Heavy element radiative parameters for line identification and abundance determination in hot subdwarfs

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Hot subdwarf stars represent a rare late evolutionary stage of low-mass stars. They are characterized by high temperatures, typically between 20,000 and 60,000 K. Their formation remains poorly understood, but is partly explained by binary interactions on the red giant branch and white dwarf mergers. In particular, the strong overabundances of certain heavy elements detected in several hot subdwarfs have yet to be explained [1-3]. One proposed hypothesis is that such overabundances are caused by radiative diffusion—a competition between radiative levitation and gravity [4]—while an alternative idea involves the i-process, a nucleosynthesis process similar to the s-process but requiring a higher neutron flux, or possibly a combination of both mechanisms [5,6]. However, the reliability of current models is limited due to the lack of atomic data for these heavy elements, which exist in ionization stages III to V under the typical conditions found in hot subdwarf atmospheres.

The goal of this work is to contribute to the study of hot subdwarf stars through the calculation of atomic parameters (energy levels, transition wavelengths, oscillator strengths) for selected lowly-charged (III – V) heavy elements (typically with atomic numbers $70 \leq Z \leq 90$), such as Hf and Tl. These elements were recently identified for the first time in a star, based on the Hubble Space Telescope (HST) spectrum of the hot subdwarf EC22536-5304 [3]. However, the lack of reliable atomic data for these species prevents the identification of many observed spectral lines, and thus leads to inaccurate abundance estimates. A multi-platform approach was used for the atomic calculations, combining the pseudo-relativistic Hartree-Fock (HFR) method as implemented in the Cowan's code [7] and the fully-relativistic Multiconfiguration Dirac-Hartree-Fock (MCDHF) approach using the GRASP2018 package [8]. In this contribution, we present the atomic data that we obtained for Hf IV and Tl IV, as well as new spectra simulations including these data, which are compared to the observed HST spectrum of the hot subdwarf EC22536-5304.

References

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