Influence of initial plasma density and mean electron energy on the Preglow effect

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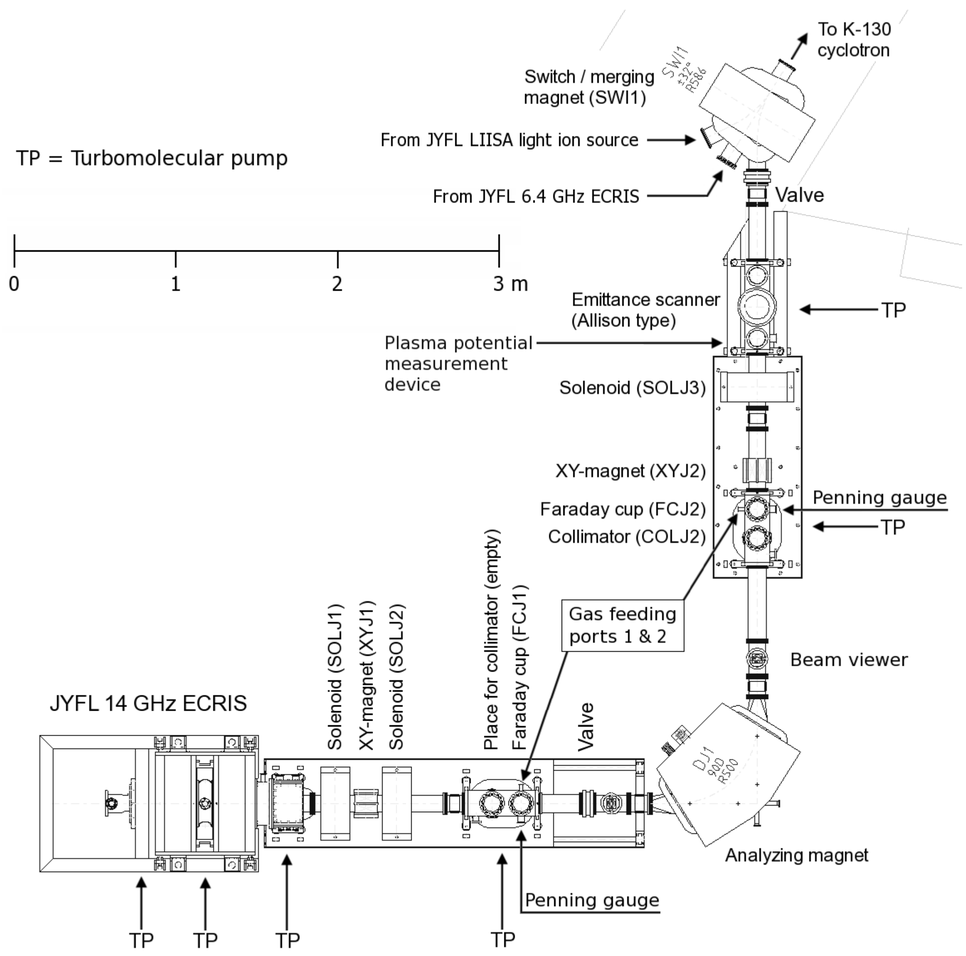
Abstract

The investigation of the Preglow effect is driven with the aim of creating a short- pulsed multicharged ion source. Recent experimental investigations have revealed strong influence of seed electrons, i.e. initial plasma density, on the amplitude and duration of the Preglow peak [1]. Present work, consisting of experiments and simulations, is dedicated to further investigation of the Preglow dependence on initial plasma density and electrons energy. Experimental investigation was performed at University of Jyvaskyla (JYFL) with the A-ECR type ECRIS operated with 14 GHz frequency. Helium was used for the study. An initial ionization degree of the gas was varied by changing the pulse duration and duty factor. Time-resolved ion currents of He+ and He2+ were recorded. Calculations were made by using 0-dimensional model described in references [2], [3] and based on the balance equations for the particles confined in the magnetic trap. Results of simulation are compared with experimental Preglow peaks and discussed. Good agreement between experimental data and simulation encourages us to conduct a further study, aimed at optimizing the Preglow by tuning source parameters and initial plasma conditions.

[1] O. Tarvainen et all. R.S.I., 81, 02A303, 2010
[2] T. Thuillier et all. R.S.I., 79, 02A314, 2008
[3] I. Izotov et all. IEEE Trans. Plasma Sci. 36, 1494, 2008

