Ultrasensitive Trace-Isotope Analysis with a Magneto-Optical Trap

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We have developed a new method of ultrasensitive trace-isotope analysis based upon the technique of laser manipulation of neutral atoms [1]. This new method allows us to count individual ^{85}Kr and ^{81}Kr atoms present in a natural krypton sample with isotopic abundances in the range of 10^{-11} and 10^{-13}, respectively. Isotope analysis of ^{81}Kr can be used to date polar ice, and ^{85}Kr is a tracer used in monitoring nuclear wastes. In this experiment metastable Kr atoms were produced in a discharge, decelerated via the Zeeman slowing technique, and captured by a MOT where the atoms were counted by measuring their fluorescence. At present our system is capable of counting, in average, one ^{81}Kr atom for about 12 minutes with a total efficiency of 2×10^{-7}. We are currently working to improve our system efficiency by applying cryogenic cooling to the Kr atoms in the discharge region and by recirculating the gas in the vacuum system.

This method can be used to analyze many other isotope tracers for a wide range of applications including measuring solar neutrino flux, searching for exotic particles, tracing atmospheric and oceanic currents, archeological and geological dating, medical diagnostics, monitoring fission products in the environment for nuclear waste management, etc. This work is supported by the U.S. Department of Energy, Nuclear Physics Division; L.Young is supported by the Office of Basic Energy Sciences, Division of Chemical Sciences (Contract W-31-109-ENG-38).

[1] C.Y. Chen et. al.,*Science* **286** 1139 (1999).