CHALLENGES OF SEISMIC WAVE PROPAGATION AND DIFFRACTION THEORY IN COMPLEX MEDIA

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Open problems in theory originate from the inverse problems of seismics, which require to separate the wave propagation process to independent factors. For example, for such tasks as true amplitude migration, subsalt imaging and AVO inversion, it is necessary to accurately model particular fragments of the wavefield, which correspond to the target reflector and the overburden. Such modeling is restrained by the absence of a mathematical apparatus for the description of the wave propagation with regard for the diffraction at concavities and edges, and the reflection and transmission at curved interfaces. The description of the propagation in the areas of complex shapes must follow generalized Fermat's principle (the "stretched-thread" principle) introduced by Hadamard in 1910, the "absorption" principle introduced by Kirchhoff in 1891, and some additional conditions in the vicinity of the edges and vertices of the boundary. The description of the reflection and transmission at curved interfaces must obey the kinematic and dynamic boundary conditions and provide the separation of the incident wavefield to the reflected and transmitted wavefields. To introduce a mathematical apparatus for the considered wave phenomena, an explicit form of the two operators has to be found.

Our approach to the construction of the feasible propagation operator for smoothly inhomogeneous domains and the reflection and transmission operators for smooth interfaces is based on the reduction of the differential statement of the direct problem to an equivalent integral statement in the form of a system of the feasible propagation and reflection-transmission operator equations. Because this approach is invariant to the type and dimension of the system, it can be generalized for large-scale blocky media with microstructure, fluid-saturated media, etc. The integral statement can be exploited for solving both the direct and inverse problems. The solution of the direct problem can be represented as a sequence of multiple reflections and transmissions with regard for head waves and diffracted waves at curved interfaces. The wave operators become the object for numerical modeling. Particular inverse problems can be solved through appropriate transformations of the integral statement.

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