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Seismic Waves in Random Heterogeneous Earth, and Related Problems

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Extended Abstract

Seismic waves in half-space homogeneous earth have been studied by Lamb, Cagniard, de-Hoop, Achenbach, and others for many years. However, seismic waves in random heterogeneous earth have been studied more recently by Aki, Sato, Fehler, Maeda, and others. [1] The researchers in these two areas are called the "smooth earth" club and the "rough earth" club, respectively.

The seismic waves for the rough earth include coherent and incoherent waves. The incoherent waves give rise to the wavetrain called the "coda", which has attracted much interest in recent years because the coda wave contains information about the scattering characteristics of the medium and the source of the seismic wave that are not apparent in the initial coherent wave ground motion that is represented by the earthquake magnitude scale. The study of the "coda" is essential in obtaining information about the exciting source, natural or man-made, the medium, and the total seismic energy. Even though many mathematical theories of seismic waves are similar to electromagnetic wave theory, the seismic waves require the study of P (pressure) waves, S (shear) waves, and Rayleigh surface waves, and the appropriate boundary conditions. In addition, the coda waves require the study of these waves in a random medium. [1, 2] The study of the seismic coda wave requires the space-time stochastic Fourier transform of the scalar and vector potentials. The boundary condition of the solid-vacuum interface gives the Rayleigh surface wave. For homogeneous earth, the space-time Fourier transform has been studied including the Rayleigh surface wave pole. However, for the coda wave it is necessary to obtain the solution based on the random medium theories. We first express the homogeneous earth solution by space-time Fourier transform. This will then be expressed using the saddle point technique and the residue of the Rayleigh surface wave pole. These will be used to obtain an approximate solution involving the scattering of the surface wave due to the random medium.

Some approximate solutions may be obtained but much work needs to be done in order to study the fundamental problem of the remote sensing of the natural and man-made seismic source characteristics and the total energy. Related to the coda study is the effect of the random medium and rough surface on the Sommerfeld dipole problem, and communication over rough surfaces. These outstanding problems are still being studied at present.

References

[1] H. Sato, M. C. Fehler, and T. Maeda, *Seismic Wave Propagation and Scattering in the Heterogeneous Earth, Second Edition*, 2012, Berlin/Heidelberg: Springer-Verlag.

[2] A. Ishimaru, *Electromagnetic Wave Propagation, Radiation, and Scattering: From Fundamentals to Applications, Second Edition*, 2017, The Institute of Electrical and Electronic Engineers, Inc., John Wiley & Sons, Inc.