ANALYSIS OF CHIRAL SPHERE RAINBOWS IN GEOMETRIC OPTICS MODEL

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Abstract
A geometric optics model is set up to analyze the rainbow phenomenon of chiral spheres. The ray traces inside the chiral sphere are determined by reflection and refraction laws of light at achiral-chiral interface and chiral-achiral interface. The calculated rainbow angles achieve good agreements with those obtained by analytical solutions. Effects of chirality parameter and refractive index of the sphere on rainbow angles are analyzed.

1 Introduction
Chiral media in nature at optical frequencies, also known as the “optical active media”, are some solutions of substances with handed microstructure, such as grape sugar and tartaric acid.[1] Some biological particles with handed microstructure may be modelled by chiral spheres. Thus theory of light scattering from chiral spheres may help the study on biological particles. Numerical results from light scattering from large sized chiral spheres show that three first-order rainbows occur for a linearly polarized wave incidence [2, 3]. We make an attempt to present a geometric optics model for rainbows of a chiral sphere based on the optical property of chiral media. The traces of a ray travelling in a chiral sphere are analyzed and the three rainbow angles are calculated.

2 Reflection and refraction of light propagating through chiral slab
Figure 1 presents the reflection and refraction of a ray incident on a general isotropic medium from a chiral medium. Two transmitted rays are generated in chiral medium; one is RCP ray and the other is LCP ray [4, 5].

Finally, the three deviation angles (angular displacements of transmitted directions from positive z axis) are obtained as:
\[ \theta_{RR} = 2\theta_i + \pi - 4\arcsin\left(\frac{n_i}{n_R}\sin\theta_i\right) \] (1)
\[
\theta_{LL} = 2\theta + \pi - 4\arcsin \left( \frac{n_i}{n_s} \sin \theta \right)
\]
(2)

\[
\theta_{RL} = 2\theta + \pi - 2\arcsin \left( \frac{n_i}{n_s} \sin \theta \right) - 2\arcsin \left( \frac{n_i}{n_s} \sin \theta \right)
\]
(3)

The extrema of the three angles are the three first order rainbow angles of the chiral sphere.

4 Numerical results

Figure 4 shows a comparison between rainbow angles calculated by GO model and rainbow structures from analytical solutions.

Figure 4 Comparison of rainbow angles of chiral spheres between GO model and MIE theory.

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6 References


