Experimental studies of vibrational modes in a 2D amorphous solid

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Boson peak, the excess states over Debye's density of states (DOS) for the lower frequency regime, is widely studied ranging from microscopic scale to macroscopic scale. Despite a variety of theoretical and numerical models trying to explain this anomalous behavior, the nature of BP is still a mystery. Here we experimentally study the origin of the boson peak in a 2D disordered granular system composed of the photo-elastic disks. Using the compressional system and the normal modes analysis, we show that the BP extracted from the granular experiments has a remarkably similar shape compared with what has been reported in the molecular glasses. In addition, we have confirmed that the spatial distribution of modes have a quantitative change across the BP, which is consistent with literatures. By fitting the self-correlations of the transverse and longitudinal modes for all the frequencies using a freely damped harmonic oscillator, we find a strong dispersion near BP for the transverse wave, while a linear dispersion for the longitudinal wave, which suggests that the BP is original from the scattering of the transverse wave when its wave length is comparable to the intrinsic length scale of the system. What's more, we analyze the local bulk modulus and shear modulus, and find that the negative local shear modulus exist below a length scale after considering the non-affine components, which is consistent with the wave length of the transverse wave quantitatively and is just the intrinsic length scale. Finally, the correlation between the non-affine local shear modulus and the low-frequency modes further verifies that the non-affine components of the local shear modulus play a key role for the boson peak.