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Francis M. Pipkin Award Talk: Simple Atom, Extreme Nucleus: Laser Trapping and Probing of Helium-8[1]

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Helium-8 (^{8}He) is the most neutron-rich matter to have been synthesized on the Earth: it consists of two protons and six neutrons, and remains stable for an average of 0.2 seconds. It is often viewed as a ^{4}He core with four additional neutrons orbiting at a relatively large distance, forming a halo. Because of its intriguing properties, ^{8}He has the potential to reveal new aspects of the fundamental forces among the constituent nucleons. We have recently succeeded in laser trapping and cooling this exotic helium isotope, and have performed precision laser spectroscopy on individual trapped atoms. Based on the atomic frequency differences measured along the isotope chain ^{4}He – ^{6}He – ^{8}He, the nuclear charge radius of ^{8}He has now been determined for the first time. Comparing this result with the values predicted by a number of nuclear structure calculations, we test theoretical understanding of the nuclear forces in the extremely neutron-rich environment. Moreover, this method of capturing and probing atoms of rare isotopes is also applied to experiments that test fundamental symmetries and to applications of ultrasensitive trace analysis.

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