HII Regions (Part II)

Photodissociation Regions

Karina Caputi

Interstellar Medium 2013-2014 Q3
Rijksuniversiteit Groningen

The Effect of Dust in HII Regions

Why is it important?

- dust absorbs some of the photons with E>13.6 eV
  effectively reduces size of Stroemgren sphere

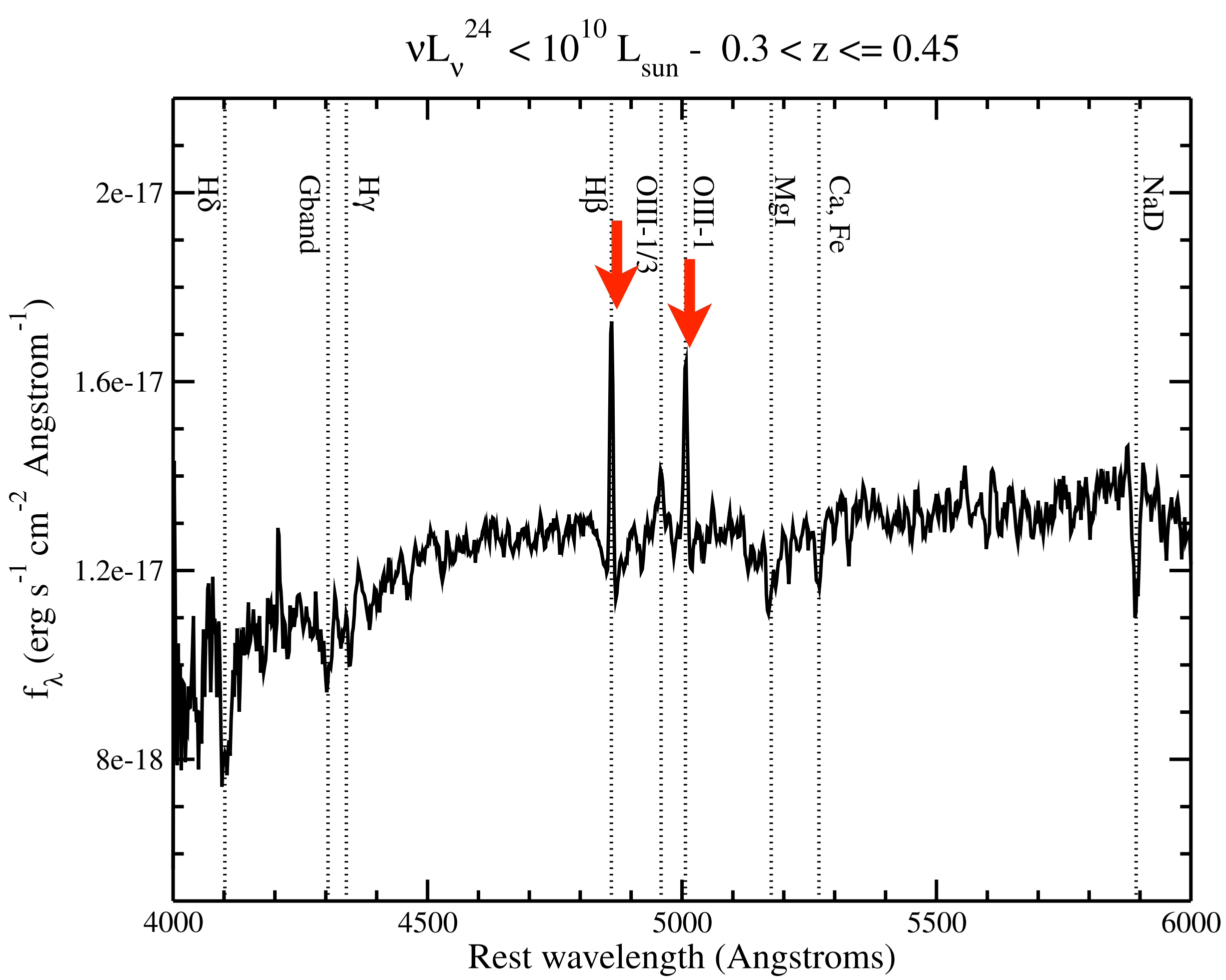
- radiation pressure acting on dust grains affects homogeneity of HII regions

