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Title : Modelling of the power flow from parasitic absorption of Lower Hybrid power in tokamak plasmas

The goal of magnetic fusion research is to demonstrate the scientific and technological feasibility of fusion power as a means to provide a clean energy source for future generations. To achieve this, very hot plasma with temperature exceeding 100 million degrees must be generated and sustained for long durations. For long pulse operation in a tokamak, additional heating and current drive are required. One of the most efficient methods to generate non-inductive current drive is by using Lower Hybrid (LH) waves. The Tore Supra tokamak, located at CEA/Cadarache, is a world leader in this field, with two 3.7 GHz LH antennas able to inject 7 MW in continuous wave (CW) mode into the plasma and thus sustain long plasma discharges. For ITER, a 20 MW LH system at 5 GHz is proposed, aiming at extending plasma duration and assisting in improving its performance and stability. However, it is known that a fraction of the LH power can be absorbed due to parasitic processes in front of the antennas and cause localized power flows of several MW/m^2 on the intercepted antenna structures. The power absorption is due to a Landau interaction with low phase velocity waves generated by the LH antennas. The calculation of the power flow requires knowledge of the electric field, which is computed with LH coupling codes, e.g. [3].

In this thesis, it is proposed to develop a code module for modelling the power flow from parasitic fast electrons in front of the LH antennas, to be integrated into the existing set of LH codes. This module will have the LH antenna electric field as input and compute the acceleration of an electron population in the electric field, using a particle-in-cell (PIC) approach. After having got acquainted with the LH coupling code and LH antenna structure, the work will consist of learning to use a particle-in-cell (PIC) code, in collaboration with IPP.CR-Prague and/or VTT-Helsinki. The most interesting approach is the 2D electromagnetic code XOOPIC, which so far has only been used in preliminary studies for LH antennas [4]. Once the code has been adapted to the Tore Supra LH antenna structure, the power flow from the parasitic electron beam will be computed for experimental cases from Tore Supra, using realistic values of electron density and temperature at the plasma edge. The resulting power flow will be validated against the thermo-mechanical models and infrared data from the experiments. Modelling of LH experiments on other tokamaks, such as JET (UK) or Alcator C-MOD (USA), who are equipped with ITER-relevant wall materials, can be envisaged and predictions for the new WEST tokamak at Cadarache can be made. In addition, the effect on the fast electron beam by mechanisms occurring at the plasma edge, such as turbulence, may be analysed.

References

[1] Fuchs, V. et al.., Phys. Plasmas **3** (1996) 4023.
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[4] Rantamäki, K.M. et al., PPCF **44** (2002) 1349.

Skills : Plasma physics, computational physics