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# Multi-machine experimental investigation of ion cyclotron emission

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Ion Cyclotron Emission (ICE) is an instability triggered by the resonant interaction between a population of fast ions and waves supported by the background plasma. The analysis of the signal passively measured with Radio-Frequency probes in time and frequency domains can provide information on the characteristics of the barely trapped and lost fusion alpha-particles in a machine such as ITER. ICE can exhibit very different features in time (steady state, transient, cyclic) and in frequency (presence of doublets or triplets at low frequency, continuum at high frequency, chirping, complicated mode structure) depending on the operational parameters, which makes it difficult to investigate it entirely on a single machine. A Joint Experiment was set up by the ITPA Energetic Particle Physics Topical Group to combine the experimental efforts of several machines (JET, DIII-D , ASDEX Upgrade, KSTAR, LHD and MAST) which have installed or upgraded ICE diagnostics.

The qualification of ICE as a diagnostic requires several steps which involve experimentation. The first step is to characterize the nature (mode numbers, effect of background plasma composition) and evolution of the excited waves (in the linear, quasi-linear, fully non-linear and decay phases). Second, the method to reconstruct the properties of the exciting ions from the emission spectrogram has to be tested for different heating scenarios (using different geometries and power profiles of neutral beam injectors and/or Ion Cyclotron Resonant Frequency Heating) and benchmarked against other methods to characterize fast ion populations (4He, protons, beam ions), such as fast ion deuterium-alpha (FIDA) spectroscopy or fast ion loss detectors (FILDs) and then has to be applied to scenarios where instabilities such as ELMs (Edge Localized Modes) or TAEs (Toroidal Alfvén Eigenmodes) are present and analyzed with methods like Electron Cyclotron Emission imaging to check that ICE can indeed provide insights into the mechanism leading to fast ion losses. Finally, different diagnostic designs have to be tested to find the most flexible and least intrusive way of measuring the emission (using a Sub-Harmonic Arc Detector like on JET), especially to determine the quality of signal that is attainable by using an RF probe in the ICRF transmission line, away from the harsh environment inside the vacuum vessel.

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