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Atom Trap, Krypton-81, and Saharan Water

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Since radiocarbon dating was first demonstrated in 1949, the field of trace analyses of long-lived cosmogenic isotopes has seen steady growth in both analytical methods and applicable isotopes. The impact of such analyses has reached a wide range of scientific and technological areas. A new method, named Atom Trap Trace Analysis (ATTA), was developed by our group and used to analyze ^{81}Kr ($t_{1/2} = 2.3\times10^5$ years, isotopic abundance $\sim 1\times10^{-12}$) in environmental samples. In this method, individual ^{81}Kr atoms are selectively captured and detected with a laser-based atom trap. ^{81}Kr is produced by cosmic rays in the upper atmosphere. It is the ideal tracer for dating ice and groundwater in the age range of 10^4–10^6 years. As the first real-world application of ATTA, we have determined the mean residence time of the old groundwater in the Nubian Aquifer located underneath the Sahara Desert. Moreover, this method of capturing and probing atoms of rare isotopes is also applied to experiments that study exotic nuclear structure and test fundamental symmetries. This work was supported by the U.S. DOE, Office of Nuclear Physics, under Contract No. DE-AC02-06CH11357.