On the role of the WNH phase in the evolution of very massive stars: Enabling the LBV instability with feedback

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We propose the new designation ``WNH'' for luminous Wolf-Rayet (WR) stars of the nitrogen sequence with hydrogen in their spectra. These have been commonly referred to as WNL stars (WN7h, for example), but this new shorthand avoids confusion because there are late-type WN stars without hydrogen and early-type WN stars with hydrogen. Clearly differentiating WNH stars from H-poor/H-free WN stars is critical when discussing them as potential progenitors of Type Ib/c supernovae and gamma ray bursts --- the massive WNH stars are {it not} likely Type Ib/c supernova progenitors, and are distinct from core-He burning WR stars in several respects. We show that the stellar masses of WNH stars are systematically higher than for {it bona fide} H-poor WR stars (both WN and WC), with little overlap. Also, the hydrogen mass fractions of the most luminous WNH stars are higher than those of luminous blue variables (LBVs). These two trends favor the interpretation that the most luminous WNH stars are still core-H burning, preceding the LBV phase (at lower luminosities the WNH stars are less clearly distinguished from LBVs). While on the main sequence, a star's mass is reduced due to winds and its luminosity slowly rises, so the star increases its Eddington factor, which in turn strongly increases the mass-loss rate, pushing it even closer to the Eddington limit. Accounting for this feedback from mass loss, we show that observed masses and mass-loss rates of WNH stars are a natural and expected outcome for very luminous stars approaching the end of core-H burning (ages sim2 Myr). Feedback from the strong WNH wind itself plays a similar role, enabling the eruptive instability seen subsequently as an LBV. Altogether, for initial masses above 40--60 M$_{odot}$, we find a strong and self-consistent case that luminous WNH stars are pre-LBVs rather than post-LBVs. The steady march toward increased mass-loss rates from feedback also provides a natural explanation for the continuity in observed spectral traits from O3~V to O3~If* to WNH noted previously.

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