Stellar evolution of massive stars at very low metallicities

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Recently, measurements of abundances in extremely metal poor (EMP) stars have brought new constraints on stellar evolution models. In an attempt to explain the origin of the abundances observed, we computed pre--supernova evolution models, explosion models and the related nucleosynthesis. In this paper, we start by presenting the pre-SN models of rotating single stars with metallicities ranging from solar metallicity down to almost metal free. We then review key processes in core-collapse and bounce, before we integrate them in a simplistic parameterization for 3D MHD models, which are well underway and allow one to follow the evolution of the magnetic fields during collapse and bounce. Finally, we present explosive nucleosynthesis results including neutrino interactions with matter, which are calculated using the outputs of the explosion models.
The main results of the pre-SN models are the following. First, primary nitrogen is produced in large amount in models with an initial metallicity $Z=10^{-8}$. Second, at the same metallicity of $Z=10^{-8}$ and for models with an initial mass larger than about 60 Mo, rotating models may experience heavy mass loss (up to more than half of the initial mass of the star). The chemical composition of these winds can qualitatively reproduce the abundance patterns observed at the surface of carbon-rich EMP stars. Explosive nucleosynthesis including neutrino-matter interactions produce improved abundances for iron group elements, in particular for scandium and zinc. It also opens the way to a new neutrino and proton rich process (νp-process) able to contribute to the nucleosynthesis of elements with A > 64.

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