The gravitational "Magnus" effect

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ABSTRACT

It is well known that a spinning body moving in a fluid suffers a force orthogonal to its velocity and rotation axis — it is called the Magnus effect. Recent (indirect) theoretical predictions [1] and numerical simulations [2], inferred from the effect of a spinning back hole on the surrounding matter, have suggested that a somewhat analogous effect may take place in gravity, although its magnitude and precise direction were still unclear. Starting from the rigorous equations of motion for spinning bodies in General Relativity (Mathisson-Papapetrou-Dixon equations), we show that indeed such an effect takes place, it is a fundamental part of the spin-curvature force, and arises whenever, relative to the body, a current of mass/energy, non-parallel to its spin, exists. We compute it in some astrophysical systems of interest: a galactic dark matter halo, a black hole accretion disk, and FLWR spacetime. We consider also the reciprocal problem: the "force" exerted by the body on the surrounding matter, showing that (from this perspective) the effect is due to the body's gravitomagnetic field. In the process we clarify some common misconceptions regarding the action-reaction law in post-Newtonian gravity.

References

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