

Nonlinear Inverse Scattering with Diffuse Light

John C. Schotland

Department of Bioengineering, University of Pennsylvania, Philadelphia, PA

We consider the inverse scattering problem for diffuse light. In previous work we have developed the scattering theory of diffusing waves in inhomogeneous media, established conditions under which the existence and uniqueness of solutions to the linearized inverse problem are guaranteed, constructed the singular value decomposition (SVD) of the forward scattering operator under conditions of weak scattering, and used these results to obtain explicit inversion formulas for the case of the linearized ISP. In this paper we extend these results to the nonlinear case. In particular, we construct a formally exact analytic solution to the nonlinear ISP. This solution, which we refer to as the inverse scattering series, has the form of a functional series expansion for the scattering potential in powers of the scattering data. The first term in the expansion corresponds to the pseudoinverse solution to the linearized inverse problem. The higher order terms may be interpreted as nonlinear corrections to the SVD inversion formulas. We have also shown that summing the inverse scattering series to all orders is equivalent to solving the ISP by the Newton-Kantorovich method. We have investigated the effects of sampling and limited data in the computation of the inverse scattering series. We have implemented the first nonlinear correction and are working to improve the computational efficiency of computing corrections to higher order.