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Single-shot high-resolution heterodyne detection of millimeter wave superradiance in Rydberg-Rydberg transitions DAVID GRIMES, Massachusetts Institute of Technology, SUSANNE YELIN, ITAMP and Department of Physics, University of Connecticut, TIMOTHY BARNUM, Massachusetts Institute of Technology, YAN ZHOU, JILA/University of Colorado-Boulder, STEVEN COY, ROBERT FIELD, Massachusetts Institute of Technology — Millimeter wave (mm-wave) superradiance has been directly detected on a shot-by-shot basis in a neon buffer gas cooled beam of barium atoms. Rydberg-Rydberg transitions are well suited for the study of superradiance due to both the large transition dipole moments and long wavelengths associated with $\Delta n = 1$ transitions. We trigger the superradiant evolution of an initially 100% inverted system of Rydberg atoms ($n = 30$) with a weak mm-wave trigger pulse that is well-characterized in both spatial intensity distribution and phase. The resultant mm-wave emission is recorded in a heterodyne detection scheme with high resolution in both the time (20 ps) and frequency (250 kHz) domains. We observe that the width and emission delay of the time-domain intensity can be well described by a mean-field theory, but that the frequency-domain effects are not even qualitatively reproduced. In particular, a density-dependent broadening, frequency chirp, and line shift are observed. Comparisons to a two-atom master equation theoretical model will be discussed.

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