Photon splitting and pair creation in a magnetar magnetosphere

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We consider the electron-positron plasma generation processes in the magnetospheres of magnetars. Until recently, the absence of observable radio emission from magnetars has been attributed to the absence of dense plasma in their magnetospheres. The inefficiency of creation of an electron-positron plasma, whose flows would generate radio emission, has been related to photon splitting, which becomes important in a superstrong magnetic field exceeding the quantum critical value $B_c \approx 4.4 \times 10^{13}$ G.

However, we have shown [1] that photon splitting, which was previously considered as a suppression factor for pair generation, is not suppressing at all. Although the splitting undoubtedly takes place in the superstrong magnetic fields of magnetars, it leads only to a strong polarization of the curvature photons, but not to a decrease in their number or energy.

Curvature photons, which are generated by primary particles accelerated in the polar gap, move in a magnetic field, and their distribution function changes so that all photons become ∥-polarized before the pair generation threshold is reached. These photons create the first-generation particles, with the multiplicity of $\lambda = N/N_{GJ} \lesssim 10^3 - 10^4$. A high magnetic field strength does not give rise to the second generation of particles produced by synchrotron photons. However, the density of the first-generation particles can exceed their density in the magnetospheres of ordinary radio pulsars.

The plasma generation inefficiency can be attributed only to slow magnetar rotation, which narrows the energy range of the produced particles. We conclude that for each specific rotation period P, there exists some minimum surface magnetic field strength at which an effective generation of secondary plasma begins. We have found a boundary in the $P - \dot{P}$ diagram that defines the plasma generation threshold in a magnetar magnetosphere. This allows us to shed some light on the recent discovery of pulsed radio emission from several magnetars.

References

[1] Ya. N. Istomin, D. N. Sobyanin. Pis'ma Astron. Zh., 33, 740 (2007) [Astron. Lett., 33, 660 (2007)]

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