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FDM Simulation of Scatterings Observed in Moonquake Coda Waves

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The moonquake seismograms taken by the Apollo seismograph network are the only ones that have been successfully recorded so far on an extra-terrestrial body. There are several types of moonquakes (e.g., the deep-focus and the shallow-focus moonquakes), but the moonquake seismograms have the following distinct characteristics irrespective of the types. (1) They show very long coda waves that continue for several tens of minutes after the initial phases. (2) The maximum amplitude does not occur at the initial phase onset, but it usually occurs after the onset: i.e., there is a 'rise time' for the seismic waves to develop to the maximum amplitude. In other words, the seismograms shows a shape like a 'spindle'. These characteristics indicate that the scattering effect is very strong and the attenuation is very weak in the shallow part of the Moon. The scatterings phenomena have been studied by many researchers by applying the diffusion process, and the diffusion coefficients as well as the mean free paths of the diffusion process were estimated as the indicators of the material properties of the shallow part of the Moon. But the correspondence between the indicator (i.e., diffusion coefficients) and the actual material parameters are remains to be investigated.

In order to directly correlate the degree of the scatterings and the material properties, we tried to simulate the coda wave by a direct 2D finite difference method. In our simulation, we assume a layered random media in which the seismic velocity fluctuates randomly. The randomness is described by a spatial auto-correlation function for the velocity distribution. We assumed a Gaussian function for our study. Although our current simulations are limited to 2D geometry and to SH problems, the results of our simulations for the deep-focus moonquakes suggest a very large fluctuations in the random velocity distribution: the standard deviation may be up to 40% of the mean velocity in order to explain the characteristics of the first 300s of the observed S-wave amplitude. Also, our study indicates the importance of thin low-velocity surface layer which is assumed based on the seismic experiments conducted on the Moon by the astronauts: the waves are effectively trapped in the low-velocity surface layer so that the duration of the coda wave gets longer than that for the case without thin surface layer. We will show the results of the simulations for the (artificial) impacts as well as the results for the deep-focus moonquake.