A.6: Hydrogen Ion Beam Extraction from ECR Ion Source and Beam Characterization

The electron cyclotron resonance ion source (ECRIS) has been built at Ion source laboratory of Proton Linac and Super Conducting Division to serve as an injector to the front-end proton linac system. Complete system photograph of the electron cyclotron resonance ion source is shown in Fig. A.6.1. Recently we have performed hydrogen ion beam extraction at 25 kV accelerating voltage and successfully extracted about 8 mA of stable hydrogen ions beam current as shown in the Fig. A.6.2. Internationally, efforts are being made to convert the ECRIS to a pulsed H- ion source with significantly higher lifetime.

A Thomson parabola ion spectrometer (TPIS) developed in the Laser Plasma Division was coupled with the ECRIS to study the ion tracks due to hydrogen and argon ions.

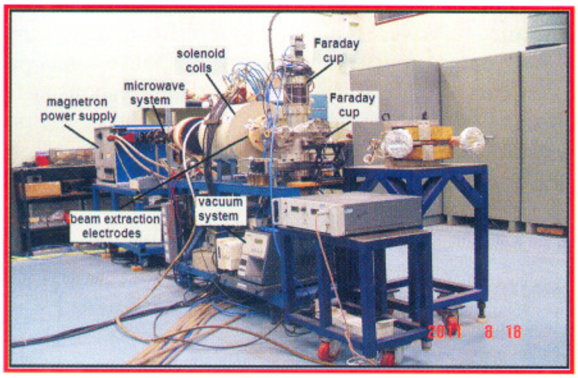

Fig. A.6.1: Photograph of the complete set-up of electron cyclotron resonance ion source.

An experiment was performed to generate stable hydrogen ions beam using 2.45 GHz microwave generated ECR plasma under solenoid fields in resonance conditions. The microwave power (800 watts) was coupled through quartz window. The ion beam current was measured using a Faraday cup (FC).

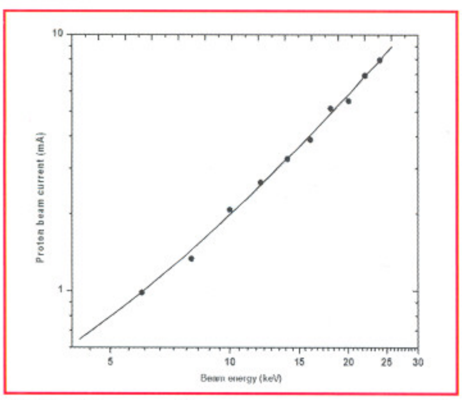

Fig. A.6.2 : Extracted ion current versus accelerating voltage.

The measured ion beam current versus accelerating voltage shows a nearly linear behaviour with a slope of 1.6, which closely matches with the slope of 1.5 expected from the Child-Langmuir law ($I \propto V^{3/2}$) for space charge limited ion current. The nature of the ion beam was determined by properly biasing the FC. In the above measurements, the FC was at zero potential. By applying a suitable negative bias voltage to the Faraday cup, it was ensured that there was no contribution due to electrons in the measured current.

The ion charge states generated in the hydrogen plasma and their energies were characterized with the help of TPIS. In a TPIS, the ions pass through a lead aperture with a pin-hole diameter of 500 μm and get deflected by parallel static electric and magnetic fields leading to parabolic ion trajectories on detector plane depending on their charge to mass ratio. A P-42 phosphor plate is used as a position sensitive detector to record the ion traces. The output of the phosphor screen was recorded using an 8 bit CCD camera. The extraction potential was varied to change the beam energy. Fig. A.6.3 shows the image recorded with TPIS at different extraction voltages. The use of TPIS enables online observation of various charge states present in the plasma. Using an in house developed algorithm, the observed parabolic trace was identified as due to the proton beam and no other species of hydrogen ion could be observed. The algorithm also provides information of the ion flux at various ion extracting voltages applied to ECRIS. The derived ion energy of the proton beam matches well with extraction voltage applied to ECRIS. The flux estimated by TPIS and FC also matches very well.

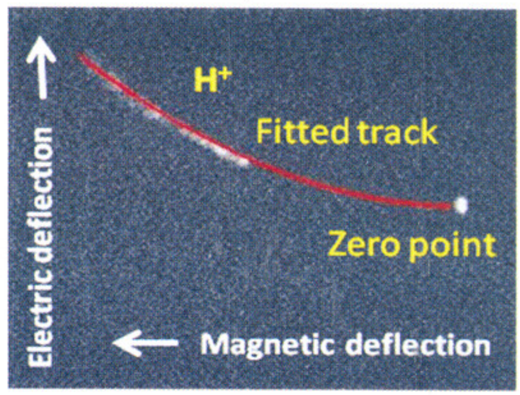

Fig. A.6.3 : The trajectory of the proton ion beam recorded using Thomson parabola.

Further experimental studies are in progress to study the x-ray emission from ion beam interaction with different target materials. Similarly, the ion beam trajectories of higher charged states for different ion species with different energies will be performed to study the parabolic tracks in the Thomson parabola.

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