The magnetized photon: properties and astrophysical applications

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Abstract

We study the transverse propagation of photons in a magnetized vacuum considering radiative corrections in the one-loop approximation, in the region of transparency ($0<\omega<2m_e$). Our aim is to explore the propagation of photons in a neutron star magnetosphere like scenario. For fixed values of the frequency, we study the dependence of photons time delay with the magnetic field strength, as well as with distance. We obtain that photons of higher energy experience a longer time delay.

The photon in a magnetized vacuum

We are here interested in a photon time delay process occurring in the vicinity of the pulsar, and unrelated with the photon interaction with the interstellar matter.
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- QED vacuum filled magnetosphere
- Surface magnetic fields varies on the range of (theoretically)estimated fields from radio pulsars to soft gamma repeaters and anomalous X-ray pulsars (magnetars)

  $B_0 \sim 10^{12} - 10^{15}$ G
- Magnetic dipole configuration
- No rotation

- **Dispersion Eq. :**

$$k^2 = \kappa^{(i)}(\omega, k_{\parallel}, k_{\perp}, b)$$

Photon self-energy eigenvalues

$$b = B/B_c$$

$$B(r) = B_0\left(\frac{r_0}{r}\right)^3,$$

$$v_{ph}(\omega, B) = \frac{\omega}{k_{\perp}}$$

Results

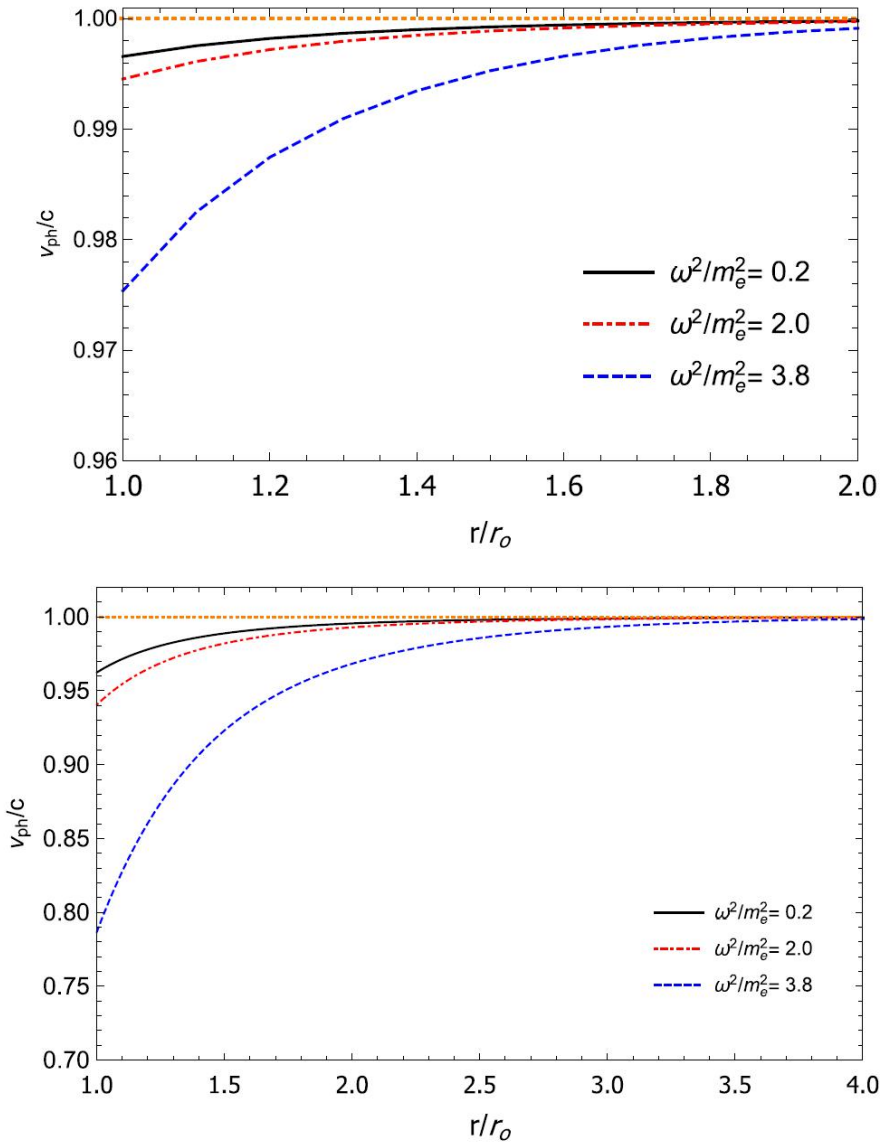

FIGURE 3 Phase velocity as a function of the distance traveled by the photons for different frequencies, top panel ($B_0 = 10B_c$), and bottom panel ($B_0 = 100B_c$)

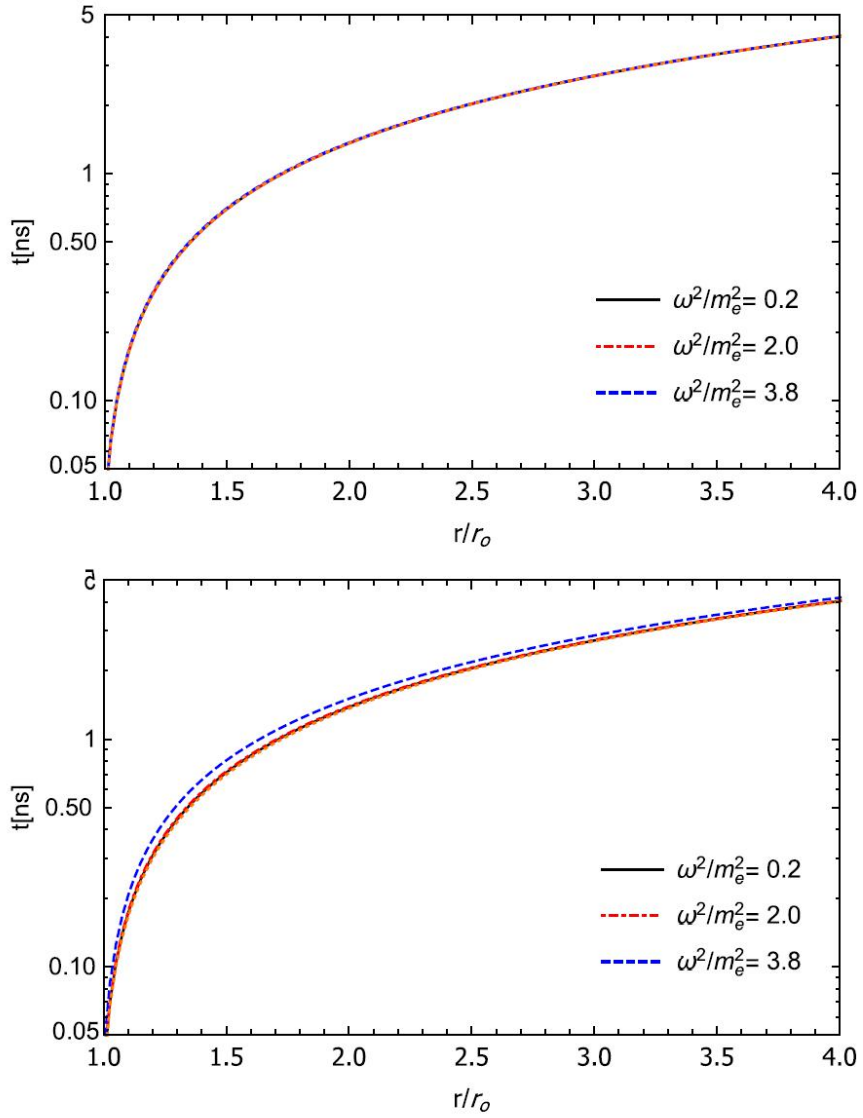

FIGURE 4 Time delay of photons for fixed values of frequencies as a function of the distance traveled, top panel ($B_o = 10B_c$), and bottom panel ($B_o = 100B_c$)