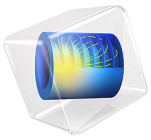
Created in COMSOL Multiphysics 5.6



Corner Cube Retroreflector

Introduction

This tutorial model shows how to simulate the reflection of a bundle of rays at a corner cube retroreflector using the Geometrical Optics interface.

A corner cube retroreflector is used to reflect rays so that the reflected rays are antiparallel to the incident rays, regardless of the angle of incidence. A basic corner cube retroreflector consists of three orthogonal reflecting surfaces.

Model Definition

1000 rays are released into the corner cube retroreflector with a conical distribution. The geometry, shown in Figure 1, is imported as a built-in Part from the Part Library for the Ray Optics Module. The initial and final directions of the rays are used to confirm that the initial and final trajectories are parallel, regardless of the angle of incidence.

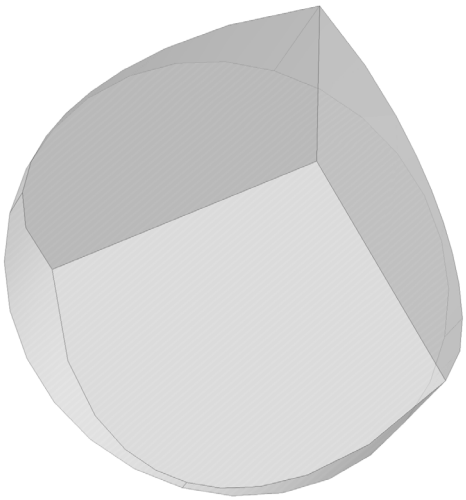


Figure 1: Geometry of a typical corner cube retroreflector.

Results and Discussion

Figure 2 shows the ray trajectories as they propagate through the geometry. The color expression corresponds to the ray index, which has a unique integer value for each ray. In Figure 3, the initial and final angles between each ray trajectory and the surface normal are plotted to confirm that the incident and reflected rays are parallel.

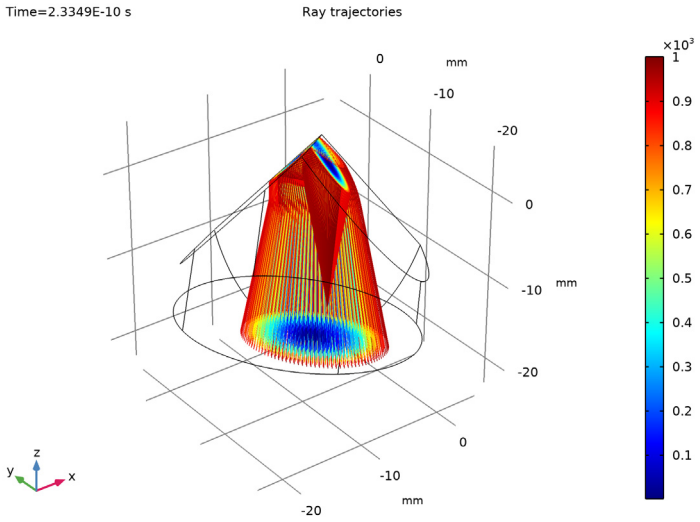


Figure 2: Ray trajectories in the corner cube retroreflector.

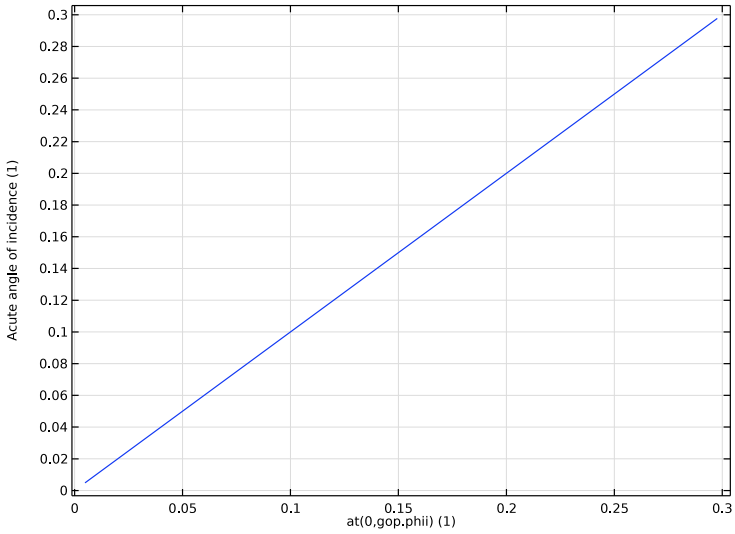


Figure 3: Acute angle of incidence for the reflected rays as a function of the initial angle between the released rays and the surface normal.

Application Library path: `Ray_Optics_Module/Tutorials/corner_cube_retroreflector`

Modeling Instructions

From the **File** menu, choose **New**.

NEW

In the **New** window, click **Model Wizard**.

