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IMAGING AN UNKNOWN OBJECT IN AN UNKNOWN MEDIUM

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Imaging an unknown object in a medium that is known, such as a medium with constant velocity, is not difficult because one knows exactly where the waves are when they interact with the object. It is much more challenging to image an object in an unknown medium, because in that case one may know the waves that one sends into the medium, but one may does not know the waves that illuminate the object because the waves are distorted during their propagation to the object and back. Yet in many applications the medium is strongly scattering and the wavefield is strongly distorted as it propagates to the object. This is like imaging through frosted glass. How can one create an image in such media? And related to this, how can one focus a wavefield through a complicated medium that one does not know?

Inverse scattering methods, as developed in quantum mechanics[1, 2], make it possible to estimate the model or object at a prescribed location without knowing the medium between that location and the point where reflected waves are recorded. These inverse scattering methods are known as the Marchenko equation or Gel'Fand-Levitan equation. Recently, these inverse scattering methods have been generalized to applications in seismology[3, 4, 5, 6] where one seeks to image a target, such as a reservoir, under a complicated overburden, such as a salt body.

The main issue we will address is how it is possible that one can image the object at one location without knowing the medium between the observation point and the reconstruction point. The reason why inverse scattering make it possible to do this is that these methods involve an integral equation[7], and the function that one solves for is akin to the Green's function for the unknown medium. The function obtained by solving the Marchenko equation is, in fact, the incident wavefield that will focus the waves at a specified target location. In order to solve this integral equation one only needs to know a smooth estimate of he velocity model and the reflected waves recorded at the acquisition surface, but the details of the complexity of the medium need not be known. That means there exists a recipe to determine, given the reflected waves, the incident wavefield that focuses at a specified target point. Such focusing is exactly what is needed to determine the image at the target point.

There are many applications in geophysics where one seeks to create an image in strongly scattering media. These include hydrocarbon reservoirs under a complicated overburden, the interior of volcanoes, possibly the core mantle boundary, and crustal structure from high-frequency seismic waves.

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