Vectorial Complex Ray Model
from Geometrical Optics to Ray Theory of Wave
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Introduction

Many theoretical models and numerical methods have been developed for the prediction of scattering properties of light by particles. However, they are either valid for objects of very simple form or seriously limited in the size of the objects. The geometric optics, or ray model, is the unique candidate which can, in principle, be applied to large particles of any shape but their precision is not sufficient. By introducing the wave front curvature as an intrinsic property of the rays, Vectorial Complex Ray Model (VCRM) improves considerably the accessibility of ray model to complex shape particle and its precision. We present here this model, the Monte-Carlo Ray Tracing of Wave (MCRTW) as its variety and Ray Theory of Wave (RTW) as their extension.

VCRM and wave front curvature equation

All waves are considered as bundles of rays which are characterized by the direction of propagation, the amplitude, the polarization, the phase and the curvature of the wave the rays present. The latter is a new property of the ray permitting to count easily the evolution of the amplitude when a wave is reflected or refracted by a curved dioptr and the phase shift due to focal line. On the other hand, Snell law, Fresnel formul

\[ \mathbf{Q'} = \mathbf{Q} + i \mathbf{C} \]

where \( \mathbf{Q} \) and \( \mathbf{Q'} \) are the wave vectors of the incident and the refracted/reflected wave.

Numerical results

Fig. 1 Scattering diagrams calculated by LMT, GO and VCRM for a homogeneous sphere : refractive index \( n = 1.33 \), radius \( a = 50 \mu m \), wavelength \( \lambda = 0.6328 \mu m \).

Fig. 2 Rainbow structure of an ellipsoid.

The rays/photons in MCRTW can possess also the 5 properties of the rays in VCRM.

Fig. 3 Comparison of Airy structure calculated with the three methods.

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References: