Sedona6 User's Guide

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1 Introduction

2 Getting Started

2.1 Getting the Code

2.2 Building the Code

Python (optional): Use python for plotting and testing scripts. Not needed for Sedona itself. Need

Python 2.7 is standard. On linux to get the necessary packages try:
sudo apt-get install python-numpy python-scipy python-matplotlib python h5py
Can also install the M

2.3 Running the Code

3 Input Data

Atomic data format

4 Model Parameters

Parameters are in the param.lua file. This is lua script, where you can specify variables and even functions inside the param file.

Defaults for all parameters are given in a defaults.lua file.

4.1 Time-stepping Parameters

Note that if

4.2 Transport Parameters

tstep_max_steps	integer number of time steps to take before exiting before stopping
tstep_time_start	start time (in seconds)
tstep_time_stop	stop time (in seconds)
tstep_max_dt	maximum size of a timestep (in seconds)
tstep_min_dt	minimum size of a timestep (in seconds)
tstep_max_delta	maximum fractional size of a timestep (multiply this by the current time to get the limit on the timestep).

transport_nu_grid	frequency grid to calculate opacities/emissivites. In the format of nu_start, nu_stop, nu_delta
transport_radiative_equilibrium	= 0 or 1. If 1, determine gas temperature after each time step from radiative equilibrium, i.e., heating equals radiative cooling
transport_steady_iterate	= integer. Do not step in time, rather iterate the radiation transport (in steady state) the number of times given.

5 Output

Spectrum files:

Ray files:

Grid files:

Level.hdf5 Files: These files continue detailed information about the ionization and excitation state for all species.

6 Test Problems

6.1 Core Into Vacuum

Setup: A spherical inner boundary emits blackbody radiation into an extremely low density medium, with optical depth so low it is essentially vacuum.

Test #1 - *Emergent Spectrum*: This should be a blackbody at the input inner core temperature. Tests general sampling of

Test #2 - *Radiation Temperature Structure*:. The radiation field outside a spherical emitter should be given by the dilution factor

$$J = \frac{1}{2}\left[1 - \sqrt{1 - R_0^2/r^2}\right] \quad (1)$$

Test #3 - *Non-LTE level populations*:

7 Physics

7.1 Bound-Bound

The extinction coefficient, corrected for stimulated emission, is calculated as (Rutten eq 2.62)

$$\alpha_{\rm bb}(\nu) = \frac{h\nu}{4\pi} n_l B_{\rm lu} \phi(\nu) \left[1 - \frac{n_u g_l}{n_l g_u}\right] \tag{2}$$

which assumes the absorption profile is the same as the emission (complete redistribution). Here $B_{\rm lu}$ can't be a constant, so we take

$$B_{\rm lu} = \frac{g_u}{g_l} \frac{c^2}{2h\nu^3} A_{\rm ul} \tag{3}$$

So the extinction becomes

$$\alpha_{\rm bb}(\nu) = \frac{1}{8\pi} \frac{g_u}{g_l} \frac{c^2}{\nu^2} n_l A_{\rm ul} \phi(\nu) \left[1 - \frac{n_u g_l}{n_l g_u}\right] \tag{4}$$

The emissivity is (Rutten eq. 2.69)

$$j_{\nu,\rm bb}(\nu) = \frac{h\nu}{4\pi} n_u A_{\rm ul} \phi(\nu) \tag{5}$$

There is still an issue here, the source function is then

$$S_\nu = j_\nu / \alpha_\nu = \frac{2h\nu^3}{c^2} (e^{h\nu_0/kT} - 1)^{-1} \tag{6}$$

which is not a blackbody because of the ν_0, not ν in the exponential. The resolution here is subtle, if I recall...