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Mira's Companion(s)

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ABSTRACT: **Recent high–angular resolution speckle interferometry measurements of the positions of Mira's companion are presented in context of the previous visual observations. The analysis of the separation measurements since 1923 show evidence for possible third body in the system.**

1. INTRODUCTION

o Ceti (Mira A), the prototype of Mira–type variables (V=3–10), is one of the few stars in its class known to have a companion. The nature of Mira B has not been yet determined; the luminosity (V=10–12) has been attributed to an accretion disk around a white dwarf or a main sequence star. Critical observational parameters for determination of the accretion rate onto the companion include true separation from Mira A and the orbital velocity of Mira B (cf. Livio & Warner 1984). These two parameters can be determined from the orbit. However, the orbit is presently very uncertain. High–angular resolution speckle interferometry observations have the potential for substantially increasing the precision in the measurements of the position of the companion which may allow better determination of the orbital parameters.

2. MIRA B

The companion of Mira was discovered by Joy in 1923 during spectroscopic observations. In 1923 Aitken visually detected a 10th magnitude star at $0''.9$ distance from Mira. Continuing since then, a number of observers have made measurements of the position angle and separation of Mira B. Several orbits with period ranging from 14 yr to 842 yr have been calculated using the visual measurements of the positions of Mira B. The errors in these measurements often exceed several degrees in position angle and more than $0''.1$ in separation, leading to large uncertainties in orbital parameters.

Mira B was resolved using speckle interferometry techniques at three epochs since 1983. Speckle autocorrelation and images yielded high precision measurements of θ, ρ, and Δm between the components in several wavelengths (Karovska *et al.* 1992). Figure 1 displays the visual measurements of separations of Mira's companion made between 1923 and 1976. It also contains the speckle observations made in 1983, 1986, and 1990. The 2σ errors in the speckle measurements of θ and ρ are, respectively, 2° and $0''.03$. A fit to the visual data (1923 to 1970) by Baize (1980) calculates an orbit with a period of 400 yr (dashed line in Figure 1). Despite the fact that Baize's orbit is very uncertain, it has been used to calculate the actual physical separation and orbital velocity of the companion for the purpose of estimating the accretion rate onto the companion (Reimers & Cassatella, 1985; Livio & Warner 1984).

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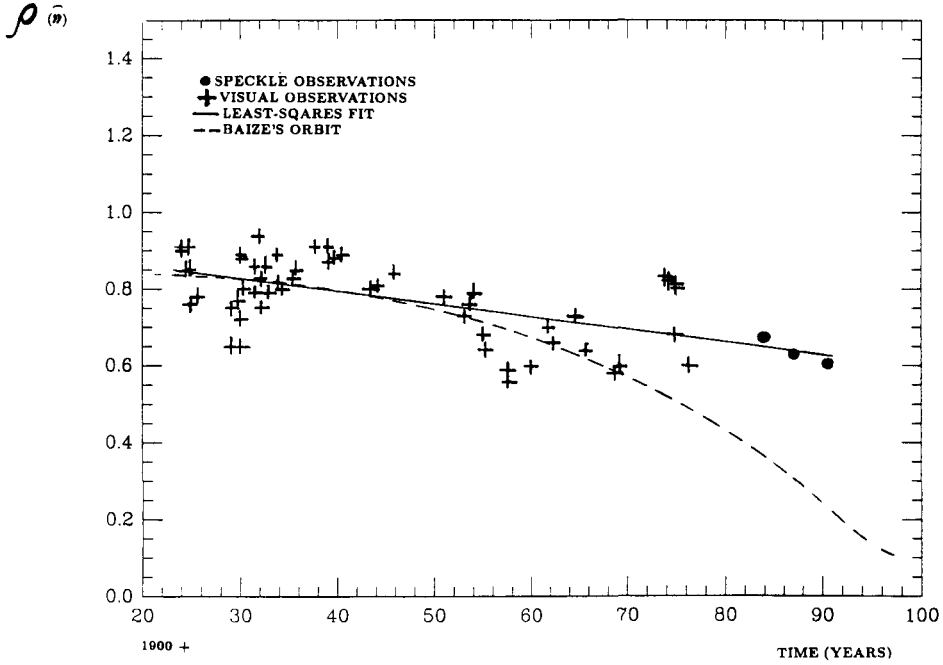

FIGURE 1. Visual and speckle measurements of separations between Mira A and Mira B and separations calculated using Baize's orbit.

