The different progenitors of type Ib, Ic SNe, and of GRB

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We discuss the properties of the progenitors of core collapse supernovae of type Ib and Ic and of long soft gamma ray bursts, as they can be deduced from rotating stellar models of single stars at various metallicities.
The type of the supernova progenitor was determined from the surface abundances at the pre-supernova stage. The type of the supernova event was obtained from the masses of hydrogen and helium ejected at the time of the core-collapse supernova event.
We find that the minimum amount of helium ejected by a core-collapse supernova (of whatever type) is around 0.3 M$_\odot$. There is no difference between the WC and WO stars in the ejected masses of helium, CNO elements, and heavy elements. Also no difference is expected between the chemical composition of a WC star resulting from a normal or a homogeneous evolution. The progenitors of type Ib supernovae are WNL, WNE, or less massive WC stars. Those of type Ic are WC and WO stars. WO stars are produced in a limited mass range (around 60 M$_\odot$) and only at low metallicity (for $Z\le\sim 0.010$) as already found. The WO stars are the progenitors of only a small fraction of type Ic. Present stellar models indicate that, at solar metallicity, there is about 1 type Ib supernova for 1 type Ic, and this ratio rises to 3 type Ic for 1 type Ib SN at twice solar metallicity. At this metallicity, type Ic's are more frequent than type Ib's because most massive stars that go through a WNE stage evolve further into a WC/WO phase. Current models can account for the observed number ratios SN Ib/SN II and SN Ic/SN II and for their observed variation with the metallicity. In case no supernova occurs when a black hole is formed, single-star models can still account for more than half of the observed (SN Ib+SN Ic)/SN II ratio for $Z \ge$ Z$_\odot$. For the gamma ray burst rate, our models produce too large a number for such an event, even if we restrict the progenitor to the WO stars. This confirms that only a fraction of the WC / WO stars evolve toward gamma ray burst event, most likely those arising from stars that were initially very rapid rotators.

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