Gabor lens – literature summary

Lens characteristics

- A theoretical work function can be defined for the lens
  - Numerical calculations (electron density, filling factor, emittance growth) mostly agree along this work function
  - Additional features and disagreement away from the work function (not explained by theory)
- Average filling factors ≈ 30-40%, average density ≈ $10^{13} – 10^{14}$ m^{-3}
- Theoretical electron densities overestimate measured values
- Simulation suggests homogenisation of the electron cloud
  - Measurements show variations of up to 3% (good linear E-field up to r=20 mm)

Diagnostics

1) Measure the residual gas loss current and the energy of ions on axis
   - Input to the numerical codes + calculate average electron density from the potential depression
2) Measure intensity and profile of the light emitted by plasma along the axis
   - Allows observation of instabilities and some correlation with electron density
3) Optical-emission cross-section method
   - Evaluate the electron temperature from the intensity and wavelength of two emission lines in the residual gas (He)
   - Clear discrepancy with numerical predictions
   - Requires several assumptions about the plasma and good knowledge of the emission spectrum of a specific gas (benchmark showed deviations of up to 100%)
4) Measure the focal length
   - Allows an evaluation of average electron density

Beam transport

- The rms-emittance usually grows by a factor of 2 to 4
  - Operation near the work function can give a growth factor less than 2
- The orientation of the phase-space ellipse is consistent with simulation
  - Transformation is highly linear
  - Aberrations near the axis are only seen in experiment
- The focusing strength changes with the ion beam current (5 – 25 mA) when the parameter of the lens are kept constant
  - Electron density during beam transport measurements is reduced

Instabilities

- No instability or aberration were seen for fast variation (100 μs) of anode potential
  - Theoretical filling factors are longer than this (some variation should have been seen)
- Diocotron instability is seen in both simulation and experiment for lens settings away from the work function
  - It evolves in time scales of ns to ms
  - Can be clearly seen in the extracted ion current – it never drops to zero (not a destructive oscillation mode)

- Full notes on the literature covered so far
  - https://imperiallondon-my.sharepoint.com/:w:/g/personal/td1719_ic_ac_uk/EbXoDZL0ohdDhWU4M5xMxi0B7etWSb0_gxHgUq17s_tPyw?e=j3sASi