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Analyzing Ca-41 sample at 1E-15 abundance level with cold atom trap techniques

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On earth, Calcium-41 is produced as a cosmogenic isotope via neutron capture process, leaving a natural isotopic abundance of 10^{-15} on earth surface. Calcium is also of vital importance for the metabolism of biological organisms. Consequently, analysis of the long lived radioactive isotope Calcium-41 is of great importance in geoscience, archeology and life sciences. The half-life of Calcium-41 is 1.03 x 10^5 years. It is a good candidate in dating rock and bone samples ranging from 50,000 to 1,000,000 years old.

The available techniques for trace analysis of Calcium-41 include accelerator mass spectrometry (AMS) and resonance ionization mass spectroscopy (RIMS). The detection limit of RIMS is on the level of 10^{-11} due to the interference of Potassium-41, which is difficult to remove from the sample. The analysis with high-energy AMS is more expensive than the table top apparatus, and it also faces similar problem as RIMS method.

We develop an atom trap trace analysis(ATTA) apparatus for Calcium-41 analysis to the sensitivity of 10^{-15} abundance level by one hour of single atom counting. ATTA uses laser tuned at the resonant wavelength for a specific element and isotope to slow down and capture single atom by fluorescence radiation. It has a very high selectivity of element and isotope, which is more advantageous than AMS and RIMS to avoid isobar interference. ATTA has been used in analysis of Krypton-81, Argon-39 dating of the hydrological samples. This work on high sensitivity Calcium-41 analysis is very promising in dating the geochemical sample to determine the exposure ages of rocks or in cosmochemistry for investigations on terrestrial ages.