Mie Scattering

Physics 259 - DS Hamilton 2005

This worksheet investigates the modified Rayleigh-Debye approximation for Mie scattering as discussed by R.M. Drake and J.E. Gordon, Am. J. Phys. **53** 955 (1985). The calculation is done for light polarized perpendicular to the scattering plane. The results for ka=10 are compared to a full Mie scattering calculation

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$m := 1.2$

relative index of refraction

$\lambda := 0.6328$

wavelength of the light in microns (μ)

$ka := 10$ $\qquad$ $k=2\pi/\lambda$

we can choose to fix either ka or a, I chose ka.

$$a := ka \cdot \frac{\lambda}{2 \cdot \pi} \qquad 2\,a = 2.014$$

2a is the sphere diameter

$$\mathrm{cosd}(\theta) := \cos(\theta \cdot \mathrm{deg})$$

I want to do the calculation with the scattering angle in degrees and not radians

$$x(\theta) := ka \cdot \left(1 + m^2 - 2 \cdot m \cdot \mathrm{cosd}(\theta)\right)^{0.5}$$

a modification to the usual R-D approximation

$$J1(z) := \frac{\sin(z) - z \cdot \cos(z)}{z^2}$$

This defines the first-order spherical Bessel function

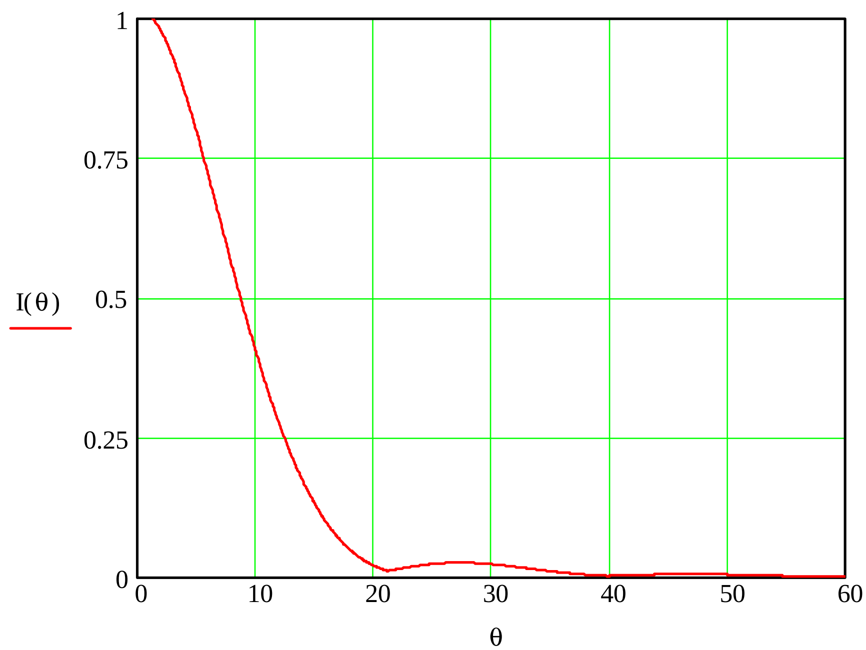
$$\gamma(\theta) := \frac{\mathrm{sign}(J1(x(\theta)))}{x(\theta)^{1.5}}$$

