$^{12}C+^{16}O$ Measurements with STELLA for Nuclear Astrophysics

PROJECT SUPERVISION :
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Context :

Fusion of two nuclei is one of the principal mechanisms of stellar nucleosynthesis of the elements. In fact, the stability and energy output of such giant objects as stars depend sensitively on the reaction probabilities between tiny objects like the cores of atoms. Light nuclei are of particular interest as they rule the beginning of the evolution of a star on its long pathway synthesizing heavier and heavier nuclei. In the early stage of stellar evolution, only limited abundance inventory is available so that only a small number of reaction dominate the fate of the star. During carbon burning, these reactions are $^{12}C+^{12}C$ and $^{12}C+^{16}O$ that happen to be among alpha conjugated nuclei. Such clusters are energetically favourable and can reveal themselves in resonances of the reaction probability. Clear knowledge from measurements hence yields valuable input for understanding the nature of stars and of the inner composition of the elements around us, like carbon or oxygen.

Project Details :

This thesis subject with the STELlar LAboratory is about ultra sensitive fusion cross-section measurements for nuclear astrophysics. The team collaborates with national (IJCLab Orsay, GANIL) and international (Univ. of York, Univ. of Padua) partners and has successfully conducted extensive high-precision measurements of the $^{12}C+^{12}C$ reaction. The measurement apparatus, notably the Double Sided Silicon Strip Detectors (DSSSD), was adapted and upgraded recently to match the requirements for identifying the more complex decay pattern of the $^{12}C+^{16}O$ system. The student will participate to the commissioning and data taking at Andromède, Orsay, with subsequent data analysis of the reaction channels of the $^{12}C+^{16}O$ compound. This work comprises characterization of DSSSDs on a test bench, proper energy and timing gate selection, display and interpretation of the angular distributions of light evaporation particles, the calculation of fusion cross-sections and discussion with respect to earlier measurements. The student will be given the opportunity to participate to national/international experiments within the STELLA collaboration and to present the results to the nuclear astrophysics community.

Technical Aspects/Requirements :

The student will be introduced into the analysis strategy for charged particles with the STELLA experiment, the selection of the decay channels and cross-section calculation. Existing ROOT macros can be integrated into the analysis code for this thesis. The Geant4 simulations will be performed with the existing STELLA framework where the necessary analysis and supplementary programs based on ROOT exist. The student will participate in the assembling, testing, data taking at Andromède, IJCLab, and the $^{12}C+^{16}O$ data analysis.

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