

## Supplemental Materials

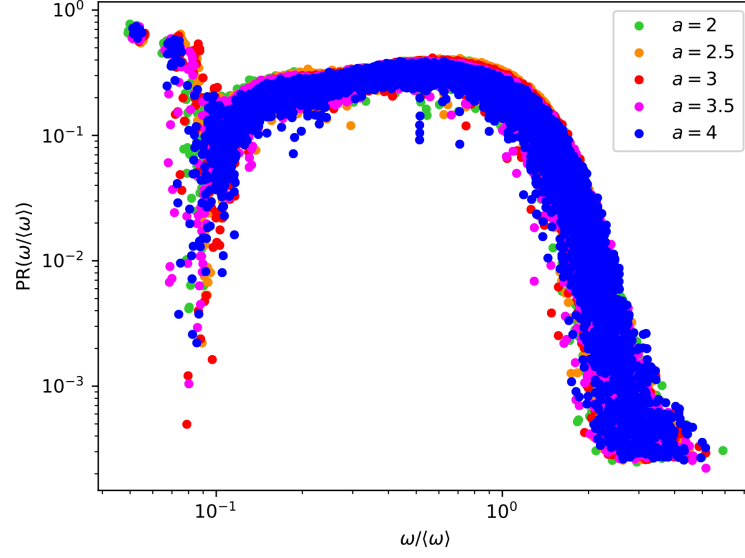


Figure 1. Participation ratio (PR) as a function of the gap distance cutoff  $h_{cut}$  for the logarithmic potential for a typical sample. Curves are plotted for  $h_{cut} = ah_{peak}$  with  $a$  ranging from 2 to 4, where  $h_{peak}$  is the size of the gap at the first peak of the gap distribution. Samples are obtained by compressing the same initial packing of  $N = 8192$  particles in  $d = 3$  from a starting packing fraction of  $\varphi = 0.55$ . Data are plotted for  $\varphi = 0.65722$ . The PR does not show any significant difference as the cutoff distance changes over the full frequency range.

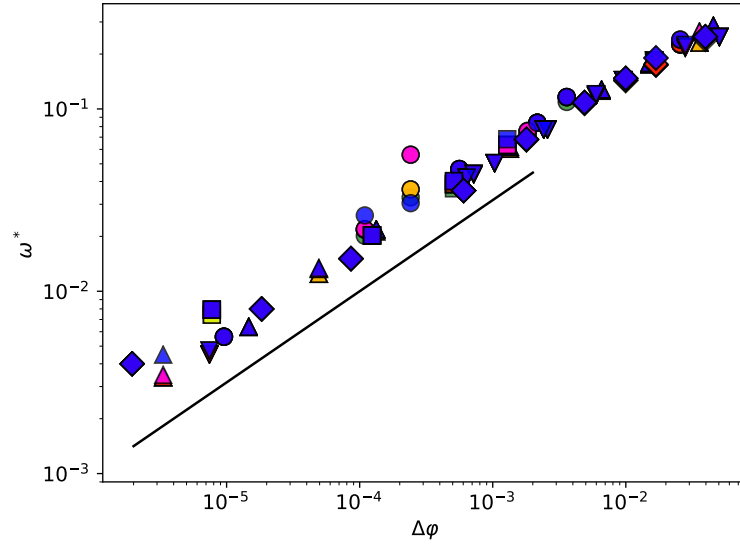


Figure 2. Dependence of  $\omega^*$  on  $PR_c$ , the cutoff threshold for the participation ratio,  $PR_c = 0.2$  (green),  $0.18$  (yellow),  $0.15$  (orange),  $0.12$  (red),  $0.1$  (magenta),  $0.08$  (blue). The curves are plotted for different system sizes from decompressions (squares  $N = 4096$ ) and compressions (circles  $N = 1024$ , upward triangles  $N = 2048$ , downward triangles  $N = 4096$ , diamonds  $N = 8192$ ). The scaling relation between  $\omega^*$  and  $\Delta\varphi$  is not affected by the choice of  $PR_c$  for  $8 \times 10^{-2} < PR_c < 2 \times 10^{-1}$ , values which correspond to 8% and 20% participating particles respectively.