Towards $^{12}C+^{16}O$ 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 work 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 be introduced into the DSSSD system and will develop search strategies to identify the reaction channels of the $^{12}C+^{16}O$ compound. This work will be based on results from existing $^{12}C+^{12}C$ data, Geant4 simulations to add information essential for the new system (decay branch, particle energy) and detection parameters (resolution, efficiency, timing) acquired from a test bench at IPHC. The subject is designed to be developed into a PhD thesis with measurements at IJCLab, analysis of coincident gamma-particle data and national/international experiments within the STELLA collaboration.

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. The existing ROOT macros can be integrated into the analysis code for this internship, that needs to be developed. The Geant4 simulations will be performed with the existing STELLA framework where the necessary analysis and supplementary programs based on ROOT exist. The work at the test bench will be guided, but with the aim of giving the student responsibility of this working task, and might be complemented with measurements at the accelerator site at Andromède, IJCLab.

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