

AST 300B – Spring 2017

In-class/Take-home Problems Due: Wednesday Mar. 29

35. Consider a 2 level system with a single collisional partner with density n_c and a “critical density” that includes stimulated emission from a background radiation field given by $n_{\text{crit}} = (1 + n_\gamma)A_{21}/\gamma_{21}$, where n_γ is equal to the ratio of stimulated to spontaneous de-excitation rates that you derived in Problem 34. In this problem, we shall explore the relative importance of radiative rates vs. collisional de-excitation.

- What are the units of the critical density, n_{crit} ?
- What is an expression for the fractional rate of radiative transitions from level 2 compared to the total de-excitation rate (by all mechanisms) from level 2? Simplify your answer to an expression with only n_c and n_{crit} .
- What is this fraction equal to when $n_c = n_{\text{crit}}$. Interpret.
- What is the limit of this fraction in the high density limit ($n_c \gg n_{\text{crit}}$)? In this limit, forbidden line transitions in HII regions are said to be “quenched”. What does this mean in terms of observing the forbidden line and why?
- What is the limit of this fraction in the low density limit ($n_c \ll n_{\text{crit}}$)?

36. Now consider a 3 level system with a single collisional partner with density n_c . Radiative transitions are only allowed from level 2 \rightarrow 1 and from level 1 \rightarrow 0. Assume $A_{20} \sim 0$.

- What is an expression for the fractional rate of radiative transitions from level 2 compared to the total de-excitation rate (by all mechanisms) from level 2, denoted by f_{21}^{rad} ? Convert all Einstein B terms to Einstein As in your expression.
- What are the limits of f_{21}^{rad} at low and high density (n_c)?
- Define the “multi-level critical density” $(n_{\text{crit}})_{21}$ as the density at which $f_{21}^{\text{rad}} = 1/2$. What is the equation for $(n_{\text{crit}})_{21}$? How is this different from the 2 level definition in Problem 35?