

On multiple small-angle scattering

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Abstract. An analytical approach has been taken for analyzing the multiple scattering effects in small angle scattering (SAS) from both monodisperse and polydisperse systems. Two limiting regions, viz the Guinier region and the Porod region have been studied. A modified form of Guinier law has been deduced for the scattered intensity distribution in the region of small wave vector transfer, q . In the region $q(=|q|) \rightarrow \infty$, it is shown that the effect of multiple scattering does not alter the Porod (q^{-4}) law. In the case of polydisperse systems, a correlation has been established between the size distribution of the inhomogeneities and the experimentally extractable parameters. The validity of the formalism has been examined by reinterpretation of the multiple SANS data (Hardman-Rhyne and Berk 1985) on polydisperse Al_2O_3 samples. This formalism is useful in characterizing the inhomogeneities from SAS measurements, particularly when thick samples are used.

Keywords. Small angle scattering; multiple scattering; Guinier law; monodisperse system; polydisperse system; Porod law.

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1. Introduction

Small angle scattering (SAS) of X-rays and neutrons has been found to be a very useful probe for studying structural and compositional inhomogeneities in condensed systems. Analysis employing the Guinier and the Porod laws which are based on the single scattering approximation is widely used (Kostorz 1979) for evaluating the size and the surface characteristics of inhomogeneities. Although these theories yield reliable estimates for the parameters derived when thin samples are used, disagreements start building up between these parameters and those measured by other complementary techniques when the sample thickness and/or number density of the scatterer cease to satisfy the single scattering approximation which is strictly valid when the sample thickness is less than the mean free path of the radiation inside the matrix. But for samples with thickness greater than the mean free path of the radiation, the multiple scattering becomes significant which is evident from the fact that the linear dimensions extracted from the SAS data are significantly smaller than those measured by other complementary techniques. Hence, a correction for multiple scattering becomes essential. A formulation which takes account of multiple scattering becomes useful not only to process the experimental data, but also enables study of large inhomogeneities, as we will see later, which are otherwise inaccessible because of the limitation of the instrumental resolution.

Several workers, e.g. Dexter and Beeman (1949), Perret and Ruland (1971), Ruland