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Assignment 11

At the time of publication, there was a large discrepancy between observed hydrogen emission line ratios in quasars and their theoretically predicted values. In observations, H-alpha/H-beta was greater than predicted values, and Ly-alpha/H-alpha was far less than theory predicted. This problem was addressed by supplementing standard photoionization calculations with self consistent hydrogen-population equilibrium calculations. Additionally their model accounted for excited state ionization. Their model accomplished this by calculating the ionization populations, temperature, density, and excited-state population of hydrogen at increasing Lyman continuum optical depths for a plane parallel slab of gas. At each tau, the populations of hydrogen levels n=1-6 were calculated. Cooling from collisional excitation of metals was also considered. What they found was that at large optical depths, collisional de-excitation becomes important for Ly-alpha, making it an ineffective coolant. However, photoionization of heavier elements continues to heat the gas. This increase in temperature means that hydrogen n=2 has a population comparable to heavy element abundances, and H-alpha becomes the most important cooling transition. These effects create a decrease in theoretical predictions of Ly-alpha and an increase in the predictions of H-alpha, corresponding with the observed values. They also find that the addition of ionization from excited states increases the ionization state of the gas at deeper depths (Fig 1). This means there are more free electrons at these depths, allowing for more collisional excitations and a lower temperature of the gas. The parameter with the most influence on line intensities is the continuum shape. This means that quasar results, which have a power law continuum, would be very different than planetary nebula results, which are illuminated by a blackbody continuum.