MICROLENSING SURVEYS AND LONG PERIOD VARIABLES

Marie-Odile Mennessier
CNRS and Univ. Montpellier II
Place Eugène Bataillon
F 34095 Montpellier, France

Presented at the AAVSO Session on Mira Stars (part of the 85th Annual Meeting), November 1, 1996

Abstract

After briefly recalling how microlensing surveys can greatly help research on Long Period Variable stars (LPVs), I present examples from two research projects, Étude et Recherche d'Objets Sombres (EROS) and DUO, and give some examples of preliminary data. This paper is essentially based on the theses of P. Grison (Institute d'Astrophysique [IAP], Paris), J. P. Beaulieu (IAP, Paris), C. Alard (Centre d'Analyse d'Images, Paris), and on the Diplôme d'Études Approfondies of Y. Audoir (IAP, Paris).

1. Microlensing surveys: EROS and DUO

EROS is a collaboration between particle physicists (Institut National de Physique Nucléaire et de Physique des Particles and Commissariat à l'Énergie Atomique) and astrophysicists (IAP, Paris Observatory) to search for dark objects in the fields of the Large and Small Magellanic Clouds (LMC, SMC). DUO is a similar research project focusing on fields close to the Galactic Center (GC).

A massive object passing between an observer and a star can produce a microlensing effect detected by a light variation with a very special shape. So project physicists search systematically for stars with light variations, record the events that could correspond to a microlensing effect, and discard the others. These rejected light curves are a providential mine of data for variable star astronomers.

EROS observations are in 2 colors (B and R), and are obtained from 2 different instruments:

• a Schmidt telescope (6.4×10^6 stars on 400 Schmidt plates; fields are 5.25 x 5.25 degrees, and B magnitude between 16 and 21)

• a T40 telescope with a CCD mosaic (10^5 stars on 17,000 images for LMC, and 6,000 for SMC. Fields are 0.4 x 1 degree, and B magnitude between 14 and 19.5).

2. Interest in LPVs

One of the fundamental unsolved problems about LPVs concerns the Period-Luminosity relationship. The elements in the complete physical relation are:

$$(T , L , M , z , p , Q)$$

The temperature T slowly varies during the LPV evolutionary stage.

Microlensing surveys give:

• the possibility of studying samples of different metallicity z (LMC, SMC, GC),

• relative absolute luminosities *L* of stars (the stars in each sample are at the same distance and so their relative apparent and absolute magnitudes are equal),

• the periods *p* because of the duration of the experiments.

So from them can be deduced indications about the mass *M* and the mass-loss that produces the enrichment of the interstellar medium, and about *Q*, the pulsation constant that is so important for the models of pulsation and for disentangling the problem of the main pulsation mode of Miras.

The data, by-products of microlensing surveys, can also be used for galactic studies, in particular for a comparison of galactic evolution and stellar formation between the Magellanic Clouds and the Milky Way.

3. Preliminary results

We have already seen just how large the amount of data is: Schmidt telescope observed each of 6.4 million stars 400 times; 120,000 stars of LMC were observed 17,000 times, and 150,000 stars of SMC were observed 6,000 times.

Schmidt observing times are scattered on 1200 days using three periods of about 200 days. The first campaign, EROS I, had a duration of about 200 days. EROS II is just beginning.

The analysis is in progress, but data and some results about variable stars have already been obtained about eclipsing binaries (P. Grison's thesis), RR Lyrae, Cepheids (J. P. Beaulieu's thesis). Unfortunately about Miras we must be patient and wait for EROS II. The 200 days of EROS I observations have allowed only the determination of short periods.

The number of already-detected red variables—more than 3000 in LMC from Schmidt plates, about 800 in the bar of LMC from CCD images, and 2000 near GC from DUO Schmidt plates—promise exciting results. For example, we can look at some light curves and make some first observations that can be deduced from their very nice accuracy:

Figures 1 and 2 correspond to stars with periods of about 120–130 days, and clearly show the amplitude smaller in R than in B.

In Figure 3 the star has a very flat maximum. We can ask if the detailed structure is real or due to noise.

Figure 4 shows an interesting detailed shape that seems to be real. It is impossible to say if this is an irregular star or a long period one ($p > 100$ days) with a bump during the time of decreasing light.

Figure 5 clearly seems to show an LPV with a bump.

Figure 6 shows that there are LPVs that exist without any special feature (at least during one hundred days!).

4. Conclusion

Microlensing surveys produce light curves in several bandpasses and of great accuracy. They are a precious resource in the study of LPVs.

Figures 1 and 2. Light curves corresponding to stars with periods of about 120–130 days, and clearly showing the amplitude smaller in R than in B.

Figure 3. A light curve showing a star with a very flat maximum. It is not clear that the detailed structure is real or is due to noise.

Figure 4. A light curve showing an interesting detailed shape that seems to be real. It is impossible to say if this is an irregular star or a long period one (p > 100 days) with a bump during the time of decreasing light.

Figure 5. A light curve that clearly seems to show an LPV with a bump.

Figure 6. A light curve showing that there are LPVs that exist without any special feature (at least during one hundred days!).