Scheme of the experiment



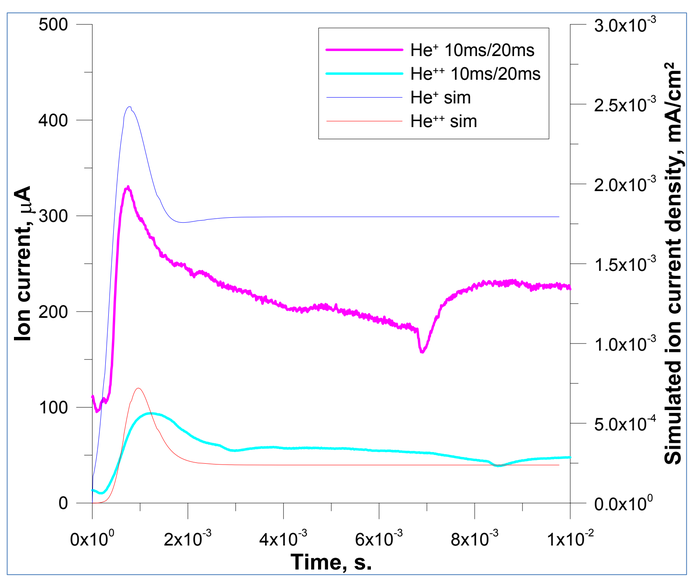
Zero-dimensional model of gas breakdown in a magnetic trap of an ECR ion source

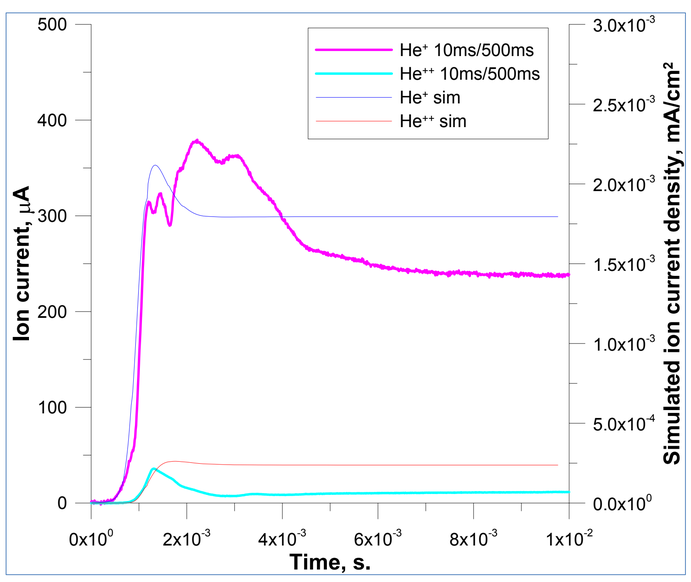
$$\begin{cases} \frac{dN_i}{dt} = (k_{i-1,i}N_{i-1} - k_{i,i+1}N_i)\cdot N_e - \frac{N_i}{\tau_i} & \text{Ions} \\ \frac{dN_e}{dt} = N_e \cdot \sum_{i=0}^{n-1} k_{i,i+1}N_i - \frac{N_e}{\tau_e} & \text{Electrons} \\ \frac{dN_0}{dt} = I(t) - k_{0,1}N_0N_e & \text{Neutrals} \\ \frac{1}{\tau_e} = \frac{1}{N_e}\sum_{i=1}^{n}\frac{iN_i}{\tau_i} & \text{Condition of quasi-neutrality} \\ \frac{3}{2}\cdot\frac{d(N_e\cdot T_e)}{dt} = \frac{P}{L} - \frac{N_e}{\tau_e}\cdot(T_e+\varphi_0) - \sum_{i=0}^{n-1} k_{i,i+1}\cdot N_e\cdot N_i\cdot E_i & \text{Balance of energy} \\ k = <\sigma v> = \frac{\int F(\varepsilon)\sigma(\varepsilon)v(\varepsilon)d\varepsilon}{\int F(\varepsilon)d\varepsilon} & \text{Ionization rate} \end{cases}$$

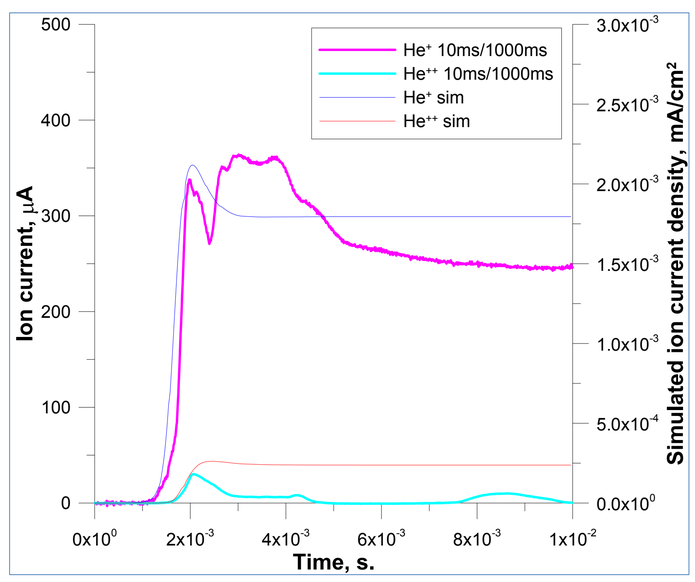
Free parameters of the model:
- *Gas density*
- *Microwave absorption rate*

