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Magnetic field screening in strong crossed electromagnetic fields

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We consider crossed electric and a magnetic fields $\left(\vec{B} = B\hat{z},\ \vec{E} = E\hat{y}\right)$, with $E/B < 1$, in presence of some initial number of $e^{\pm}$ pairs. We do not discuss here the mechanism of generation of these initial pairs. The electric field accelerates the pairs to high-energies thereby radiating high-energy synchrotron photons. These photons interact with the magnetic field via magnetic pair production process (MPP), i.e. $\gamma + B \rightarrow e^{+} + e^{-}$, producing additional pairs. We here show that the motion of all the pairs around the magnetic field lines generates a current that induces a magnetic field that shields the initial one. For instance, for an initial number of pairs $N_{\pm,0} = 10^{10}$, an initial magnetic field of 10^{12} G can be reduced of a few percent. The screen occurs in the short timescales $10^{-21} \leq t \leq 10^{-15}$ s, i.e. before the particle acceleration timescale equals the synchrotron cooling timescale. Our results indicate that the screening of magnetic fields can be very relevant in some astrophysical systems such as pulsars and gamma-ray bursts.

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