for the astrometric binary BD +6° 398 are presented. The mass of the unseen companion is discussed.**

1. INTRODUCTION

The nearby late–type, large proper motion dwarf star BD+6° 398 (HR753 = HD 16160 = LHS 15, $2^h35^m59^s$+6° 52′.0 [2000]) is a triple system. The primary is a K3 V star and an unresolved astrometric binary; there is a dM4 common proper motion companion at about 3 arcmin distance. Two earlier astrometric studies, Lippincott (1973) and Martin & Ianna (1975), found periods of 50 years and 60 years for the perturbation and estimated the mass for the unseen companion to be about 0.1 $\mathcal{M}_\odot$.

BD+6° 398A has been observed on a number of occasions with a speckle interferometry by McAlister (1978), and Hartkopf & McAlister (1984), but has remained unresolved. Furthermore McCarthy (1990) has not detected the companion in the infrared with his speckle observations and suggests the companion may be considerably less than a tenth of a solar mass. Thus a revisit to the McCormick plate material for this object seemed worthwhile.

2. ASTROMETRIC RESULTS

The photographic plates taken with the McCormick 67-cm refractor (scale = 20″.75 mm^{-1}) span the interval from 1915.85 to 1992.03, and so cover more than one period. Included here are 276 exposures. From measurements with the McCormick PDS 1010GM of these plates using 12 reference stars, the following results are found:

$$\begin{aligned} \pi &= 0''.115 \pm 0''.004 \\ \mu_x &= 1''.8102 \pm 0''.0001 \\ \mu_y &= 1''.4631 \pm 0''.0001 \\ P &= 59.5 \text{ years} \\ T &= 1931.0 \\ e &= 0.35 \\ \alpha &= 0''.293 \end{aligned}$$

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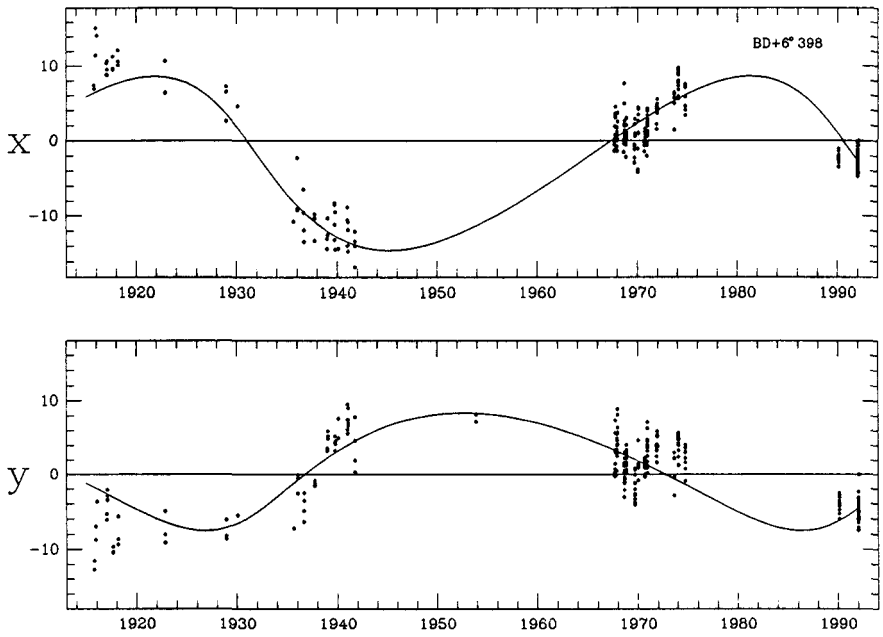

FIGURE 1. Plots against time of the residuals for BD+6° 398A after removal of parallax and proper motion. The points are the individual exposures; the vertical scale is in microns. The solid lines are the orbital displacement curves in right ascension (X) and declination (Y) calculated from the parameters given in the text.

The Modified Thiele–Innes Constants are:

$$\begin{aligned} (B) &= +0''.0634 \pm 0''.0059 \\ (A) &= -0''.1322 \pm 0''.0077 \\ (G) &= -0''.2475 \pm 0''.0072 \\ (F) &= +0''.1058 \pm 0''.0094 \end{aligned}$$

The orbital elements are not well constrained by the data owing to the uneven distribution of the plate material, and they are likely to change somewhat with further observation. Solutions using various periods rule out values differing by more than about one year from the one adopted above. The fit of the orbit to the data is illustrated in Figure 1.

3. DISCUSSION

The mass of the unseen companion may be estimated from Kepler's third law if we assume no light contribution from the companion. Using the numbers above and adopting a sum of the masses of 0.8 $\mathcal{M}_\odot$, the mass of companion = 0.13 $\mathcal{M}_\odot$, which is essentially the same as our earlier result (Martin & Ianna 1975).

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The nondetection by infrared speckle (McCarthy 1990) however suggests the companion may be less massive than the astrometric estimate. From the Henry & McCarthy (1990) infrared mass–luminosity calibration for the K3 V primary ($0.7\,\mathcal{M}_\odot$) we find $M_K = 4.5$; if the companion is $0.1\,\mathcal{M}_\odot$, its $M_K = 9.0$ and thus $\Delta m_K = 4.50$. Such an object is likely to have been detected (Henry *et al.* 1992); this implies a mass possibly significantly less than $0.1\,\mathcal{M}_\odot$. Further attention to this interesting system is clearly warranted.

4. ACKNOWLEDGMENTS

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