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Updates about the multi-detectors system of the PANDORA facility aiming at the measurement of β-decay in astrophysical conditions

PANDORA (Plasmas for Astrophysics Nuclear Decays Observation and Radiation for
Archaeometry) is an INFN project aiming at measuring, for the first time, possible variations of in-plasma β-decay lifetimes in selected isotopes of astrophysical interest, as a function of thermodynamical conditions of the in-laboratory controlled plasma environment. Theoretical predictions say that the ionization state can dramatically modify the β-decay lifetime (several orders of magnitude) due to the opening of a new decay channel as the bound state β-decay [1,2]. The PANDORA experimental approach consists of creating and confining a plasma whose main features can mimic specific stellar-like conditions, thus measuring the evolution of the nuclear lifetime as a function of plasma parameters [3]. The density and temperature of radionuclides can be maintained in dynamical equilibrium even for weeks when diffused in a buffer plasma confined by a B-minimum superconducting magnetic trap, now under construction. The β-decay events will be tagged by detecting the γ-ray emitted by the daughter nuclei by an array of 14 HPGe detectors placed around the magnetic trap. In this frame, plasma parameters have to be continuously monitored online: in PANDORA they will be measured through an innovative, non-invasive multi-diagnostic system which will work synergically with a γ-rays detection system [3]. In this contribution we will describe this multi-diagnostics system and advanced analysis methods that have been already developed, and which allow unprecedented investigations of magnetoplasma properties (in terms of plasma density, temperature, charge state distribution), including high resolution time- and space-resolved X-ray analysis. The developed setup includes an interfero-polarimeter for total plasma density measurements, a multi-X-ray detectors system for volumetric X-ray spectroscopy (including time resolved spectroscopy), a X-ray pin-hole camera for high-resolution 2D space-resolved spectroscopy and imaging, and optical spectrometers for the plasma-emitted visible light characterization. A description of recent results about plasma parameters characterization in quiescent and turbulent Electron Cyclotron Resonance-heated plasmas will be given. This synergic operation of the diagnostics will be crucial also for the additional case-studies of PANDORA: a) the determination of metallic ECR plasma opacities resembling thermodynamical conditions of post neutron-star-merging ejecta [4]; b) the study of kinetic plasma turbulence in laboratory plasmas, such as the cyclotron maser instability causing radio and X-ray bursts emission in astrophysical objects.

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[4] Pidatella A., et al., Front. Astron. Space Sci. 9:931744 (2022)

Summary

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