DAMOP20-2020-000673

Abstract for an Invited Paper
for the DAMOP20 Meeting of
the American Physical Society

Progress Towards a Single Atom Microscope for Nuclear Astrophysics[1]

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We are developing a new method for measuring the cross section of low-yield nuclear reactions by capturing the products in a cryogenically frozen noble gas solid. Once embedded in the noble gas solid, which is optically transparent, the product atoms can be selectively identified by laser-induced fluorescence and individually counted via optical imaging to determine the cross section. Single-atom sensitivity by optical imaging is feasible because the surrounding lattice of noble gas atoms facilitates a large wavelength shift between the excitation and the emission spectrum of the product atoms. The tools and techniques from the fields of single-molecule spectroscopy and superresolution imaging in combination with an electromagnetic recoil separator, for beam and isotopic differentiation, allow for a detection scheme with near-unity efficiency, a high degree of selectivity, and single-atom sensitivity. This technique could be used to determine a number of astrophysically important nuclear reaction rates. We will report on our first tests of this approach using the Rb and Kr ion beams from the ReA3 facility at the National Superconducting Cyclotron Lab at Michigan State University.

[1]This project is supported by U.S. National Science Foundation under CAREER grant number 1654610.