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Fusion in massive stars: Pushing the 12C+12C cross-section to the limits with the STELLA experiment at IPN Orsay

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The 12C+12C fusion reaction is one of the key reactions governing the evolution of massive stars as well as being critical to the physics underpinning various explosive astrophysical scenarios [1]. Our understanding of the 12C+12C reaction rate in the Gamow window –the energy range relevant to the different astrophysical scenarios –is presently confused. This is due to the large number of resonances around the Coulomb barrier and persisting down to the lowest energies measured. In usual circumstances, where the fusion cross-section is smooth it can be readily extrapolated from the energy range measured in the laboratory down to the Gamow window but this is not possible for 12C+12C. Moreover, the existing data on this reaction obtained either through detection of evaporated charged particles or detection of gamma rays do not agree. This is a known problem which has been attributed to low-level contamination of targets with e.g. deuterium. In addition, there is considerable disagreement in the theoretical extrapolation of the data down to the Gamow window.

Jiang et al. have developed a new experimental approach to study of the 12C+12C reaction which can circumvent issues related to target contamination [2]. They used the Gammasphere array to detect fusion gamma rays in coincidence with detection of evaporated charged particles using annular silicon strip detectors [2]. This technique has shown considerable promise in essentially removing experimental background from the measurement [2]. However, very long running times and high beam currents are needed to push this technique to the lowest beam energies approaching the Gamow window.

The STELLA experiment has recently been commissioned at IPN Orsay. A intense 12C beam from the Andromede accelerator is incident on thin self-supporting 12C foils. A target rotation system can allow for cooling supporting μA beam currents. Evaporated charged particles are detected with a dedicated silicon array while gamma rays are detected in coincidence with an array of 30 LaBr3 detectors [3]. The design and status of STELLA will be presented along with initial results showing good agreement with earlier measurements of the 12C+12C system.

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