Reflection and transmission coefficients of self-similar interfaces

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The derivation of seismic reflection and transmission coefficients is generally based on the assumption that the medium parameters behave as step-functions of the depth coordinate, at least in a finite region around the interface. However, borehole measurements of e.g. the propagation velocity in the earth's subsurface reveal outliers that behave quite different from step-functions. These outliers have been analyzed by Herrmann (1997), using the multi-scale singularity detection procedure, proposed by Mallat and Hwang (1992). From this type of analysis it appears to make sense to parameterize many of the outliers in the borehole measurements as self-similar singularities, with positive as well as negative singularity exponents. Note that the step-function is a special case of a self-similar singularity, with its singularity exponent equal to zero.

The angle-dependent reflection and transmission coefficients of self-similar interfaces reveal self-similar properties as well (Wapenaar, 1999). For a step-function interface (singularity exponent zero) the angle-dependent reflection and transmission coefficients are independent of the frequency; this can be seen as a special case of self-similarity. For a self-similar interface with a non-zero singularity exponent, the reflection and transmission coefficients are constant along specific contours in the rayparameter-frequency plane. These contours are characterized by the singularity exponent of the interface. The self-similarity properties of the reflection and transmission coefficients are reflected in the amplitude and phase behaviour of the seismic response. Conversely, by analyzing the angle-dependent seismic response with wavelet transform techniques, information on the singularity exponents of the interfaces in the earth's subsurface can be retrieved.

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