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ICANT code: a tool to compute the characteristics of ICRH realistic antennae and their near fields

S. Pécoul, S. Heuraux, R. Koch*, G. Leclert&, M. Bécoulet+ and L. Colas+.

Laboratoire de Physique des Milieux Ionisés, Unité CNRS 7040,
Université Henri Poincaré, Nancy I, BP 239, 54506 Vandœuvre Cedex (France)
*Laboratoire de Physique des Plasmas - Laboratorium voor Plasmafysica, Association "Euratom-Etat Belge" - Associatie "Euratom-Belgische Staat",
Ecole Royale Militaire -Koninklijke Militaire School 1040 Brussels (Belgium)
&LPIIM UMRCNRS 6633 Univ.de Provence St Jérome, Case 321 13397 Marseille Cedex 20
+Ass. Euratom-CEA pour la fusion contôlée CEA Cadarache 13108 St Paul les Durance (France)

1. Antenna Modelling and improvements of the ICANT code.

The ICANT code solves the antenna radiation problem using a finite boundary method combined with a spectral solution of the interior problem [1]. A large number of cases have been tested: either in vacuum with and without magnetic shielding on thin conductor [2-5], or with a plasma propagating the magnetosonic (fast) wave only [4-6]. The ICANT code has been improved to compute self consistently the current profile on a 3D antenna with a protection around the strap and a finite screen with thick blades. Different launching structures have been considered, from of a single strap with a finite Faraday screen to a more realistic modelling of the Tore Supra ICRH antenna (two straps, finite Faraday screen with protections, bumper limiters) [6]. Maps of the near electric field have been used in a RF sheath code to describe the convective cells in front of the antenna [7].

We show in this paper two important improvements: (i) the impedance matrix which describes the plasma includes now both the fast and the slow wave for a plasma step, and (ii) it is possible to include thick elements. For instance we have considered the case of thick screen blades with a constant distance between the strap and the plasma. Hereafter in most cases, the computation parameters correspond to the antenna of the Tore Supra Tokamak (R_o= 2.4 m, a= 0.83 m, l_y =0.7 m (strap length), l_z= 0.23 m (strap width) and B_t= 3 T). We first present results for inhomogeneous plasmas in the case of the fast wave only.

2. Effects of the density profile on the antenna coupling in the case of the fast wave

For inhomogeneous plasmas in the case of the fast only, the optimal density for the coupling is shifted toward higher values compared to homogeneous plasma cases. At low central density, the radiated power is smaller than in the homogeneous plasma case because the propagation region of the plasma is pushed farther away. On the contrary, at higher density, coupling is improved by the smoother density gradient (see fig. 1). This fact can be illustrated by changing the exponent ß at fixed α in the expression of the density profile $n_e(r)= n_{center}(1-(r/a)^{\alpha})^{ß}$, where a is the plasma radius. However, at high enough central density, the inhomogeneous plasma looks again like a metallic wall. These facts explain why an optimal density can be found for each frequency. For inhomogeneous plasmas, the contribution of the coaxial modes [6] is usually lower, although in some cases the contrary may happen.