The speckle data give a separation which is at least twice that used for the accretion calculations. This larger separation will result in lowering the estimated accretion rate from Mira onto the companion, and it may be too low to account for the observed accretion luminosity. Future speckle observations combined with the photometric and spectroscopic observations at Mira's minima will provide more information on the orbital motion of Mira B and its physical characteristics such as the total accretion luminosity and the structure of the accretion disk.

3. A THIRD BODY IN THE SYSTEM?

Baize (1980) found evidence for possible perturbations of the orbit with a period of about 29 yr that could be due to the presence of a third body in the system. The residuals of the speckle data from the straight line best fit to the whole data set show a systematic trend consistent with the short-period perturbations of Mira's orbit suggested by Baize. Analysis of the residuals of the measurements obtained since 1923 (including the speckle observations) from the straight line best fit, using Horne & Baliunas' (1986) period searching algorithm show the presence of perturbations with a period 34 ±2 yr. A similar period was obtained from the least-squares fit of a sinusoid to the residuals.

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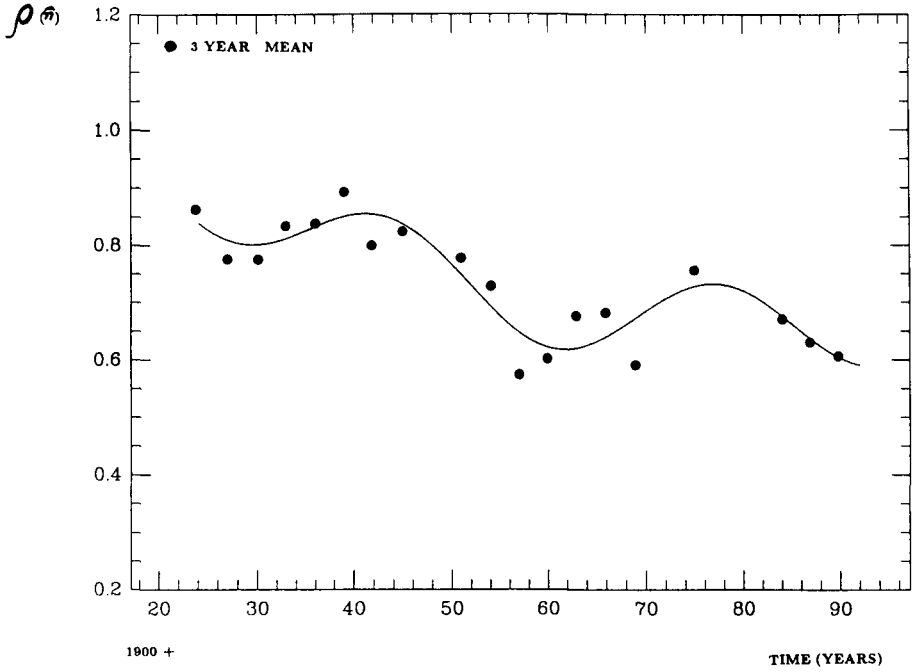

FIGURE 2. Best least-sqares fit of two sinusoids with periods of 33 and 211 yr to the separation measurements from 1923 to 1990.

A least-squares fit of two sinusoids to the measurements of the θ and ρ since 1923 yielded two periods; a short period of 33 yr and a long period of 211 yr. Figure 2 shows the best least-squares fit of two sinusoids to the θ measurements. Very similar results were obtained using the Kalman filter algorithm (in collaboration with C. Neily). The amplitude of the perturbations is about 0".15. If the perturbations are due to a third body in the system, the object could be orbiting either Mira A or Mira B. High-precision speckle interferometry measurements within the next few years will provide a definitive answer to the question concerning the presence of a third body in the system.

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