Contacts:

Dr. Olli Tarvainen
olli.tarvainen@jyu.fi
tel.: +358408054088
https://www.jyu.fi/

Dr. Thomas Thuillier
thomas.thuillier@lpsc.in2p3.fr
tel:+33476284022
http://lpsc.in2p3.fr/index.php/en/

Joint JYFL-LPSC PhD. Offer (Granted)

Field of activity: plasma physics, accelerator physics, ECR ion source

PHd. Project description

Electron cyclotron resonance ion sources (ECRIS) are widely used in accelerator based nuclear and material physics for the production of highly charged ion beams. ECR ion sources are capable to produce highly charged ions from a great variety of elements. The ionization occurs in a magnetically confined plasma sustained by high-frequency microwave radiation.
The performance of an ECRIS is traditionally quantified by measuring the beam current and quality of the extracted ion beams of different charge state ions. The stability of the extracted ion beam currents has drawn more attention recently as the technology is pushing its limits towards higher ion charge states and beam intensities. The stability of the ion beam is important for high power accelerator applications, medical applications such as carbon therapy and industrial applications such as electronic component testing, for example.
ECRIS plasmas are prone to kinetic instabilities due to anisotropy of the electron energy distribution function. The anisotropy arises from the nature of the resonant heating mechanism of the electrons and is affected by the microwave frequency and magnetic field configuration of the ion source. The observed plasma instabilities are associated with strong microwave emission and a burst of energetic electrons escaping the plasma, and explain the periodic oscillations of the extracted beam currents observed in several laboratories. The instabilities have been shown to restrict the performance of ECR ion sources, which needs to be taken into account as the ion source technology is pushing its limits towards future applications in accelerator physics.
The purpose of the project is to

- *Improve the diagnostics methods for the detection of the plasma instabilities and study their occurrence in ECR ion sources operating at frequencies from 6.4 GHz to 60 GHz.*

- *Determine the role of the magnetic field configuration, especially the field strength and gradient at the resonance, on the transition from the stable into unstable operating regime*.

  It has been observed previously that the transition from stable to unstable operation regime depends primarily on the magnetic field configuration of the ion source. However, it remains unsolved whether the transition is primarily affected by the field strength or the field gradient at the resonance. The experiment will be realized by varying the magnetic field strength and the microwave frequency of the ion source. The experiments will be conducted at LPSC where the magnetic field configuration of the PHOENIX-booster ion source can be modified mechanically to allow varying the field gradient at the resonance. The experiments will be complemented at JYFL studying the effect of the field strength on the transition from stable to unstable plasma regime. The ultimate purpose is to build a database making it possible to define whether the field strength or the gradient drives the transition from stable to unstable plasma state.

- *Quantify the electron losses associated to the instabilities and study the energy distribution of the electrons escaping the magnetic confinement*.

  The instabilities cause electron losses from the ECR ion source plasma. The amount of expelled charge is connected to the fluctuations of the beam current. The electron losses can be estimated by measuring the flux of the electrons and the fluctuation of the plasma potential during the instability. A systematic study connecting the electron losses and fluctuation of the plasma potential and measured ion beam current will be conducted during the described project. The energy distribution of the electrons escaping the magnetic confinement will be measured using the dipole magnet of the ion source beam line as electron spectrometer. The electron energy distributions measured in stable and unstable operating regimes will be compared to gain understanding on the instability mechanism.

The thesis work consists of installation of the diagnostics to various ECR ion sources at LPSC and JYFL, collecting experimental data and analysis of the results.

Thesis course information

The thesis work is a joint research (“cotutelle”) between University of Jyvaskyla (Finland) and University of Grenoble Alpes (France). The laboratories involved are Jyvaskylan Yliopisto University of Jyvaskyla (JYFL) and Laboratoire de Physique Subatomique et de Cosmologie de Grenoble (LPSC). In this framework, the student will be registered in both universities. A thesis grant is provided for this topic for 3 years. The work will start for 18 months at LPSC and will continue for 18 months at JYFL. A 4th year of study is likely to be financed by the University of Jyvaskyla to continue the work there.

Application Information

The applicant should hold a European Master of Science degree in physics. Students with skills and interests in accelerator physics or plasma physics are very welcome to apply. The deadline for application is set to June 15 2017. Please send a curriculum vitae along with at least two recommendation letters.