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The Effect of Plasma Instabilities on the Background Impurities in Charge Breeder ECRIS

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Experimental observation of plasma instabilities in 14.5 GHz PHOENIX charge breeder ECRIS is reported. It is demonstrated with ^{133}Cs and ^{85}Rb that the injection of the 1+ ion beam into oxygen (^{16}O) discharge of the CB-ECRIS can trigger electron cyclotron instabilities, which restricts the parameter space available for the optimization of the charge breeding efficiency. It is concluded that the transition from stable to unstable plasma regime is caused by gradual accumulation and ionization of Cs/Rb and simultaneous change of the discharge parameters in 10 - 100 ms time scale, not by a prompt interaction between the incident ion beam and the ECRIS plasma. The delayed appearance of instabilities is presumably due to the variation of the electron energy distribution in a time scale similar to the reported breeding times of the high charge states of the injected ions. Since the commonly applied method of measuring the breeding time, i.e. pulsing the 1+ injection, clearly affects the charge state distribution of the buffer gas discharge and its electron energy distribution, it is argued that the actual breeding times in continuous operation can differ significantly from those obtained by studying the injection transient. Even more importantly, the instabilities lead to loss of ion confinement, which results to sputtering of the surfaces exposed to the plasma, followed by up to an order of magnitude increase of impurity currents in the extracted n+ ion beam. The data demonstrating the instability-induced sputtering is supported by time-resolved measurements of the biased disc current and ion beam energy spread conducted with the conventional JYFL 14 GHz ECRIS.

Authors: Dr TARVAINEN, Olli (University of Jyväskylä, Department of Physics); ANGOT, Julien (CNRS - IN2P3); IZOTOV, Ivan (IAP RAS); SKALYGA, Vadim (Institute of Applied Physics of Russian Academy of Sciences); Dr KOIVISTO, Hannu (University of Jyväskylä, Department of Physics); THUILLIER, Thomas; KALVAS, Taneli (University of Jyväskylä, Department of Physics); TOIVANEN, Ville (GANIL); KRONHOLM, Risto (University of Jyväskylä); LAMY, Thierry (LPSC Laboratoire de Physique Subatomique et de Cosmologie (LPSC))

Presenter: Dr TARVAINEN, Olli (University of Jyväskylä, Department of Physics)

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