Mie Theory – Computer Exercise

12.815 Fall 2006

References

An Introduction to Atmospheric Radiation, K. Liou

Atmospheric Radiation, R.M. Goody, and Y.L. Yung

"Light Scattering in Planetary Atmospheres," J.E. Hansen and L.D. Travis, *Space Science Review* **16**, 527-610, 1974. ***Read This**

Mie Scattering Program: The Mie scattering program calculates quantities such as the single scattering albedo *a* and the asymmetry parameter *g*. the program outputs columns of numbers that can be plotted using standard plotting routines. To obtain the program and the necessary documentation, follow the steps outlined in detailed instructions. After these steps have been followed, you should have seven files in a directory called Mie. The file descriptions are:

(1) Compile_Run describes the process of compiling and running the source code for the exercise.
(2) MIEV.doc is the documentation for the Mie scattering code. This is recommended reading.
(3) MIEV0.f is the main subroutine which the user calls.
(4) ErrPack.f is a set of 4 error-handling routines needed by MIEV0.f.
(5) qscat.f is the driver for exercise 2.
(6) phs_fnc.f is the driver for exercise 3.
(7) g.f is the driver for exercise 4.

Only minor modifications to the drivers are required for the exercises. The important driver inputs are:
(1) XX is the Mie size parameter.
(2) CREFIN is the complex index of refraction.
(3) NUMANG is the number of angles at which quantities are output.
(4) XMU(N) is the array of the cosines of the angles at which quantities are output.

The important output quantities are:
  (1) QEXT is the extinction efficiency.
  (2) QSCA is the scattering efficiency.
  (3) GQSC is the asymmetry parameter times QSCA.
  (4) S1 and S2 are the Mie scattering amplitudes, and are related to the normalized phase function P by the following:

$$P = (4/XX^2 QSCA) \, (|S1|^2 + |S2|^2)/2$$

Exercise 1 Calculate the attenuation for a ray traversing the diameter of a drop for $x = (1,100)$ and $\tilde{n}' = (10^{-1}, 10^{-3}, 10^{-5})$.

Exercise 2 Calculate and plot Q_{scat}, Q_{abs}, Q_{ext}, and a (where a = single scattering albedo) from $x = 1$ to 100, for $\tilde{n} = 1.33$ and $\tilde{n}' = (1, 10^{-1}, 10^{-2}, 10^{-3})$. Discuss the Q_{scat} curves in light of the van der Hulst theory of anomalous diffraction. Why does the large-scale oscillatory structure disappear as $\tilde{n}' \to 1$? Why does the asymptotic value of Q_{scat} for large x go from ~2 to ~1 as $\tilde{n}'$ goes from 10^{-3} to 1? Explain the trend of the single scattering albedo as a function of $\tilde{n}'$ for $x = 100$?

Exercise 3 Plot the unpolarized phase function (in any convenient units) as a function of the scattering angle for $x = 1$, $\tilde{n} = 1.33$, $\tilde{n}' = 10^{-3}$, and for $x = 100$, $\tilde{n} = 1.33$, $\tilde{n}' = (10^{-3}, 10^{-1})$. For each case discuss the relationship between the phase function and the value of $g = <\cos \theta> = $ asymmetry parameter.

Exercise 4 Plot g as a function of $\tilde{n}'$ from 10 to 10^{-3} for $\tilde{n} = 1.33$ and $x = (1,100)$. Can you account for the behavior of the $x = 100$ curve between $\tilde{n}' = 10^{-2}$ and 10? For $x = 1$ and $\tilde{n}' = 10$, g is negative. Given that $\tilde{n}' >> 1$ defines a specular reflector, can you account for the negative values? Ignore any sharp spikes that might appear in the output, they are due to resonances.