Numerical Challenges in Modelling Near-Antenna Field Behaviour in Cold Plasmas

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Ion Cyclotron Radio Frequency antennas are metallic strip lines embedded in a metallic housing with a Faraday screen at the interface with the main plasma. Because of their highly different mass, electrons and ions respond differently to waves and to the proximity of metallic objects, close to which plasma sheaths tend to form. Since the dimensions of the antennas and the typical scale lengths on which sheaths occur differ by various orders of magnitude, it is numerically challenging to model near-antenna-field behaviour accounting for the actual density profiles and for the different types of waves that the plasma supports. Describing wave propagation in plasmas using the cold plasma tensor [1] has proven to be numerically difficult, in particular in the presence of metallic boundaries and in low to very low density plasmas, where both slow and fast wave branches are present, either as propagative or as evanescent waves. The field behavior in the neighbourhood of resonances (e.g. the Lower Hybrid resonance where the slow wave switches character) requires particular attention [2].

New simulations have been performed on the IFERC-CSC supercomputer Helios [3], which allowed pushing the number of grid points well beyond that of earlier results [2]. After optimizing the solver settings, the actual time for solving cases with up to 10 million unknowns is still modest, but memory allocation issues set the limits. The physical quantities are better resolved in the plasma interior, but still highly influenced by the metallic boundaries and the resonance layers. The effect of introducing ion and electron collisions to damp part of the short wavelength effects is demonstrated, as well as the use of a finite element description instead of a finite difference scheme. An outlook for a further self-consistent treatment of the sheath layer will be given.