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The Inverse Scattering Problem and the role of measurements in its solution

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The electromagnetic inverse scattering problem suggests that if a homogeneous and non-absorbing object be illuminated with a monochromatic light source and if the far field scattered light intensity is known at sufficient scattering angles, then, in principle, one could derive the dielectric structure of the scattering object. In general, this is an ill-posed problem and methods must be developed to regularize the search for unique solutions. An iterative procedure often begins with a model of the scattering object, solves the forward scattering problem using this model, and then compares these calculated results with the measured values. Key to any such solution is instrumentation capable of providing adequate data. To this end, the development of the first laser based absolute light scattering photometers is described together with their continuing evolution and some of the remarkable discoveries made with them. For particles much smaller than the wavelength of the incident light (e.g. macromolecules), the inverse scattering problems are easily solved. Among the many solutions derived with this instrumentation are the in situ structure of bacterial cells, new drug delivery mechanisms, the development of new vaccines and other biologicals, characterization of wines, the possibility of custom chemotherapy, development of new polymeric materials, identification of protein crystallization conditions, and a variety discoveries concerning protein interactions. A new form of the problem is described to address bioterrorist threats. Over the many years of development and refinement, one element stands out as essential for the successes that followed: the R and D teams were always directed and executed by physics trained theorists and experimentalists. 14 Ph. D. physicists each made his/her unique contribution to the development of these evolving instruments and the interpretation of their results.

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