Radiokrypton Analysis in the 21st Century: Development and Application of a Laser Atom Trap

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It has long been recognized that ^{81}Kr is a near-ideal tracer for determining residence times of old groundwater and for dating glacial ice in the 10^4–10^6 year range, yet because of its low abundance (atmospheric ^{81}Kr/Kr ~ 10^{-12}) it has been nearly impossible to measure. However, the end of the 20th century was the dawn of a powerful new method for radiokrypton analysis, when the ability for isotope-selective single-atom counting of Kr was demonstrated using a laser atom trap [1 – see Figure]. Improvements in efficiency and calibration of the Atom Trap Trace Analyzer (ATTA) led to its first quantitative measurements of ^{81}Kr and ^{85}Kr in air [2] and ^{81}Kr in very old groundwater from the Nubian Aquifer in Egypt [3].

The initial applications of ATTA to radiokrypton analysis of environmental samples involved an instrumental efficiency of 10^{-4}, sample size of ~50 microliters Kr (representing ~1,000 L of water or ~50 L of air), and complicated procedures for extraction of dissolved gas from water and purification of Kr from dissolved gas. Work in progress includes improving the instrumental efficiency of ATTA (which will decrease the sample size requirement) and optimizing the sample extraction and purification procedures.

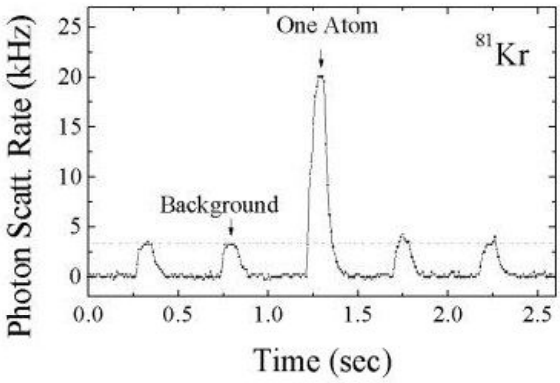

Figure: Signal of a single ^{81}Kr atom detected by ATTA.

References

[1] Chen C.-Y. et al. (1999) *Science* **286**, 1139-1141; [2] Du X. et al. (2003) *Geophys. Res. Lett.* **30**, 2068-2071; [3] Sturchio N.C. et al. (2004) *Geophys. Res. Lett.* **31**, L05503.