The inverse scattering problems arise in a variety of areas of science and in particular in the detection of objects in space and several aspects of material properties. Solving these problems requires the knowledge of the scattered waves near or far away from the object.

We first consider the inverse scattering problems of determining the shape and the material properties of the thin dielectric infinite cylinder having an open arc as cross section from knowledge of the TM-polarized scattered electromagnetic field at a fixed frequency. We develop two methods for solving the direct problem for thin dielectric infinite cylinder, namely an integral equation method and a variational method. We also investigate two reconstruction approaches, namely the linear sampling method and the reciprocity gap functional method, using far field or near field data, respectively. Numerical examples are given showing the efficaciousness of our algorithms.

We also consider the inverse scattering problem of detecting dielectric objects partially coated with a very thin layer of highly conductive material in the scalar case. Using the linear sampling method, we show that the approximate solution of the far field equation can be used to reconstruct the support of the coating in addition to the reconstruction of the shape of the scattering obstacle without any a priori information. Based on a detailed analysis of Green's function for several boundary value problems, we also deduce formulas providing point-wise reconstruction of the surface conductivity on the coated portion and the real index of refraction on the uncoated portion of the boundary. Numerical examples are given for the case with constant surface conductivity and index of refraction showing the viability of our reconstruction procedure.

In this thesis we also study the problem of distinguishing between a perfect conductor and a dielectric object partially coated by a thin highly conducting layer, of the same shape using multifrequency and multistatic data.