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Hybrid frequency singularity in oblique incidence cold model plasmas

A cold plasma model couples the Maxwell equations with a linearized fluid model equation for the motion of electrons. The model is based on two physical quantities, respectively linked with the electrons density $n_0(x)$ and the imposed magnetic field $B_0(x)e_3$, e_3 being the vertical unit vector.

When an electromagnetic wave, of wave vector k enters this plasma, two cases are of interest. The case k is orthogonal to e_3 is the normal incidence case, and the global system boils down to two decoupled 2 by 2 systems of ODEs (called respectively the ordinary and extraordinary systems). The case where k is not orthogonal to e_3 yields a fully coupled system of ODEs of order 4.

We study this system, and we show that this system is rigorously understood by studying the behavior of the underlying ordinary and extraordinary systems, the coupling of these results being possible.
The resulting electromagnetic wave mixes, for all components of the field, the natural resonance points in very general situations.