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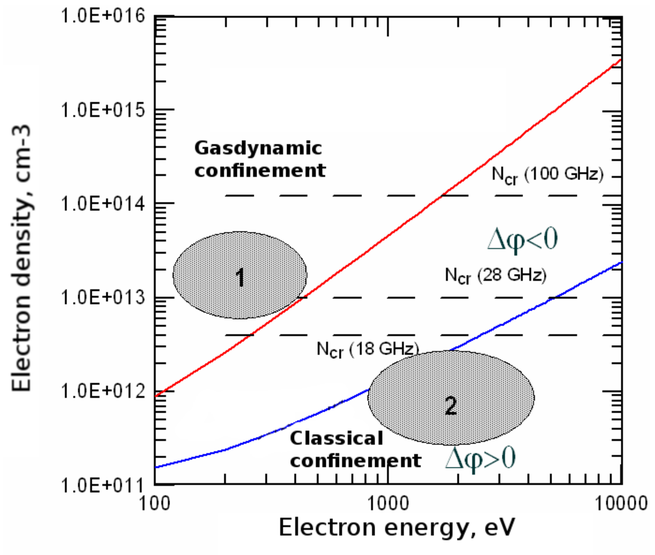
Study of plasma parameters in a CW gasdynamic ECRIS

Ivan Izotov, Vadim Skalyga, Sergey Golubev, Aleksey Bokhanov
Institute of applied physics of Russian academy of sciences
ivizot@ipfran.ru

Recent investigations of pulsed gasdynamic ECR plasma [1] resulted in development of a new type of electron cyclotron resonance ion source (ECRIS) – a so-called gasdynamic ECRIS - at the Institute of applied physics (IAP RAS). The main advantages of gasdynamic ECRIS are extremely high ion beam current in comparison with conventional classical ECRISes - current density up to 600 – 700 emA/cm2 in combination with low emittance i.e. normalized RMS emittance below 0.1 pi·mm·mrad. Previous investigations were carried out in pulsed operation mode with 37.5 and 75 GHz gyrotron radiation plasma heating with power up to 100 kW at SMIS-37 experimental facility. While the pulsed operation of gasdynamic ion source was studied in details [1,2], CW operation of such device is not well investigated. The present work demonstrates results of the first experiments of gasdynamic ECRIS operation in CW mode. A test bench named SMIS-24 has been developed at IAP RAS. Microwave radiation of 24 GHz CW gyrotron with power up to 5 kW was used for plasma heating in a magnetic trap with simple mirror magnetic field configuration. Preliminary studies of plasma parameters were conducted using Langmuir probe and X-Ray spectrometry of bremsstrahlung. Ion beam was successfully extracted from the CW discharge. The experiments demonstrated plasma parameters similar to those obtained in pulsed mode at SMIS 37 facility. Three electron components were observed - “cold” fraction with energies on the order of helium ionization potential, “warm” fraction with energies in the range of 30-70 eV, which is optimal for low charge states production, and “hot” fraction with spectral temperature in the range of 10-20 keV. Plasma density found to be on the cut-off level, i.e. $6*10^{12}$ cm-3. A long-term reliable operation with ion current density >1 A/cm2 (estimated) was demonstrated. Obtained experimental results demonstrate that the main advantages of the gasdynamic ECR ion source are preserved when switching to CW operation.

1. Golubev S et al. // Nucl. Instrum. Meth. in Phys. Research B, 2007, 256, 537
2. Skalyga V et al // Rev Sci. Instrum., 2014, 85, 2, 02A702-1



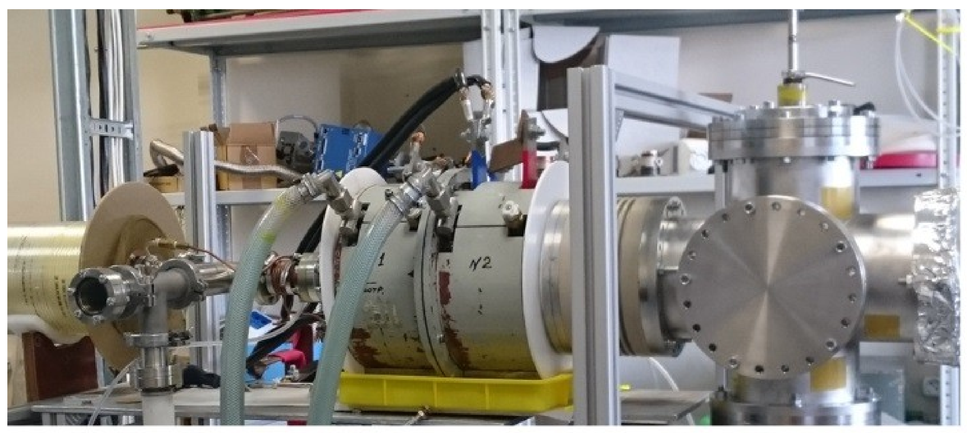
Gasdynamic ion source:

