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Effect due to Cs injection upon the beam current oscillation extracted from the J-PARC negative hydrogen ion source

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A negative hydrogen (H^-) ion source with the plasma excited by 2 MHz radio frequency (RF) power serves as the beam source for the Japan Proton Accelerator Research Complex (J-PARC). We have been studying the H- ion beam intensity modulation at the frequency of plasma excitation RF power since we have found the beam carried the fluctuation at 2 MHz after the RFQ linac [1]. Higher frequency components were found present in the peripheral region of the plasma [2], and the high-speed emittance measurement system developed to clarify the change of the beam in phase space revealed the existence of diverging halo component oscillating at 2 MHz [3]. The fluctuation amplitude at the beam center was less than about 20%, while there was observed the component oscillating at 4 MHz.

The 4 MHz component seems related to the production of high energy electrons by the RF antenna as the intensity of the RF induction electric field takes the maximum twice in each cycle. On the other hand, the direction of RF magnetic field and the direction of electron flow change at 2 MHz frequency. Thus, H- ion formation mechanisms in the ion source can be estimated through precisely characterizing the extracted H^- ion beam. The H^- ion beam fluctuation can be observed in the H^- ion current measured with a Faraday cup. Before introducing Cs, the measured beam current showed the fluctuation at 4 MHz frequency when the axial magnetic field correction (AMFC) coil was turned off. The main fluctuation frequency changed to 2 MHz as the voltage to excite the coil to induce AMFC was increased. Injection of Cs into the ion source increased the H- ion current, while the 4 MHz component nearly disappeared for both cases of AMFC on and AMFC off. Possible mechanisms responsible for diminishing 4 MHz fluctuation component by Cs injections are discussed.

[1] K. Shinto et al. AIP Conf. Proc. 2011, 080016 (2018).
[2] M. Wada et al. Rev. Sci. Instrum. 91, 013330 (2020).
[3] T. Shibata et al. AIP Conf. Proc. 2373, 05002 (2021).

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