

Study of nuclear decay properties relevant in the explosive stellar nucleosynthesis of heavy elements

Research Project / Research Group Description:

The Gamma Spectroscopy and Neutrons Group of the Instituto de Física Corpuscular (CSIC and University of Valencia) has as main research lines the study of a) nuclear structure in exotic atomic nuclei, b) nuclear properties relevant to astrophysics (beta decay and neutron capture reactions), and c) applications to reactor technology. These are carried out using techniques where the Group has recognized expertise: total absorption gamma-ray spectroscopy, moderated neutron counters and imaging gamma-ray total energy detectors. Experiments are pursued at forefront international facilities like GSI-Darmstadt (Germany), IGISOL-JYFL (Finland), ISOLDE-CERN, n_TOF-CERN, and RIKEN Nishina Center (Japan).

The research topic for the PhD position can be chosen from the following two:

a) Measurement of half-lives and beta-delayed neutron emission probabilities of very neutron-rich nuclei relevant for the rapid neutron capture process (r-process) synthesizing half of the elements heavier than iron. The process occurs in explosive astrophysical environments like core collapse supernovae (CCSN) and mergers of a neutron stars (NSM). The measurements are performed with the new BRIKEN neutron counter, the largest of its kind, and the advanced AIDA implant-decay detector, installed at the RIBF facility in RIKEN, currently producing the largest intensities of in-flight separated relevant n-rich nuclei.

b) Measurement of beta-decay strength distributions of neutron-deficient Ge and Ga isotopes important for the rapid proton capture process (rp-process) synthesizing heavy element isotopes that cannot be produced by neutron capture. The process occurs in hydrogen-rich explosive stellar environments like X-ray bursts (XRB), mergers of a neutron star and a normal star. The measurements are performed with the total absorption gamma-ray spectrometer "Lucrecia" developed by the group installed at ISOLDE-CERN where isotopes can be cleanly produced using a laser-ionization source.

Job position description:

a) Data in different regions of the nuclear chart were measured or will be taken during 2018-2020. The candidate will participate in setting-up the instrumentation (detector, electronics, data acquisition system) and in the data taking runs. This will be followed by data reduction and analysis of a subset of the data: reconstruction and fitting of implant-beta-neutron time correlation histograms using ad-hoc software. Systematic uncertainties will be studied and minimized; in particular those related to beta and neutron detection efficiencies, involving dedicated Monte Carlo simulations. Comparison of measured and theoretical half-lives and neutron emission probabilities will be carried out. The impact of the new data on calculated r-process abundances will be evaluated.

b) The experiment has been performed and a continuation for Se isotopes is planned. The initial task is the analysis of existing data, which needs filtering using appropriate cuts. The analysis involves a careful characterization of the spectrometer response by means of Monte Carlo simulations and calibration measurements. The response is needed for the complex deconvolution procedure applied to the data. Training in the analysis technique developed by the group will be followed by the analysis itself. In addition the candidate will explore possible new methods. The extracted strength will be compared with calculations to validate theoretical nuclear models. The impact of data on calculated XRB luminosity curves will be

evaluated. In parallel the setup for the new experiment will be prepared and tested and the measurement will be carried out.

The candidate will take the main responsibility for the topic of her/his choice, but as part of the training will participate in the other research lines developed by the group. In any case partial results of the work will be prepared and presented at different workshops and conferences as well as submitted to peer reviewed journals.

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Research project/Research Group website

<http://webgamma.ific.uv.es/gamma/en>