Atom-Trap Method for Radio-krypton and Radio-argon Dating of Water and Ice

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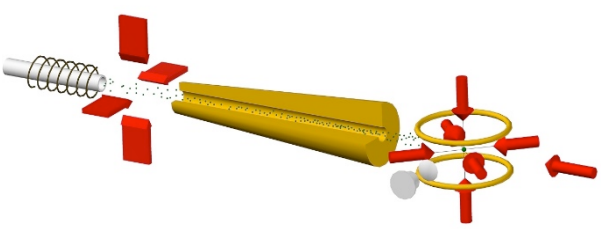
The noble gas radionuclides, including ^{81}Kr ($t_{1/2}$ = 229,000 yr), ^{85}Kr ($t_{1/2}$ = 10.8 yr), and ^{39}Ar ($t_{1/2}$ = 269 yr), possess nearly ideal chemical and physical properties for studies of earth and environmental processes. Recent advances in Atom Trap Trace Analysis (ATTA), a laser-based atom counting method, have enabled routine measurements of ^{81}Kr and ^{85}Kr in environmental samples, as well as the demonstration of the ability to measure ^{39}Ar. Analyses of these three isotopes can be used to determine groundwater residence times, date glacial ice, and study ocean circulation pathways. In this talk, I will provide an overview of the ATTA technique and a survey of recent progresses made in several laboratories.

In an ATTA instrument, individual neutral atoms, not ions, of the desired isotope are captured by laser beams, and detected by measuring their fluorescence. $^{81}Kr/Kr$ and $^{85}Kr/Kr$ ratios of environmental samples in the range of 10^{-14}-10^{-10}, and $^{39}Ar/Ar$ at the level of 10^{-16}, can be analyzed. For ^{81}Kr-dating in the age range of 50 – 1200 kyr, the required sample size is 5 micro-L STP of krypton gas, which can be extracted from approximately 100 kg of water or 40 kg of ice. For $^{85}Kr/Kr$ analysis, the required sample size is approximately 20 kg of water. It is expected that the required sample sizes will become smaller as the technique continues to advance.

Search “TANGR2012” and “TANGR2015” for the websites of two workshops dedicated to this subject. An article reviewing both the ATTA method and applications is available here: http://dx.doi.org/10.1016/j.earscirev.2013.09.002.



Schematic of an ATTA instrument (Figure by T.P. O’Connor)
Author’s research website: http://atta.ustc.edu.cn