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A Fermi-LAT study of magnetar wind nebulae powering superluminous supernovae

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Superluminous supernovae (SLSNe) are a recent class of astronomical transients whose luminosities exceed those of typical core-collapse supernovae by 10 to 100 times. What makes SLSNe so different from regular core-collapse SNe is still in debate. There are mainly four different energy sources being considered to explain the high peak luminosity of SLSNe: ejecta fallback accretion onto a black hole, radioactive decay of 56Ni, circumstellar interaction, or a magnetar wind nebula. Gamma-ray observations can help to constrain the emission models, and it has been predicted that gamma-ray emission from a magnetar wind nebula could be visible approximately 100 days after the explosion when the opacity decreases.

To test this hypothesis, we studied SLSNe gamma-ray light curves using 16 years of Fermi-LAT data for a sample of 6 nearby sources (< 200 Mpc) SLSNe. From this sample, we report on some hints of variability for SN 2019ieh and confirm a significant detection for SN 2017egm that coincides with the temporal and spectral predictions of the magnetar-dominated models. In particular, comparison of the models with the observed Fermi gamma-ray spectrum allows us to constrain the magnetization parameter of the nebula, which is critical for the TeV counterpart of the magnetar nebula. Based on our best model, we explore predictions for the detectability of such objects with the CTAO and the horizon of detectability. However, while the magnetar model is the most tempting model, the interaction of the shock with multiple CSM shells also offers a possible explanation.

The discovery of SN 2017egm as a gamma-ray emitter establishes a new category of gamma-ray sources and could provide a novel opportunity to investigate these extreme neutron stars, which possess millisecond rotational periods and magnetic fields of 10ˆ14 G.

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