Power-Law Spectrum of the Isotropic Scattering Coefficient of the Solid Earth

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Recent observations focusing on scattering of seismic waves have revealed the existence of the random velocity fluctuation in the solid Earth medium. There have been many quantitative measurements of the power spectral density function (PSDF) of the random velocity fluctuation of the solid Earth. Plotting reported PSDFs against wavenumbers, we find that their spectral envelope is proportional to the inverse cube of wavenumber for a very wide range of wavenumbers (Sato, 2019, SE, JpGU).

Since 1970s, the isotropic scattering model, which is the simplest model of the radiative transfer theory, has been often used for the measurement of the scattering power per unit volume. This is a phenomenological model without specifying the origin of scattering. Plotting reported isotropic scattering coefficients against frequency, we find that they increase with frequency (Sato, 2019, GJI).

We know that the scattering process is well approximated by the diffusion equation in the multiple scattering regime, where the transport scattering coefficient effectively functions as an isotropic scattering coefficient even if the elementary scattering is anisotropic. We calculate the transport scattering coefficient from the spectral envelope of the velocity fluctuation using the Born approximation. We find that the calculated transport scattering coefficient linearly increases with frequency, which well explains most of the observed isotropic scattering coefficients for a wide range of frequencies. However, some reported isotropic scattering coefficients show unusual behavior; reported isotropic scattering coefficients beneath volcanoes and in the moon are larger than those in the lithosphere. Those differences may suggest possible scattering contribution of pores and cracks widely distributed in addition to the scattering by random velocity fluctuations (Sato, 2019, GJI).

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