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ORIGINAL ARTICLE

Gravitational lensing by a rotating massive object in a plasma

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Abstract We study gravitational lensing in the vicinity of a slowly rotating massive object surrounded by a plasma. We have studied two effects: (i) the influence of the frame dragging on the deflection angle of the light ray in the presence of plasma (ii) Faraday rotation of the polarization plane of the light. We derive the expression for the lensing angle in a non-diagonal space-time in the weak field regime in the presence of plasma and discuss it for the spacetime metric of the slowly rotating object. The obtained deflection angle depends on (i) the frequency of the electromagnetic wave, due to the dispersion properties of the plasma; (ii) the gravitational mass M; and (iii) the angular momentum J of the gravitational lens. We studied the influence of rotation of the gravitational lens on the magnification of brightness of the source star in the case of microlensing and have shown that it is negligibly small. For the completeness of our study the effect of the Faraday rotation of the polarization plane is considered.

Keywords Gravitational lensing · Plasma · Rotating gravitating object

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1 Introduction

Gravitational lensing is one of the direct consequences of the Einstein's general theory of relativity. Light propagating from the source to the observer may be bent by intervening mass and come to the observation point through different pathways. The gravitating mass in this case acts as a lens and produces several different images of one radiating source object. Despite the fact that gravitational lensing is extremely complicated phenomena because light can be bent by many different objects (such as stars, galaxies or clusters of galaxies, "dark" objects) while propagating from the source to the observer, investigation of simple model cases remains an important task and gives us deeper understanding of the physics of the phenomena. Gravitational lensing serves as important astronomical tool because it can provide us the information about sources and lenses as well as about content and large-scale geometry of the Universe. One particular and very important case of gravitational lensing is microlensing, when different images of the source cannot be optically resolved but lensing affects the appeared brightness of the radiating object. Since the pioneering works of Paczyński (1986), Alcock et al. (1993), Aubourg et al. (1993), Udalski et al. (1993) various aspects of microlensing were studied by many authors (see for review, for example Paczyński 1996; Wambganss 2006).

Investigations of general relativistic effects connected with non-diagonal components of the metric tensor are proved to be fruitful and have important consequences in astrophysics. For example, as has been noted by several authors (e.g., Beskin 1990; Muslimov and Tsygan 1992; Muslimov and Harding 1997; Mofiz and Ahmedov 2000; Morozova et al. 2008; Beskin 2009), the effect of general relativistic frame dragging on the field geometry in the plasma