Un formalisme 3+1 pour les corrections quantiques aux équations de Maxwell en relativité générale

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Magnetized neutron stars constitute a special class of compact objects harbouring gravitational fields that deviate strongly from the Newtonian weak field limit. Moreover strong electromagnetic fields anchored into the star give rise to non-linear corrections to Maxwell equations described by quantum electrodynamics (QED). Electromagnetic fields close to or above the critical value of $B=4{,}4*10^9$ T are probably present in some pulsars and for most of the magnetars. To account properly for emission emanating from the neutron star surface like for instance thermal radiation and its polarization properties, it is important to include general relativistic (GR) effects simultaneously with non-linear electrodynamics. This can be achieved through a 3+1 formalism known in general relativity and that incorporates QED perturbations to Maxwell equations. Starting from the lowest order corrections to the Lagrangian for the electromagnetic field, as given for instance by Born-Infeld or Euler-Heisenberg theory, we derive the non-linear Maxwell equations in general relativity including quantum vacuum effects. We also derive a prescription for the force-free limit and show that these equations can be solved with classical finite volume methods for hyperbolic conservation laws. It is therefore straightforward to include general relativity and quantum electrodynamics in the description of neutron star magnetospheres by using standard classical numerical techniques borrowed from Maxwell and Newton theory. As an application, we show that spin-down luminosity corrections associated to QED effects are negligible with respect to GR corrections.

[1] J. Pétri, *A 3+1 formalism for quantum electrodynamical corrections to Maxwell equations in general relativity*, MNRAS **in press**, (2015).

[2] W. Heisenberg, H. Euler, Zeitschrift fur Physik, 98, 714, (1936).