Numerical code for calculating plasma waves dispersion in relativistic magnetized plasma

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Propagation of electromagnetic waves in a plasma and a problem of plasma instabilities play a crucial role for both astrophysics and laboratory tasks. In such studies, it is important to know how dielectric tensor $\varepsilon_{\alpha\beta}(\omega,\mathbf{k})$ of the medium depends on the frequency ω and wave number $\mathbf{k}$ of oscillations. Often, the considered systems have a significant temperature, a non-Maxwellian distribution and are immersed in an external magnetic field. In this case, the calculation of $\varepsilon_{\alpha\beta}(\omega,\mathbf{k})$ is associated with significant difficulties. Therefore, researchers restrict themselves usually to either the case of a cold plasma or other simplifications and limiting cases. However, results of calculations in various models differ dramatically. In fig. 1, the growth rate maps $\Gamma(k_\perp,k_\parallel)$ for the beam-plasma instability are shown. Great differences in the transition from the cold case to hot and magnetized ones are clearly visible.

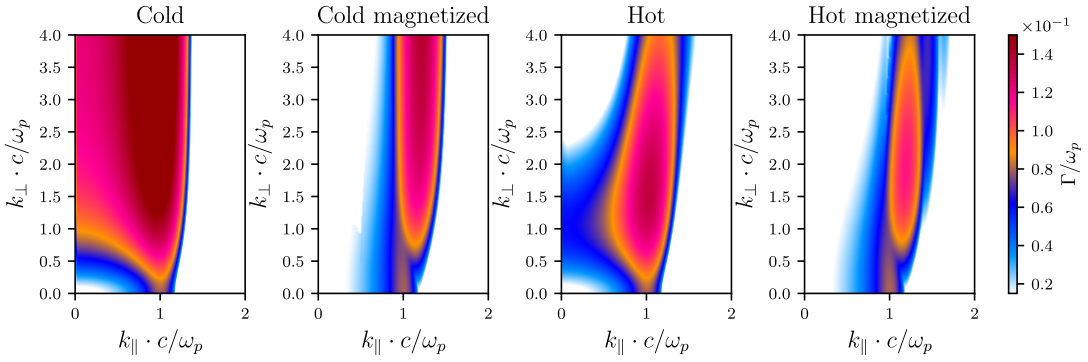

Figure 1: *Growth rate map* $\Gamma(k_\perp,k_\parallel)$ *for the beam-plasma instability. Electron beam density is* $n_b = 0.05n_0$ *(*n_0 *– plasma density), while energy is 1 MeV. In magnetized cases cyclotron frequency of electrons is* $\Omega_e = 0.5\omega_p$*. In hot cases plasma and beam have Maxwellian distribution with temperatures* $T_e = 80$ *eV and* $T_b = 10$ *keV respectively.*

In this work, we present a numerical code capable of calculating $\varepsilon_{\alpha\beta}(\omega,\mathbf{k})$ for arbitrary functions of the charged particles distribution and taking into account an external magnetic field and relativistic effects as well as several examples of its application. This code is developed as a shared library, which makes possible to integrate it into third-party programs. The computing architecture can be Nvidia GPGPU (via CUDA) or conventional multi-core CPU (via openMP).

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