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Constraining Stellar Evolution through Helium Spectral Line Broadening Experiments at Sandia National Laboratories' Z-Machine[1]

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White Dwarfs (WDs) are the final evolutionary state of nearly all stars in the sky, including our Sun. Fundamental WD parameters such as surface temperature (T_{eff}) and gravity (log g) can constrain many aspects stellar evolution. The origin of helium atmosphere WDs (DBs) is unknown and thus highlights deficiencies in current stellar evolution models. Several DB evolutionary channels have been proposed, but a lack of accurate DB log g measurements makes discriminating between different models difficult. DB log g values are obtained by fitting model atmospheres to observed spectra. The derived log g strongly depends on our understanding of line broadening in DB atmospheres. Results presented in Bergeron et al. (2011) and Kepler et al. (2015) show an unexpected DB log g increase at T_{eff} <16,000 K, indicating that the modeled line widths at those temperatures are severely underestimated. An incomplete understanding of neutral broadening has been identified as the leading hypothesis for this behavior. We investigated this phenomenon by performing first-of-their-kind at-parameter neutral broadening experiments at Sandia National Laboratories' Z-machine, the most energetic pulsed x-ray source on earth. Our line width measurements of He I at 5875 _, the strongest optical transition in DB spectra, are at least a factor of 1.5 wider than that of any previous experiment or Stark broadening prediction for this feature. The varying neutral helium fraction in these experiments provides evidence that the extra broadening is most likely caused by neutrals in the plasma. Derrider et al. (1975), the neutral broadening theory used by the WD community, underpredicts the neutral broadening contribution by at least an order of magnitude. This experimental evidence suggests that the DB log g upturn could result from an incomplete neutral broadening theory and could thereby also constrain DB evolution.

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