# Coincidence measurements of $^{12}$C+$^{30}$Si fusion

PROJECT SUPERVISION :
INSTITUT PLURIDISCIPLINAIRE HUBERT CURIEN (IPHC –CNRS, UMR 7178)
23 RUE DU LŒSS, 67037 STRASBOURG
TEL : 03 88 10 10 64 48; E-MAIL : MARCEL.HEINE@IPHC.CNRS.FR

**Context :**
Fusion of two nuclei is one of the principal mechanisms of stellar nucleosynthesis of the elements. At the temperature present at the stellar site, the so called *fusion hindrance* phenomenon plays a crucial role as it defines the reaction rate of element production as well as the thermodynamics conditions influencing *e.g.* the life time of the star. This demonstrates the fundamental influence of nuclear structure (see above: calculation of cluster states in $^{24}$Mg) on astrophysics. Hindrance was evidenced for the first time 20 years ago in the studies of heavy ions (Ni, Zr) at sub-Coulomb relative energies of the colliding nuclei. For lighter systems (C, Si) that are of astrophysics interest, such measurements are even more challenging, because a significant background hampers the conventional experimental approach at the energy of interest. Hence, to diminish the background, coincidence measurements of several characteristic particles must be done.

**Project Details :**
This work comprises the preparation of a nuclear physics experiment, as well as participation in data taking at LNL and an analysis of experimental data. The project is about a test run of PISOLO (detection of heavy residue) with EUCLIDES (detection of light charged particles) in a team of experimental physicists. It offers the opportunity to understand the fusion mechanism and it's influence on stellar nucleosynthesis in the framework of an international collaboration with strong support of the university of Padua giving the opportunity in participating in several test experiments with beam that are foreseen for the beginning of 2021. During the preparation of the experiment as well as the analysis, Geant4 simulations will be employed for the determination of the charged particle detection-efficiency and for optimization and precise definition of the detector geometry (C++ code). The analysis carried out with ROOT (C/C++) serves to obtain the coincidence efficiency as well as to calculate $^{12}$C+$^{30}$Si reaction cross-sections at deep sub-Coulomb-barrier energies. The subject has the potential to be followed up by a PhD in the STELLA team of DNE.
We plan to be strongly involved in the preparation of this experiment. This offers to the student the possibility to also obtain profound knowledge of two different experimental approaches. PISOLO is an electrostatic deflector for the separation and identification of heavy reaction residue by measuring the characteristic energy loss (ΔE) and the total energy (E) of the nuclei. The ΔE-E correlation allows for the extraction of the fusion reaction-rate as well as the background contribution. EUCLIDES is a so called 4π telescope-detector composed of two layers of silicon detectors for alpha particle and proton detection *via* a ΔE-E correlation. With the combination of PISOLO and EUCLIDES, the detection efficiency of measuring fusion residue in coincidence with light evaporation particles is to be determined for well known cross sections. At such energies (slightly below the Coulomb barrier) the accuracy of the experimental approach will also be measured. The obtained coincidence rate will then be extrapolated towards the measurements of fusion cross-sections at deep sub-barrier energies in order to deter the global trend of the cross-section function on the path to eventually shed light on the fusion-hindrance behavior of light systems like (C, Si).

MEMBERS OF THE TEAM **:** Sandrine Courtin, Dominique Curien, Marcel Heine, Emma Monpribat, Mohamad Moukaddam, Jean Nippert