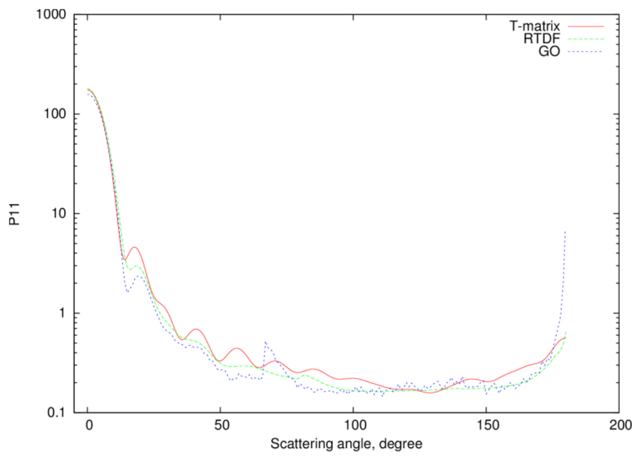
On the Applicability of Physical Optics in the mm-wave Region of the Electromagnetic Spectrum

Anthony J. Baran[1], **Evelyn Hesse**[2], **and Odran Sourdeval**[3]

[1]Met Office, Fitzroy Road, Exeter, EX1 3PB, Devon, United Kingdom
[2]Centre for Atmospheric and Instrumentation Research, University of Hertfordshire
Hatfield, Hertfordshire AL10 9A, United Kingdom
[3]Institute of Meteorology, Universität Leipzig, Leipzig, Germany

Abstract— From 2022 onwards, space-based satellites will measure the upwelling microwave and sub-millimetre emission from the Earth. The purpose of these new Earth observation satellites is to measure the total integrated ice column amount in the atmosphere to constrain climate model predicts of the amount of ice mass that is contained in the earth's atmosphere. To interpret these new measurements from across the microwave spectral region and invert them to find the total amount of ice mass, it will be necessary to construct realistic models of ice crystals contained in cirrus clouds and efficiently compute their light scattering properties. However, it is possible that in large-scale storm clouds there can exist ice particles with sizes easily in excess of several cm, such sizes of ice crystals preclude the current application of electromagnetic methods to compute their light scattering properties.

In this abstract, we explore the applicability, in size parameter space, of a novel physical optics method to compute the integral optical properties and phase functions of highly irregular ice crystals. The classical approach to geometric optics is to add Fraunhofer diffraction at the particle cross-section to the ray tracing result to obtain the full scattering phase function of the particle. In the approach presented here, developed by Hesse and called the Ray Tracing Diffraction on Facets method (RTDF), not only is Fraunhofer diffraction at the cross-section of the particle included but also diffraction at each of the facets on the ray tracing paths. We will show the applicability of the RTDF method down to size parameters of only 18 in the mm-wave and sub-mm-wave spectral regions, where the size parameter is defined by ($\pi\times$ the crystal maximum dimension)/wavelength. This result means that the more onerous electromagnetic methods need only be applied at up to size parameters of 18, which excludes significant computational cost in time and memory loading. The figure below shows the phase functions of a randomly oriented hexagonal ice column of size parameter 18 at 874 GHz calculated using T-matrix (red line), RTDF (green line), and classical geometric optics (blue line).



It is apparent from the figure that the addition of diffraction at each of the facets results in a much closer solution to T-matrix than classical geometric optics. The classical method is shown to over-estimate the halo and the backscattering amplitude by factors and orders of magnitude, respectively. In the presentation, results from other ice crystal shapes will be presented, which show similar results to those shown in the figure above.