

# Exercises for Radiative Transfer in Astrophysics (SS2013)

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Exercise sheet 8

## Make your own opacities with a Mie code

### 1. Make an opacity table

- (a) Download the Bohren & Huffman Mie code `bhmie.f` from the website of Draine<sup>3</sup>.
- (b) Download the `Makefile` and `make_ca_cs_g.f90` codes from the lecture website.
- (c) Put them all into a directory and type “make” to compile. If all goes well, a code with the name `makeopac` has been generated.
- (d) Download an optical constants file from the Jena database<sup>4</sup> or from the Refractive Index website<sup>5</sup>. Take what you like. Make sure that the file has three columns: first is the wavelength in *micron* ( $\mu\text{m}$ ), the second is  $n$  and the third is  $k$ . Remove any header lines that may be present. The file *must* have `.lnk` as extension to the file name.
- (e) Create a file called `param.inp` with four lines:
  - i. First line is the name of the optical constants file *without* the `.lnk` extension.
  - ii. Second line is the grain radius in *centimeter*.
  - iii. Third line is the material density in gram/cubic-centimeter.
  - iv. Fourth line should, for now, be “1”.
- (f) Now call the `makeopac` code and make a plot of the absorption opacity that was created (the file `dustkappa_***.inp` where `***` stands for the name of the material). Repeat this for different grain sizes.

### 2. Make a scattering phase function

- (a) Select one line from your refractive index file (the `***.lnk` file) for a wavelength near to  $\lambda = 0.55 \mu\text{m}$ . Make a new `***.lnk` file that contains only this single line.
- (b) Now change the 1 in the `param.inp` file into 901. This is the number of angles.
- (c) Restart the `makeopac` code and study the `dustmatrix_***.inp` file, which contains 5 columns:  $\theta$ ,  $Z_{11}$ ,  $Z_{12}$ ,  $Z_{33}$ ,  $Z_{34}$  for 1801 angles<sup>6</sup>.
- (d) Plot the phase function for scattering.

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<sup>3</sup><http://www.astro.princeton.edu/~draine/scattering.html>

<sup>4</sup><http://www.astro.uni-jena.de/Laboratory/Database/databases.html>

<sup>5</sup>[refractiveindex.info](http://refractiveindex.info)

<sup>6</sup>The normalization of the  $Z$  matrix here is per gram of dust instead of per particle.