RAY-BORN MODELING OF EDGE DIFFRACTIONS

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Most seismic migration techniques are based on inverse scattering theory (Tarantola, 1984; Beylkin and Burridge, 1990). They assume a smooth and known subsurface background, in which wave propagation can be accurately modeled, e.g., by asymptotic ray theory. Unknown scatterers or perturbations on the background are the objective of inversion by migration. Forward modeling of the seismic response of the scatterers is an essential component of migration. For backscattering this is usually done by the first-order term of the Born scattering series (Beydoun and Tarantola, 1988).

The forward modeling by ray-Born modeling is a very useful tool in itself which has been studied in many publications (Červený 2001, and references listed there). It is closely related to demigration, the process whereby synthetic seismic sections are generated from a migrated image (Santos et al., 2000). The fact that ray-Born modeling underlies most seismic migration techniques, and therefore shares their assumptions, is a justification in itself to consider it for forward modeling. Depending on its implementation and the definition of the background model, ray-Born modeling has the potential to model the first-order scattering in structural models of arbitrary complexity, i.e. there are no restrictions to so-called layer-cake models or raytracing-friendly models. If the scatterers are aligned along smooth horizons, the scattering response consists of specular reflections. Additionally, if the scatterers are not restricted to smooth horizons and the scattering is not restricted to specular reflection, ray-Born modeling has the potential to model diffractions from discontinuities and small scattering objects (Červený and Coppoli, 1992).

The representation of the wave field by the ray-Born integral is a high-frequency and weak-scattering approximation, which becomes exact in the limit to high frequency and zero scattering potential. Therefore, in asymptotic sense, the ray-Born integral results in correct kinematics, for specular reflections as well as (non-specular) diffractions. For correct amplitudes and in asymptotic sense, the dynamics are correct as well. Several applications of ray-Born modeling can be mentioned. First, it can serve to generate synthetic data under controlled and idealized circumstances for the testing of migration algorithms – a useful property in this regard is that first-order scattering involves primaries only. Second, it can be used to study the effect of small modifications of an existing subsurface model (scenario testing). Third, for a given subsurface model it can be used to investigate illumination of a migration target and help in acquisition survey design. This paper reviews some of the properties of ray-Born modeling and discusses some of its benefits, with a special attention to diffractions from structural edges and small scattering objects.

References

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