**Counting 42Ar atoms at the 10-21 isotopic-abundance level**

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Atom Trap Trace Analysis (ATTA) is a technique that utilizes laser to selective capture and detect individual atoms of the desired isotope. This technique loads atoms into a magneto-optical trap (MOT) through laser cooling and trapping, realizing high sensitivity and detection efficiency of the desired isotope.

Due to the use of multi-photon repetitive excitation in the experiment, the ATTA method has extremely high isotope selectivity and has been successfully applied to the detection of 39Ar with an abundance level of 10-17.

In recent years, we have significantly improved the counting rate and detection efficiency of the Ar isotope ATTA device, and developed a strong flow mass spectrometry isotope pre-concentration method. These advancements have enabled us to successfully detect 42Ar (with a half-life of 33 years) atoms in the air with an isotopic-abundance level of only 10-21 using single atom counting method.

Previously, people used dark matter detectors detecting the decay of 42Ar from tons of liquid argon to calculate the natural abundance of 42Ar. The sample consumption in this work is only 1-2L of gaseous argon, and the final measured natural abundance of 42Ar is (5.4±0.8)×10-21, which is twice more accurate than previous measurements. This work demonstrates the lowest detection limit that can be achieved by all current ultra-sensitive isotope detection methods.

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