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Formation of Neutron Stars from the ONeMg Core of Super-AGB Stars

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The stellar mass range (8 - 10) Msun corresponds to the most massive AGB stars and the most numerous massive stars. We study the transition from super-AGB star to massive star and find that a propagating neon-oxygen burning shell is common to both the most massive electron capture supernova (EC-SN) progenitors and the lowest mass iron-core collapse supernova (FeCCSN) progenitors. Of the models that ignite neon burning off-center, the 9.5 Msun model will evolve to an FeCCSN after the neon-burning shell propagates to the center. The neon-burning shell in the 8.8 Msun model, however, fails to reach the center as the URCA process and an extended region of low Y_e in the outer part of the core begin to dominate the late evolution; the model evolves to an EC-SN. This is a new evolutionary path to EC-SN in addition to that from S-AGB stars undergoing thermal pulses. We show that the two evolutionary fates (EC-SN and FeCCSN) are separated by the dynamics of the neon and oxygen burning shells and the behavior of the URCA process. We have also computed an 8.75 Msun super-AGB star through its entire thermal pulse phase until electron captures on 20Ne begin at its center, and examine the differences between the pre-SN evolution and progenitor structure of the 8.75 and 8.8 Msun models. We present two supernova progenitor structures for EC-SNe (a super-AGB star and a 'failed massive star') and one FeCCSN progenitor structure from a 12 Msun star. We discuss how the different pathways to collapse affect the pre-supernova structure and compare our results to the observed neutron star mass distribution. Finally, we demonstrate the light curves of EC-SNe from super-AGB stars to compare the observation including the Crab supernova 1054.

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