THE MOA STRATEGY FOR MICROLENSING PLANET SEARCHES

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Abstract

High magnification microlensing events have been identified as promising hunting grounds for extra solar planet searches. In such events excursions due to planetary microlensing events occur near the times of peak amplification and at significant detection probabilities. MOA has carried out intensive observations of two high magnification microlensing events. Starting in 2000, MOA plans to issue alerts of high magnification events in progress using online analysis based on image subraction.

1 Introduction

The MOA Collaboration carries out both survey observations of selected fields towards the Galactic Bulge and Magellanic Clouds and follow-up observations of selected microlensing events. A particular objective is to detect excursions from the single lens light curve due to the presence of planets in the lensing system.

To obtain an observational detection of a planet by microlensing, two conditions need to met. The source trajectory must intersect or pass very close to one of the caustics and one must be observing the event at the time of the caustic crossing. The characteristic crossing times range from 2–3 days for a Jupiter mass planet down to a few hours for an Earth mass planet. When compared with the typical Einstein ring crossing times of ~ 40 days, one can appreciate the difficulty in meeting these conditions. A study by Griest and Safizadeh (1997) argued that in the case of high magnification events, there is a significant chance of planetary caustic crossings occurring around the time of peak magnification.

Thanks to the online analysis capabilities of the survey groups MACHO, OGLE, and EROS, reliable estimates of the times and sizes of peak amplification of ongoing microlensing events can be determined well before the event peak. Thus if an ongoing event is known to be of high amplification, intensive observations can be planned accordingly. Such intensive observations were carried out by MOA on two high magnification events, 98-BLG-35

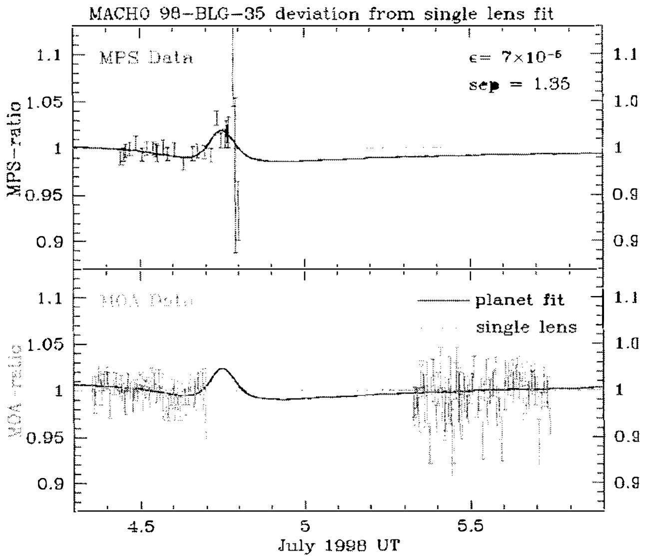

Figure 1: Deviation from a single lens fit for MPS and MOA observations of MACHO-98-BLG-35.

and 99-LMC-2, which were alerted by the MACHO Collaboration. These are described in the following sections.

2 MOA Observations of MACHO-98-BLG-35

The microlensing event MACHO-98-BLG-35 attained a peak amplification of 70.3 on 1998 July 4.6 UT. A total of 163 measurements were obtained by the MOA group over two nights around the time of peak amplification. On the night of the peak itself, 65 measurements were taken over an 8 hour period with a median sampling time of 5 minutes. This event was also observed intensely by the Microlensing Planet Search (MPS) Collaboration. The results of a detailed analysis of the combined MOA and MPS data were presented by Rhie et al (2000). Large planets of around Jupiter masses were excluded within the lensing zone. Furthermore a deviation from the single

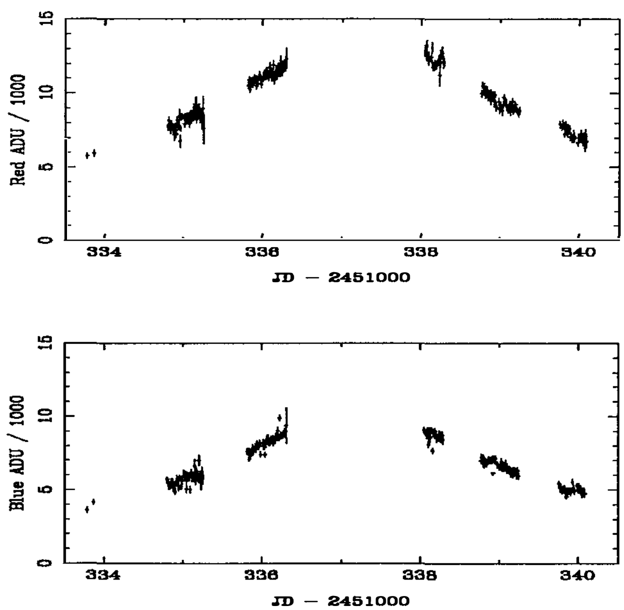

Figure 2: Light of MACHO-99-LMC-2 obtained by MOA in red and blue passbands.

lens light curve was detected (Fig. 1) and attributed to a planet in the lensing system with a mass between that of the Earth and Neptune. The detection was statistically significant at 4.5σ.

3 MOA Observations of MACHO-99-LMC-2

The microlensing event MACHO-99-LMC-2 attained a peak amplification of 43.3 on 1999 June 7.7 UT. This event was intensely observed by MOA over 5 nights around the time of peak amplification. A total of 200 measurements were made in each of the red and blue passbands with a median sampling time of 10 minutes per passband. Unfortunately, cloud prevented observations on the night of the peak. Otherwise, weather permitting, it is possible to observe targets in the Magellanic Clouds continuously for 12 hours during the Winter nights in New Zealand.

The light curve of 99-LMC-2 obtained by MOA is shown in Fig. 2. These observations will be used to determine how one can constrain the planetary configurations of the corresponding lensing system. A joint analysis of data on this event obtained by all the microlensing groups would be even more constraining. Because of its high magnification, this event is a good prospect for obtaining information on the distance to the lensing system through an analysis of parallax signatures. Furthermore, if the source star turns out to be a spectroscopic binary it may be possible to study the inverse effect of parallax in the light curve - the so-called "xallarap" effect (D. Bennett, these proceedings).

If subsequent constraints on the distance to the lensing system show 99-LMC-2 to an LMC self-lensing effect, this raises the prospect of constraining or studying the configurations of extra-galactic planetary systems.

4 MOA Planet Hunting Strategy

High amplification events appear to be the best hunting grounds for extra-solar planets through microlensing follow-up observations. The planet hunting strategy for MOA is to concentrate on agressively observing high magnification events around the times of their peak amplifications. Alerts for such events would come from the established survey groups OGLE and EROS (MACHO has now finished).

From the southern Winter of 2000, MOA began issuing alerts of ongoing "transient" events based on an online image processing pipeline using image subtraction analysis. The image subtraction procedure is our implementation of the method of Alard & Lupton (1998). The use of image subtraction analysis is potentially very powerful since it allows the detection of high magnification microlensing events whose baseline fluxes are below the detection threshold. This increases the number of potential microlensing sources. The MOA Alert Web pages can be found at:

`http://www.phys.canterbury.ac.nz/~physib/alert/alert.html.`

5 References

Alard, C. & Lupton, R.H. 1998, ApJ, 503, 325
Griest, K. & Safizadeh, N., ApJ, 500, 37
Rhie, S. et al 2000, ApJ, 532