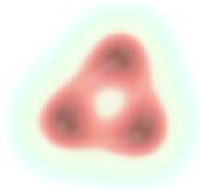
Angular Distributions for Astrophysics

PROJECT SUPERVISION :
SUPERVISION: MARCEL HEINE
INSTITUT PLURIDISCIPLINAIRE HUBERT CURIEN (IPHC –CNRS, UMR 7178)
23 RUE DU LŒSS, 67037 STRASBOURG
TEL : 03 88 10 10 68 87; E-MAIL : MARCEL.HEINE@IPHC.CNRS.FR

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 sometimes happen to develop cluster structures, that are energetically favourable, because they are more stable (*e.g.* Hoyle state in ^{12}C)**,** that then reveal themselves in resonances of the reaction probabilites. These peaks in the spectrum can be attributed a spin-parity value from measuring the angular distribution of the emitted light particles from the decay of a resonance.



Project Details :

This work is about developing a robust and reliable search strategy for the properties of such resonances in STELLA (STELar Laboratory) data of $^{12}C+^{12}C$ measurements by quantifying the properties of the charged particle spectra from DSSSDs/DSSSDs+PIXEL. The aims is to get a precise idea of the sensitivity of the experimental setup to different particle-emission distributions, *e.g.* for the reaction $^{12}C+^{12}C \rightarrow ^{20}Ne+\alpha$ with different final states in neon, and to develop a consistent description of beam-induced effects including all particle detectors of STELLA.
The $^{12}C+^{12}C$ experiments were performed in 2016 and 2022 at Andromede, IJCLab (Orsay). Several previous studies were made to fit particle energy distributions to nominal beam energies or to investigate the effect of an extended beam spot size on the energy resolution of the particle detectors. These results will be complemented by this project in basically two ways: Firstly by evaluating the effect of integrating the newly commissioned PIXEL detector into the fits for angular distributions of light charged particles with a detailed analysis of the associated uncertainties. And secondly by reproducing the particle spectra shapes with Geant4 simulations based on the findings in the previous works in combination with the precise determination of the detector at IPHC.
The latter can layout the experimental strategy for measurements with resonances that have the potential to be followed by a PhD theses in the STELLA team. The astrophysics implications can be investigated exploiting the nucleosynthesis competences of the group.

Technical Aspects/Requirements :

The student will be introduced into the analysis strategy for charged particles with the STELLA experiment as well as the display and characterization of angular distributions. The existing simple ROOT macros can be integrated into the analysis code, that needs to be developed. The Geant4 simulations will be performed with the existing STELLA framework where basic analysis and supplementary programs based on ROOT exist.

TEAM **:** A. Bonhomme, S. Courtin, D. Curien, T. Dumond, E. Gregor, M. Heine, E. Monpribat, J. Nippert