**Diagnostics for high-power helicon plasmas: from lasers to magnetic probes**

I. Furno1\*, M. Baquero-Ruiz1, Ph. Guittienne1, R. Jacquier1, L. Kadi1, R. Karimov1,

A.A. Howling1, C. Stollberg1

*1Ecole Polytechnique Fédérale de Lausanne (EPFL), Swiss Plasma Center (SPC), CH-1015, Lausanne, Switzerland*

The Resonant Antenna Ion Device (RAID) [1, 2] is a linear device (1.5 m length, 20 cm radius) at the Swiss Plasma Center in which high-power (up to 20kW), steady-state helicon plasmas are created by helicon wave excitation using twin resonant antennas (10 kW each, birdcage-geometry, 13.56 MHz). A modular set of copper magnetic coils, surrounding the vacuum vessel, is currently used to produce an axial magnetic field up to 700 G on-axis and a divergent magnetic field in the source region. Many gases can be used such as H2, D2, Ar and He, and typical electron densities of 1018 m-3 and 1019 m-3, respectively, in hydrogen and argon can be attained with electron temperature in the range 1-10 eV. RAID is equipped with an extensive set of diagnostics for plasma profiles and wave fields allowing to advance the physics understanding of helicon plasmas as well as validating novel theories of electrostatic probes. Here, I will discuss the technical implementation of diagnostics on RAID and the experimental challenges in a high-power helicon plasma environment as well as selected physics results.

Detailed two-dimensional plasma profiles in RAID are obtained using in-situ double Langmuir probes, which provide electron temperature Te and plasma density ne measurements. We developed a novel probe theory, based on a two fluid solution for isothermal and collisionless plasma sheaths, which allows to compute Te and ne, as well as the ion temperature Ti from double-probe I-V characteristics. This new theory is tested on RAID using data from a Thomson Scattering system and laser-induced fluorescence system in argon plasmas. To investigate the physics of helicon waves, we have equipped RAID with a set of in-situ three-dimensional magnetic probes, which reconstruct the magnetic field associated with the helicon wave. By measuring the phase and amplitude of each magnetic field component along the axial and radial direction, the structure of the helicon wave is reconstructed and compared with numerical simulations, confirming that RAID plasmas are mainly sustained by the propagation of helicon waves, with a minor contribution from Trivelpiece-Gould modes and other modes depending on the plasma density profile.

[1] I. Furno, et al., EPJ Web Conf. **157**, 03014 (2017).

[2] R. Jacquier, et al., Fusion Engineering and Design **192**, 11361(2023).