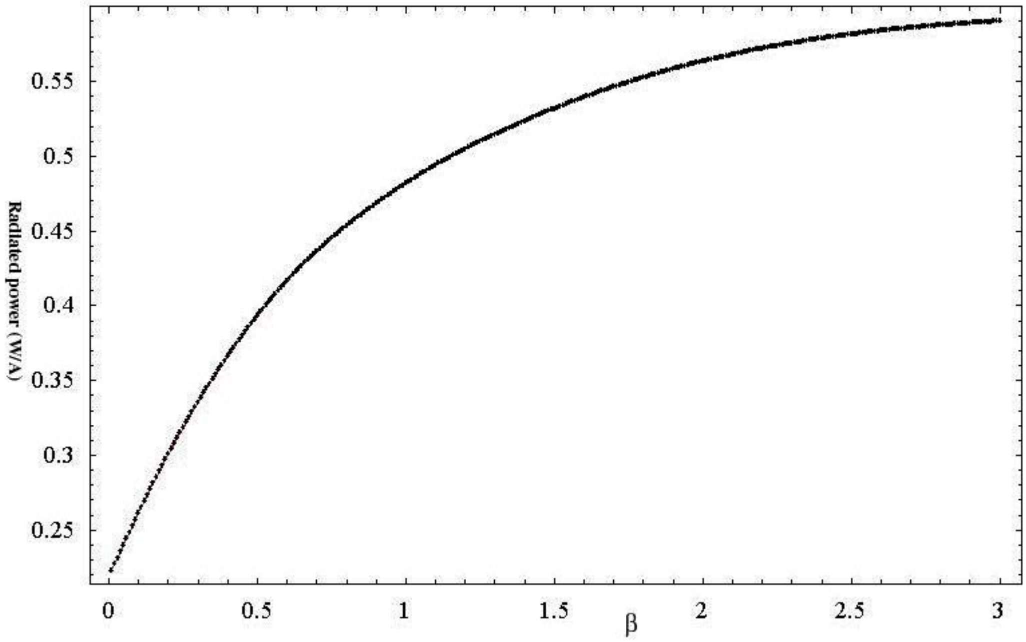

Figure 1: Effects of the shape of the density profile $n_e(r)= n_o(1-(r/a)^2)^ß$ *on the radiated power P(ß) (ν= 48 MHz and* n_o *=5* 10^{19} m^{-3}*).*

3. Role of the slow wave on the antenna coupling

One expects that the effect of the slow wave is stronger when there is no polarising screen. Indeed, for an unscreened strap, specially at low density (n_e < 10^{18} m^{-3}), the effects induced by the slow wave on the radiated power become more and more significant as the launched frequency increases. With a Faraday screen, the radiated power is nearly unchanged (figure 2); there is only a small variation at low density. The large peak in Fig.2 corresponds to a density, where coupling between the vacuum wave and the fast wave inside the uniform plasma is optimal. For much lower densities, the fast wave goes to cut-off and, at high enough central density, the plasma looks like a metallic wall. The irregular variations around 10^{17} and 10^{18}m^{-3} are due to the presence of the lower hybrid resonance layer ($\varepsilon_1 = 0$), and for the lower $k_{//}$ part of the spectrum, the associated confluence between the fast and the slow wave. As the frequency is increased the density at which the lower hybrid resonance is taking place also increases, moving these secondary peaks to higher density. On the contrary, because the wavelength becomes shorter at higher frequency, the main peak corresponding to optimal density shifts to lower density, such that they ultimately merge (around 100 MHz).

For an impedance matrix computed from the IBWWG code (LPP/ERM Brussel) including the Ion Berstein Wave is used in the case of a plasma step (ν= 42 MHz), only small changes on power and near field computations have be seen. But to say more about its subject, it is necessary to compute an impedance matrix in the case of an inhomogeneous.

