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Toward Probing Many-Body Correlations in Ultracold Gases using Ultralong-Range Rydberg Molecules[1] J. D. WHALEN, R. DING, F. CAMARGO, F. B. DUNNING, T. C. KILLIAN, Rice University — Experimental techniques such as photoassociation spectroscopy and, more recently, quantum gas microscopes have been developed to probe correlations between atoms in ultracold quantum systems. These techniques have been remarkably successful at measuring correlations at very short ranges, $r < 200\,a_0$, and at ranges of the order of an optical lattice site, $r > 5000\,a_0$. However, many physical systems such as halo dimers, Efimov trimers, Cooper pairs, etc. express correlations in a more intermediate regime. We propose a new method of probing this intermediate regime using photoassociation of ultralong-range Rydberg molecules. Excitation to well localized dimer states of varying principal quantum number ($20 < n < 100$) will provide a tunable probe of interparticle correlations and direct measurement of the two-body correlation function $g^{(2)}(r)$. We present an experimental proposal and preliminary results using this technique to measure the two-body wavefunction of a strongly interacting gas of ^{84}Sr and ^{88}Sr.

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Joseph Whalen
Rice University

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