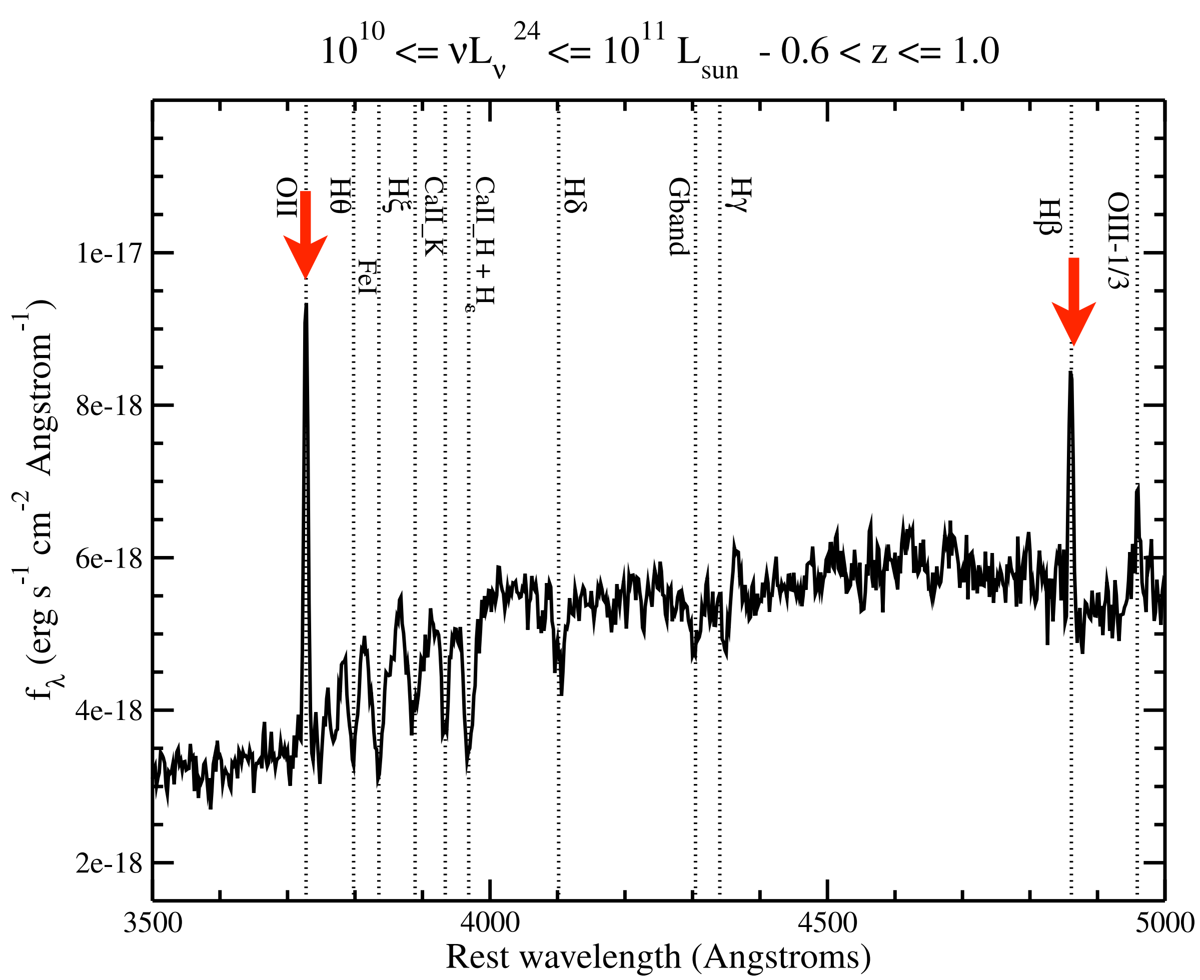
Equilibrium condition:

$$n_H \sigma_{\rm dust} \frac{L_n e^{-\tau} + L_i \phi(r)}{4\pi r^2 c} + \alpha_B n_H^2 \frac{< h\nu >_i}{c} - \frac{d}{dr}(2 n_H k T) = 0$$