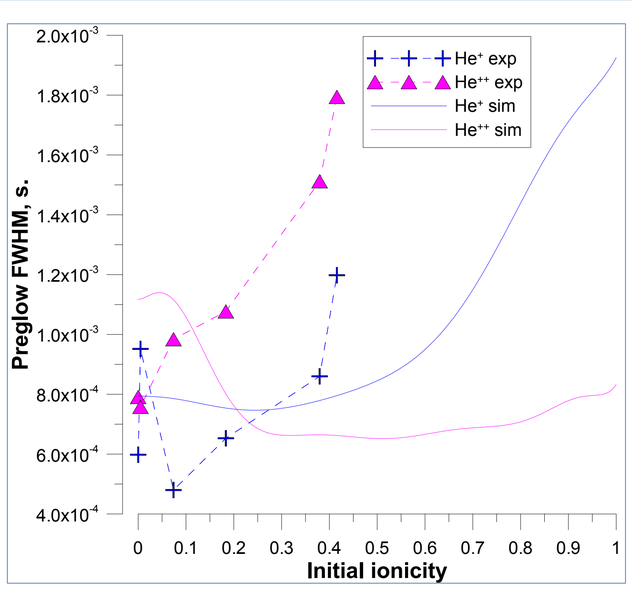
[1] S.V. Golubev, I.V. Izotov, S.V. Razin, V.A. Skalyga, A.V. Vodopyanov, V.G. Zorin. Multicharged Ion Generation in Plasma Created by Millimeter Waves and Confined in a CUSP Magnetic Trap. Transactions of Fusion Science and Technology, v. 47, n. 1T , fuste8, p. 345-347, 2005.
[2] V. Skalyga, V. Zorin, V. Izotov, A. Sidorov, T. Lamy, P. Sortais, T. Thuillier. Gas Breakdown in ECR ion Source. Review of Scientific Instruments. v.77, n3, p. 03A325-1 – 03A325-3, 2006.

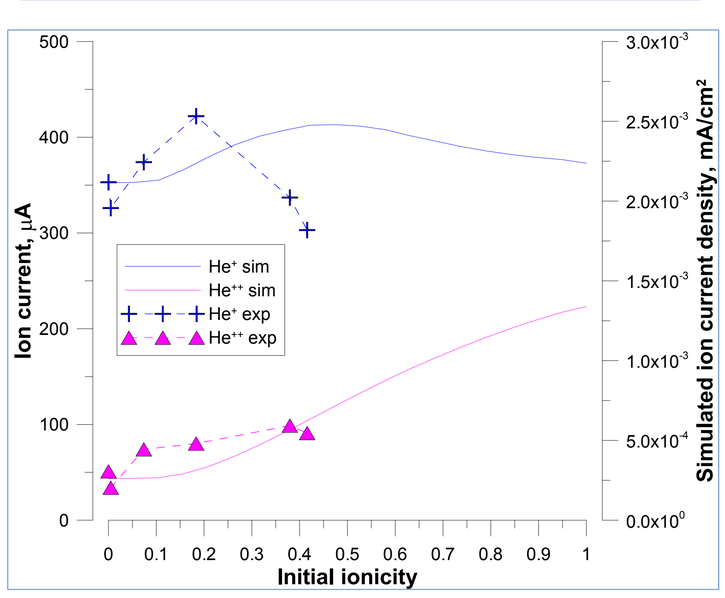
Comparison of experimental and simulation results:

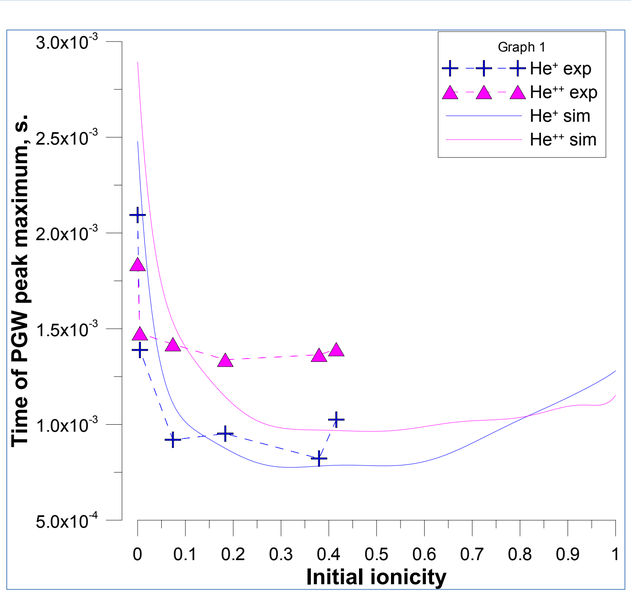












Summary

Preglow parameters dependences on initial plasma density were investigated experimentally and numerically. Results of simulation are in a good agreement with experimental data, allowing usage of suggested simulation model for Preglow numerical investigation. However, the second peak in an ion current oscillogramme couldn't be explained within the frame of suggested model and should be investigated further.