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Rotation of polarization in the gravitational field of a laser beam—Faraday effect and optical activity

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We investigate the rotation of the polarization of a light ray propagating in the gravitational field of a circularly polarized laser beam. The rotation consists of a reciprocal part due to gravitational optical activity, and a non-reciprocal part due to the gravitational Faraday effect. We discuss how to distinguish the two effects: letting light propagate back and forth between two mirrors, the rotation due to gravitational optical activity cancels while the rotation due to the gravitational Faraday effect accumulates. In contrast, the rotation due to both effects accumulates in a ring cavity and a situation can be created in which gravitational optical activity dominates. Such setups amplify the effects by up to five orders of magnitude, which however is not enough to make them measurable with state of the art technology. The effects are of conceptual interest as they reveal gravitational spin–spin coupling in the realm of classical general relativity, a phenomenon which occurs in perturbative quantum gravity.

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