Emission Lines of HII Regions in the Optical

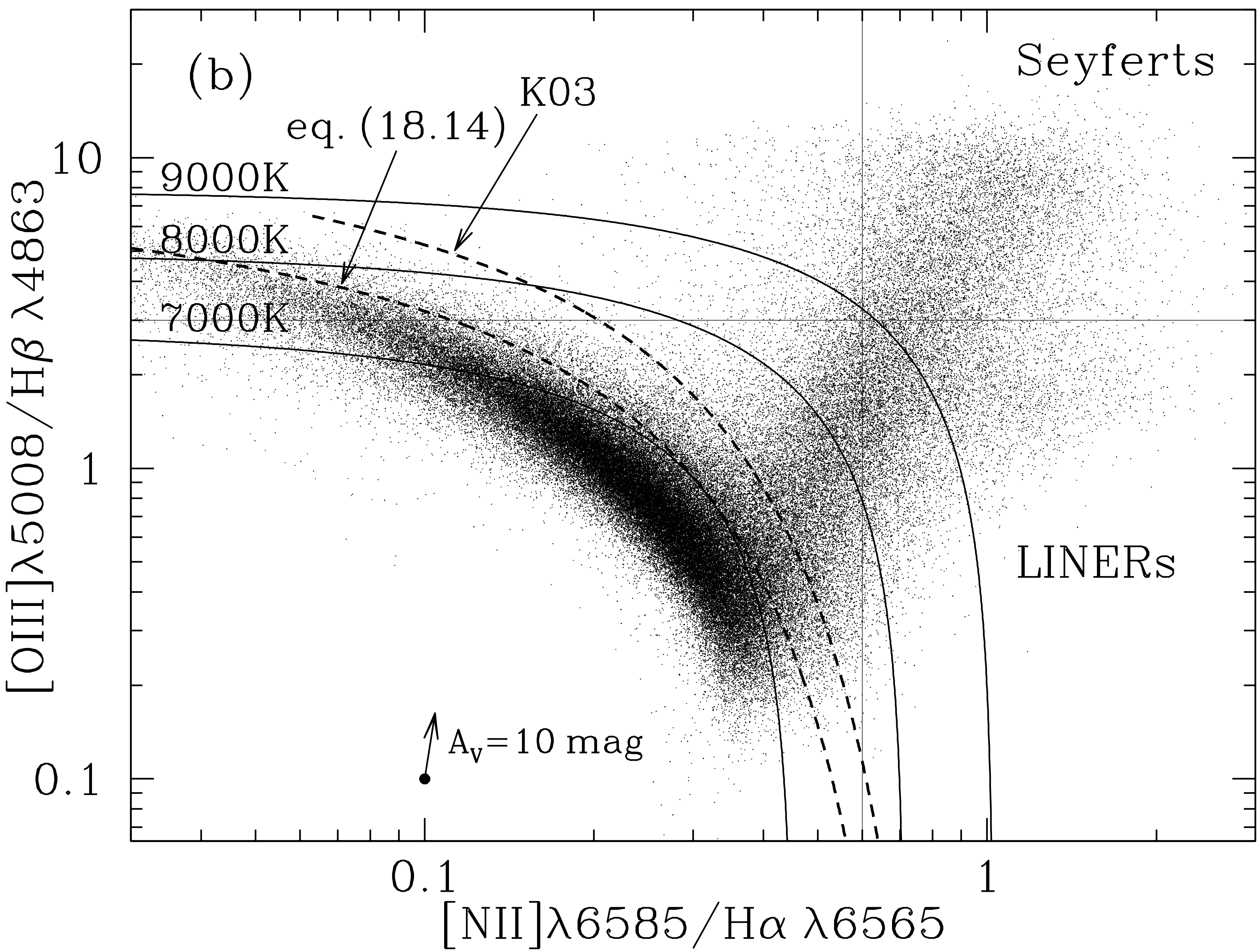
Average optical spectra of mid-IR-selected galaxies





