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Magnetars as Powering Sources of Gamma-Ray Burst Associated Supernovae

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The era of long gamma-ray bursts (LGRBs) and supernovae (SNe) connections started with the discovery of the first direct temporal and spatial connection of GRB 980425 and SN 1998bw. This field has evolved enormously over the last two decades, with more than fifty LGRBs and SNe association events. The association of a SN with a GRB can be seen as a late-time bump in the optical/NIR light curves after fading the afterglow nearly 2-3 days after the burst. Numerous studies suggest that LGRBs and stripped-envelope SNe share similarities in their progenitors and host environments to some extent. Another probable contributing factor to these events' diversity in observed properties could be the underlying powering mechanism, where spin-down millisecond magnetars are one of the most popular powering sources for these events. Internal plateau, extended emission, precursor and flaring activities in GRBs also support the underlying magnetars as power sources. Furthermore, different magnetar properties, such as the initial spin period, magnetic field, and central engine activity duration, can give rise to different transient types and properties of the transients within the same class. Hence, investigating the characteristics of the central engine powering sources and comparing them across various types of transients can provide valuable insights into the distinct properties of transients (for details, see Kumar, A., et al. 2024, MNRAS, in press, arXiv:2403.18076). My talk will aim to provide a comprehensive overview of the spin-down millisecond magnetars as powering sources for GRB-SNe and the potential of magnetars with varying characteristics to give rise to a diverse array of transient events, which is crucial to understanding how the life of stars ends differently.

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