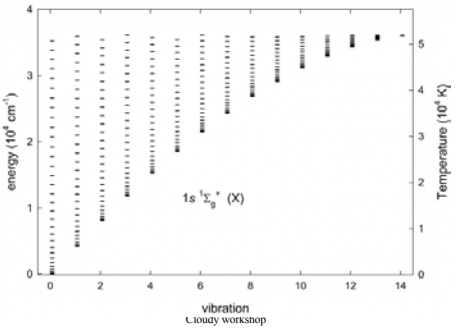
Databases in Cloudy

- Iso-electronic sequences (H and He like)
- H_2
- Stout (atoms & low ionization)
- Chianti (higher ionization)
- LAMDA (heavy-element molecules)

- Database print command
  - Reports all databases in us
  - The number of levels used
- Species "C+2" levels 40

H_2 (Shaw+05) - species H2 command



Controlling model atoms

- Series of SPECIES XXX commands
- Compare exec time species limit vs small
- C17 review

Converging the optical depths

- Iterate command, hazy 10.7
- Iterate to convergence
- Hazy 10.7.3 Convergence problems
  - Trouble if outer edge of cloud changes between iterations
  - For instance, by lowest temperature
  - Set outer radius or column density

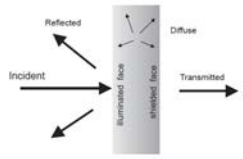


Figure 2.1: Several of the radiation fields that enter in the calculations.

Inward vs total emission

- "Inwd" label for line
- Inward/outward emission computed on second and later iterations
  - Iterate to convergence
  - Print last

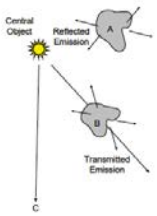
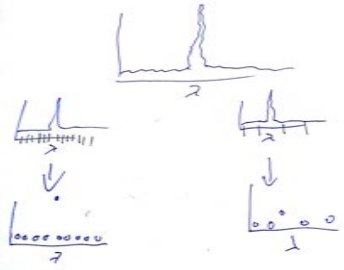


Figure 16.2: This figure illustrates several components of the radiation field that enter in the calculations.

Line to continuum contrast

- Hazy 1, sec 16.43.2, 19.14.44
  - Line to continuum contrast in save continuum
  - Command SET SAVE LINE WIDTH



Resolution of continuum mesh

- **Default resolution set by data/continuum_mesh.ini**
  - Will trip our checksum monitor
  - This is a permanent change in how Cloudy works
- **Set continuum resolution 0.5**
  - Increases the resolution by a factor of two for this model
- **Set save linewidth 500 km/s**
  - Changes appearance of lines in save continuum output. The calculation is not changed

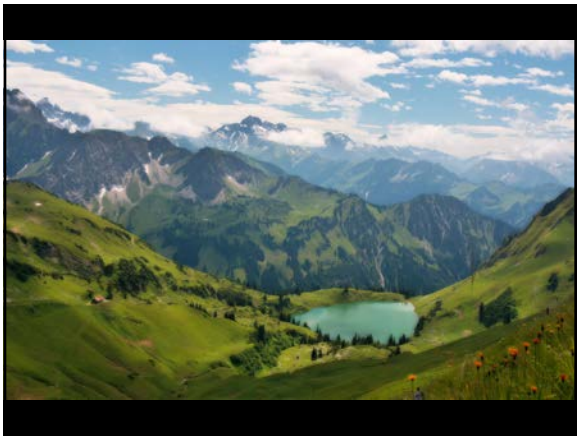
The optimizer

- **Hazy 1 Chap 17**
- **Examples in tsuite / auto**
  - ls *optim*.in

Downhill simplex

- **Evaluate sum of differences between predictions and observations at every set of parameter**
- **Vary the parameters to minimize this sum of errors**

$$\chi_i^2 = \left(\frac{F_i^m - F_i^0}{\min(F_i^m, F^0)\,\sigma} \right)^2 \qquad (17.1)$$



Specify observed quantities

- **Series of "optimize" commands**
- **Column density**
  - optimize column densities
  - hydrogen 1 < 17
  - carbon 4 17.4 error =.001
  - silicon 3 14.6 // The Si+2 column density
  - end of column densities

Luminosity or intensity of normalization line

- optimize intensity -0.3
- normalize to "O 3" 5007
- // we want a 5007 luminosity of 10^34.8 erg/s
- optimize luminosity 34.8

Line spectrum

- optimize lines
- O 3 5007 intensity =13.8 error =0.1
- Blnd 3727 < 2.1 (only upper limit)
- O 3 88.33m 1.2
- O 1 145.5m 1.6
- end of lines

Temperatures

- optimize temperature
- Hydrogen 1 36200K volume
- H2 0 150K radius
- end of temperatures

Controlling the optimizer

- **Hazy 1 Sect 17.7**
  - Optimize increment = 0.4 dex
  - Optimize iteration = 1000
  - Optimize range -2.3 to 3.9
  - Optimize tolerance 0.01