A unique and novel ultra high-mass-resolution gas-source multi-collector mass spectrometer

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We describe a unique and novel isotope ratio mass spectrometer (IRMS), the *Panorama*, developed explicitly for high-mass-resolution analysis of isotopologue ratios of gas samples. The double-focussing instrument routinely operates at a mass resolving power (MRP, instrumental $m/\Delta m$) of 45,000 with a maximum MRP of ~60,000. The instrument achieves this exceptional MRP for a multi-collector using a Matsuda ion optical design with an ESA radius of 1018 mm and a magnetic sector radius of 800 mm. Collectors comprise 9 Faraday cups and a single channel of ion counting each with a continuously variable collector slit.

First results demonstrate both accuracy and precision comparable to, and in some cases, surpassing, other gas-source multi-collector IRMS instruments. For example, accurate bulk D/H and $^{13}C/^{12}C$ for methane gas measured with CH_4 as the analyte are measured simultaneously with internal precision of 0.02 to 0.04 ‰ (1 std error) and ~ 0.006 ‰ (1se), respectively. Ion counting with continous rebalancing of sample and standard gases permits high-precision measurements of rare, multiply-subsituted isotopologues with relative abundances as small as ~0.1 ppm. For example, in the case of methane, both $^{13}CH_3D/CH_4$ and CH_2D_2/CH_4 ratios are measured with precision of ~0.2 and ~0.7 ‰, respectively. Accuracy of the multiply-substituted species measurements is demonstrated in part using isotope ratio mixing experiments. The ability to measure both $\Delta^{13}CH_3D$ and ΔCH_2D_2 (‰ variations relative to the stochastic reference frame) provides heretofore unmatched capabilities to identify kinetic reaction pathways, isotope fractionation during transport, mixing, as well as temperatures of formation for methane gas.

The high-resolution instrument can be used for a wide variety of applications. For example, it easily resolves $^{36}Ar^+$ from $^{18}O^{18}O^+$ for oxygen bond-ordering studies. It also easily resolves NF^+ from $^{16}O^{17}O^+$, removing ambiguity for high-precision $\Delta^{17}O$ analyses of rocks and minerals by fluorination. Additional applications will be discussed.