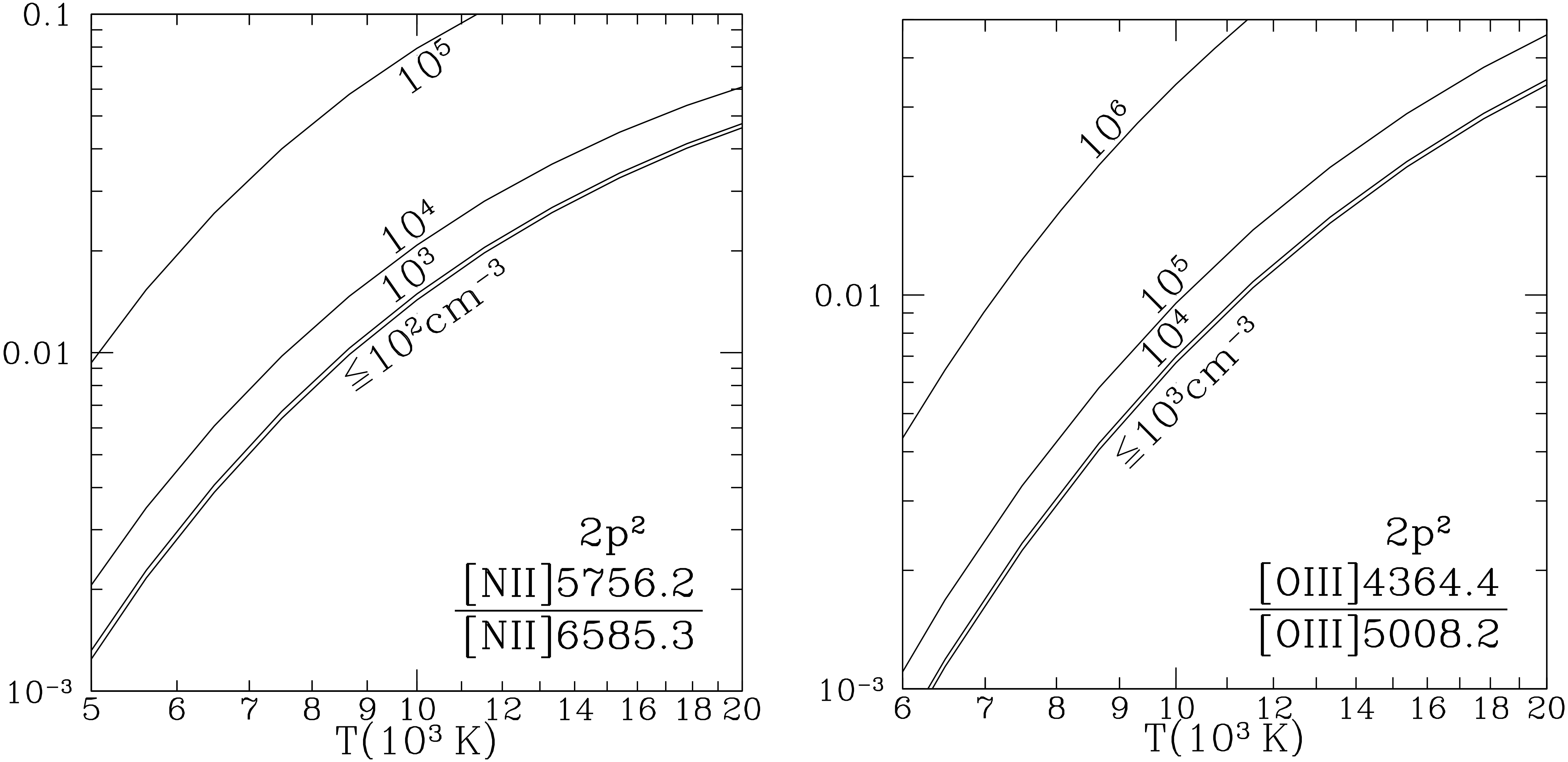
Caputi et al. (2008)

Nebular Diagnostics - the BPT diagram



Part of fig. 18.7 in Draine's book.

Nebular Diagnostics - determination of T



Part of fig. 18.2 in Draine's book.

Heating of HII Regions

dominant process: photoionisation

Probability of photoionisation per unit time:

$$\zeta(X^{+r}) = \int_{\nu_0}^{\infty} \sigma_{pe}(\nu) c \left[\frac{u_\nu}{h\nu}\right] d\nu$$

Heating rate per unit volume:

$$\Gamma_{\rm pe} = n(x^{+r}) \int_{\nu_0}^{\infty} \sigma_{\rm pe}(\nu)\, c \left[\frac{u_\nu}{h\nu}\right] (h\nu - h\nu_0)\, d\nu$$

