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Supernova axion emissivity with $\Delta(1232)$ resonance in heavy baryon chiral perturbation theory

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In this talk, we evaluate the energy loss rate of supernovae induced by the axion emission process $\pi^- + p \rightarrow n + a$ with the $\Delta(1232)$ resonance in the heavy baryon chiral perturbation theory for the first time. Given the axion-nucleon- Δ interactions, we include the previously ignored Δ -mediated graphs to the $\pi^- + p \rightarrow n + a$ process. In particular, the $\Delta 0$ -mediated diagram can give a resonance contribution to the supernova axion emission rate when the center-of-mass energy of the pion and proton approaches the $\Delta(1232)$ mass. With these new contributions, we find that for the typical supernova temperatures, compared with the earlier work with the axion-nucleon (and axion-pion-nucleon contact) interactions, the supernova axion emissivity can be enhanced by a factor of ~ 4 (2) in the Kim-Shifman-VainshteinZakharov model and up to a factor of ~ 5 (2) in the Dine-Fischler-Srednicki-Zhitnitsky model with small $\tan \beta$ values. Remarkably, we notice that the $\Delta(1232)$ resonance gives a destructive contribution to the supernova axion emission rate at high supernova temperatures, which is a nontrivial result in this study.

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