POLARIZATION PROFILES FOR SELECTED MICROLENSING EVENTS TOWARDS THE GALACTIC BULGE

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Gravitational microlensing, in case of relevant finite source size effects, provides an unique tool for the study of stellar atmospheres through the enhancement of a characteristic polarization signal. Here, we consider a set of highly magnified events and show that for different types of source stars (as hot, late type main sequence and cool giants) showing that the polarization strength may be of $\sim 0.04$ percent for late type stars and up to a few percent for cool giants.

Keywords: Gravitational Lensing - Physical data and processes: polarization - The Galaxy: bulgy

1. Introduction

Gravitational microlensing, initially developed to search for MACHOs in the Galactic halo and near the Galactic disc, has become nowadays a powerful method to test the stellar atmosphere models and to study of the star limb-darkening profile, i.e. the variation of the intensity from the disc center to the limb. Furthermore, this technique allowed the discovery of exoplanetary systems by observing deviations in the light-curves expected for single-lens events. Microlenses can also spatially resolve a source star thanks to caustic structures created by a lens system. Caustics are formed by a set of closed curves, along which the point source magnification is formally infinite, with a steep increase in magnification in their vicinity.

The aim of the present work is to consider the polarization variability of the source star light for real events, taking into account different polarization mechanisms according to the source star type. Indeed, variations in the polarization curves are similar to finite source effects in microlensing when color effects may appear due
to limb darkening and color distribution across the disc. However, the light received from the stars is usually unpolarized, since the flux from each stellar disc element is the same. A net polarization of the stellar light may be introduced by some suitable asymmetry in the stellar disc as eclipses, tidal distortions, stellar spots, fast rotation and magnetic fields or also in the propagation through the interstellar medium.

In the case of microlensing events, polarization in the stellar light may be induced by the proper motion of the lens star through the source star disc. In such case, different parts are magnified by different amounts giving rise not only to a time dependent gravitational magnification of the source star light but also to a time dependent polarization.

Good candidates for polarization observations would be events microlensing involving young, hot giant star sources. Indeed, these objects have electron scattering atmospheres needed for producing limb polarization through Thomson scattering. However, the bulge of the Galaxy does not contain a large number of hot giant stars. However, polarization may be also induced by the scattering of star light off atoms, molecules and dust grains in the adsorptive atmospheres of evolved, cool stars as shown by Refs. 12 and 13. These objects, that do not have levels of polarization as high as those predicted by the Chandrasekar model, may display an intrinsic polarization of up to several percent, due to the presence of stellar winds that give rise to extended adsorptive envelopes. This is the case for many cool giant stars, in particular for the red giants. Such evolved stars constitute a significant fraction of the lensed sources towards the Galactic bulge, the LMC and the M31 galaxy making them valuable candidates for observing variable polarization during microlensing events.

In Ref. 14 (but see also the references therein for more details) we calculated the polarization profile as a function of the time for a selected sample of both single events (11 highly magnified single-lens cases with identified source star type) and 6 exoplanetary microlensing events observed towards the Galactic bulge. In predicting the polarization light curves of each event we considered the nature of the source star, i.e. a late type main sequence and/or cool giant stars. Indeed, different polarization mechanisms take place in the stellar atmospheres, depending on the source star type: photon (Thomson) scattering on free electrons, coherent (Rayleigh) scattering off atoms and molecules, and photon scattering on dust grains, for hot, late type and cool giant stars (with extended atmospheres), respectively.

We note that high magnification (up to 12 mag in I band) events, the expected polarization signal can reach values as high as 0.04 percent at the peak in the case of late type source stars and up to a few percent in the case of cool giant source stars (red giants) with extended envelopes. For these events the primary lens crosses the source star disc (transit events) and relatively large values of $P$ are thereby produced due to large finite source effects and the large magnification gradient throughout the source star disc, with the time duration of the polarization peak varying from 1 h to 1 day (depending on the source star radius and the lens impact parameter). Similar values of polarization may also be obtained in exoplanetary events when
the source star crosses the primary or the planetary caustics. While in the former case (as for single-lens events) the peak of the polarization signal always occurs at symmetrical points with respect to the instant $t_0$ of maximum magnification, in the latter case the polarization signal may occur at any (and generally unpredictable) time during the event.

As a last remark, we note that the available instrumentation may already detect a polarization signal down to a degree of few percent: the FORS2 camera on the ESO VLT telescope is capable to measure the polarization signal for a 12 mag source star with a precision of 0.1 percent in 10 min integration time, and for a 14 mag star in 1h. Hence, polarization measurements in highly magnified microlensing events may offer the unique opportunity to probe stellar atmospheres of Galactic bulge stars and, given sufficient observational precision, may in principle provide independent constraints on the lensing parameters also for exoplanetary events.

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