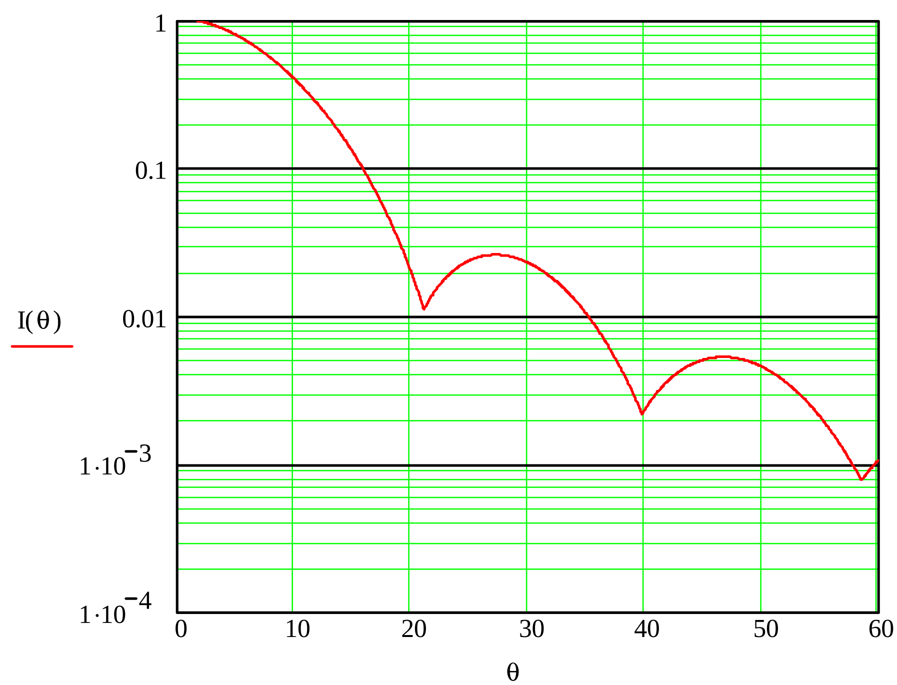
another improvement to the R-D approximation

$$I(\theta) := \left(\frac{3\,J1(x(\theta))}{x(\theta)} + \gamma(\theta)\right)^2$$

The scattering efficiency as a function of scattering angle. The forward direction is $\theta=0^\circ$ and $I(0^\circ)=1.0$.

Here are the graphs of the inensity of the scattered light as a function of scattering angle. On the semi-log graph you can clearly see the local minima at 22°and 40°.





We next compare the modified R-D approximation to the full Mie scattering calculation using the results on the web at http://omic.ogi.edu. Values of λ=0.6328μ and a diameter of 2.014μ give us ka=10.

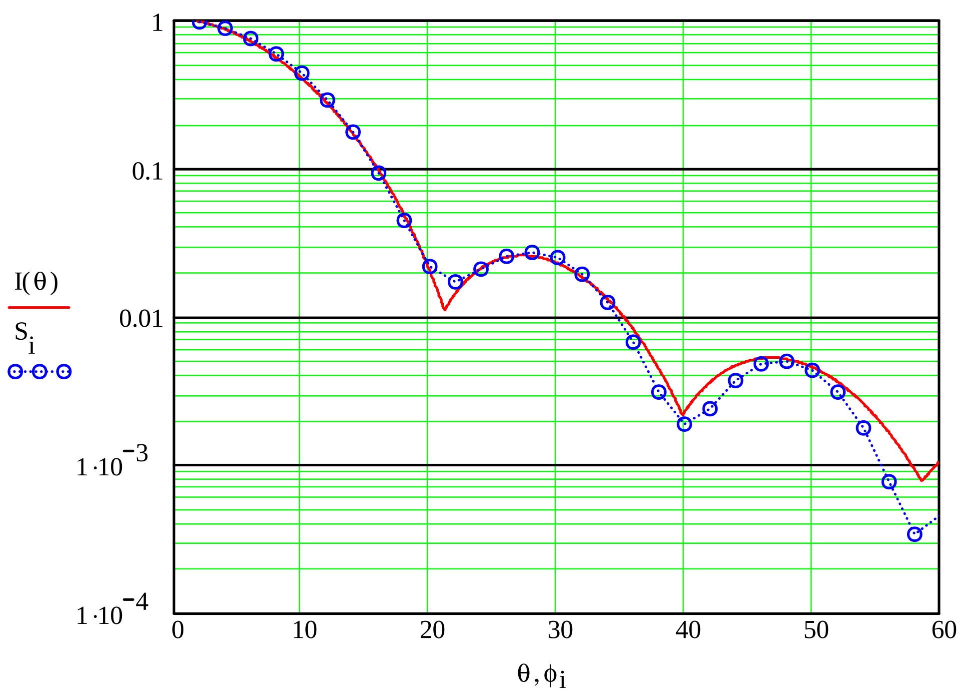
$i := 1 .. 60$

$S :=$

1
0.969
0.881
0.749
0.593
0.434

$\phi :=$

0
2
4
6
8
10



The R-D approximations seem to be best for the smaller scattering angles and for ka<30.