High precision measurement of isotope ratios using faraday collectors with ATONA amplifiers

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We present isotope ratio measurements using Faraday collectors equipped with new ATONA amplifiers. The ATONA amplifier replaces the resistor in the detector feedback circuit with a capacitor. This results in extremely low noise when compared with resistors. For example a Thermal Ionization (TIMS) with ATONA has a noise level of $3x10^{-17}$ amps for a typical 10 second integration, reducing to $6\ x10^{-18}$ amp for 100 second integrations. These noise levels are comparable with 1e13 ohm resistors. However, while 1e13 ohm resistors have similar noise, they have a restricted dynamic range, i.e they cannot measure ion signals greater than $5x10^{-13}$amps. ATONA amplifiers in contrast can be used to measure ion signals in excess of $1\ x10^{-9}$ amps. This unique combination of low noise with a dynamic range in excess of nine orders of magnitude offers the opportunity to measure extremely small ion signals (samples) on Faraday collectors and also large isotope ratios using the same detector, without using a range of resistors, or combining Faraday with ion counting detection. Multiple analyses of $^{234}U/^{238}U$ in natural uranium with a $1x10^{-10}$ amp ^{238}U, ($5.4X10^{-15}$ amp,or 33,000cps), yield reproducibility of 1 per mil 2σ. This is more than ten times better precision than conventional 1e11 ohm resistors and is comparable with ion counting/Faraday precisions, with ^{234}U measured on the ion counter. There is no need to calibrate ion counting deadtime or gain drift. $^{43}Ca/^{44}Ca$ reproducibilities of 50ppm 2σ, are comparable with $^{40}Ca/^{44}Ca$ reproducibilities, despite a ^{43}Ca ion signal of only $2\ x10^{-13}$ amps, more than an order of magnitude lower than ^{44}Ca. The similarity in precision is due to the difficulty in fractionation correcting the $^{40}Ca/^{44}Ca$ ratio using $^{42}Ca/^{44}Ca$. A more accurate fractionation correction would imply that reproducibilities of better than 20ppm 2σ are possible for $^{40}Ca/^{44}Ca$ with low noise high gain Faraday amplifiers. Combining ATONA with ion counting offers further opportunity to improve precisions in U-Pb geochronology, since gain measurement between ion counter and Faraday can be achieved at higher precision with lower intensities.