There and back again: outspiralling motion in non-Kerr compact objects

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In Keplerian dynamics, a test body orbiting a point particle in circular motion has a monotonically increasing frequency, with decreasing radius. If a dissipative channel is introduced, such as gravitational wave (GW) emission, (say) under the quadrupole approximation, the corresponding GW strain has an ever increasing frequency with time. A similar statement holds for equatorial motion of a test particle on the Kerr manifold, except such inspiral is cut off at the ISCO, wherein stable circular orbits cease to exist and a plunge is expected. We analyse circular timelike orbits in generic spinning spacetimes and study the conditions in which exotic motion can occur, due to the presence of non-Kerr features. In particular, we derive conditions under which an inspiral towards a compact object is naturally followed by an outspiral motion, and give concrete examples, as well as the corresponding GW phenomenology. This analysis serves both as a theoretical exploration of non-Kerrness as well as an example of a concrete smoking gun of exotic spacetimes.