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Scattering attenuation of elastic waves due to weak discrete inhomogeneities (2)

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There are two major theoretical approaches for predicting seismic scattering attenuation due to the lithospheric random inhomogeneity. In one approach, inhomogeneous media are modeled by materials with randomly and weakly (usually, continuously) perturbed elastic wave velocity and density, and the single-scattered energy due to the perturbation is evaluated on the basis of the Born approximation. Note that the perturbation is described using the autocorrelation function (Sato & Fehler, 1998). In the other, the mean wave formalism is adopted for treating wave propagation within a disperse system of discrete inhomogeneities, such as inclusions and cracks. The first-order approximated solution for this problem was first obtained by Foldy (1945).

The scattering attenuation due to discrete inhomogeneities could be estimated also using the Born approximation, if the autocorrelation function would be correctly given. Moreover, the Born- and Foldy-approximation solutions of the scattering attenuation would be equivalent for sparsely distributed *weak* inhomogeneities, that satisfy the condition that kaz is much less than 1 (k: wavenumber, a: inhomogeneities' size, z: contrast of elastic wave velocities), since it is a generally accepted condition of applying the Born approximation to a single scatterer. In our previous study (JGU Meeting 2007, S230-P005), we numerically proved the equivalence of both the solutions for P wave scattering due to spherical inclusions with the radius a. However, we assumed kaz to be much less than 1 in advance for simplicity, and hence the validity range of the Born approximation solution was not quantitatively clarified. In addition, S wave scattering was not treated. In this study, we reexamine the same problem in a general way. We use the method of Korneev & Johnson (1996) to compute the scattering cross section of a spherical inclusion, necessary for evaluating the Foldy-approximation solution. It is shown that the Born- and Foldy-approximation solutions are nearly equivalent (and hence the former is correct) for both P and S wave scattering attenuation, if kaz is just less than 1. This inequality condition is identical to that we previously obtained for SH wave scattering due to 2-D inclusions (JGU Meeting 2006, S206-P005), that implies its universality.

We also show the methods to evaluate the Born-approximation solution of scattering attenuation due to inclusions of other types, such as ellipsoidal ones and ones with distributed radii. It is shown that the spatial power spectrum of a medium with inclusions could resemble that of the von Karman type with the Hurst number 0.5 or lower, if the radus distribution obeys power laws with certain exponents.

References: Foldy, Phys. Rev., 67, 1945; Korneev & Johnson, PAGEOPH, 147, 1996; Sato & Fehler, Springer, 1998.