The nonlinear inverse problem of seismic velocities

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Widely accepted models of seismic wave propagation consist of linear partial differential or integro-differential equations. Material density, stiffnesses, wave velocities, and other geophysically significant parameters appear as coefficients in these equations. The fundamental "inverse" problem of seismology is the inference of these parameters at points in the Earth's interior from observations of seismic waves near the surface. Since solutions of linear equations depend nonlinearly on their coefficients, this inference problem is nonlinear. The problem remains nonlinear even when basic models (PDEs) are replaced by linearized or perturbational models, since the reference coefficients, about which the coefficient-solution relation is linearized, are themselves unknown. This short course will describe some of the ideas which have proven fruitful in attacking this partly linearized "velocity analysis" version of the seismic inverse problem. The course will end with some discussion of the fully nonlinear problem. Computer labs will accompany the lectures; in the labs, participants will experiment with computer simulation of seismic data and basic data processing techniques.