An introduction to microlocal analysis and its applications to geophysical and radar imaging.

In this sequence of two lectures, we will introduce/review the standard model for reflected waves in various scenarios, such as geophysical and radar imaging. The model is essentially based on a formal linearization of a scalar wave equation, or more generally, a hyperbolic system of partial differential equations. The data measurements then consist of time- and space-sampled wavefields which have scattered from material inhomogeneities. Such inhomogeneities are associated with rapid changes in material properties, e.g., a discontinuous change in the speed of wave propagation at the interface of two different materials. Such inhomogeneities are captured by the so-called "reflectivity function" and our goal is to reconstruct an approximation of the reflectivity function from the data - this is an inverse problem. We will show how to use geometrical optics, or more specifically, the progressing wave expansion to approximate this data and express it as the output of a Fourier Integral Operator (FIO) applied to the reflectivity function. At this point, the lectures will include a mini-crash-course on Fourier Integral Operators, which are studied in the field of microlocal analysis. Finally, we will show how to harness the FIO approach to develop reliable (i.e., artifact-free) images of the reflectivity function.