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The direct measurement of the C12+C12 cross section at astrophysical energies at LUNA

Carbon burning is the third stage of stellar evolution determining the final destiny of massive stars and of low-mass stars in close binary systems. Only stars with a mass larger than a critical value $M_{up}^{*} \sim 10M_{\odot}$, can ignite C in non-degenerate conditions and proceed to the next advanced burning stages up to the formation of a gravitationally unstable iron core. Various final destinies are possible, among which a direct collapse into a black hole or the formation of a neutron star followed by the violent ejection of the external layers (type II SN). Less massive stars $M < M_{up} \sim 7M_{\odot}$, never attain the conditions for C ignition and will evolve into CO White Dwarfs. The values of M_{up}^{*} and M_{up} are linked to the $^{12}C +^{12} C$ reaction rate: the little knowledge we have of it at astrophysical energies is the greater contribution to the uncertainty of these masses.

Stellar C burning proceeds mainly through the $^{12}C(^{12}C, \alpha)^{20}Ne$ and $^{12}C(^{12}C, p)^{23}Na$ channels. The cross-sections can be measured either detecting the emitted charged particles or the γ-rays produced by the decay of the excited states of ^{20}Ne and ^{23}Na.

$^{12}C +^{12} C$ fusion reactions were investigated in a wide energy range, down to 2.2 MeV, still above the astrophysical energies. A direct measurement is necessary for both stellar evolution models and the correct analysis of indirect data.

The aim of my PhD project is the direct determination of the cross section of the $^{12}C +^{12} C$ reaction at astrophysical energies through γ spectroscopy at LNGS. Here a devoted setup is being developed to reach an extremely low background condition. The project will also make use of the new MV accelerator available at the Bellotti Ion Beam Facility at LNGS, in the context of the LUNA MV research project. This accelerator is capable of producing a high intensity carbon beam ($\sim$ 0.15 mA) with great energy resolution and stability: as of our knowledge this is the highest C beam intensity available in the world. The detection setup will be made of several NaI scintillators and an HpGe. NaI detectors will be placed in a compact arrangement around the HpGe, covering a 2π angle: such a configuration guarantees a high detection efficiency, while preserving the excellent HpGe resolution (1.2 keV at 1.33 MeV). The NaI configuration will also function as an active veto for beam-induced background.

In this contribution I will present details of recent results in setup development.

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