Three-dimensional modeling of ionized gas. II. Spectral energy distributions of massive and very massive stars in stationary and time-dependent modeling of the ionization of metals in HII regions

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HII regions play a crucial role in the measurement of the chemical composition of the interstellar medium and provide fundamental data about element abundances that constrain models of galactic chemical evolution. Discrepancies that still exist between observed emission line strengths and those predicted by nebular models can be partly attributed to the spectral energy distributions (SEDs) of the sources of ionizing radiation used in the models as well as simplifying assumptions made in nebular modeling. The influence of stellar metallicity on nebular line strength ratios, via its effect on the SEDs, is of similar importance as variations in the nebular metallicity. We have computed a grid of model atmosphere SEDs for massive and very massive O-type stars covering a range of metallicities from significantly subsolar (0.1 Zsun) to supersolar (2 Zsun). The SEDs have been computed using a state-of-the-art model atmosphere code that takes into account the attenuation of the ionizing flux by the spectral lines of all important elements and the hydrodynamics of the radiatively driven winds and their influence on the SEDs. For the assessment of the SEDs in nebular simulations we have developed a (heretofore not available) 3d radiative transfer code that includes a time-dependent treatment of the metal ionization. Using the SEDs in both 1d and 3d nebular models we explore the relative influence of stellar metallicity, gas metallicity, and inhomogeneity of the gas on the nebular ionization structure and emission line strengths. We find that stellar and gas metallicity are of similar importance for establishing the line strength ratios commonly used in nebular diagnostics, whereas inhomogeneity of the gas has only a subordinate influence on the global line emission.

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