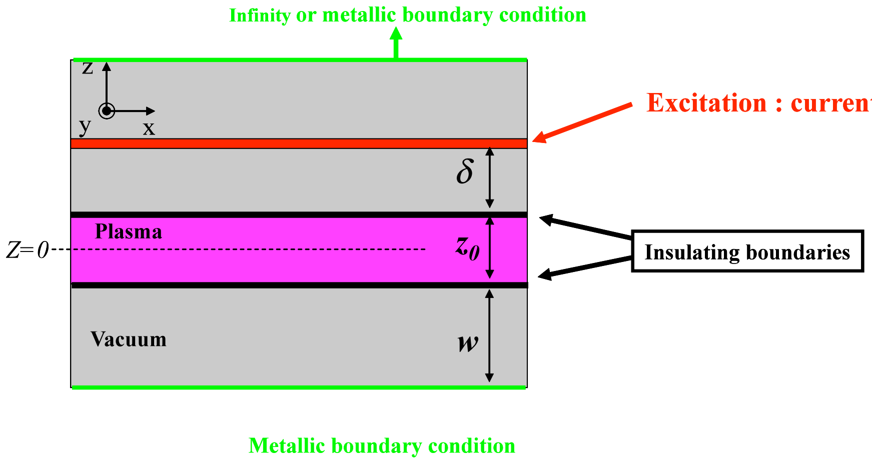
Helyssen plane antenna (mention the patent)

Here we deal with a totally unexplored field, which is the excitation of plane polarised "helicon like" waves into magnetised plasma. For convenience, we decided to call this kind of plane polarized modes "planons" in order to make the distinction with helicons which are cylindrical circularly polarised modes.

From a theoretical point of view, it can be shown that electromagnetic normal modes of magnetised plasmas can also exist in a plane geometry, which is not so surprising. The question is: how can we excite such interesting waves to produce dense plasmas over large areas. Let's consider a plasma slab, as shown on figure 15, unlimited in the (x,y) plane and with a thickness z_0. We also suppose that a static magnetic field is applied to the plasma slab.



Normal electromagnetic modes for such a plane geometry will be of the following form:

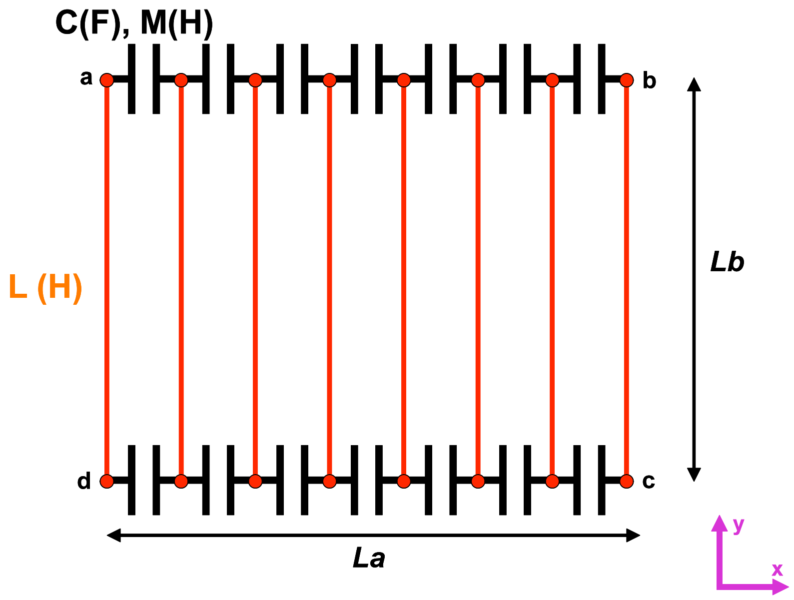
$$\{\vec{E}(x,y,z,t),\vec{B}(x,y,z,t)\}=\{\vec{E}(z),\vec{B}(z)\}\exp\{i[-\omega t+k_x x+k_y y]\}$$

where the wave numbers k_x and k_y and the pulsation ω are supposed to be fixed. This being stated, the z dependence of the E,B fields will depend on the plasma density, on the slab thickness z_0, on the direction and the intensity of the static magnetic field, etc…As for the cylindrical geometry, an ideal excitation for planons should generate a wave field that match as well as possible these normal modes structure. This means that the current sheet shown on figure 15, which represents an idealisation of the exciting antenna, should have the following form:

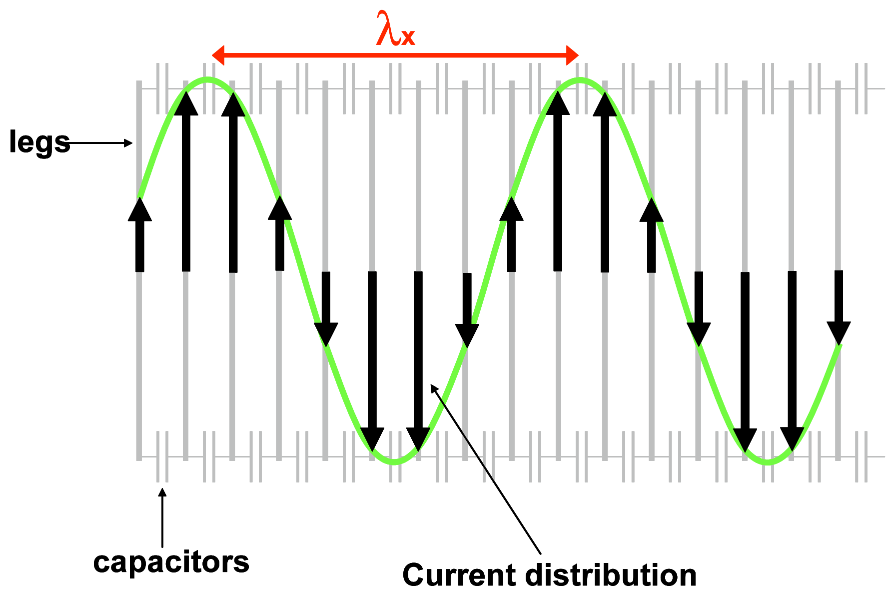
$$\vec{I}=\begin{pmatrix} I_{x0} \\ I_{y0} \\ 0 \end{pmatrix}\cdot e^{i(k_x x+k_y y-\omega t)}$$

Optimal relative values for I_{x0} and I_{y0} can be found, depending only on the orientation of the static magnetic field. For a field applied in the x direction one would find the condition $I_{x0}=0$ for an optimal wave-antenna coupling.

Lets then consider the plane Helyssen antenna schematically represented bellow:



As for the cylindrical geometry this antenna is a resonant system. For each resonant frequency, a sinusoidal current distribution is generated in the antenna legs.



This gives a very good approximation of a current sheet: $\vec{I} = \begin{pmatrix} 0 \\ I_{y0} \\ 0 \end{pmatrix} \cdot e^{i(k_x x)}$

As for the cylindrical antenna, if we now perform a proper quadratic excitation of the plane antenna we can generate a travelling current distribution with a phase velocity $v_x = \frac{\omega}{k_x}$, which means that this structure gives a very good approximation of a current sheet: $\vec{I} = \begin{pmatrix} \mathbf{0} \\ I_{y0} \\ \mathbf{0} \end{pmatrix} \cdot e^{i(k_x x - \omega t)}$, which is almost the ideal current sheet expression.