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Spin-induced non-geodesic motion, Wigner rotation and EPR correlations of massive spin-1/2 particles in a gravitational field[1]

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We investigate in a covariant manner, the spin-induced non-geodesic motion of massive spin-1/2 particles in an arbitrary gravitational field for trajectories that are initially geodesic when spin is ignored. Using the WKB approximation for the wave function in an arbitrary curved spacetime, we compute the $O(\hbar)$ correction to the Wigner rotation of the spin-1/2 particle, whose$O(1)$ contribution is zero on timelike geodesics. We consider specific examples in the Schwarzschild metric for motions in the equatorial plane for (i) particles falling in from spatial infinity with non-zero angular momentum and (ii) circular geodesic orbits. For the latter case we consider the Bell inequalities for a perfectly anti-correlated EPR entangled pair of spins as the separate qubits traverse the circular geodesic in opposite directions.

[1]In collaboration with G.J. Stephenson Jr., University of New Mexico and Patrick Kilian, Universitat Wuerzburg, Germany.