AMPLITUDE CALCULATIONS FOR 3-D GAUSSIAN BEAM MIGRATION USING COMPLEX-VALUED TRAVELTIMES

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Gaussian beams are often used to represent Green's functions in three-dimensional Kirchhoff-type true-amplitude migrations because such migrations made using Gaussian beams yield superior images to similar migrations using classical ray-theoretic Green's functions. Typically, the integrand of a migration formula consists of two Green's functions, each describing propagation to the image point – one from the source and the other from the receiver position.

The use of Gaussian beams to represent each of these Green's functions in 3D introduces two additional double integrals when compared to a Kirchhoff migration using ray-theoretic Green's functions, thereby adding a significant computational burden. Hill proposed a method for reducing those four integrals to two, compromising slightly on the full potential quality of the Gaussian beam representations for the sake of more effcient computation. That approach requires a two-dimensional steepest descent analysis for the asymptotic evaluation of a double integral. The method requires evaluation of the complex traveltimes of the Gaussian beams as well as the amplitudes of the integrands at the determined saddle points. In addition, it is necessary to evaluate the determinant of a certain (Hessian) matrix of second derivatives. Hill did not report on this last part; thus, his proposed migration formula is kinematically correct but lacks correct amplitude behavior. In this paper, we derive a formula for that Hessian matrix in terms of dynamic ray tracing quantities. We also show in a simple example how the integral that we analyze here arises in a true amplitude migration formula.