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Atom Trap Trace Analysis

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Abstract. A new method of ultrasensitive trace-isotope analysis has been developed based upon the technique of laser manipulation of neutral atoms. It has been used 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. The atom counts are free of contamination from other isototopes, elements, or molecules. The method is applicable to other trace-isotopes that can be efficiently captured with a magneto-optical trap, and has a broad range of potential applications.

INTRODUCTION

Much can be learned from the concentrations of the ubiquitous long-lived radioactive isotopes. W. Libby and coworkers first demonstrated in 1949 that trace analysis of ^{14}C ($t_{1/2}$ = 5715 yr, isotopic abundance = 1×10^{-12}) can be used for archaeological dating [1]. Since then, two well established methods, low-level counting [2] and accelerator mass spectrometry [3], have been used to analyze many more trace-isotopes at about the parts-per-trillion level and to extract valuable information encoded in the production, transport, and decay processes of these isotopes. The impact of ultrasensitive trace-isotope analysis has reached a wide range of scientific and technological fields. We have recently developed a new method, Atom Trap Trace Analysis (ATTA) [4], which is capable of analyzing trace-isotopes with an isotopic abundance at the parts-per-trillion level. This new method promises to enhance the capability and expand the applications of ultrasensitive trace-isotope analysis.

In this paper, we will first describe the motivation of analyzing ^{81}Kr and ^{85}Kr. We will then survey the existing techniques, followed by a description on ATTA and our work on the detection of the rare krypton isotopes. Finally, we will discuss some other potential applications of ATTA.

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