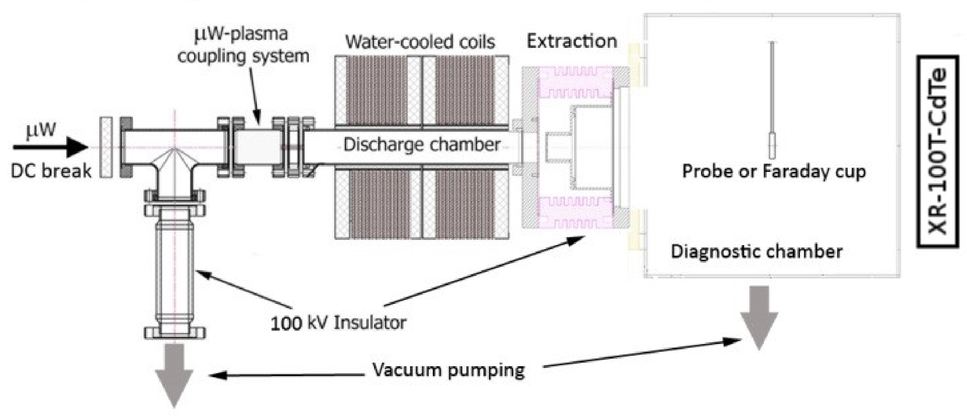
- Collisional plasma
- High plasma density (>10^{13} cm^{-3})
- Low electron temperature (~10-50 eV)
- High plasma flux density (>1 A/cm^2)
- Low emittance (normalized RMS emittance E_{RMS}<0.1 pi*mm*mrad)

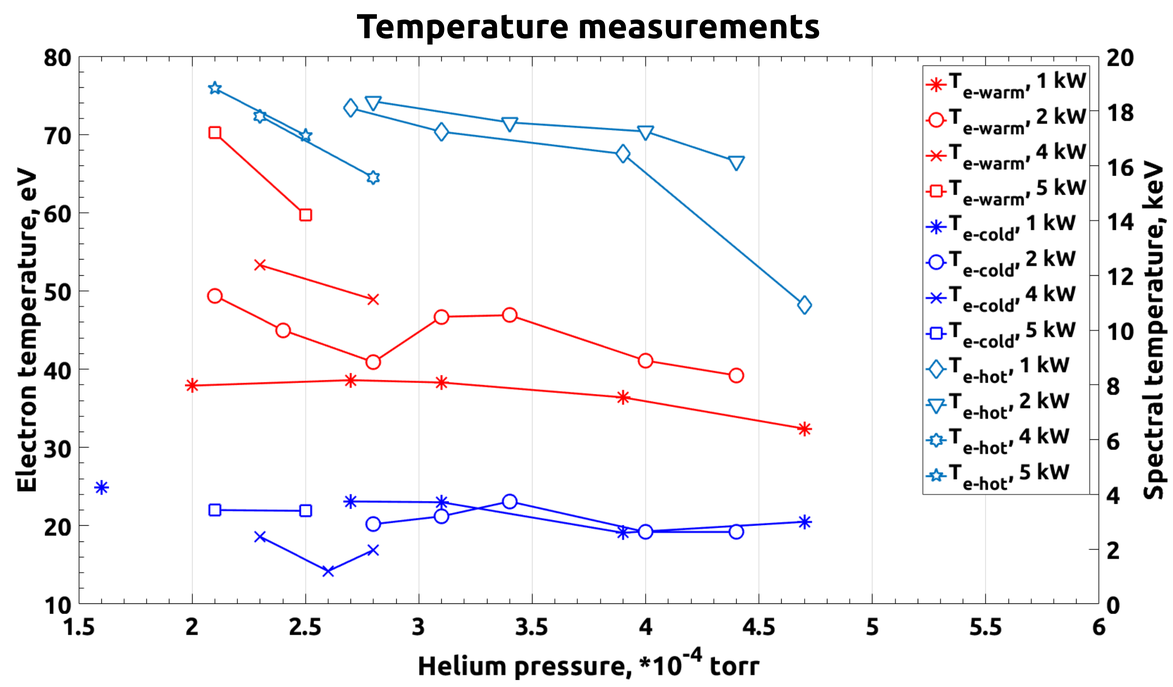
Obtained pulsed beams at SMIS-37:

