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Helicon waves in toroidal geometry

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Helicon waves, long known for their high plasma generation efficiency, have been the focus of extensive studies in linear low temperature plasma devices in the last decades [1]. More recently, the use of helicon waves has been considered as a good candidate for current drive in tokamaks and is now showing promising results [2, 3]. However, the experimental and fundamental characterization of toroidal helicon waves is still scarce in the literature and limited to tabletop toroidal devices [4, 5]. To fill this gap, a 13.56 MHz helicon antenna has been mounted in TORPEX [6], a versatile toroidal low-temperature plasma device of major radius 1 m and cross-section diameter 0.4 m, which produces a wide variety of magnetic configurations.

In this talk, a 3D characterization of toroidal helicon waves is provided for the first time. Argon and hydrogen plasmas are explored, under two magnetic configurations (consisting of a toroidal field with and without a small vertical field). The parallel helicon wave numbers are measured with a pair of miniaturized magnetic probes, inserted at different toroidal locations. A surprisingly good agreement with a simplified cylindrical modelling indicates that parallel wavelength is little affected by toroidicity. On the other hand, 2D measurements provide the distribution of the helicon wave magnetic fields across a poloidal section. The global shape of the mode is also found to resemble that of a cylindrical helicon mode, although strongly distorted by the toroidicity. COMSOL simulations are also presented, in good agreement with the experiments. Finally, we show that the helicon wave amplitudes are modulated by low-frequency (LF) waves (at ~kHz), and that these LF waves are in turn spectrally enhanced by the helicons, suggesting non-linear interactions between helicon and LF waves, a feature yet unreported in the literature. These unprecedented results extend the state-of-the-art of helicon studies and pave the way to a better understanding of their fundamental properties in toroidal geometry.

References

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