【Grant-in-Aid for Scientific Research (S)】
Science and Engineering (Interdisciplinary Science and Engineering)

Title of Project : Interdisciplinary Science Explored by Cryogenic Electrostatic Ion Storage Ring: from Astrochemistry to Radiation Biology

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Research Project Number : 26220607　Researcher Number : 70212529
Research Area : Quantum beam science
Keyword : Ion beam

【Purpose and Background of the Research】

An ion storage ring is the large-scaled device originally developed to increase the intensity and quality of the ion beam in high-energy or nuclear physics. However, an electrostatic ion storage ring has recently emerged. It opened up a chance to investigate much heavier ions like polyatomic molecular ions, cluster ions, and bio-molecular ions taking advantage of the required storage condition independent of the mass of the ions. We recently developed a new type of tabletop electrostatic ion storage ring. We cooled the whole ring device down to the ultralow temperature (5K) and attained an extreme good vacuum (10^{-15} Torr). We can prepare a variety of isolated cold molecular ions in vacuum under this cryogenic environment for the long period of the order of hour. The stored ions posses a translational energy of 10–20keV, and the reaction products from collisions or excitation are efficiently and easily detected.

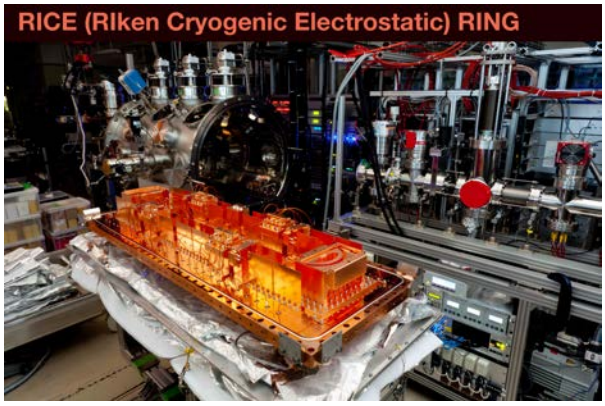

Figure 1 an assembly of the electrodes of the cryogenic electrostatic ion storage ring

Based on this newly developed device, we aim to create interdisciplinary research fields related with astronomy, chemistry, and biology.

【Research Methods】

We introduce a variety of ion sources to produce specific molecular ions to be stored. Large molecular ions produced by an electrospray ion source (ESI) are trapped in an additional cryogenic RF ion trap prior to the injection into the ring in order to enhance the number and to be extracted in a pulsed mode. By injecting an energy-tunable OPO laser and a dye laser into the straight section of the ring, we perform spectroscopy of the vibrationally and rotationally cooled ions. For studying low-energy collision dynamics, where the property of the molecules manifests itself, we also merge a neutral particle beam into the stored ions. The neutral beam is prepared by photo-induced electron-detachment of the accelerated negative ions. We obtain reaction probabilities as a function of the collision energy, namely energy-differential cross section by controlling the relative velocity.

【Expected Research Achievements and Scientific Significance】

The ion-neutral reaction in the region of low-temperature and low energy plays a crucial role in molecular evolution in space, and our project will bring a plenty of new data in this field. The expected energy-differential cross sections of the large molecular ions relevant to biological interests have not been measured due the experimental difficulty, and they also will bring new information in radiation biology.

【Publications Relevant to the Project】

・"Cooling dynamics of photo-excited C_6^- and C_6H^-", G. Ito, H. Shiromaru, M. Goto, T. Azuma, and K. Hansen at al, Phys. Rev. Lett. 112, 183001 (2014).
・ "Direct observation of internal energy distributions of C_5^-", M. Goto, A.E.K. Sundén, H. Shiromaru, T. Azuma, and K. Hansen et al, J. Chem. Phys. 139, 054306 (2013).

【Term of Project】 FY2014-2018

【Budget Allocation】 147,000 Thousand Yen

【Homepage Address and Other Contact Information】

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