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Rotating metrics and multipole moments from scattering amplitudes

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We review how the vacuum metric generated by a generic rotating object is determined by computing the classical contribution of scattering amplitudes describing the graviton emission by massive particles with spin. By focusing on the case of spin 1, In D = 4 spacetime dimensions we recover the vacuum Hartle-Thorne solution describing a generic spinning object to second order in the angular momentum, of which the Kerr metric is a particular case obtained for a specific mass quadrupole moment dictated by the uniqueness theorem. In D > 4, the absence of black-hole uniqueness theorems implies that there are multiple spinning black hole solutions with different topology. Using scattering amplitudes, we find a generic solution depending on the mass, angular momenta, the mass quadrupole moment, and a new stress quadrupole moment which does not exist in D = 4. Inspired by this analysis, we derive the most general class of energy-momentum tensors associated with a given multipolar structure of the spacetime in arbitrary dimensions, working in momentum space and at linear order in the gravitational coupling. We derive directly from the energy-momentum tensor the full multipolar structure of any solution in complete analogy to Newtonian gravity.

Presenter: RICCIONI, Fabio (Istituto Nazionale di Fisica Nucleare)

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