Chemical Ionization of Xenon and Detection Utilizing a High Precision Digital Ion Trap (DIT)

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Isotope ratio mass spectrometry (IRMS) is commonly used in space applications to perform radiometric dating, and in the sourcing of gas distributions on an extraterrestrial body. Typically, these measurements are taken utilizing instruments such as time-of-flight and magnetic sectors. Ion traps however, are not normally considered due to sensitivity and precision issues that arise from space charge effects. To improve sensitivity, xenon will undergo chemical ionization (CI) to improve ionization efficiency. Additionally, improvements to the y-axis resolution of the data acquisition (DAQ) will allow for higher precision measurements.

Xenon gas is introduced into an external ion volume at a partial pressure of ~1 x 10^{-6} $torr_{,Xe}$ where it is ionized utilizing either an EI source or a CI source when introducing the appropriate reagent gas. Ions are then gated into a 3D – quadrupole ion trap operating in resonance ejection mode while utilizing digital square waveforms (DIT) for trapping and ejection. The ion trap operates with a constant 1 MHz frequency and 300 $V_{0\text{-}p}$ on the ring electrode while the endcap electrodes are operated with a frequency sweep ranging from 1 MHz – 15 kHz at 2 V_{dc}. For signal acquisition, a variable y-axis resolution (8-16 bit) DAQ system was initially employed. Data obtained was compared to a previously used fixed y-axis (8-bit) resolution DAQ.

Upon taking measurements it was found that our fixed DAQ system provided per mille deviations of 18.8 ± 105.8 $^{0}/_{00}$ while the variable DAQ system provided 0.5 ± 1.0 $^{0}/_{00}$ resulting in ~2 orders of magnitude improvement. To obtain these results, the new DAQ was operated with 16-bit y-axis resolution and with an integrated low pass filter set at 23 kHz.