HELIUM ABUNDANCES IN GASEOUS NEBULAE

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ABSTRACT. New collision strengths, from a 19-state quantum calculation for He I, are used to derive revised He/H ratios in planetary nebulae (PN). Empirical formulae are given, for the correction of He I recombination line fluxes for collisional effects, and for the calculation of the population of metastable helium (He I 2^3S) in gaseous nebulae. The revised He abundances for PN, for four samples of published line fluxes, show a mean ratio He/H = 0.100 ±0.007 if nebulae with neutral He and Type I PN are excluded. The mean reduction due to collisional effects is only 10% for Galactic PN. It is shown that the hypothesis, that He/H should be independent of nebular temperature and density, is better satisfied when collisional effects are allowed for. The new He abundances indicate that there is very little He enrichment in Galactic PN of Types II, III, and IV, and that the enhancement of Type I PN in He over H II regions is reduced from earlier values by one third.

Photo-ionization models are used to study the destruction of metastable helium by H I Lyman α and stellar continuum photons. It is shown that photo-ionization can reduce collisional effects on He I line strengths by up to 30%. Collisional excitation of metastable helium can provide a small but significant amount of cooling in nebulae with low heavy-element abundances. We also find that collisional ionization of metastable helium becomes significant at high temperatures, reaching 20% of all collisions out of 2^3S at 20 000 K.

We show that the line used as an indicator of self-absorption effects in the He I spectrum, λ7065 A, is mostly excited by collisions in PN. Derived optical depths for transitions from He I 2^3S are much reduced over previous values. Such depths calculated from model nebulae now appear to agree approximately with depths deduced from λ7065 A for a few objects, if velocity fields are included. Results are given for the formation of the He I λ10830 A resonance line and its attenuation by dust in PN and H II regions.

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