GENERAL RELATIVISTIC THEORY OF LIGHT PROPAGATION

IN THE FIELD OF GRAVITATIONAL MULTIPOLES

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ABSTRACT

We consider propagation of electromagnetic signals through the time-dependent gravitational field of an isolated astronomical system emitting gravitational waves. The system is assumed to possess multipole moments of arbitrary order. Working in the linear, weak-field approximation of general relativity, we obtain analytical expressions for light-ray trajectory and observable effects of bending of light, time delay, and gravitational rotation of the polarization plane. The relative positions of the source of light, the isolated system, and the observer are not restricted, which makes our formalism quite general and applicable for most practical situations. Asymptotic expressions for observable effects are obtained in two limiting cases of arrangement of light source, observer, and the source of gravitational waves: the gravitational-lens approximation and the approximation of plane gravitational waves. It is shown that in the gravitational-lens approximation the leading contributions to the effects due to multipole moments of arbitrary order fall off with the impact parameter as $1/d^2$ and $1/d^3$ for time delay and deflection of light respectively. Such, stronger than it could be a priori expected, dependance on impact parameter hinders observation of time-dependent effects in gravitational lensing. In the plane-gravitational-wave approximation the expressions for observable effects due to gravitational waves of arbitrary multipolarity are obtained in terms of the transverse-traceless (TT) part of the spacial components of the metric tensor.