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ORIGINAL ARTICLE

Shadow of rotating Hořava-Lifshitz black hole

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Abstract The shadow of rotating Hořava-Lifshitz black hole has been studied and it was shown that in addition to the specific angular momentum a, parameters of Hořava-Lifshitz spacetime essentially deform the shape of the black hole shadow. For a given value of the black hole spin parameter a, the presence of a parameter Λ_W and KS parameter ω enlarges the shadow and reduces its deformation with respect to the one in the Kerr spacetime. We have found a dependence of radius of the shadow R_s and distortion parameter δ_s from parameter Λ_W and KS parameter ω both. Optical features of the rotating Hořava-Lifshitz black hole solutions are treated as emphasizing the rotation of the polarization vector along null congruences. A comparison of the obtained theoretical results on polarization angle with the observational data on Faraday rotation measurements provides the upper limit for the δ parameter as $\delta \leq 2.1 \cdot 10^{-3}$.

Keywords Photon motion · Shadow of black hole · Hořava-Lifshitz spacetime

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1 Introduction

Few years ago Petr Hořava suggested new candidate of quantum field theory of gravity with dynamical critical exponent being equal to $z = 3$ in the UV (Ultra-Violet). This theory is a non-relativistic power-counting renormalizable theory in four dimensions which admits the Lifshitz scale-invariance in time and space that reduces to Einstein's general relativity at large scales (Hořava 2009a, 2009b). The Hořava theory has received a great deal of attention and since its formulation various properties and characteristics have been extensively analyzed, ranging from formal developments (Visser 2009), cosmology (Takahashi and Soda 2009), dark energy (Saridakis 2010), dark matter (Mukohyama 2009), and spherically symmetric or axial symmetric solutions (Cai et al. 2009).

In the paper of Lobo et al. (2010) the possibility of observationally testing Hořava gravity at the scale of the Solar System, by considering the classical tests of general relativity (perihelion precession of the planet Mercury, deflection of light by the Sun and the radar echo delay) for the Kehagias-Sfetsos (KS) asymptotically flat black hole solution of Hořava-Lifshitz gravity has been studied. The stability of the Einstein static universe by considering linear homogeneous perturbations in the context of an Infra-Red (IR) modification of Hořava gravity has been studied in Böhmer and Lobo (2010). Potentially observable properties of black holes in the deformed Hořava-Lifshitz gravity with Minkowski vacuum: the gravitational lensing and quasinormal modes have been studied in Konoplya (2009). Lü et al. (2009) derived the full set of equations of motion, and then obtained spherically symmetric solutions for UV completed theory of gravity proposed by Hořava. The particle motion in the space-time of a Kehagias-Sfetsos black hole which is a static spherically symmetric solution of a Hořava-Lifshitz gravity model has been studied in Enolskii et al. (2011).