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New Fascinating Properties and Potential Applications of Love Surface Waves

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Background, Motivation and Objective

Love surface waves propagating in elastic waveguides have many unique features that differentiate them from other types of surface waves, such Rayleigh, Lamb or Stoneley waves. In fact, Love surface waves:

1. have only one shear horizontal (SH) component of vibration (mechanical displacement)
2. have relatively simple mathematical description
3. have an exact analogue in electromagnetism (planar dielectric waveguides)
4. have a direct analogy with quantum mechanics (movement of quantum particles in potential wells)

Love surface waves were predicted theoretically in 1911 by A. E. H. Love, who analyzed seismic data registered in wake of Earthquakes. Love surface waves revealed their benign face by the end of the twentieth century with the advent of Love wave sensors, biosensors and chemosensors with parameters superior to those achievable with other types of acoustic sensors.

Despite their centennial history Love surface waves do not stop to surprise us by unveiling new unexpected properties and possibilities for novel applications. Indeed, in recent two years the author discovered a number of new original phenomena that occur in lossy Love wave layered waveguides loaded with Newtonian liquid that were entirely unexpected and are completely counterintuitive, e.g.,

1. abrupt changes in phase velocity v_p and attenuation α, as a function of viscosity η of the loading Newtonian liquid
2. resonant-like maxima in attenuation, as a function of thickness "h" of a lossy surface layer and frequency f
3. maximum in attenuation α as a function of viscosity η of the loading Newtonian liquid
4. minimum in phase velocity v_p as a function of viscosity η of the loading Newtonian liquid

In fact, the phase velocity v_p and attenuation α of the Love wave can abruptly change their qualitative character from aperiodic to oscillatory and vice-versa for a certain value of viscosity of the loading viscoelastic liquid. These phenomena may be attributed to a sudden repartition of Love wave energy from one surface layer to another.

Statement of Contribution/Methods

Applying the equations of motion and appropriate constitutive equations for the viscoelastic waveguide and loading liquid, we have obtained complex dispersion relation for phase velocity v_p and attenuation α of the Love wave propagating in the loaded waveguide. Further calculations relied on judicious employment of the notion of the total differentiation of an implicit function of two variables.

Results/Discussion

The author intends to cover the following topics:

1. applications of Love waves in seismology and sensors
2. mathematical modeling (direct Sturm-Liouville problems for Love waves)
3. analogies with electromagnetism and quantum mechanics
4. theoretical analysis of the mass sensitivity of Love wave sensors
5. relationship between the mass sensitivity and the slope of the Love wave dispersion curves
6. power flow in Love wave waveguides. Distribution of active and reactive power in Love wave waveguides. Poynting vector
7. newly discovered phenomena in Love wave waveguides:
   a) minimum of phase velocity as a function of viscosity
   b) maximum of attenuation as a function of viscosity
8. new unexpected phenomena in Love wave waveguides:
   a) sudden qualitative changes in phase velocity and attenuation
   b) resonant-like attenuation of Love waves