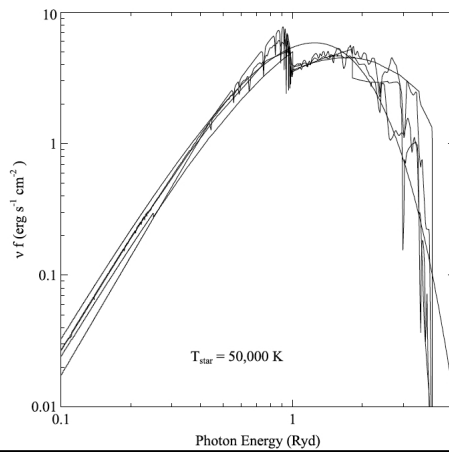


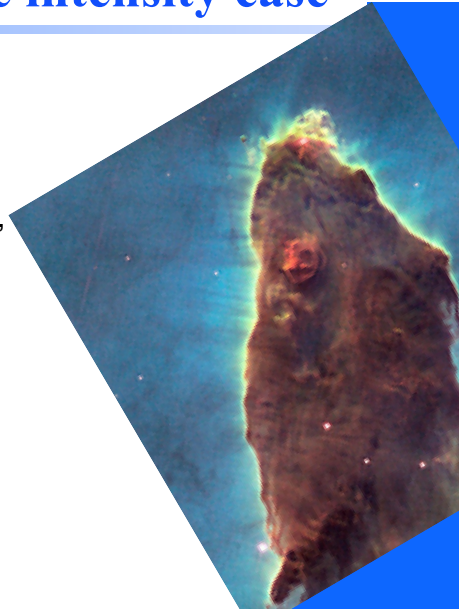
## Parameters – the SED shape

- ◆ Quick start guide Chapter 5
- ◆ Hazy 1, Chapters 4, 6
- ◆ Can be specified as a fundamental shape such as a blackbody
- ◆ Generally entered as table of points



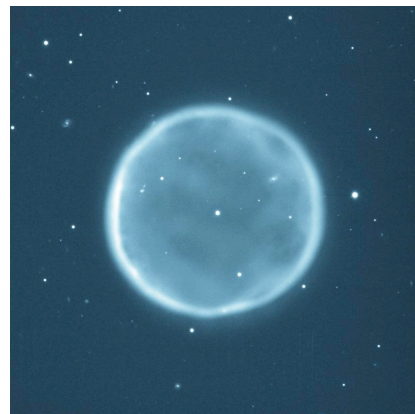
## SED brightness – the intensity case

- ◆ Specify  $\varphi(H)$  – flux of photons per unit area
  - The “intensity case”
  - predicts surface brightness, emission per unit area  $\text{erg cm}^{-2} \text{s}^{-1}$
  - Inner radius of cloud does not need to be specified



## SED brightness – the luminosity case

- ◆ Specify  $Q(H)$  – photon luminosity
  - Inner radius of cloud must be specified, since  $\varphi(H) = Q(H) / 4\pi r^2$
  - predicts emission line luminosities  $\text{erg s}^{-1}$



