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Sensitivity Limits of Rydberg Atom-Based Radio Frequency Electric Field Sensing[1] AKBAR J. JAHANGIRI, SANTOSH KUMAR, 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, Universitt Stuttgart, Pfaffenwaldring 57 D-70550 Stuttgart, Germany, HAOQUAN FAN, JAMES P. SHAFFER, Homer L. Dodge Department of Physics and Astronomy, The University of Oklahoma, 440 W. Brooks St. Norman, OK 73019, USA — We present progress on Rydberg atom-based RF electric field sensing using Rydberg state electromagnetically induced transparency (EIT) in room temperature atomic vapor cells. In recent experiments on homodyne detection with a Mach-Zehnder interferometer and frequency modulation spectroscopy with active control of residual amplitude modulation we determined that photon shot noise on the probe laser detector limits the sensitivity. Another factor that limits the accuracy is residual Doppler broadening due to the wave-vector mismatch between the coupling and the probe lasers. The sensor as limited by project noise can be orders of magnitude better. A multi-photon scheme is presented that can eliminate the residual Doppler effect by matching the wave-vectors of three lasers and reduce the photon shot noise limit by correctly choosing the Rabi frequencies of the first two steps of the EIT scheme. Using density matrix calculations, we predict that the three-photon approach can improve the detection sensitivity to below 200 nV $\mathrm{cm}^{-1}\,\mathrm{Hz}^{-1/2}$ and expand the Autler-Townes regime which improves the accuracy.

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Akbar J. Jahangiri
University of Oklahoma

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