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# Long-term Spectroscopic Monitoring of Cool Hypergiants HR 8752, IRC+10420, and 6 Cas near the Yellow Evolutionary Void

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**Abstract.** We discuss the spectral variability of three white (A-type) hypergiants ($Ia^+$) near the region of atmospheric dynamical instability in the upper H-R diagram, called the *Yellow Evolutionary Void*. The Void represents an obstacle for the fast blueward evolution of the most massive cool hypergiant stars. Optical and near-IR spectra observed between 1993 and 2011 with several high-resolution spectrographs, including the WHT-Utrecht Echelle Spectrograph, Mercator-HERMES, NOT-Sofin, and Keck-HIRES, are compared to investigate the wind-physics and -dynamics of the hypergiants.

## 1. Introduction

Cool hypergiants are luminous Ia-supergiants with $5.2 < \log(L_\star/L_\odot) < 5.8$ and $T_{\rm eff} < 10$ kK of which there are only a handful known in the Galaxy. They are the most massive cool stars with $\dot{M}{\sim}10^{-5}$ $M_\odot\,yr^{-1}$, but which can increase by 3 orders of magnitude during outburst events. $\rho$ Cas is notorious for its recurrent outbursts in the last century (Lobel et al. 2003). They are thought to be evolving on blue loops and are approaching the Yellow Evolutionary Void (de Jager 1998) from the right-hand side in the H-R diagram. They may rapidly evolve across the Void on time-scales of a few thousands of years and are the most likely progenitors of Type II SNe. We monitored HR 8752, IRC+10420, and 6 Cas with several high-resolution spectrographs over the last 18 years. We investigate the spectral variability of these remarkable stars entering from the cool border of ∼8300 K into the Void. Over the past 30 yr $T_{\rm eff}$ of HR 8752 dramatically increased and is currently inside the Void (Nieuwenhuijzen et al. 2012).

## 2. HR 8752 (G0 - A6 $Ia^+$), IRC+10420 (F8 - A9 $Ia^+$), and 6 Cas (A3 $Ia^+$)

The prominent [N II] $\lambda$6582 emission line of HR 8752 reveals a dramatic increase of the normalized maximum flux by ∼40% between 1993 and 2011 (*Fig. 1, left-hand panel*). The increase of emission flux is also observed in the triple-peaked H$\alpha$ line. The forbidden [N II] line forms in an extended tenuous gas envelope around the hypergiant. The [N II] line shape transforms from flat-topped (1993-1996) into a 'wine-bottle'-type profile (2002-2011) with line wing inflections. The latter type of emission profile oc-

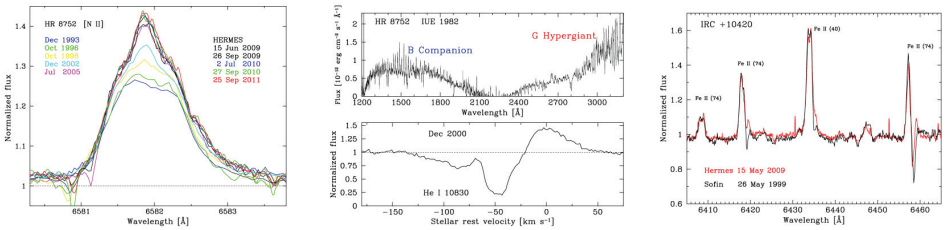


Figure 1. Long-term spectroscopic monitoring of HR 8752 and IRC+10420.

curs in B[e]-stars with extended discs observed almost pole-on. The peculiar emission line shape has also been modeled in colliding wind binaries. HR 8752 has a B-type companion determined from IUE spectra (*Fig. 1 upper middle panel*). We observe that the steady increase of [N II] emission line fluxes decelerated over the last 6 years, possibly signaling that maximum emission line intensity will soon occur. The He I $\lambda$10830 line reveals a strong P Cygni-type line profile that signals fast wind expansion above $\sim$120 km s$^{-1}$ at gas kinetic temperatures exceeding $\sim$20 kK (*Fig. 1 lower middle panel*).

The optical spectrum of IRC+10420 is crowded with ionized metal emission lines, showing very limited variability over the past 3 years. Various lines reveal inverse P Cygni-type profiles with double-peaked emission. We observe a significant decrease in the depth of red-shifted (inverse P Cyg) absorption between 1999 and 2009 (*Fig. 1, right-hand panel*). It signals the decrease of opacity of infalling circumstellar material, for example in Fe II $\lambda$6456. We do not detect the He I $\lambda$10830 line in IRC+10420.

We observe strong flux variations in blue-shifted absorption of Balmer H$\alpha$ and H$\beta$, and Ca II K lines of 6 Cas, signaling wind outflow velocities above $\sim$160 km s$^{-1}$. The H$\beta$ line reveals prominent emission on time-scales of several months linked to enhanced H$\alpha$ line emission. We do not detect the He I $\lambda$10830 line in 6 Cas.

## 3. Conclusions

Long-term spectroscopic monitoring of HR 8752 reveals a steady flux increase of [N II] emission lines over a time-scale of $\sim$20 yr for which $T_{\rm eff}$ increased by more than 2000 K. The remarkable [N II] wine-bottle emission line profiles can result from ongoing orientation changes of a colliding wind-interaction region by the (long-period) B-type companion approaching its periastron passage. HR 8752 is currently the only (A-type) hypergiant with very strong He I $\lambda$10830 emission, comparable to the LBV Pistol Star (of B-type). The P Cygni-type He I line profile signals expanding high-temperature plasma, possibly linked to the interaction of the B-companion with the extended and copious hypergiant wind. Although IRC+10420 is also known to have increased $T_{\rm eff}$ by $\sim$2000 K from 1980 to 2000, we observe rather modest changes of its optical spectrum over the last 12 years. A preliminary analysis of the long-term spectral variability reveals that white hypergiant 6 Cas is a single-lined spectroscopic binary.

## References

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