## Cloud density, Hazy 1 Chap 8

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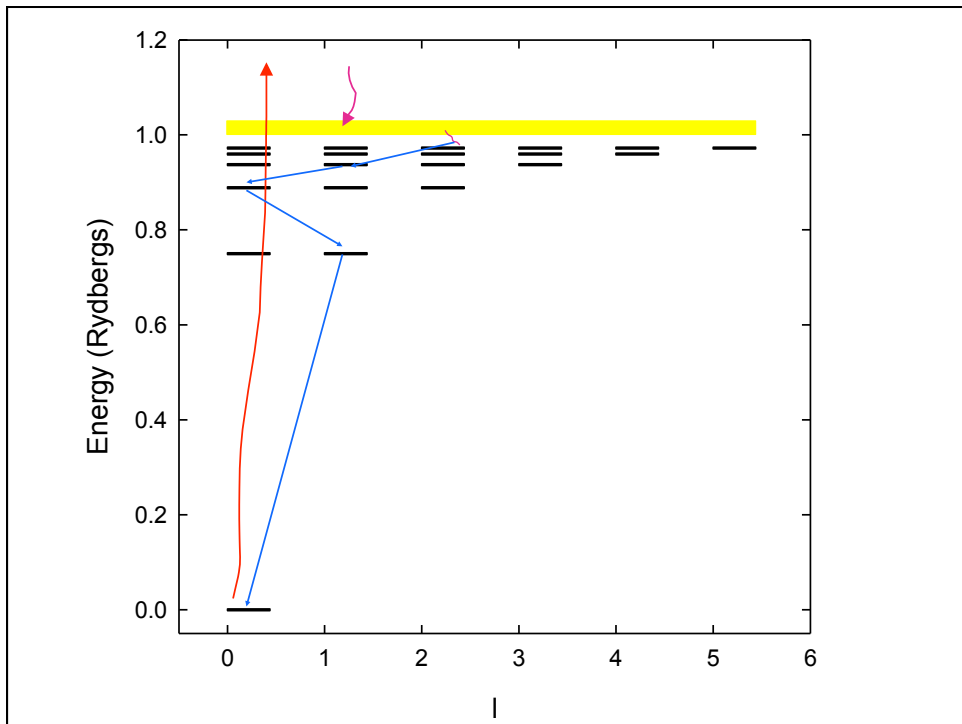
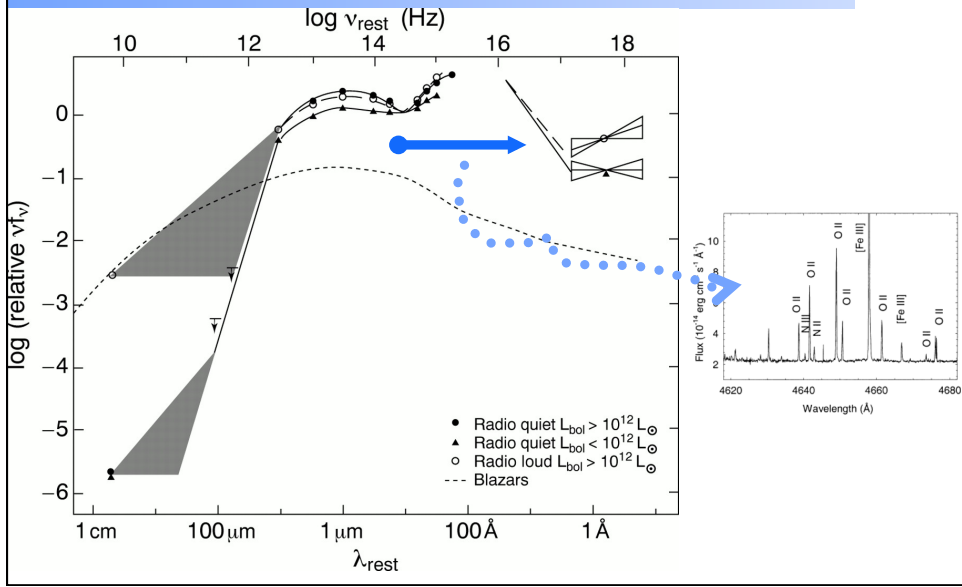
- ◆ **“hden” command set H density  $\text{cm}^{-3}$**
- ◆ **Constant density by default**
  - the H density is the same across the cloud
- ◆ **Other equations of state possible**
  - Constant pressure, flows, power-laws

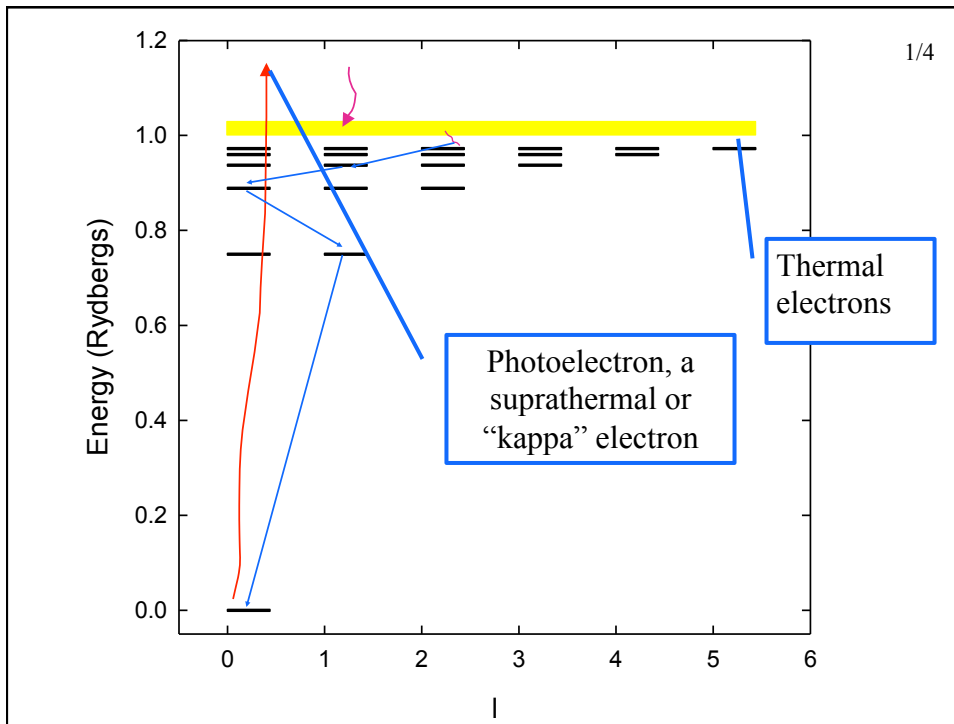
## Composition, Hazy 1 Chap 7

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- ◆ **Solar, no grains, by default**
- ◆ **Other standard mixtures possible,**
- ◆ **Stored in data / abundances**

