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Photo production from anomaly terms in supernovae and neutron stars

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Compact stellar objects like Supernovae (SN) and Neutron Stars (NS) are believed to cool by emitting axions via processes emission of neutrinos and possibly emission of axions, if they exist. In this talk, we study a previously overlooked contribution to the photo-production channel of interactions like $\gamma N \to N\nu\nu$ and $\gamma N \to Na$. This originates from the unavoidable anomaly-induced Wess-Zumino-Witten term $\propto \epsilon^{\mu\nu\alpha\beta} F_{\mu\nu} \partial_\alpha a \, \omega_\beta$ and $\propto \epsilon^{\mu\nu\alpha\beta} F_{\mu\nu} Z_\alpha \, \omega_\beta$. Such a term is inevitable within the Standard Model if one wants to explain the experimentally observed QCD processes that are disallowed by the symmetries of an effective Chiral Lagrangian. We find that due to those additional contributions, SN and SN can cool faster than what was previously thought, translating into stronger bounds on the axion decay constant f_a and modifying the cooling curve in general. Furthermore, the spectrum of axions and neutrinos emitted in the process is significantly harder than those originating from bremsstrahlung. The modified spectrum peaks around $6T$ and consequently helps us to uniquely discriminate between different cooling channels. In addition to this, these axions are also more likely to show up in the near future Water Cherenkov detectors.

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