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ORIGINAL ARTICLE

# External electromagnetic fields of a slowly rotating magnetized star with gravitomagnetic charge

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**Abstract** We study Maxwell equations in the external background spacetime of a slowly rotating magnetized NUT star and find analytical solutions for the exterior electric fields after separating the equations for electric field into angular and radial parts in the lowest order in angular momentum and NUT charge approximation. The star is considered isolated and in vacuum, with dipolar magnetic field aligned with the axis of rotation. The contribution to the external electric field of star from the NUT charge is considered in detail.

**Keywords** General relativity · Kerr-Taub-NUT spacetime · Electromagnetic fields

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## 1 Introduction

The existence of strong electromagnetic fields is one of the most important features of rotating magnetized neutron stars observed as pulsars (Hewish et al. 1968) and magnetars (Duncan and Thompson 1992). It was shown starting pioneering paper of Deutsch (1955) that the electric field is induced due to the rotation of highly magnetized star. The general relativistic effect of dragging of inertial frames is a source of additional electric field around rotating magnetized relativistic stars (Muslimov and Harding 1997; Muslimov and Tsygan 1992; Rezzolla et al. 2001a; Rezzolla et al. 2001b; Rezzolla and Ahmedov 2004; Kojima et al. 2004).

One of the exotic solution of the Einstein's equation of general relativity is achieved by introducing an extra nontrivial parameter, the so-called gravitomagnetic monopole moment or NUT charge. The generalized solution describing spacetime of a localized stationary and axisymmetric object with nonvanishing gravitomagnetic charge is known as the Kerr-Taub-NUT, where NUT stands for Newman-Unti-Tamburino (Newman et al. 1963). In the presence of the NUT charge the spacetime loses its asymptotically flatness property and, in contrast to the Kerr spacetime, becomes asymptotically nonflat. One of the features of the spacetime with NUT charge is that the later has no curvature singularity, there is conical singularity on its axis of symmetry that results in the gravitomagnetic analogue of Dirac's string quantization condition (see e.g., Misner 1963; Misner and Taub 1968). The conical singularity can be removed by imposing an appropriate periodicity condition on the time coordinate. However, this generates closed timelike curves in the spacetime that makes it hard to interpret the solution as a regular black hole. In an alternative interpretation, one may consider the conical singular-