Centre for Imaging Research and Advanced Materials Characterization

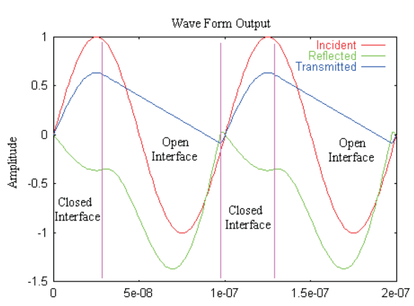
Simulation of Acoustic Non Linearities at an Interface

Basic Theory and Purpose

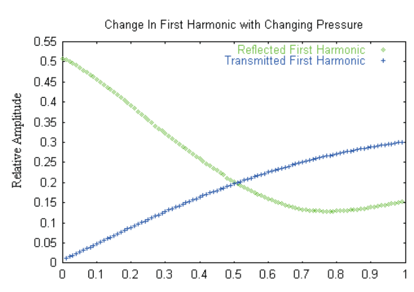
By utilizing a set of acoustic boundary value equations, appropriate to the type of interface involved, various simulations have been designed to explore the acoustic properties of the interface. The simulations are run in the time domain, but offer time domain output, frequency spectrum output, and change in frequency spectrum output

Clapping Interface

The clapping interface is composed of two unbonded half spaces that have the option of either being perfectly connected (a closed interface), or perfectly disconnected (an open interface). An external static pressure is added to ensure the system is able to change between the open and closed states. The incident wave is restricted to be a longitudinal wave at normal incidence to the boundary.

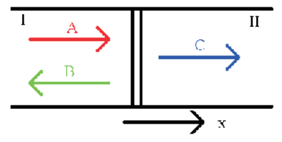


Above: Wave form output of clapping interface using two different metals. The second material is of greater impedance causing an inverted reflection when the interface is closed

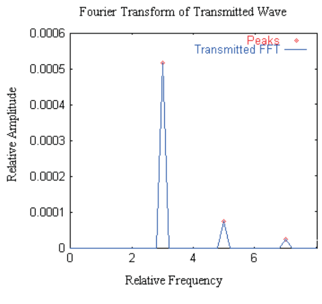


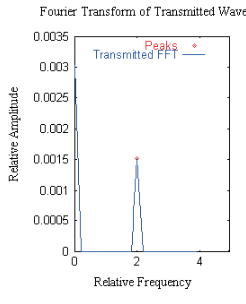
Above: Change in the first harmonic as pressure is changed. At low pressure there is total reflection, while at high pressure the harmonics correspond to an interface that is always closed

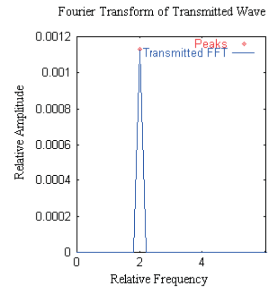
Basic Thin Layer



This interface is composed of two half spaces joined together by a thin layer with a thickness much less than the incident wave's wavelength. The boundary conditions on the thin layer are such that the nonlinearity is a generic function allowing for many types of nonlinearities to be explored. In this simulation the incident wave is restricted to normal incidence, and longitudinal polarization.

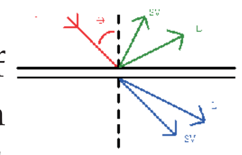




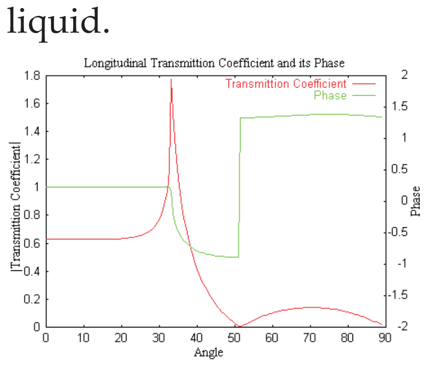


Fourier Transforms showing additional harmonics due to non-linearities in the thin layer.
Left: Nonlinearity proportional to |Stress|
Center: Nonlinearity proportional to Stress
Right: Nonlinearity proportional to Displacement

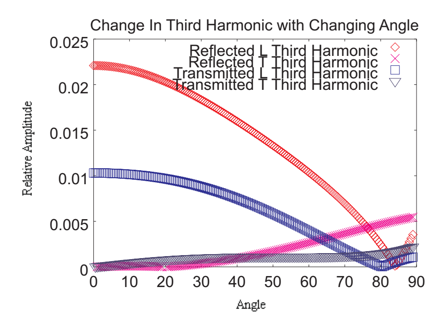
Two Dimensional Thin Layer Interface



This interface is composed of two half spaces joined together by a thin layer with a thickness much less than the incident wave's wavelength. The incident wave is no longer restricted to normal incidence, allowing critical angles in either medium. The incident wave is also allowed to be either a longitudinal wave, or a shear vertical wave. In addition either (or both) media can be defined to be a liquid.

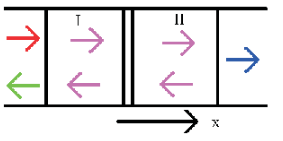


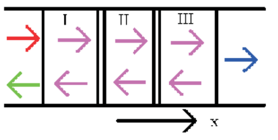
Above: Change in the longitudinal transmission coefficient and phase as the angle of incidence is changed at a liquid solid boundary . The large spike in the graph is due to the presence of a critical angle.



Above: Change in the third harmonic as the angle of incidence is changed in a system of two different metals joined together by a thin layer of nonlinear adhesive. For the Longitudinal waves the nonlinearity is greatest for normal incidence

Thin Layers with Finite Surrounding Media





These more realistic interfaces are composed of materials of finite thickness joined together by a thin layer. To date, two finite media simulations have been created, one allows for two finite layers joined by a thin layer, and the other three finite layers and two thin layers. The surrounding media to both these structures can either be defined as an additional infinite material, or vacuum.

Future Work

Plans for future simulations include the possibly of a two dimensional thin layer structure with finite layers, or allowing the thin layer in the two dimensional structure to be anisotropic.

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