Creation and investigation of antimatter plasmas

H. Saitoh

Graduate School of Frontier Sciences, The University of Tokyo, Kashiwa, Japan

saito@ppl.k.u-tokyo.ac.jp

Recent progress in atomic and beam physics has made it possible to generate varied types of antiparticles that are utilized in various fields of science and technology today. On the other hand, however, there have been few experimental studies on the collective phenomena of antiparticle ensemble, such as waves, stabilities, and structure formation. In the antimatter related activities of the plasma apparatus unit, we aim to create magnetically-confined states of many antimatter particles and to investigate their plasma phenomena based on technologies in the field of plasma fusion sciences. As a primary goal, we focus on the formation and experimental understanding of electron-positron pair-plasmas [1]. The antimatter pair-plasmas, which consist of electrons and their antiparticles, positrons, are predicted to exhibit collective phenomena that greatly differ from ordinary ion-electron plasmas because of their mass symmetry and response to electromagnetic fields [2]. Phenomena related to electron-positron plasmas are important not only in basic plasma science context but also in the understanding of space environment where electron-positron plasma are believed to exist ubiquitously. Furthermore, the accumulation of a large amount of positrons, which is realized in the process of electron-positron plasma formation, enables a variety of research using more complicated antimatter such as positronium and antihydrogen atoms. In this project, we utilize mirror magnetic fields [3] and magnetic levitation dipoles [4], which have been developed as confinement configurations for fusion plasma [5-7], as trap geometries for antimatter plasmas. By experimentally investigating the dispersion relationship and stability of the generated electron-positron plasma, we will clarify the collective phenomena peculiar to pair plasmas defined by mass symmetry. Starting from the understanding of pair-plasma physics, we aim to realize the stable confinement of more diverse antimatter plasmas and to expand the scope of experimental antimatter plasma physics.

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