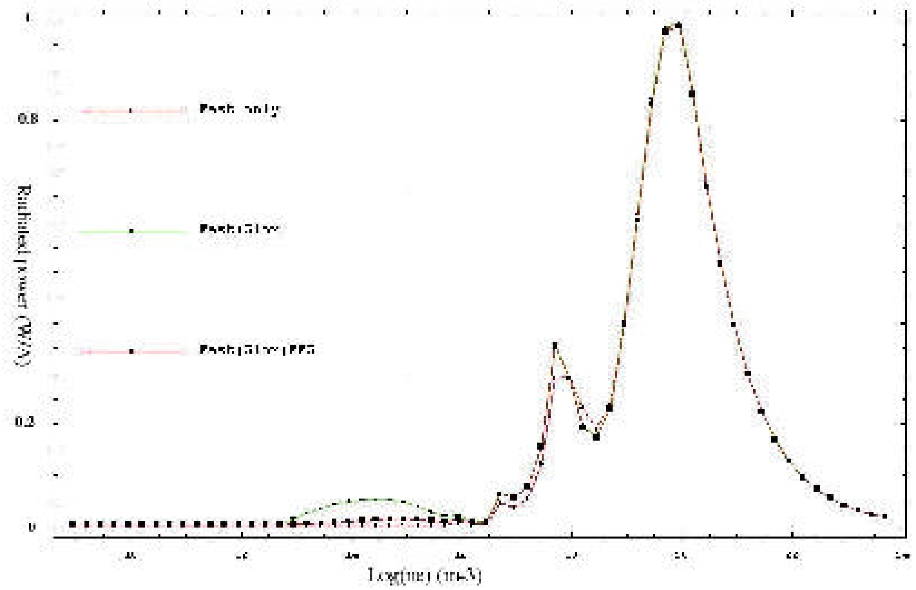

Figure 2: Radiated power versus electron density in the case of a plasma step in the case of fast wave only, fast and slow wave with and without Finite Faraday Screen.

4. A realistic modelling of a two strap antenna (dipole) with thick blades.

The geometrical features of the antenna must be properly included in the modelling (slanted Faraday screen, trombone shaped elements, …). Trapezoidal elements have been implemented to take into account the tilted screen blades connected to a vertical boundary, thus allowing to describe more realistic antennas (e.g. the Tore Supra antenna). A good description of the electric properties of each antenna part is needed (anisotropy of the bumper conductivity, tuned antenna and so on)[7].

As an example, let us consider a two-strap antenna with an unslanted screen with thick blades where the thickness of the screen blades is four times smaller than the blade width. The part of the screen blades in front of the plasma is at the same radial position for the thin or thick screen. First the comparison between the k-spectrums in the case of homogeneous plasma for thin and thick blades shows that the maximum value of the k-spectrum for the thick blades is shifted to higher values in the k_z direction (see fig.3) and is more extended in the (k_y,k_z) space.

In this case, the radiated power given by the antenna with thick screen blades is larger than the radiated power given by the antenna with thin screen blades.

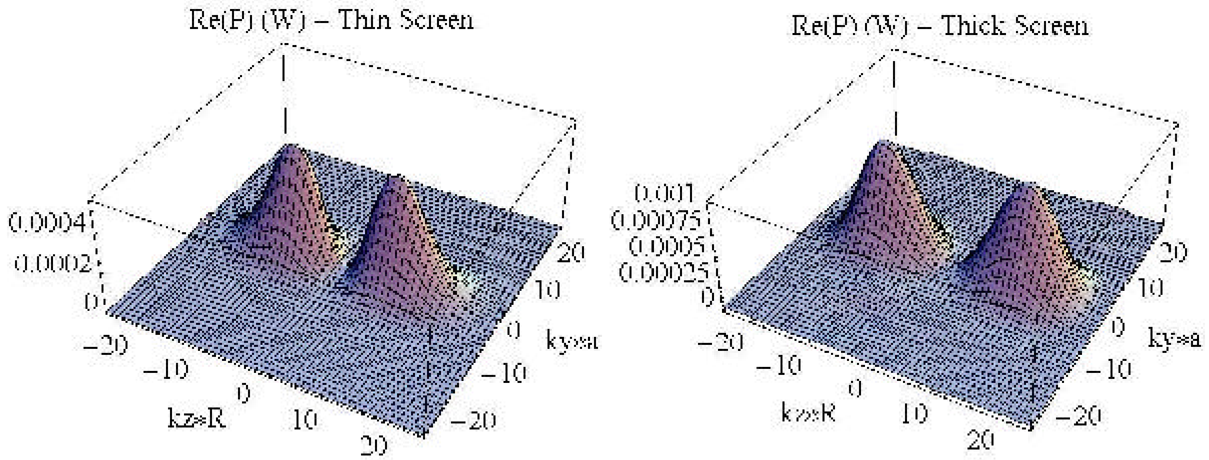

Figure 3: *K-spectrums for plasma step in the case of two straps (dipole) with thin and thick screen blades.*

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