Abstract Submitted
for the MAR17 Meeting of
The American Physical Society

Real Space Bose-Einstein Condensation of Optical Phonons in Intercalated van der Waals Heterostructures IGOR ALTFEDER, Air Force Research Laboratory, ANDREY VOEVODIN, University of North Texas, MICHAEL CHECK, Air Force Research Laboratory, SARAH EICHFELD, JOSHUA ROBINSON, Pennsylvania State University, ALEXANDER BALATSKY, Los Alamos National Laboratory — Using quantum tunneling of electrons into vibrating surface atoms, phonon oscillations can be observed on the atomic scale. Here we present scanning tunneling microscopy study of coherent quasi-bound states produced by almost dispersionless optical phonons in intercalated van der Waals heterostructures. Our results show that the effective radius of quasi-bound states, the real-space distribution of phonon standing wave amplitudes, the scattering phase shifts, and the non-linear intermode coupling strongly depend on the presence of defect-induced scattering resonance. The coherence of these quasi-bound states arises from phase- and frequency-synchronized dynamics of all phonon modes, and indicates the formation of quantum many-body condensate of optical phonons around resonant defects. We found that increasing the strength of the scattering resonance causes the increase of the condensate droplet area without affecting its density. The observed phenomenon represents the real-space analogue of non-equilibrium phonon Bose-Einstein condensation.

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Date submitted: 11 Nov 2016 Electronic form version 1.4