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HEI LINE INTENSITIES IN CLOUDY

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RESUMEN

Hemos incorporado en el código para simulación de plasmas CLOUDY, un modelo completo de emisión tipo helio en líneas y en continuo. Se incluyen todos los elementos entre el He y el Zn, se pueden considerar cualquier número de niveles y se incluye un tratamiento completo de los procesos radiativos y colisionales. Esto incluye fotoionización de todos los niveles, transferencia en líneas incluyendo bombeo por el continuo y destrucción por las opacidades del fondo, dispersión, y procesos colisionales. Esto se hace de manera autoconsistente con la estructura de ionización de la nebulosa que rodea a la región. El resultado es un espectro completo de líneas y del continuo de la nebulosa. En este trabajo nos concentramos en las fuentes de error en la intensidad de la líneas de HeI.

ABSTRACT

We have incorporated a complete model of helium-like line and continuum emission into the plasma simulation code CLOUDY. All elements between He and Zn are treated, any number of levels can be considered, and a full treatment of radiative and collisional processes is included. This includes photoionization from all levels, line transfer including continuum pumping and destruction by background opacities, scattering, and collisional processes. These are done self-consistently with the ionization structure of the surrounding nebula. The result is a complete line and continuum spectrum of the nebula. Here we will focus on sources of error in HeI line intensities.

Key Words: **ATOMIC PROCESSES — LINE FORMATION — SCATTERING**

The results of Benjamin *et al.*, (1999, denoted BSS99) mark the current standard in predicting HeI line ratios at nebular temperatures and densities and in the case B, non-photoionized limit. Because we are not at present prepared to publish our results as final, due to ongoing work discussed below, we aim here to discuss sources of error in the line intensities presented in BSS99.

One of the more significant sources of error is in collisional data. We have built test cases for our helium model that are nearly identical to the treatment given in BSS99, except that BSS99 makes use of the collision strengths of Sawey and Berrington (1993), whereas we use the more recent results of Bray *et al.*, (2000). At an electron temperature of 10^4 K, our test cases produce line intensities which differ from those of BSS99 by as much as 5%, 15%, and 18% at electron densities of 100 cm^{-3}, 10^4 cm^{-3}, and 10^6 cm^{-3}, respectively. Neither these test cases nor BSS99 include collisional excitation to levels with $n_u > 5$. In a complete Cloudy treatment, we include collision strengths for all transitions, using a g-bar approximation based upon the work of Vriens and Smeets (1980). While in such simulations the atomic data used originates from different sources than those used in BSS99 – details will be given in a future publication - we again believe that the differences we find are for the most part due to treatments of collisional processes. Our full simulations find line intensities differing from those of BSS99 by as much as 7%, 26%, and 33% at electron densities of 100 cm^{-3}, 10^4 cm^{-3}, and 10^6 cm^{-3}, respectively. These errors should be compared with the maximum expected errors listed in BSS99, of order 0.5%, 5%, and 6%, respectively.

Another significant source of error is due to fine-structure mixing, discussed in this conference proceedings by Bauman *et al.*, (2003). That work demonstrates that the effect on line intensities of including or omitting fine-structure mixing can be of order 5-10%, an error that alone is greater than that expected by BSS99. Thus, we have decided to postpone the reporting of our results until we have completed the incorporation of a fine-structure mixing approximation.

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