The Galactic WC stars: Stellar parameters from spectral analyses indicate a new evolutionary sequence

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CONTEXT: The life cycles of massive stars from the main sequence to their explosion as supernova or gamma ray burst are not yet fully clear, and the empirical results from spectral analyses are partly in conflict with current evolutionary models. The spectral analysis of Wolf-Rayet stars requires the detailed modeling of expanding stellar atmospheres in non-LTE. The Galactic WN stars have been comprehensively analyzed with such models in their latest stage of sophistication, while a similarly comprehensive study of the Galactic WC sample is still missing.
AIMS: The stellar parameters and mass-loss rates of the GalacticWC stars shall be established. These data shall provide the empirical basis for studies of (i) the role of WC stars in the evolution of massive stars, (ii) the wind-driving mechanisms, and (iii) the feedback of WC stars as input for the chemical and dynamical evolution of galaxies.
METHODS: We analyze the nearly complete sample of un-obscured Galactic WC stars, using optical spectra as well as UV spectra if available. The observations are fitted with theoretical spectra, using the Potsdam Wolf-Rayet (PoWR) model atmosphere code. A large grid of line-blanked models has been established for the range of WC subtypes WC4 - WC8, and smaller grids for the WC9 parameter domain. WO stars and WN/WC transit types are covered as well using special models.
RESULTS: Stellar and atmospheric parameters have been derived for more than 50 Galactic WC and two WO stars, covering almost the whole Galactic WC population as far as the stars are single, and un-obscured in the visual. In the Hertzsprung-Russell diagram, the WC stars reside between the hydrogen and the helium zero-age main sequences, having luminosities L from 10^4.9 to 10^5.6 Lsun The mass-loss rates scale very tightly with L^0.8. The two WO stars in our sample turned out to be outstandingly hot (~200 kK) and do not fit into the WC scheme.
CONCLUSIONS: From comparing the empirical WC positions in the Hertzsprung-Russell diagram with evolutionary models, and from recent supernova statistics, we conclude thatWC stars have evolved from initial masses between 20 and 45 Msun. In contrast to previous assumptions, it seems that WC stars in general do not descend from the most-massive stars. Only the WO stars might stem from progenitors that have been more massive than 45 Msun initially.

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Comments: PoWR grid models are available online at http://www.astro.physik.uni-potsdam.de/PoWR.html

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