Helium stars as supernova progenitors

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We follow the evolution of a helium star of mass $2.4M_{\odot}$, and show that it undergoes off-center carbon burning, which leaves behind about $0.01M_{\odot}$ of unburnt carbon in the inner part of the core. Later on, as the carbon-oxygen core grows to Chandrasekhar mass, the left-over carbon is enough to ignite thermonuclear runaway similar to the well known SN Ia scenario. However, at the moment of explosion, the star will possess an envelope of several tenths of solar mass, consisting of helium and its burning products, probably making it appear as a SN Ib. We find that in the approximate mass range $2.20 - 2.60M_{\odot}$ similar off-center carbon burning takes place. To demonstrate the possible outcomes, we explored the similar case of carbon-oxygen cores undergoing off-center carbon burning followed by mass accretion, showing that as a function of the amount of residual carbon we can get thermonuclear runaway at a broad range of central densities of $1 - 6 \times 10^9 g\,cm^{-3}$. We verified the feasibility of our helium star progenitor scenario by evolving a close binary system with initial masses of 8.5 and $7.7M_{\odot}$ and initial period of $150day$, resulting in a remnant of $2.28M_{\odot}$, close to the model we considered.