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Long-duration Gamma-Ray Burst Progenitors and Magnetar Formation

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Millisecond magnetars produced in the center of dying massive stars are one prominent model to power gammaray bursts (GRBs). However, their detailed nature remains a mystery. To explore the effects of the initial mass, rotation rate, wind mass loss, and metallicity on the GRB progenitors and the newborn magnetar properties, we evolve 227 of 10–30Me single star models from the pre-main sequence to core collapse by using the stellar evolution code MESA. The presupernova properties, the compactness parameter, and the magnetar characteristics of models with different initial parameters are presented. The compactness parameter remains a nonmonotonic function of the initial mass and initial rotation rate when the effects of varying metallicity and the "Dutch" wind scale factor are taken into account. We find that the initial rotation rate and mass play the dominant roles in whether a star can evolve into a GRB progenitor. The minimum rotation rate necessary to generate a magnetar gradually reduces as the initial mass increases. The greater the initial metallicity and "Dutch" wind scale factor, the larger the minimum rotation rate required to produce a magnetar. In other words, massive stars with low metallicity are more likely to harbor magnetars. Furthermore, we present the estimated period, magnetic field strength, and masses of magnetars in all cases. The typical rotational energy of these millisecond magnetars is sufficient to power long duration GRBs.

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