RAY FIELD MAPPINGS IN REDUCED PHASE SPACE WITH APPLICATION TO RAY MODELLING IN LAYERED MEDIA

Dirk Kraaijpoel and Tijmen Jan Moser

KNMI, The Netherlands

In large scale ray modeling projects, sources and/or receivers can be densely distributed over one ore more acquisition surfaces. The total collection of rays to be traced for a single wave-mode then spans a hypersurface in phase space that contains, within some practical limits, all physical ray paths supported by the medium. A restriction of the full phase space to this hypersurface is often refered to as the reduced phase space.

Two types of coordinate systems can be defined for the hypersurface. Let N be the spatial dimension of medium, and $2N - 1$ the dimension of the reduced phase space. Then Eulerian-type coordinates consist of N spatial coordinates and $N - 1$ coordinates parameterizing the slowness, such as angles or slowness components. Lagrangian-type coordinates are associated with a specific surface the rays intersect non-tangentially. These consist of $N - 1$ coordinates parameterizing the position of intersection with the surface and $N - 1$ coordinates parameterizing the slowness – together uniquely labeling a ray – plus a measure of distance or travel time along the ray. Several Lagrangian-type coordinate systems may be defined with respect to various surfaces in the medium, such as acquisition surfaces, structural interfaces and boundaries, depending on the application. The regularity of ray fields in (reduced) phase space ensures that all coordinate systems map back and forth non-degenerately.

As an application of the ray field mapping we show how they can be applied for the modeling of complex ray codes in layered media. By organizing the ray tracing effort in between adjacent structural interfaces in terms of ray field maps, it is possible to reconstruct complex, multiply reflected ray paths without redundant ray tracing. Both propagation and reflection/transmission/conversion can be treated as ray field mappings. Any ray code can be constructed by composing the appropriate maps.