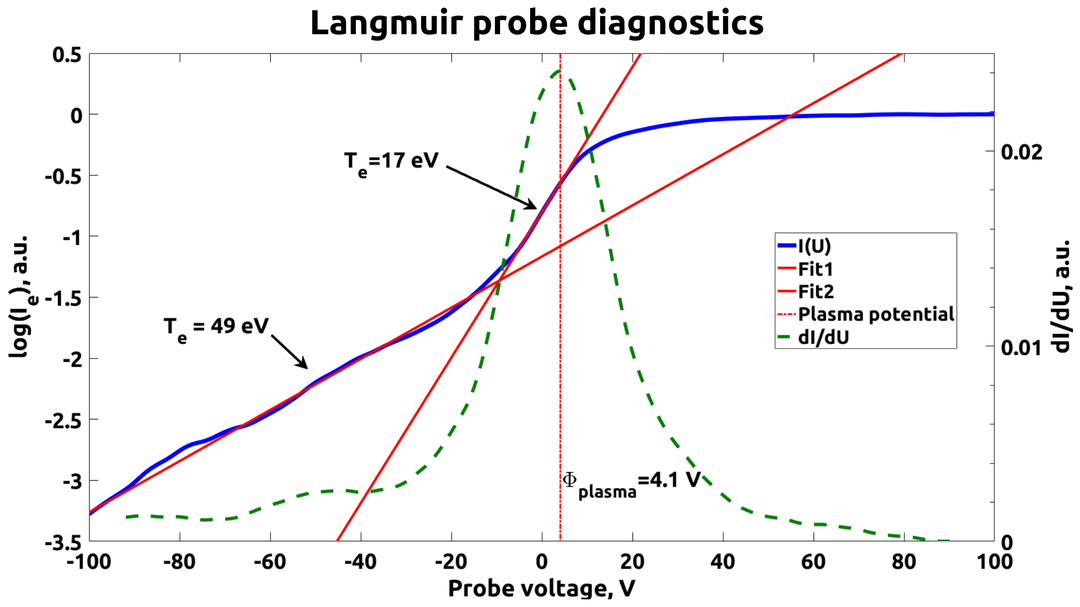
H+: 450 mA, 1 ms, E_{RMS}=0.07 pi*mm*mrad
D+: 500 mA, 1 ms, E_{RMS}=0.07 pi*mm*mrad

