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Photon Shot Noise Limited Radio Frequency Electric Field Sensing Using Rydberg Atoms in Vapor Cells[1] SANTOSH KUMAR, AKBAR J. JAHANGIRI, HAOQUAN FAN, Homer L. Dodge Department of Physics and Astronomy, The University of Oklahoma, 440 W. Brooks St. Norman, OK 73019, USA, HARALD KUEBLER, 5. Physikalisches Institut, Universitat Stuttgart, Germany, JAMES P. SHAFFER, Homer L. Dodge Department of Physics and Astronomy, The University of Oklahoma, 440 W. Brooks St. Norman, OK 73019, USA — We report Rydberg atom-based radio frequency (RF) electrometry measurements at a sensitivity limited by probe laser photon shot noise. By utilizing the phenomena of electromagnetically induced transparency (EIT) in room temperature atomic vapor cells, Rydberg atoms can be used for absolute electric field measurements that significantly surpass conventional methods in utility, sensitivity and accuracy. We show that by using a Mach-Zehnder interferometer with homodyne detection or using frequency modulation spectroscopy with active control of residual amplitude modulation we can achieve a RF electric field detection sensitivity of 3 μVcm^{-1}Hz$^{/2}$. The sensitivity is limited by photon shot noise on the detector used to readout the probe laser of the EIT scheme. We suggest a new multi-photon scheme that can mitigate the effect of photon shot noise. The multi-photon approach allows an increase in probe laser power without decreasing atomic coherence times that result from collisions caused by an increase in Rydberg atom excitation. The multi-photon scheme also reduces Residual Doppler broadening enabling more accurate measurements to be carried out.

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