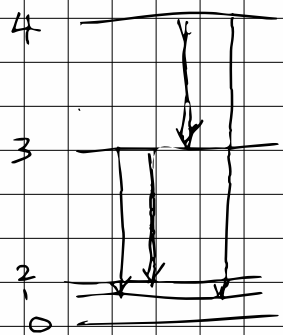
Nebular Diagnostics

np^2 atoms/ions are good thermometers

NII, OIII $\quad 1s^2 2s^2 2p^2$



Consider		NII	OIII
	level $4 \to 3$	5756 Å	4364 Å
	level $3 \to 2$	6585 Å	5008 Å

We will assume $n_{crit} < n_e$

In that case power in each line is

$$P(4 \to 3) = E_{43} \left[n_0 C_{04} \right] \frac{A_{43}}{A_{43} + A_{41}}$$

$$P(3 \to 2) = E_{32} \left[n_0 C_{03} + n_0 C_{04} \frac{A_{43}}{A_{43} + A_{41}} \right] \frac{A_{32}}{A_{32} + A_{31}}$$

$$C_{lu} = \frac{8.7 \times 10^{-8}}{\sqrt{T_4}} \frac{\Omega_{lu}}{g_l} \exp\left(-\frac{E_{ul}}{RT} \right) n_e \quad cm^{+3}\, s^{-1}$$

Then the ratio is

$$\frac{j(4\to3)}{j(3\to2)} = \frac{A_{43}E_{43}}{A_{32}E_{32}} \frac{(A_{32}+A_{31})\Omega_{04}e^{-E_{43}/kT}}{\left[(A_{43}+A_{41})\Omega_{03}+A_{43}\Omega_{04}e^{-E_{43}/kT}\right]}$$

$= f(T)$ only (no dependence on n_e)

Other np^2 atoms/ions: ~~CI~~, FIV, NeV, SIII

Other np^4 atoms/ions: OI, FII, NeIII,

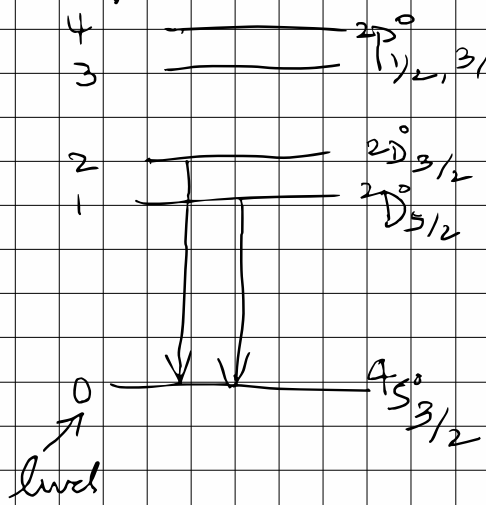
Density Diagnostics:

Consider np^3 atoms/ions

$1s^2 2s^2 2p^3$ NI, OII, FIII, NeIV,

$1s^2 2s^2 2p^6 3s^2 3p^3$ ~~PI~~, SII, ClIII, ArIV

Spectroscopic terms:



ex:
3730/3727 [OII]
6733/6718 [SII]

Consider $2 \to 0$, $1 \to 0$ ... almost same energy

In the low density limit

$$\frac{j(2\to 0)}{j(1\to 0)} = \frac{\Omega_{20} E_{20}}{\Omega_{10} E_{10}} \exp\left(-\frac{E_{21}}{kT}\right) \simeq \frac{\Omega_{20}}{\Omega_{10}}$$

In the high density limit:

$$\frac{j(2\to 0)}{j(1\to 0)} = \frac{n_2 E_{20} A_{20}}{n_1 E_{10} A_{10}} = \frac{g_2}{g_1} e^{-E_{21}/kT} \frac{E_{20} A_{20}}{E_{10} A_{10}}$$

$$\simeq g_2 A_{20} / g_1 A_{10}$$