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RIKEN Nishina Center for Accelerator Based Science
The 274th RIBF Nuclear Physics Seminar

Mass Spectrometers to Mars and Beyond

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Spaceflight mass spectrometers have helped to reveal the origin, evolution, and current state of planetary environments across the Solar System. Past missions to Venus, Mars, Jupiter, Saturn, and small bodies such as comets and asteroids have all incorporated compact, high-performance mass spectrometers that have operated autonomously in extreme environments and analyzed chemical, isotopic, and molecular composition of materials utterly unknown a priori.

The landing of the Curiosity Rover in Gale Crater on Mars on August 6, 2012 represented a landmark achievement in the exploration of Mars and indeed of the solar system. Thus began the in situ investigation of martian habitability, establishing a scientific basis of the possibility for life to have existed on Mars in the past. Enabled by the Sample Analysis at Mars (SAM) quadrupole mass spectrometer investigation, Curiosity has provided definitive in situ evidence of indigenous organic compounds in a martian sample, with more detections to come. SAM has also played a key role in the first K-Ar radiometric and surface exposure age measurements on Mars.

Looking ahead, ESA and Roscosmos, including contributions from NASA, are developing the ExoMars rover mission to be launched in 2020. ExoMars seeks to detect in situ signs of life in ancient materials with a new instrument payload and a unique sampling drill. Materials from as deep as two meters beneath the surface, where organics may be protected from damaging cosmic rays, will be delivered for analysis by several analytical instruments including infrared and Raman spectrometers and the Mars Organic Molecule Analyzer (MOMA). MOMA is a broadly sensitive dual source linear ion trap mass spectrometer investigation of complex organics that directly supports the ExoMars astrobiology goal. Its pyrolysis- and derivatization-based gas chromatography (GC) mode combined with a laser desorption (LD) mode to detect organics in drill samples over a wide range of molecular weights (50-1000 Da) and volatilities. Compounds of particular interest can then be isolated and structurally analyzed with MOMA’s tandem mass spectrometry capabilities. The MOMA flight model is now integrated into the ExoMars rover and preparing for launch in July, 2020 and landing in March, 2021.

Future missions will require even more capable mass spectrometers exhibiting capabilities to detect and characterize molecular composition to exceedingly low limits of detection and with high stability for quantitative studies. Specifications such as mass resolving power as high as 105 - 106 that can be achieved with technologies such as Orbitrap or multi-reflection time-of-flight mass spectrometry (MR-TOF-MS), and the ability to interface to a variety of sampling front end environments and concepts, are of great interest for mission and instrument concepts currently under study at NASA.

＊The talk will be given in English language.

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