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Comparing Spin Supplementary Conditions for Circular Equatorial Orbits

The Mathisson-Papapetrou-Dixon (MPD) equations describe the motion of an extended test body in general relativity. This system of equations, though, is underdetermined and has to be accompanied by constraining supplementary conditions, even in its simplest version, which is the pole-dipole approximation corresponding to a spinning test body. In particular, imposing a spin supplementary condition (SSC) fixes the center of the mass of the spinning body, i.e. the centroid of the body. In the present talk, we examine whether characteristic features of the centroid of a spinning test body, moving in a circular equatorial orbit around a massive black hole, are preserved under the transition to another centroid of the same physical body, governed by a different SSC. For this purpose, we establish an analytical algorithm for deriving the orbital frequency of a spinning body, moving in the background of an arbitrary, stationary, axisymmetric spacetime with reflection symmetry, for the Tulczyjew-Dixon, the Mathisson-Pirani and the Ohashi-Kyrian-Semerak SSCs. Then, we focus on the Schwarzschild as well as Kerr black hole backgrounds and a power series expansion method is developed, in order to investigate the discrepancies in the orbital frequencies expanded in power series of the spin among the different SSCs. Lastly, by employing the fact that the position of the centroid and the measure of the spin alters under the centroid's transition, we impose proper corrections to the power expansion of the orbital frequencies, which allows to improve the convergence between the SSCs. Our concluding argument is that when we shift from one circular equatorial orbit to another in the Schwarzschild/Kerr background, under the change of a SSC, the convergence between the SSCs holds only up to certain powers in the spin expansion, and it cannot be achieved for the whole power series.

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