



## Light is much harder than gravity

$$F = G \frac{m_1 m_2}{d^2}$$

$$\begin{aligned} \psi = & \left( -\frac{\dot{R}}{R^2} + \frac{i\dot{F}}{R} \sum_{i=1}^N x_i^2 + \frac{i\dot{G}}{R} \sum_{i=1}^N x_i + i\frac{\dot{M}}{R} \right) e^{i\phi(y_i, \tau)} \Phi(y_i, \tau) \\ & + \frac{1}{R} e^{i\phi(y_i, \tau)} \sum_{i=1}^N \frac{\partial \Phi(y_i; \tau)}{\partial y_i} \left[ x_i \left( -\frac{\dot{L}}{L^2} \right) + \dot{S}(t) \right] + \frac{1}{R} e^{i\phi(y_i, \tau)} \frac{\partial \Phi(y_i; \tau)}{\partial \tau} \dot{\tau}, \quad (\text{A.2}) \end{aligned}$$



## Documentation

- ◆ In docs directory in Cloudy download
- ◆ Also on web share under “docs” folder

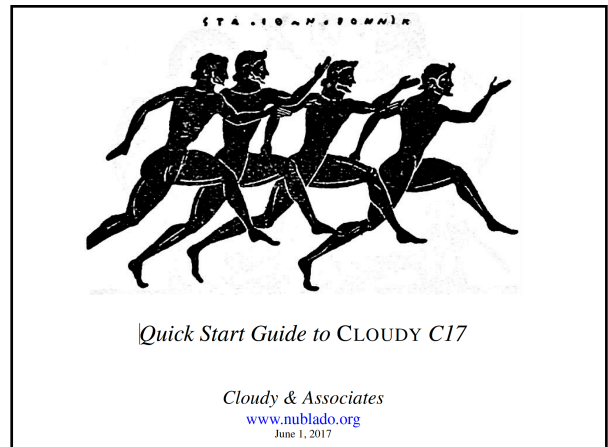
THE 2017 RELEASE OF CLOUDY

Review

THE 2017 RELEASE OF CLOUDY

G. J. Ferland<sup>1</sup>, M. Chatzikos<sup>1</sup>, F. Guzmán<sup>1</sup>, M. L. Lykins<sup>1</sup>, P. A. M. van Hoof<sup>2</sup>, R. J. R. Williams<sup>3</sup>,  
N. P. Abel<sup>4</sup>, N. R. Badnell<sup>5</sup>, F. P. Keenan<sup>6</sup>, R. L. Porter<sup>7</sup>, P. C. Stancil<sup>7</sup>

RESUMEN



## Quick Start Guide to CLOUDY C17

- > Introduction
- > Two very simple models
- > Geometry
- > Composition and density
- > The incident radiation field
- > Other commands
- > The code's predictions
- > Example calculations
- > How to make this plot
- REFERENCES
- > Veusz Cookbook

## Cloudy QSG Chapter 1

- ◆ **Accurate simulation of physical processes at the atomic & molecular level**
  - Physical processes treated from first principles, not with sub-grid physics or simple fitting formulae
- ◆ **Assumptions:**
  - energy is conserved
  - (usually) atomic processes have reached steady state
- ◆ **Limits:**
  - Kinetic temperature  $2.7 \text{ K} < T < 10^{10} \text{ K}$
  - No limits to density (low density limit, LTE, STE) for 1 and 2 electron atoms
  - Radiation field 30 m to 100 MeV

### Simultaneous solution of

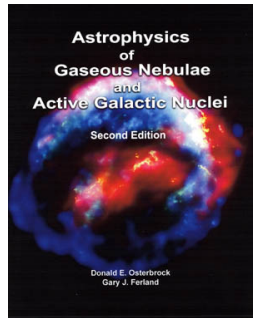
- ◆ **Gas ionization**
  - From ionization balance equations
- ◆ **Chemistry**
  - Large chemical network based on UMIST
- ◆ **Gas kinetic temperature**
  - Heating and cooling
- ◆ **Level populations and emission**
- ◆ **Grain physics**
  - Charging, CX, photoejection, quantum heating
- ◆ **The observed spectrum**
  - Radiative transport

### Cloudy is a microphysics code

- ◆ **Emphasis is on doing the atomic and molecular physics from first principles**
- ◆ **If we get the microphysics right, the macrophysics will take care of itself**
  
- ◆ **Many codes have dynamics, shocks, or 3D, as an emphasis, sometimes using Cloudy to get the microphysics**

### Osterbrock & Ferland Astrophysics of Gaseous Nebulae

- ◆ **There were three versions, this is the 3<sup>rd</sup>**
  - Don called this “AGN3”
- ◆ **Any version is OK**
- ◆ **PDFs of chapters we will use are in the docs folder of the web share**

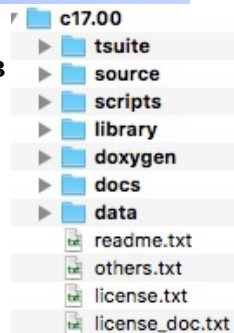


### Cloudy version C17.01

- ◆ **We set this up, ran a model, and created plots, as our homework last week**
- ◆ **The last three major Cloudy reviews are also in the docs folder of the web share**

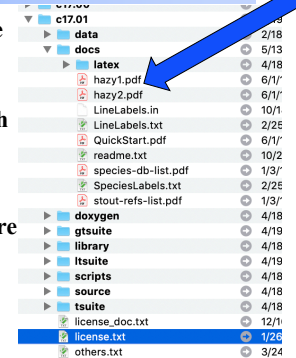
### The Cloudy download

- ◆ **527 MB uncompressed**
- ◆ **468 MB of this is data, 9.4 MB is source**
- ◆ **88.8% atomic & molecular data**



### Documentation

- ◆ **QSG Quick Start Guide**
- ◆ **Hazy 1, all commands**
- ◆ **Hazy 2, description of output, comparison with observations**
- ◆ **Hazy 3, not compiled, badly out of date, some physics is described there**



## Documentation

- ◆ **LineLabels.txt**
  - List of all lines known to the code
- ◆ **SpeciesLabels.txt**
  - List of all species (atoms, ions, and molecules) known to the code
- ◆ **Can be recreated by running LineLabels.in**

## Where to go for help

- ◆ [https://groups.yahoo.com/neo/groups/cloudy\\_simulations/info](https://groups.yahoo.com/neo/groups/cloudy_simulations/info)

## Running cloudy

- ◆ “run” file contains  
/Users/gary/cloudy/trunk/source/sys\_llvm/cloudy.exe -r \$1 2> \$1.err

- ◆ If file “model.in” contains input, then
  - run model &
  - Produces output “model.out”
  - The model will run in the “background” when the line ends with &

## Runtime options

- ◆ Appear after cloudy.exe
- ◆ Described at  
<http://trac.nublado.org/wiki/RunningC17>
- ◆ -r
  - I use this in my workflow
  - Required for grids to work
  - Study the options and consider what is best for your workflow
- ◆ Cloudy.exe -h
  - Will show all options

## The test suite

- ◆ Fully tests the code after any change

– “Monitors” allow automatic comparison of current with previous results

- ◆ Provides examples of how to use Cloudy

– But may include extraneous commands for testing  
– Or backwards compatible

- ◆ Useful examples of how to set up a simulation

