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PhD PROPOSAL 2010

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Title : Self consistent non-linear description of radio-frequency wave propagation and of peripheral magnetized plasmas.

Summary :

In order to heat the fuel and drive current in magnetic Fusion devices, high power radio-frequency (RF) waves are used. Excited at the plasma periphery, they propagate to its centre where they are damped by resonant interaction, giving their energy (heating) and momentum (current drive) to the plasma. Among the types of waves, those in Ion Cyclotron Range of Frequencies (ICRF – 30-80MHz) represent an essential means to heat the plasma on the tokamaks Tore Supra (TS), JET and later ITER.

ICRF waves being evanescent in vacuum and below a critical electron density, they are excited in the immediate vicinity of the well-confined plasma and are very sensitive to the properties of the peripheral plasma. Conversely the presence of intense near RF fields tends itself to modify the peripheral plasma in the immediate vicinity of the wave launchers. This non-linear interaction is likely caused by the biasing of the plasma edge by sheaths, with a non-linear electrical behaviour, at the plasma-wall interface. These processes are potentially harmful to the wave launchers themselves, but also to the magnetically connected objects as well as the plasma itself. Still badly known, these physical processes need first to be understood and then reduced as far as possible in next step devices, primarily in ITER.

So far the ICRF wave propagation and the direct current (DC) self-biasing of the plasma have been at best studied *sequentially*. This PhD thesis aims at describing the two phenomena *self-consistently*: two linear codes corresponding to each process are coupled non-linearly *via* proper boundary conditions accounting for the presence of sheaths at the walls. The current version of the RF part propagates ones wave polarization in two dimensions (parallel and transverse to the confinement magnetic field). The DC part of the model treats each magnetic field line independently of its neighbour.

The proposed PhD work includes first the extension of the RF model in three dimensions and with any wave polarization. This means establishing the equations of the physics model and implementing them numerically. The new numerical model will then be confronted with simplified analytical cases as well as particle simulations produced at University Nancy I, within the framework of project ANR SPICE RF (under submission). The model will also be confronted to experimental observations, in particular during the plasma tests of a new antenna front face on Tore Supra. Among the unexplained observations are for example the radial extension of the DC plasma biasing and the flow of wave-induced parallel DC currents in the plasma edge. If the new physics model successfully describes the present machines it will be applied in a predictive approach to simulate the plasma environment of the ITER ICRF antenna. This latter work, undertaken under the CYCLE cluster, will imply close collaborations with the Royal Military School (Brussels) and Politecnico Torino (Italy).

Skills : An outstanding physicist with inter-disciplinary competence in plasmas and wave propagation, the successful candidate will have special skills for non-linear analytical calculations and their numerical implementation. He/she will be able to communicate with experimentalists and engineers.