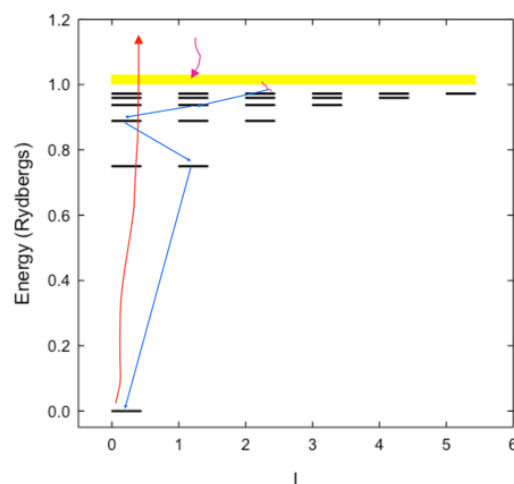
# The “primary mechanism” Continuum → emission lines





## Life history of an Orion electron

- ◆ **H<sup>0</sup> ground state**  
– 1 day
- ◆ **Suprathermal**  
– 1 second
- ◆ **Thermal**  
– 1 yr
- ◆ **H<sup>0</sup> excited states**  
– 10<sup>-7</sup> s
- ◆ **H<sup>0</sup> ground state**



## Let's model a ...

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- ◆ Relatively dense,  $n_{\text{H}} = 10^4 \text{ cm}^{-3}$
- ◆ ISM cloud
- ◆ One parsec away from an
- ◆ O6 star



