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Polarization rotation in geometric optics approximation and its subleading order correction

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Geometric optics approximation is sufficient to describe the effects in the near-Earth environment. In this framework a careful analysis of the local standard polarization directions allows to obtain transparent expressions for polarization rotation. We provide a simple estimation of this emitter/observer-dependent phase and give its explicit form in different settings: 1) Considering the relative motion between the earth and the satellite and ignoring any gravitational effects. 2) Considering the gravitational effects of the earth up to the leading order post-Newtonian for light propagation between the earth and the satellite and ignoring any relative motions between them. Even if the gravitationally-induced polarization rotation also called gravitational Faraday effect is a pure gauge effect in the geometric optics approximation, it cannot be simply dismissed. Interpretation of the results of Faraday effects in the framework of geometric optics, and in the spin-optics approximation is sometimes contradictory. The reason is the crucial role of local reference frames and the ensuing introduction of the standard polarization directions sometimes were not treated in a fully satisfactory manner. Establishing local reference frame with respect to some distant stars leads to the Faraday phase error between the ground station and the spacecraft of the order of 10^{-10}, while the Wigner phase of special relativity is of the order 10^{-4}–10^{-5}. Both types of errors can be simultaneously mitigated.

We also present briefly the covariant formulation of geometric optic correction up to the subleading order approximation, which is necessary for the propagation of electromagnetic/ gravitational waves of large but finite frequencies.

Primary author: DAHAL, Pravin (Macquarie University)

Presenter: DAHAL, Pravin (Macquarie University)

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