MODEL WIZARD

1 In the **Model Wizard** window, click **3D**.

2 In the **Select Physics** tree, select **Optics>Ray Optics>Geometrical Optics (gop)**.

3 Click **Add**.

4 Click **Study**.

5 In the **Select Study** tree, select **Preset Studies for Selected Physics Interfaces>Ray Tracing**.

6 Click **Done**.

GEOMETRY 1

1 In the **Model Builder** window, under **Component 1 (comp1)** click **Geometry 1**.

2 In the **Settings** window for **Geometry**, locate the **Units** section.

3 From the **Length unit** list, choose **mm**.

PART LIBRARIES

1 In the **Home** toolbar, click **Windows** and choose **Part Libraries**.

2 In the **Part Libraries** window, select **Ray Optics Module>3D>Retroreflectors>corner_cube_retroreflector_3d** in the tree.

3 Click **Add to Geometry**.

GEOMETRY 1

Corner Cube Retroreflector 1 (pi1)

1 In the **Model Builder** window, under **Component 1 (comp1)>Geometry 1** click **Corner Cube Retroreflector 1 (pi1)**.

2 In the **Settings** window for **Part Instance**, locate the **Input Parameters** section.

3 In the table, enter the following settings:

Name	Expression	Value	Description
niy	1	1	Incident ray direction, y component
niz	1	1	Incident ray direction, z component

GEOMETRICAL OPTICS (GOP)

1 In the **Model Builder** window, under **Component 1 (comp1)** click **Geometrical Optics (gop)**.

2 In the **Settings** window for **Geometrical Optics**, locate the **Ray Release and Propagation** section.

3 In the **Maximum number of secondary rays** text field, type `0`.

Medium Properties 1

1 In the **Model Builder** window, under **Component 1 (comp1)>Geometrical Optics (gop)** click **Medium Properties 1**.

2 In the **Settings** window for **Medium Properties**, locate the **Medium Properties** section.

3 From the n list, choose **User defined**. In the associated text field, type `1.5`.

Mirror 1

1 In the **Physics** toolbar, click **Boundaries** and choose **Mirror**.

2 Select Boundaries 5–7 only.

Wall 1

1 In the **Physics** toolbar, click **Boundaries** and choose **Wall**.

2 Select Boundary 2 only.

Release from Grid 1

1 In the **Physics** toolbar, click **Global** and choose **Release from Grid**.

2 In the **Settings** window for **Release from Grid**, locate the **Initial Coordinates** section.

3 In the $q_{x,0}$ text field, type `-22/sqrt(3)`.

4 In the $q_{y,0}$ text field, type `-22/sqrt(3)-5`.

5 In the $q_{z,0}$ text field, type `-22/sqrt(3)+5`.

6 Locate the **Ray Direction Vector** section. From the **Ray direction vector** list, choose **Conical**.

7 In the N_w text field, type `1000`.

8 Specify the **r** vector as

1	x
1.3	y
1	z

9 In the α text field, type `pi/18`.

STUDY 1

Step 1: Ray Tracing

1 In the **Model Builder** window, under **Study 1** click **Step 1: Ray Tracing**.

2 In the **Settings** window for **Ray Tracing**, locate the **Study Settings** section.

3 From the **Time-step specification** list, choose **Specify maximum path length**.

4 From the **Length unit** list, choose **mm**.

5 Click **Range**.

6 In the **Range** dialog box, type `0.2` in the **Step** text field.

7 In the **Stop** text field, type `70`.

8 Click **Replace**.

9 In the **Home** toolbar, click **Compute**.

RESULTS

Ray Trajectories (gop)

In the **Model Builder** window, expand the **Ray Trajectories (gop)** node.

Color Expression 1

1 In the **Model Builder** window, expand the **Results>Ray Trajectories (gop)> Ray Trajectories 1** node, then click **Color Expression 1**.

2 In the **Settings** window for **Color Expression**, locate the **Expression** section.

3 In the **Expression** text field, type `gop.pidx`.

4 Click the **Zoom Extents** button in the **Graphics** toolbar.

5 In the **Ray Trajectories (gop)** toolbar, click **Plot**. Compare the resulting plot to Figure 2.

Create a plot to display the angle of incidence of the reflected rays as a function of the angle of the incident rays with respect to the boundary normal. Use the `at` operator to get the angle of incidence at $t = 0$ s.

Acute Angle of Incidence

1 In the **Home** toolbar, click **Add Plot Group** and choose **1D Plot Group**.

2 In the **Settings** window for **1D Plot Group**, type `Acute Angle of Incidence` in the **Label** text field.

3 Locate the **Data** section. From the **Dataset** list, choose **Ray 1**.

4 From the **Time selection** list, choose **Last**.

Ray 1

1 In the **Acute Angle of Incidence** toolbar, click **More Plots** and choose **Ray**.

2 In the **Settings** window for **Ray**, locate the **y-Axis Data** section.

3 In the **Expression** text field, type `gop.phii`.

4 Locate the **x-Axis Data** section. From the **Parameter** list, choose **Expression**.

5 In the **Expression** text field, type `at(0,gop.phii)`.

Acute Angle of Incidence

1 In the **Model Builder** window, click **Acute Angle of Incidence**.

2 In the **Settings** window for **1D Plot Group**, click to expand the **Title** section.

3 From the **Title type** list, choose **None**.

4 Click the **Zoom Extents** button in the **Graphics** toolbar.

5 In the **Acute Angle of Incidence** toolbar, click **Plot**. Compare the resulting plot to Figure 3.