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Probing nonlocal correlations in quantum gases with ultra-long range Rydberg molecules[1] JOSEPH WHALEN, R. DING, S. K. KANUNGO, H. Y. RATHORE, Rice University, Y. WANG, Peking University, F. B. DUNNING, T. C. KILLIAN, Rice University, J. SOUS, University of British Columbia, H. R. SADEGHPOUR, ITAMP, Harvard-Smithsonian Center for Astrophysics, M. WAGNER, R. SCHMIDT, Max-Planck-Institute of Quantum Optics, Hans-Kopfermann-Strae, S. YOSHIDA, J. BURDRFER, Institute for Theoretical Physics, Vienna University of Technology — Photo-excitation of ultra-long range Rydberg molecules (ULRRMs) provides a new, *in situ* probe of spatial correlations in quantum gases at previously inaccessible length scales. Excitation of the ground-state dimer ULRRM measures the nonlocal pair correlation function $g^{(2)}(R)$, with R tunable by changing the principal quantum number, n, of the target Rydberg state ($R \sim 2n^2$). We present observations of the effects of quantum statistics, showing anti-bunching (Pauli exclusion) in a spin-polarized Fermi gas of ^{87}Sr and bunching in a spinless Bose gas of ^{84}Sr. We will also discuss measurement of the scattering wave function with ULRRM dimer excitation, which should display a node for internuclear separation equal to the s-wave scattering length. This length scale is accessible for resonant interactions such as between ^{84}Sr and ^{88}Sr ($a_{84-88} \sim 1800\, a_0$).

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