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Dynamic effective mass of granular media

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We report an experimental and theoretical investigation of the frequency-dependent effective mass, M(ω), of loose granular particles which occupy a rigid cavity to a filling fraction of 48%. We demonstrate that this is a sensitive and direct way to measure those properties of the granular medium that are the cause of the changes in acoustic properties of structures containing grain-filled cavities. The dominant features of M(ω) are a sharp resonance and a broad background, which we analyze within the context of simple models as well as with molecular dynamic simulations. We find that: a) These systems may be understood in terms of a height-dependent and diameter-dependent effective sound speed ($\sim$ 130 m/s) and an effective viscosity ($\sim 2\times 10^4$ Poise). b) There is a dynamic Janssen effect in the sense that, at any frequency, and depending on the method of sample preparation, approximately one-half of the effective mass is borne by the side walls of the cavity and one-half by the bottom. c) On a fundamental level, dissipation is dominated by adsorbed films of water at grain-grain contacts in our experiments, not by global viscous damping.