Contribution ID: **67**

Type: **Oral (in presence)**

Numerical virtual experiments for in-plasma nuclear beta-decay study in the framework of the PANDORA project

Monday, 20 June 2022 15:20 (25 minutes)

Nuclear and atomic parameters both play a crucial role in constraining reaction rates of processes involved in several astrophysics domains. Reactions relevant for the s-process nucleosynthesis largely request for assessing yet open uncertainties on neutron capture cross sections and weak-interaction rates, for specific nuclear reactions, which branching ratio highly impacts on the final abundance pattern, as well as on a proper modelling of abundance-dependent mechanisms. In particular, the beta decay of radioisotopes is theoretically predicted to be largely influenced by the surrounding atomic environment, where strongly ionized plasma conditions can modify their half-life. The PANDORA (Plasmas for Astrophysics Nuclear Decays Observation and Radiation for Archaeometry) project can offer a unique experimental facility and approach aiming at measuring first-of-its-kind in-plasma beta-decay lifetimes as a function of thermodynamical conditions of the environment, namely a laboratory magnetized plasma able to mimic some stellar-like conditions. A direct correlation of the plasma environment and nuclear activity is possible via the gamma-rays tagging of excited daughter nuclei following the parent beta decay. A devoted multi-diagnostic system working synergically with a gamma-rays HPGe detection system will be capable to monitor plasma parameters, as well as to detect and discriminate photons emitted by the plasma from those emitted after the beta-decay. In view of the experimental measurements, numerical "virtual experimental runs"have been largely motivated by recent attempts to constrain atomic input for s-process branching ratios in models which try to reproduce isotopic admixtures of s-process elements in presolar SiC grains. Some specific radioisotopes, e.g., ^{134}Cs, ^{94}Nb, ^{176}Lu, have been investigated. Here, we present the numerical progresses done on the sensitivity of the designed experiment in PANDORA, based on the measurement time required in terms of 3σ-confidence-level for the decay-rates measurement. These estimates are based on calculations of reduced mean lifetime of ionized nuclei, considering the charge state distribution led by electron densities and energies typical of the plasma trap. Furthermore, an advanced estimate of the expected signal-to-noise ratio is here reported, including for the first time the simulated impact of short-lived radioisotopes'neutral depositions on the chamber walls of the plasma trap, being an additional source of background for the HPGe detectors array.

Session

Experimental Nuclear Astrophysics

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Session Classification: Nuclear Astrophysics