Control of plasmas for production of ultraslow antiproton beams

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Ultraslow antiproton beams in the 10 – 500 eV will be applicable for studies of the elementary processes of production of antiprotonic atoms [1]. ASACUSA collaboration prepared ultraslow antiproton beam source, MUSASHI (Monoenergetic Ultra Slow Antiproton Source for High-precision Investigation), by a combination with the CERN Antiproton Decelerator (AD) and a radio frequency quadrupole decelerator (RFQD) [2]. The MUSASHI is composed of two parts, an electro-magnetic trap (called multiring trap, MRT), and a low energy beam transport line. After the deceleration and cooling by the AD and the RFQD, antiprotons in 10 keV were captured and cooled to sub-eV energy via collisions between simultaneously trapped electrons in the MRT. Such cold antiprotons were extracted out of a strong magnetic field, re-accelerated, and focused into field-free region by using electrostatic lenses [3].

Since charged particles tend to follow magnetic field lines, a cloud of antiprotons should have a small radius in the MRT for better focusing of extracted beams. Without any radial compression, we have observed that the most of extracted antiprotons from the MRT annihilated around the entrance electrodes of the low energy antiproton beam transport line, where the strength of the magnetic field dropped. Therefore we developed a technique to control the radial distribution of antiproton clouds by rotating electric dipole fields.

In the MRT, it is known that cold charged particle clouds behave as non-neutral plasmas. Since electrostatic mode frequencies of non-neutral plasmas depend on the temperature, the observation of their modes allows nondestructive measurement of antiproton cooling process. We realized it by real time monitoring of electrostatic mode frequencies with a real time spectrum analyzer.

References

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