ELECTROMAGNETICALLY-INDUCED FRAME-DRAGGING AROUND ASTROPHYSICAL OBJECTS

Andrés. F. Gutiérrez.[1] Leonardo. A. Pachón.[2]

Frame dragging is generally associated with rotating astrophysical objects. However, it can also be generated by electromagnetic fields if electric and magnetic fields are simultaneously present. In most models of astrophysical objects, macroscopic charge neutrality is assumed and the entire electromagnetic field is characterized in terms of a magnetic dipole component. Hence, the purely electromagnetic contribution to the frame dragging vanishes. However, strange stars may possess independent electric dipole and neutron stars independent electric quadrupole moments that may lead to the presence of purely electromagnetic contributions to the frame dragging.

Frame dragging (Lense-Thirring effect) is the quintessential hallmark of general relativity and is the result of the spacetime vorticity. It was detected by the Gravity Probe B, and traditionally, it has been associated with rotating stellar astrophysical objects. Surprisingly, if the astrophysical object does not rotate but possesses both electric and magnetic fields, the spacetime vorticity does not vanish. In this case, frame dragging is of purely electromagnetic nature and it is associated with the existence of a nonvanishing electromagnetic Poynting vector around the source.

In most of the early models of astrophysical objects, macroscopic charge neutrality is assumed and the magnetic field is characterized in terms of a pure dipole component. This idea was endorsed by the confirmation of many predicted features of a star with a dipole field using two- and three-dimensional magnetohydrodynamic numerical simulations of magnetospheric accretion .
Thus, under this configuration the *purely* electromagnetic contribution to the vorticity tensor vanishes.
However, astrophysical objects such as strange stars may possess independent electric dipole and neutron stars independent electric quadrupole moments, which may lead to the presence of purely electromagnetic contributions to frame dragging.
A precise account of those contributions is not available because of the lack of an analytic exact solution with such a complex electromagnetic field configuration.

Moreover, recent observations have shown that in stars with strong electromagnetic fields, the magnetic quadrupole may have significant contributions on the dynamics of stellar processes.
Therefore, it is well known by now that the actual configuration of the magnetic field of strongly magnetized stars may depart from the dipole configuration.
As an attempt to describe the spacetime geometry surrounding these kind of astrophysical objects, an analytic solution to the Einstein-Maxwell field equations is constructed here on the basis that the electromagnetic field is generated by the combination of arbitrary magnetic and electric dipole plus arbitrary magnetic and electric quadrupole moments.
This analytic exact solution allows for analyzing, e.g., the effect of each multipole contribution on the vorticity scalar and the Poynting vector.
Moreover, it is possible to predict corrections to important quantities such as the innermost stable circular orbit and the epicyclic frequencies.

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[1] Grupo de Física Atómica y Molecular, Universidad de Antioquia, Apartado Aéreo 1226, calle 67 No. 53 - 108, Medellín, Colombia. (afelipe.gutierrez@udea.edu.co).
[2] (leonardo.pachon@udea.edu.co).

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