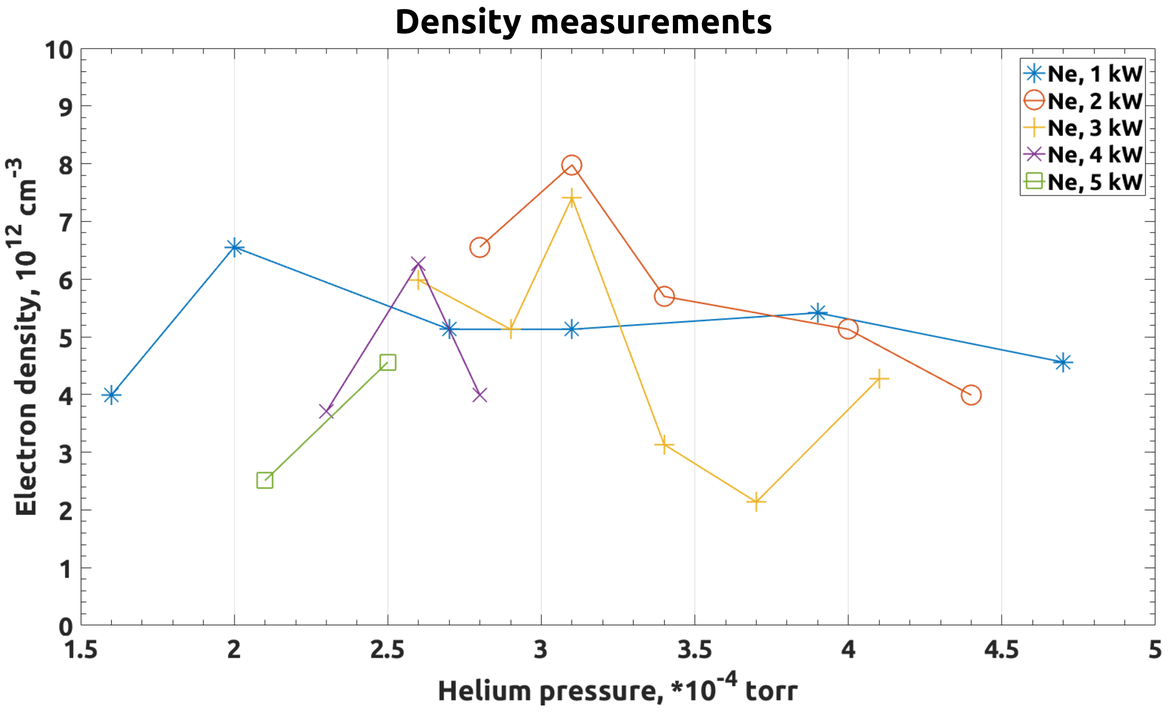
SMIS-24 – a CW gasdynamic ion source with simple mirror trap: experiments with Helium

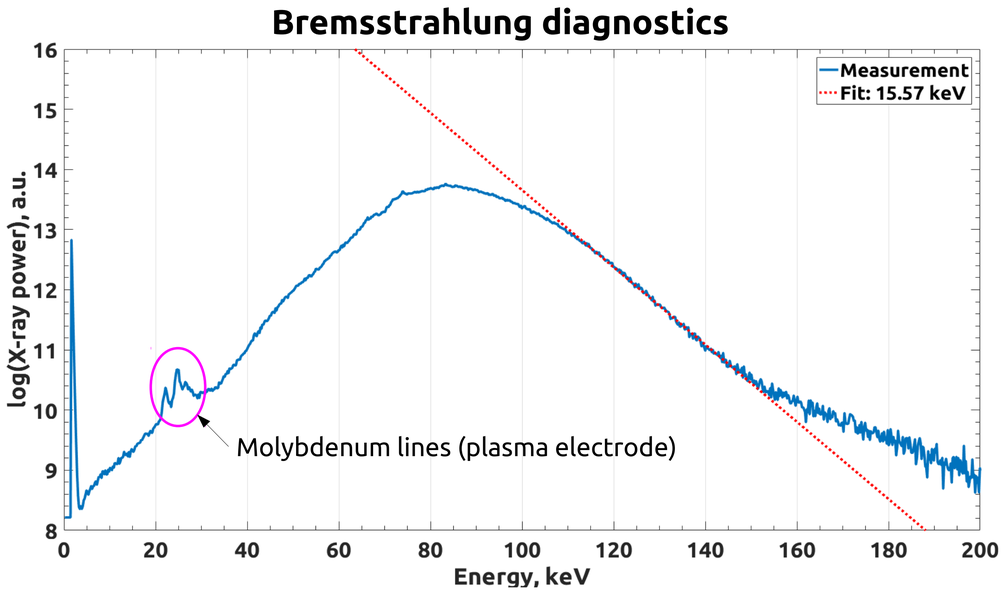












Summary

The experiments in gasdynamic CW ECR discharge sustained by 24 GHz gyrotron radiation demonstrated plasma parameters similar to those obtained in pulsed mode at SMIS 37 facility. Three electron components were observed - “cold” fraction with energies on the order of helium ionization potential, “warm” fraction with energies in the range of 30-70 eV, which is optimal for low charge states production, and “hot” fraction with spectral temperature in the range of 10-20 keV. Plasma density found to be on the cut-off level. **A long-term reliable operation with ion current density >1 A/cm^2 (estimated) was demonstrated.**