BINARY MICRO-PARALLAX EFFECTS

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1. Introduction

Of the large number of microlensing events detected towards the galactic bulge, there has been at least one clear case of a binary lens system, the OGLE 7 event. If this event had been observed simultaneously from three 1 m class ground-based telescopes during its second caustic crossing, an identification of the lens as a bulge or disk object and a determination of the orientation of the lens velocity on the sky could have been made.

Mao & Paczyński (1991) have shown that if the microlensing population is similar to the stellar population, then roughly 10 percent of all microlensing events should be due to binary lenses, and a significant fraction of these will exhibit caustic crossings. Thus, given sufficient warning – a capacity already demonstrated by the OGLE and MACHO teams in detecting microlensing events in real time – it should be possible to acquire the photometric measurements necessary for this experiment on future binary microlensing events. In conjunction with one other measurement, this permits a full determination of the basic parameters of the lens (Hardy & Walker 1995).

2. Expectation, Observation, and Interpretation

The crossing of a fold caustic during a binary lensing event leads to an extremely steep light curve, and this implies a sensitive dependence of the magnification on the source-lens-observer alignment at this time. It is this property that allows the detection of parallax effects from very short observing baselines.

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A convenient means for describing such parallax information is through a temporal offset between essentially identical lightcurves observed at each telescope. For two telescopes separated by an Earth radius, this offset is approximately

$$\delta t \simeq 40 \left(1 - \frac{D_d}{D_s}\right) v_{\perp 200}^{-1} \quad \text{sec} \tag{1}$$

where D_d and D_s are the distance to the lens and source respectively and we have assumed that the relative velocity of the Earth-lens-source system is dominated by the transverse velocity of the lens, $v_\perp \simeq 200 v_{\perp 200}$ km s^{-1}.

Current technology is sufficient to measure such small time differences. Indeed, five minutes of observing a source such as OGLE 7 with a 1m class telescope produces a signal-to-noise of around 150, which translates to an uncertainty of roughly 30 sec in our ability to determine the temporal location of the light curve from a single photometric measurement. Thus, two hours of quasi-simultaneous data from telescopes separated by about an Earth radius would correspond to an error in δt of around 6 sec. For the OGLE 7 event, assuming that the lens was half a solar mass and half way along the line of sight to the source, $\delta t \simeq 70$ sec, implying a detection in excess of 10 standard deviations. Indeed, the experiment should still yield a significant result provided that the lens is not within 2 kpc of the source.

3. Conclusion

Observation of parallax from 3 ground-based observatories serves to constrain two lens parameters: the Einstein ring radius per unit mass, and the velocity of the lens on the sky. In conjunction with other observations this may then lead to a unique characterization of the lens – its mass, distance and velocity. This experiment can be performed with current technology and the experiment may be pursued as soon as the next binary lensing event displaying a fold caustic crossing is identified. Moreover, new programs are now starting which will acquire just this sort of data in search of planets orbiting the microlenses.

References

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Mao, S., & Paczyński, B, 1991, ApJL, 374, L37

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