VISRAD Benchmark Calculation:
Reflection of Laser Light Off a Sphere

Glint can occur in high energy density physics experiments when laser light reflects off a surface. The purpose of this benchmark calculation is to compare the distribution of laser light reflecting off a curved surface calculated using VISRAD with an analytical solution.

The geometry for this problem is illustrated in Figure 1. There are two spheres: an inner sphere of radius 1 cm (indicated by the solid blue circle), and an outer sphere of radius 3 cm (the outer blue circle). A laser beam is incident on the inner sphere. In this benchmark simulation, the laser beam is allowed to pass through the outer sphere. The axis of the beam goes through the sphere center. The beam intensity is cylindrically symmetric about the z-axis and is independent of z.

We consider two cases for the radial dependence of the beam: a supergaussian profile with n = 2.3, and a uniform beam. The total power in the beam is 1 TW. The radius of the beam is 0.9 cm; *i.e.,* slightly less that the radius of the inner sphere.

The beam reflects off the inner sphere. The angle to the point of reflection is given by ψ. For the analytic solution, we assume perfect reflection, so that all the intensity is reflected off the inner sphere by an angle of 2θ. The light then reaches a point on the outer sphere which can be specified by an angle α. The goal of the problem is to compute the intensity seen at the boundary of the outer sphere as a function of α for the two beam profiles.

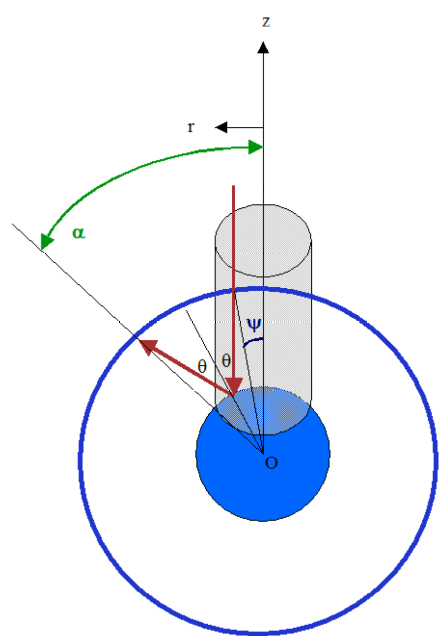

Figure 1. Geometry for reflecting laser beam benchmark problem.

The analytic solution for the intensity at the outer sphere is:

$$I(R_o,\alpha) = I(r)\,\frac{r}{R_o^2}\,\frac{1}{\sin(\alpha)}\left[\frac{2}{R_i\cos(\theta)} - \frac{1}{R_o\cos(\psi)}\right]$$

where R_i and R_o are the inner and outer sphere radii, the angles θ, ψ, and α are defined above and in Figure 1, *I(r)* is the laser beam intensity incident onto the inner sphere, and *r* is the radial distance from the beam axis.

Figure 2 shows the reflected laser beam intensity onto the outer sphere as a function of the angle α. The squares represent the results computed using VISRAD, while the solid curves are the analytic solutions. The results for the uniform beam profile are shown in blue, while the n = 2.3 supergaussian results are shown in red.

The agreement between the VISRAD results and the analytic solution for the two cases is seen to be good. Since that maximum radius of the beam is 0.9 cm, the intensity falls abruptly to zero at 111 degrees in the analytic solution. The intensity drops off more gradually in the VISRAD case because of the use of the Phong reflection model. That is, the reflected laser light is not treated as a perfect reflection, but instead the intensity of the reflected light is spread out over some (small) angle. The calculated results are also seen to be somewhat low at low polar angles. However, given the fact that the VISRAD model is designed to compute reflections for grids with arbitrary shapes and multiple objects, we find the overall agreement to be very satisfactory.

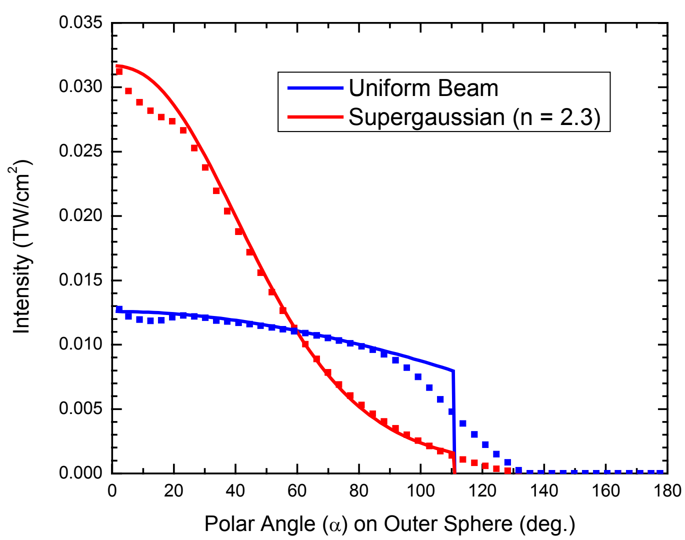

Figure 2. Intensities calculated at the radius of the outer sphere for the reflecting laser beam benchmark calculation. The solid curves are the analytic results. VISRAD results are represented by the squares. Red: supergaussian beam profile. Blue: uniform beam profile.