Formation of Helium Lines and Continua in a Late-Type Giant Star

Ramiro de La Reza
Observatorio Nacional

Celso Batalha
Observatorio Nacional & University of California Berkeley

Due to the atomic structure and properties of neutral helium, its spectrum can be an excellent diagnostic of the hot components of the atmosphere of a late-type giant star. Having this in mind, we have studied the formation of the helium lines and continua in the K giant star β Cet. For that purpose different NLTE atmospheric models were constructed. We have also solved the NLTE problem for the formation of lines and continua for a model helium atom consisting of twelve bound levels and three ionized stages.

The theory is confronted with the observations of the He II 1640 Å and the 10830 Å lines of β Cet taken from the literature. We have also attempted to observe the D3 line of He I at 5876 Å (also in other red giant stars) but were successful only in setting upper limits of the order of 10 mÅ to the strength of this absorption line.

Because β Cet is an X-ray source, we have examined the influence of this radiation on the formation of the neutral helium spectrum. We find that the He II 1640 Å line is sensitive to the coronal radiation that also forms the continuum of He II at 228 Å. In fact, the layers of formation of both transitions are similar. The He II lines at 304 and 256 Å are formed at higher temperatures ($T \geq 10^5$ K) by collisional processes if the coronal fluxes are small and by a photoionization-recombination process if the coronal fluxes are large.

However, one important conclusion of our work is that the mechanism of formation of the neutral helium lines at 10830 and 5876 Å is not directly related to the coronal radiation but to the resonant He II radiation at 304 Å (especially by the emission at the wings of the line). In fact, this resonant radiative emission produces a strong contribution to the ionization of the proper He I continuum at 504 Å (and consequently influencing the 10830 Å line) by an overlapping radiation process.

In general, with the atmospheric models considered, our calculations produce lines somewhat smaller in intensity than those observed, with the exception of the residual D3 absorption line. A better adjustment to the observed absorption 10830 Å line could be obtained by means of non-homogeneous atmospheric models in which the overlapping between the 304 and 504 Å radiations could be more efficient.

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