ASTR 541 - Interstellar Medium

Problem Set 6 — Tom Wagg

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For reference, if you'd ever like to see the code that I've used to get my answers to these, here's a link to my GitHub repo! (#astropy.units for life)

1. Spectroscopy

I'm going to summarise my results in a single table to make it a bit easier to parse.

Galaxy	Redshift	SII Ratio	O3HB	N2	O3N2	Oxygen Abundance
J0929+4644_172_157	0.017	1.27	5.45	0.05	2.06	8.17
J0943+0531_106_34	0.228	1.30	0.43	0.55	-0.11	8.77

Density regimes: Both of these galaxies are in a low density regime since the SII ratios are both close to 1.44 (which we calculated in the last homework).
Spectrum Noise: The second galaxy is noisier because it is at a higher redshift and therefore all fluxes are lower.
Galaxy Masses: The second galaxy has a higher oxygen abundance. Therefore I think this means that **the second galaxy must be more massive**. The reason for this is that massive stars enrich the gas and increase the oxygen abundance. So a higher stellar mass would result in a larger oxygen abundance.

2. HII Heating and Cooling Balance

2a. Heating

$$\boxed{\Gamma_{\rm ion,H} = n_e n_p \alpha_B(T) \cdot \frac{3}{2} k_B T_{\rm init}} \tag{1}$$

2b. Cooling

$$\Lambda_{\rm recomb,H} = n_e n_p k_B T \beta_H(T) \tag{2}$$

$$\boxed{\Lambda_{\rm recomb,H} = 0.86 n_e n_p k_B T \alpha_B(T)} \tag{3}$$

2c. Balance

$$n_e n_p \alpha_B(T) \cdot \frac{3}{2} k_B T_{\rm init} = 0.86 n_e n_p k_B T \alpha_B(T) + 0.54 n_e n_p \alpha_B(T) \left(\frac{T}{10^4\,{\rm K}}\right)^{0.37} k_B T \tag{4}$$

$$\alpha_B(T) \cdot \frac{3}{2} T_{\text{init}} = 0.86 T \alpha_B(T) + 0.54 \alpha_B(T) \left(\frac{T}{10^4\,\text{K}} \right)^{0.37} T \tag{5}$$

$$\boxed{\frac{3}{2} T_{\text{init}} = T \left[0.86 + 0.54 \left(\frac{T}{10^4\,\text{K}} \right)^{0.37} \right]} \tag{6}$$