

EXCITATION AND ATTENUATION OF SURFACE WAVES IN DISORDERED MATERIALS

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ABSTRACT

We use amorphous silicon (a-Si) as a model system for studying frictional energy dissipation in disordered solids. Our core hypothesis is that frictional dissipation occurs through excitation and attenuation of surface phononic modes. We use a combination of atomistic and continuum calculations to study these modes. Our atomistic a-Si system comprises a free surface and an opposing rigid one, with periodic boundary conditions enforced on the remaining boundaries. We determine the eigenmodes of this system by diagonalizing its Hessian matrix. Conversely, at a continuum scale, amorphous materials are modeled as isotropic solids. We use the theory of linear elasticity to derive semi-analytical expressions of the phononic modes of an isotropic system subject to the same boundary conditions. We identify six different types of waves and plot the dispersion curves of those with a non-zero surface wave vector. The atomistic normal modes are characterized by computing their phonon order parameter in reference to the continuum solution [1]. Further analysis involves examining the vibrational density of states and participation ratio [1]. Additionally, we measure the vibrational lifetime of each mode from the decay of its total energy autocorrelation function in microcanonical simulations [2]. In a Langevin scheme, the vibrational lifetimes correlate with the frictional forces acting on the normal modes. We use this to make predictions on the rate of energy dissipation in our a-Si system subject to surface excitation.

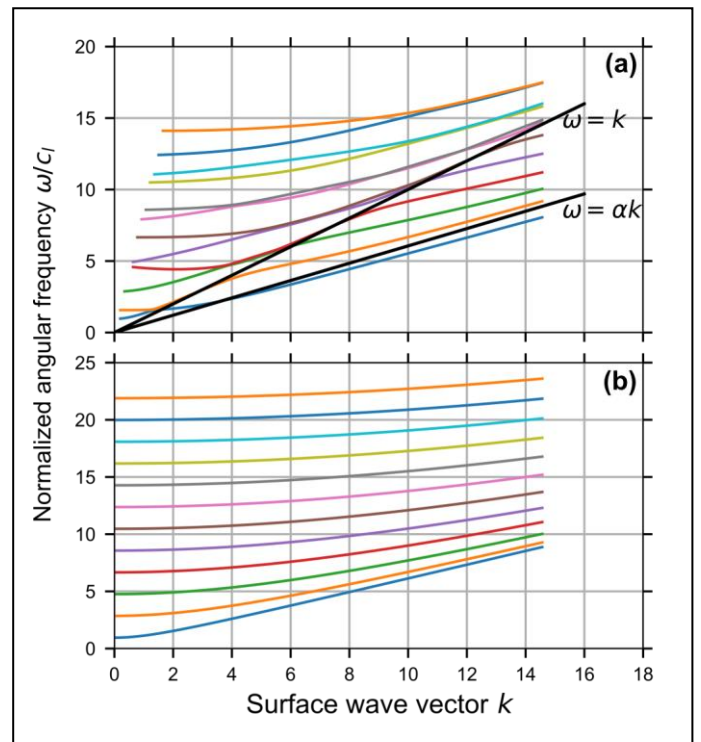


Fig. 1. Dispersion curves for Rayleigh-like waves (a) and Love waves (b). The surface wave vector k is the component of the wave vector which is parallel to the free surface. In (a), only one mode becomes a Rayleigh wave with an exponentially decaying S and P-wave. This mode is the one which crosses the $w = \alpha k$ line.

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