Cooling of HII Regions

Collisional de-excitation - cooling rate per unit volume:

$$\Lambda_{ce} = \sum_X \sum_i n(X,i) \sum_{j<i} A_{ij}(E_i - E_j)$$

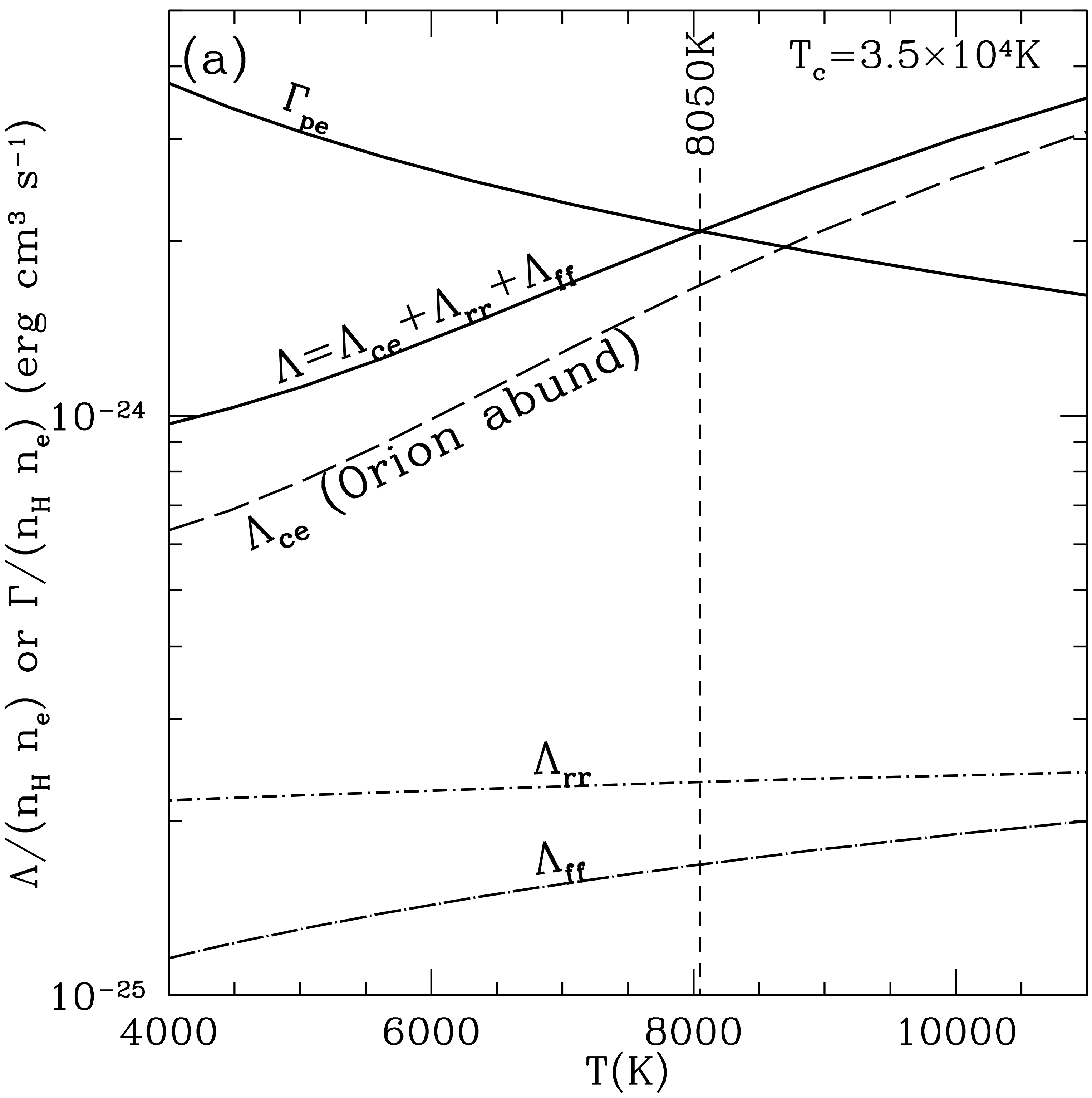
Radiative recombination - cooling rate per unit volume:

$$\Lambda_{\rm rr} \; = \; \alpha_B \, n_e \, n(H^+) < E_{\rm rr} >$$

Assuming: $\sigma_{\rm rr}(E) \; = \; \sigma_0(E/E_0)^\gamma$

$$< E_{\rm rr} > = \frac{\int v^2 dv \, e^{-E/kT} \sigma v E}{\int v^2 dv \, e^{-E/kT} \sigma v} \; = \; \frac{\Gamma(3+\gamma)}{\Gamma(2+\gamma)} kT \; = \; (2+\gamma) kT$$

