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On the independent scattering assumption in the electromagnetic and acoustic case

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The assumption of independent scattering is of some importance in a variety of different scattering scenarios not only in the realm of remote sensing but also in technical and medical diagnostics. This assumption is related to an ensemble of scattering particles within an illuminated volume element. Its justification requires the consideration of two different effects. These are the interference of the scattered fields produced by -, and the scattering interaction between different particles of the ensemble.

In our investigations, we consider the simplest ensembles consisting of two and three particles. When dealing with plane electromagnetic wave scattering, the program mstm by Mackowski and Mishchenko (Mackowski D. W. and Mishchenko M. I., “A multiple sphere T-matrix Fortran code for use on parallel computer clusters,” J. Quant. Spectrosc. Radiat. Transfer 112, 2182, 2011) is used. Note that this program is based on a T-matrix approach. The ensemble T-matrix is obtained by an iterative solution of an interaction equation system. Setting the number of iterations to zero results in a solution where no scattering interactions between the spherical particles are taken into account. However interference effects remain. In this way, the two different aspects of the independent scattering assumption – the interference and the scattering interaction – can be studied separately. To deal with plane acoustic wave scattering, an own T-matrix program has been developed. It also allows a separate investigation of above both aspects.

In our contribution we discuss conditions under which the scattering interaction between the particles can be neglected. We show that even under these conditions and if averaging over the particle distances, the overall scattering behavior of the ensembles cannot be described by a simple sum over those of the single isolated particles. In analogy to the double and triple slit experiments, interference effects remain in the forward scattering direction. Depending on the particle configuration, interference effects can be also observed in the backscattering direction. We show furthermore that they are attenuated by particle interactions only to a certain degree. It is therefore concluded that in scattering measurements that are based on coherent incident fields (such as Lidar and Radar measurements) the violation of the independent scattering assumption in the near forward and backward direction has to be considered as a potential source of errors in the data analysis.