Parallax and orbital effects in astrometric microlensing with binary sources

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1. Introduction

Gravitational microlensing is a mature technique for detecting compact objects in the disk and in the halo of our Galaxy via the observation of the light magnification of source stars due to the intervening lenses. Indeed, the technological instrument advances allowed gravitational microlensing to detect and characterized low-mass objects as well as binary lens systems including planetary systems with planets masses down to Earth mass with host-planet separations of about a few AU.

In addition to the magnification of the source brightness, another phenomenon related to microlensing is the shift of the light centroid of the source images. In the simplest case of a point lens, lensing causes the source image to split into two and the position of the light centroid with respect to the unlensed source star position traces out an ellipse with semi-axes depending, in general, on the lens impact parameter u_0 (the minimum projected distance of the lens to the source star) and the shape of the astrometric trajectory does not depend on the Einstein time t_E.

When the lens is a binary system, the number and the position of the images differ from those of the single lens case and the astrometric signal trajectory and the deviation varies depending on on the binary system parameters (i.e., the mass ratio and the component separation).

It is evident that in both cases astrometry gives more information than that derived from the analysis of light curves (photometry), allowing one to better constrain the lens system.

A further advantage of the astrometric microlensing is that an event is potentially observable for a much longer time with respect to the typical photometric event because astrometric signals persit to much longer lens-source separations than photometric signals (see next sections). In addition, interesting events can be predicted in advance and, indeed, by studying in detail the characteristics of stars with large proper motions, dozens of candidates for astrometric microlensing observations using the Gaia satellite, an European Space Agency (ESA) mission, is expected to perform photometry, spectroscopy and high precision astrometry.

Binary star systems can act as sources of microlensing events. In this regard, each component of the binary system acts as an independent source (with given impact parameter) for the intervening lens and the resultinng light curve corresponds to a a superposition of the single-lensing light curves associated with the individual source stars. However, although it is predicted that about 10% of the observable events should involve features of a binary source, few clear detection of such systems was claimed up today. The lack of binary source events may be explained by the fact that most of the light curves for events involving a binary source can be explained by single lens model with a blended source. So, binary sources are hidden in photometric observations. This is certainly not the case for astrometric microlensing observations, for which the binarity of the source strongly modifies astrometric signals. However, these authors accounted for the binary source effect by considering the centroid shift as due mainly to the primary object while treating its companion as a simple blending source. This simplifying assumption is overcome in the present paper where both components of the binary source and their relative motion are considered in calculating the resulting astrometric path.

Here, we investigate the effects on the astrometric signals of the binary source orbital motion taking also into account the Earth parallax effect. We show that both effects are not negligible in most astrometric microlensing observation and considering the above-mentioned effects is important in the analysis of astrometric data in order to correctly estimate the lens-event parameters. For more details see Nucita et al. (2016).

Riferimenti bibliografici

[1] Nucita et al., 2016, ApJ,823, 120