Evaluation of the performance of prototype ATONA amplifiers for argon isotope measurements

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The new ATONA Faraday cup amplifier with a very low noise floor and effectively no upper limit will dramatically improve the measurement of isotope ratios for mass spectrometry. We show preliminary air standard results from the prototype ATONA amplifiers, designed and built by Isotopx, on the new NGX noble gas mass spectrometer at Lamont-Doherty Earth Observatory. Rather than using high-value resistors like traditional Faraday amplifiers, the ATONA measures the rate of change of the charge on a capacitor connected directly to the Faraday cup. Signal intensities are reported in units of A (for example, a 1 V beam on a 10^{11} Ω resistor amplifier is equivalent to 1E-11 A, or 62.4 million ion per second). We measured air standards of 6.6E-13, 7.7E-14, and 7.0E-15 moles, with ^{40}Ar signals of 8.5E-12, 1E-12, and 9E-14 A with ^{40}Ar and ^{38}Ar on ATONA Faraday detectors and ^{36}Ar on an ion counting multiplier. Reproducibility of ^{40}Ar/^{36}Ar was 0.08%, 0.21%, and 0.42% (1σ SD), respectively, for the three different splits.

To take advantage of the relationship between noise and integration time on the ATONA, we measured standards for the same amount of time with both 1 s and 10 s integration. The reproducibility of ^{40}Ar/^{36}Ar, which is controlled by the noise on the ICM, was identical, but the reproducibility of both ^{40}Ar/^{38}Ar and ^{38}Ar/^{36}Ar improved significantly because of the lower noise on the small ^{38}Ar Faraday measurement. This result is consistent with baseline noise tests that indicate noise levels of 8E-18 to 1.2E-17 A for the detectors with 10 s integrations. ATONA noise performance is between ideal 10^{13} to 10^{14} Ω (10^{12} to 10^{13} Ω) resistor amplifiers for 10 s (1 s) integration. Reproducibility for ^{40}Ar/^{38}Ar was 0.21% (.31%), 1.1% (3.8%), and 12% (26%) for 8.5E-12, 1E-12, and 9E-14 A signals using 10 s (1 s) integration.

In practical terms, the ATONA allows us to measure ion beams larger than we can measure on a 10^{11} Ω resistor amplifier or as small as we can typically measure on an analog multiplier or a 10^{14} Ω resistor amplifier, and without the same limitations on dynamic range and response time imposed by those detectors. In contrast to conventional amplifiers, the baseline signal on the ATONA does not change on the timescale of at least two weeks.