

ATTA Device for Measuring Trace Krypton Contamination in Xenon Dark Matter Detectors

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The XENON dark matter experiments search for low-energy elastic scatters of Weakly Interacting Massive Particles off of Xe nuclei [1]. For Xe targets and other noble liquids used in rare process searches, Kr contamination contributes background events through the beta decay of long-lived radioactive ^{85}Kr . To achieve the sensitivity required of the next generation of dark matter detectors, the Kr contamination must be reduced to the part per trillion (ppt) level. Xe is extracted from the atmosphere with a typical Kr contamination at the part per million (ppm) level. While cryogenic distillation is an established technology for the purification of Xe from Kr at the ppt level, there is no conventional method capable of reliably measuring such extremely low contamination.

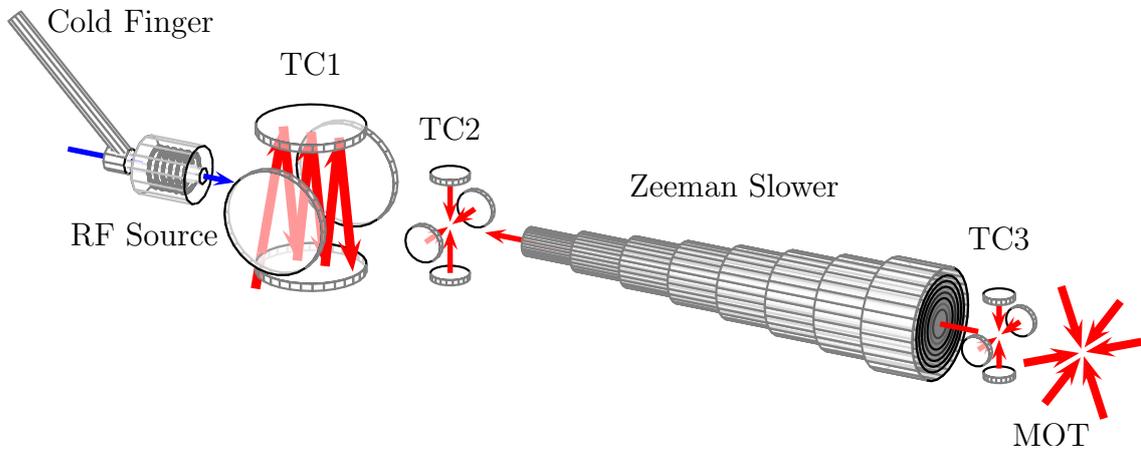


Fig. 1 Schematic of the ATTA device. TC1, TC2 and TC3: transverse cooling stages.

We developed an atomic trap trace analysis (ATTA) system based on the laser cooling, trapping and counting of single Kr atoms in Xe, which will enable a rapid and reliable measurement of Kr concentration at the required ppt level [2]. A RF plasma discharge is used to excite ^{84}Kr atoms to the metastable state (5^3D_3). The $^{84}\text{Kr}^*$ are cooled and trapped in a MOT using traditional magneto-optical techniques. The low contamination level of Kr in Xe leads to an average population of the MOT of less than one atom. $^{84}\text{Kr}^*$ atoms that are periodically arriving in the MOT are detected and counted by their fluorescence with a sensitive photodetector. Since Ar and Kr have similar wavelengths, the apparatus has been initially tested with Ar to avoid contamination. Results from tests with Ar will be presented.

References

- [1] <http://xenon.astro.columbia.edu/>
- [2] <http://atta.phys.columbia.edu/>