Diocotron instability.

The classical diocotron instability is one of the most common instabilities in a low density non-neutral electron plasma with shear in the velocity flow. It is important in an electron plasma with ωpe/ωce less than 1 with low or zero density ions, ωpe is the electron plasma frequency and ωce is the electron cyclotron frequency. The instability is common in electron layers and electron beams such as those found in the Gabor lens where electrons are confined radially by a uniform axial magnetic field Bo, and there is a conducting outer boundary of the cylinder. The cross product of the radial electric field and axial magnetic field produce a radially dependent azimuthal velocity and angular rotation frequency ωr = -cE(r)/rBo. The azimuthal velocity shear that develops is responsible for the instability generating an azimuthally propagating mode with frequency ωD = ωpe2/2ωce, the diocotron frequency, the growth rate can be of order of the diocotron frequency for annular electron beams which is the most unstable configuration. The mode is a flute like structure on the surface of the beam.

The outer conducting boundary ensures there is zero tangential electric field this also results in the radial velocity being zero. Some configurations use an inner conducting cylinder that also ensures the tangential electric field is zero on the inner conductor. The Gabor lens will have no inner conductor.

The equations used to study the stability of the configuration are the momentum equation, continuity equation and Poisson’s equation. These have been solved for a number of different density profiles shown below with the real and imaginary components of the frequency being of the order of the diocotron frequency times a geometric factor (see R Davidson ref below).

A uniform density profile is always stable. The proximity of the outer conducting wall also influences the stability. Growth rates reduce if the electron column is close to the wall.

Below are cross-sections of the electron density that have been studied in the literature see R.Davidson, Physics of Fluids 28, 1937 (1985). The most unstable is (c) with (b) next most unstable (a) is stable while (d) is weakly unstable. It should be noted that these were obtained in a slab geometry and not cylindrical.

Electromagnetic and relativistic effects can influence the stability making the beam more stable.

Calculations of the instability will follow. These depend on electron density, magnetic field and size of electron column and cylinder radius.

