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Modelling Ion Population Kinetics in ECR Plasmas to Extract Inputs for In-Plasma β-Decay Rates

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Lifetimes of radioactive nuclei are known to be affected by the level configurations of their respective atomic shells. Immersing such isotopes in environments composed of energetic charged particles like stellar plasmas can result in β-decay rates orders of magnitude different from those measured terrestrially. Accurate knowledge of the relation between plasma parameters and nuclear decay rates are essential for reducing uncertainties in present nucleosynthesis models. Currently, the full effect of a charge state distribution (CSD) as exists in plasmas is only modelled theoretically but PANDORA (Plasmas for Astrophysics, Nuclear Decay Observations and Radiation for Archaeometry) aims to be the first experiment to verify these models by measuring β-decay rates of select isotopes diffused in electron cyclotron resonance (ECR) plasmas. We present here a comprehensive study of the inputs required by the model of Takahashi and Yokoi for calculating the perturbed decay rates, as well as a 3D ion dynamics model combining a quasi-stationary particle-in-cell (PIC) ion dynamics code with a Monte Carlo (MC) population kinetics routine to extract said data from the plasma. The simulation scheme is robust, comprehensive and makes few assumptions about the state of the plasma. While the method has been tested only on light ions till now, it has the potential to be extended to heavy nuclei of interest, including as many reactions as needed to populate the relevant atomic/ionic levels for precise estimation of the decay rates.

Session

Experimental Nuclear Astrophysics

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