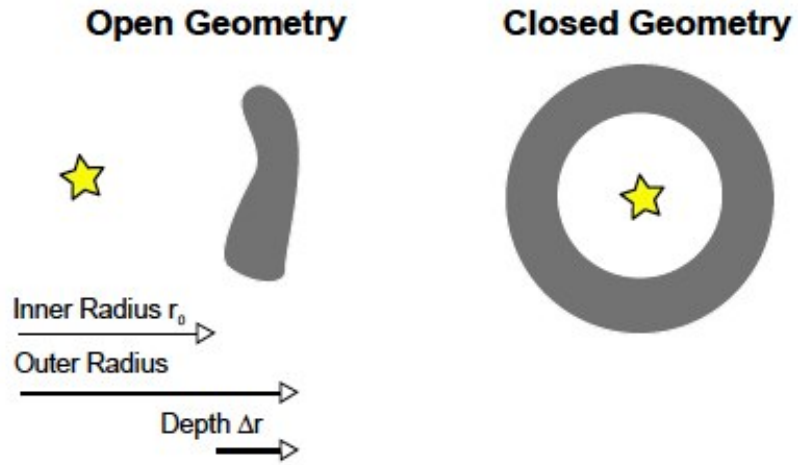
Cloudy workshop

## definitions

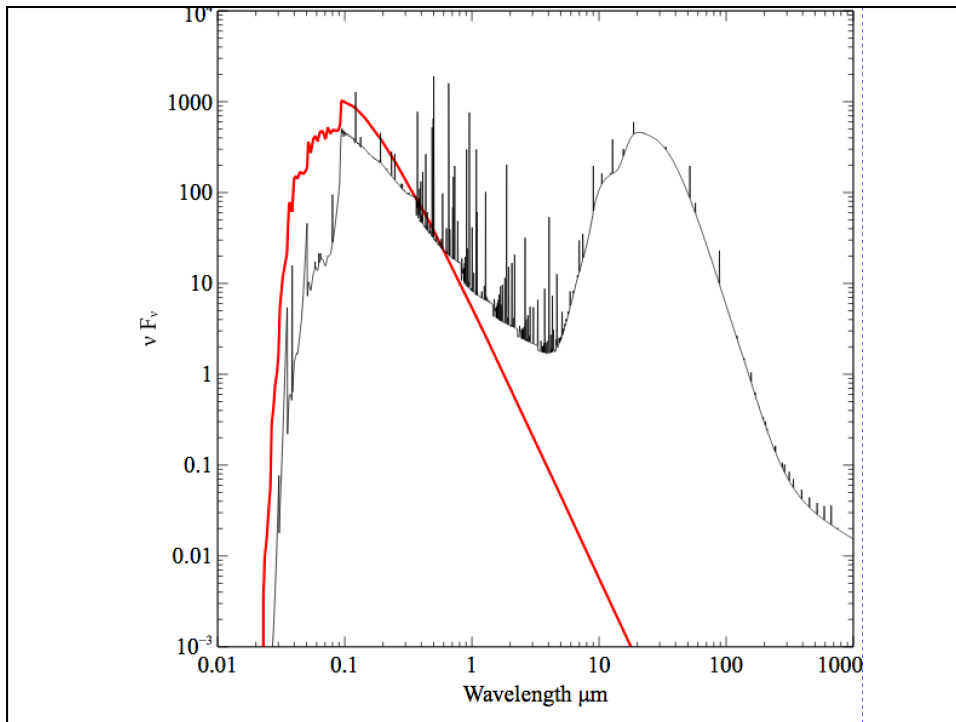
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- ◆ Illuminated and shielded face
- ◆ Incident, transmitted, emitted, reflected, components of radiation field
  - Hazy 1, section 2.2
- ◆ Open – closed geometry
  - Hazy 1 section 2.3

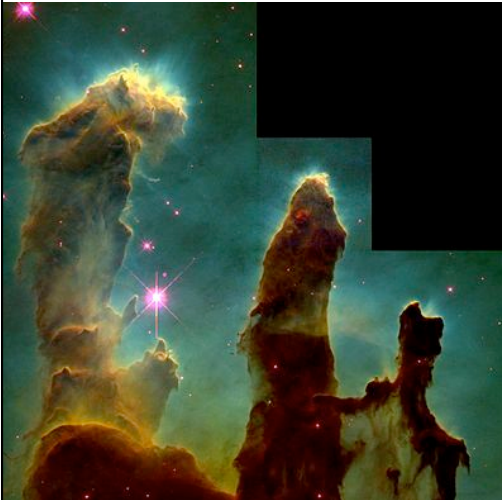
## Open vs closed geometry Hazy 2.3



2014 Cloudy workshop



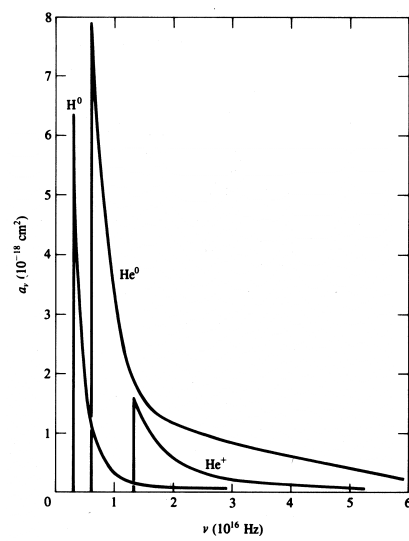
## Strömgren length



2014 Cloudy workshop

## Photoionization

- ◆ Highest cross section at lowest photon energies
- ◆ AGN3 Fig 2.2





## **Make plot of total opacity for zone 1 of H II region**

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## **Recombination AGN3**

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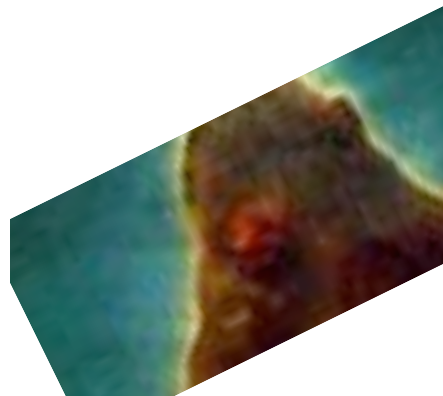
- ◆ **Electron and ion recombine, emitting energy**
- ◆ **Radiative recombination for H and He**
- ◆ **Dielectronic recombination for heavy element**
  
- ◆ **Print arrays command (a debugging tool) will report recombination rates**

## Strömgren length

- ◆ Number of ionizing photons entering layer is balance by number of recombinations along it

$$\Phi(H) = n_e n_p \alpha L$$

$$L \propto \frac{\Phi(H)}{n_e n_p \alpha}$$



## Matter vs radiation bounded



## Beyond the H<sup>+</sup> layer

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- ◆ Little H<sup>+</sup> ionizing radiation gets past the H<sup>+</sup> layer
- ◆ Deeper regions are atomic or molecular
- ◆ Also cold and produce little visible light
- ◆ Large extinction due to dust

