Gravitational properties of light

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As Einstein's equations tell us that all energy is a source of gravity, light must gravitate. We can expect the gravitational field of light to be extremely weak. However, the properties of light are premises in the foundations of modern physics: they were used to derive special and general relativity and are the basis of the concept of time and causality in many alternative models. Studying the back-reaction of light on the gravitational field could give new fundamental insights to our understanding of space and time as well as classical and quantum gravity.

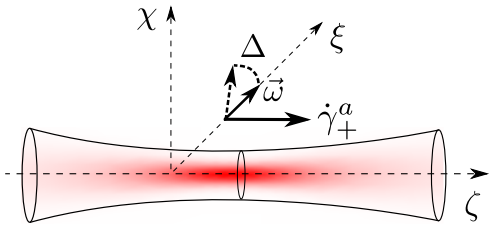

FIG. 1: The gravitational field of a circularly polarized laser beam leads to frame dragging and the rotation of the polarization of nearby test light-rays, which can be decomposed into the gravitational Faraday effect and gravitational optical activity.

In this talk, an overview is given of the gravitational properties of light including those of laser pulses and focused laser beams with well defined angular momentum. Studying the gravitational field of laser pulses reveals a close relationship between the emission of light and the formation of its gravitational field [1, 2]. The gravitational field of a focused laser beam shows effects of the fundamental wave properties of light and parallel co-propagating test light-rays are deflected [3] in contrast to the seminal result by Tolman et al. obtained in the geometric optical limit [4]. The angular momentum of light leads to frame dragging [3] and the rotation of the polarization of a test beam of light [5]. The latter effect can be separated into the gravitational Faraday effect and gravitational optical activity which are analogues of the Faraday effect and optical activity in dielectric media. Additionally, the sensitivities necessary to detect the effects are discussed.

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