Carbon abundances of early B-type stars in the solar vicinity. Non-LTE line-formation for C II/III/IV and self-consistent atmospheric parameters

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Precise determinations of the chemical composition in early B-type stars consitute fundamental observational constraints on stellar and galactochemical evolution. Carbon is one of the most abundant metals in the Universe but analyses in early-type stars show inconclusive results, like large discrepancies between analyses of different lines in C II, a failure to establish the C II/III ionization balance and the derivation of systematically lower abundances than from other objects. We present a comprehensive and robust C II/III/IV model for non-LTE line-formation calculations based on carefully selected atomic data. The model is calibrated with high-S/N spectra of six apparently slow-rotating early B-type dwarfs and giants, which cover a wide parameter range and are randomly distributed in the solar neighbourhood. A self-consistent quantitative spectrum analysis is performed using an extensive iteration scheme to determine stellar atmospheric parameters and to select the appropriate atomic data used for the derivation of chemical abundances. We establish the carbon ionization balance for all sample stars based on a unique set of input atomic data, achieving consistency for all modelled lines. Highly accurate atmospheric parameters and a homogeneous carbon abundance with reduced systematic errors are derived. This results in a present-day stellar carbon abundance in the solar neighbourhood, which is in good agreement with recent determinations of the solar value and with the gas-phase abundance of the Orion H II region. The homogeneous present-day carbon abundance also conforms with predictions of chemical-evolution models for the Galaxy. The present approach allows us to constrain the effects of systematic errors on fundamental parameters and abundances. (abridged)

Reference: A&A
Status: Manuscript has been accepted

Weblink: http://arxiv.org/abs/0711.3783

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