EFFECT OF DENSITY VARIATIONS ON ELEMENTAL ABUNDANCE DETERMINATIONS IN GASEOUS NEBULAE

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ABSTRACT. When there are changes in gas density within a nebula, various methods of determining the electron density N_e can give different results. Irrespective of differences in ionization structure, there will be deviations in derived values of N_e due to the physics of populating the energy levels. To focus on N_e variations, the electron temperature is held constant. For two cases presented, the values of N_e inferred range over a factor of ten from nine species (line pairs); in order of increasing N_e, they are N^+(122/204 μm), O^{++}(52/88 μm), S^+(6716/6731 A), S^{++}(18.7/33.5 μm), O^+(3726/3729 A), Ne^{++}(15/36 μm), Ar^{+3}(4711/4740 A), Ar^{++}(8.99/21.8 μm), and C^{++}(1906/1909 A). This is basically a progression from lower to higher critical densities, N_c, for the lines involved, although other factors are involved. The above order can change somewhat for different mixes of densities.

Together with observations of a third line from another species, an elemental abundance ratio may be derived by standard empirical techniques. When N_c(3rd line of species X) is an extreme value relative to N_c(2 lines for obtaining N_e from species Y), the BIAS > 1, where $[N(X)/N(Y)]_{inferred}$ = BIAS $[N(X)/N(Y)]_{true}$. However when N_c(3rd line) is intermediate in value, the BIAS is closer to unity and may be < 1. This implies that when there are N_e fluctuations, chemical abundance ratios obtained with 3 lines that satisfy the latter condition should be more reliable than those satisfying the former. The degree of potential bias in the average N_e value and elemental abundance ratio inferred depends on the extent of density variations. For the cases considered, BIAS can be greater than 2 and much larger when using lines with very different N_c's.

The fact the N_e values from Cl^{++}(5518/5538 A) are higher than those from S^+ and O^+, and that those from N^0(5199/5202 A) are lowest of all (Stanghellini and Kaler this volume) is consistent with what is presented here. Again, this is predominantly a progression from higher to lower N_c values.

S. Torres-Peimbert (ed.), Planetary Nebulae, 221.