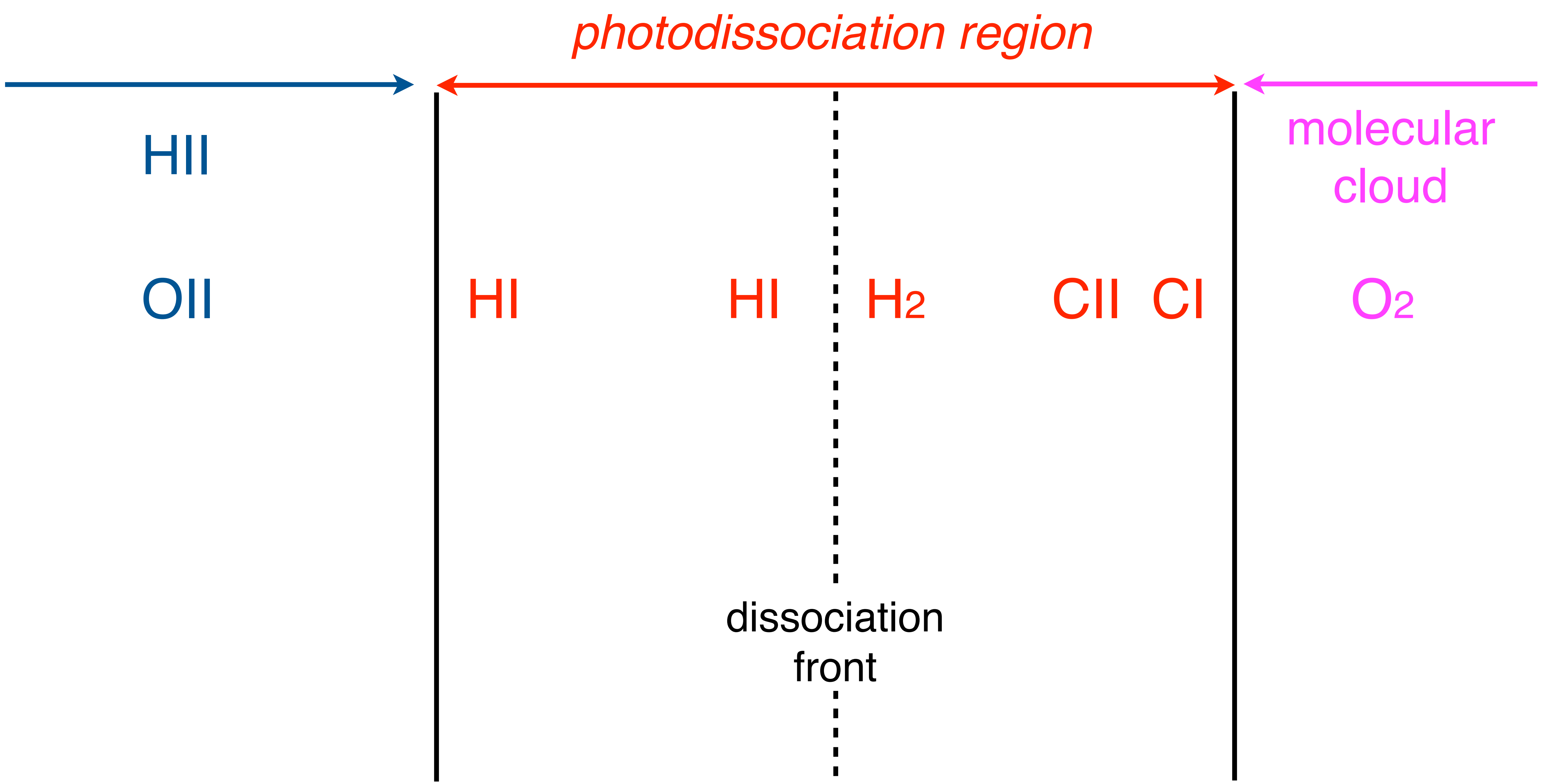
Comparison of heating and cooling rates vs. T



Part of fig. 27.1 in Draine's book.

Photodissociation Regions

Schematic View of a PDR



The Orion Bar in the Orion Nebula