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Constraints on the non-minimal coupling of Electromagnetic fields from astrophysical observations

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Strong gravity regions, like the neighborhood of black holes or neutron stars, can induce non-minimal couplings between electromagnetic fields and gravity. In these regions, gravitational fields behave as a non-linear medium in which the electromagnetic fields propagate. For a system of mass M and size R, the surface potential scales as M/R. Pulsar timing array, Double pulsar Shapiro delay, and Event horizon telescope probe that largest surface potentials $[10^{-4} - 10^{-2}]$. With many future experiments, it is possible to constrain the non-minimal coupling between electromagnetic fields and gravity. As a step in this direction, we consider the non-minimal coupling of EM field tensor through Riemann tensor for a dynamical black-hole, described by the Sultana-Dyer metric. The non-minimal coupling leads to modified dispersion relations of photons, which get simplified at E/L » 1 regime, where E and L are two conserved quantities obtained by taking into account the symmetries of the metric. We calculate polarization-dependent photon deflection angle and arrival time from these dispersion relations, which we evaluate considering different astrophysical sources of photons. We compare the analytical results with the current astrophysical observations to constraint the non-minimal coupling parameters to Riemann tensor more stringently.

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