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Visible Axinovae: Axion Star Explosions with Photon Emissions

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Axion dark matter or any ultralight bosonic dark matter can go through Bose-Einstein condensation due to the large phase density, leading to the formation of axion stars or solitons in the halo center. The formation rate is further enhanced in the presence of substructures such axion miniclusters which are expected in the post-inflationary scenario of the QCD axion or axion-like particles. Axion stars will continue to growth until its critical mass is reached, after which axion stars collapsed to the dense branch and explode along with the emission of relativistic axions, called axinovae. However, the photon emission channel can be turned on during the explosion of axion stars due to the stimulated decay of axions in coherent compact axion stars. We study the condition of axion model parameters that leads to a significant emission of photons in comparison to the emission of relativistic axions. We found that axinovae will contain a significant amount of visible photons when κ
$gtrsim64\,(f_a/10^{10}\mathrm{GeV})^{1/3}$ where κ represents the strength of the axion-photon coupling with respect to the axion self-coupling, $g_{a\gamma} = \kappa\alpha/(2\pi f_a)$. We point out that an slight enhancement on the axion-photon coupling compared to self-interaction is required to make axinovae visible. The condition of forming axion stars and triggering axinovae is also systematically studied, which reveals axion parameter space that can lead to bright radio axinovae that is ruled out by radio transient searches. If the axion mass corresponds to a frequency much lower than radio frequencies, it points out an interesting signal to search for that involves low energy photon emission from axion star explosions.

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