Yellow Hypergiants in M33

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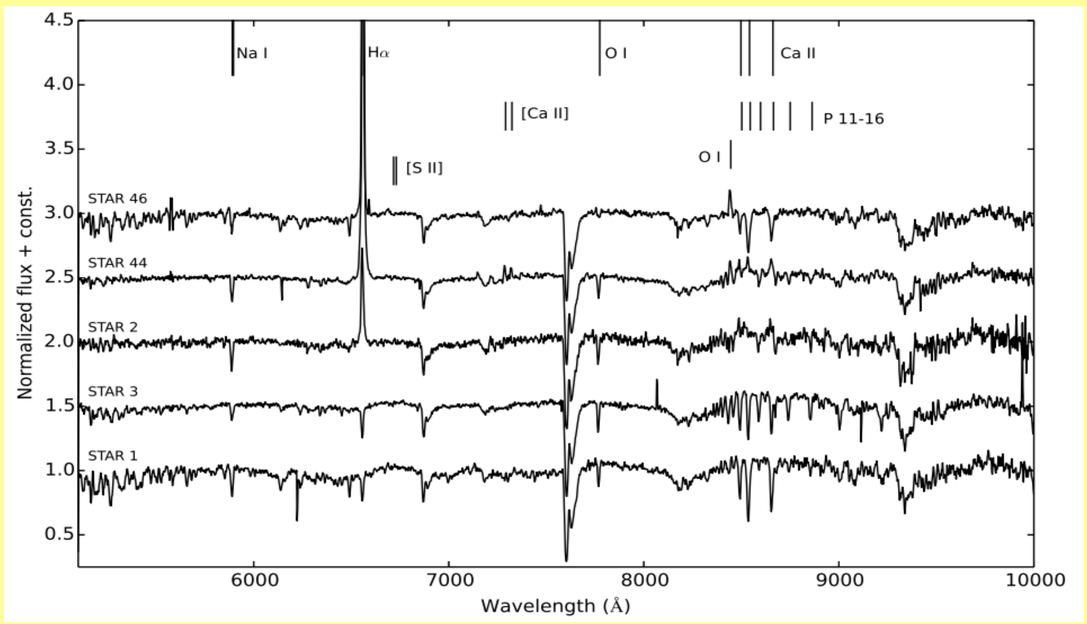
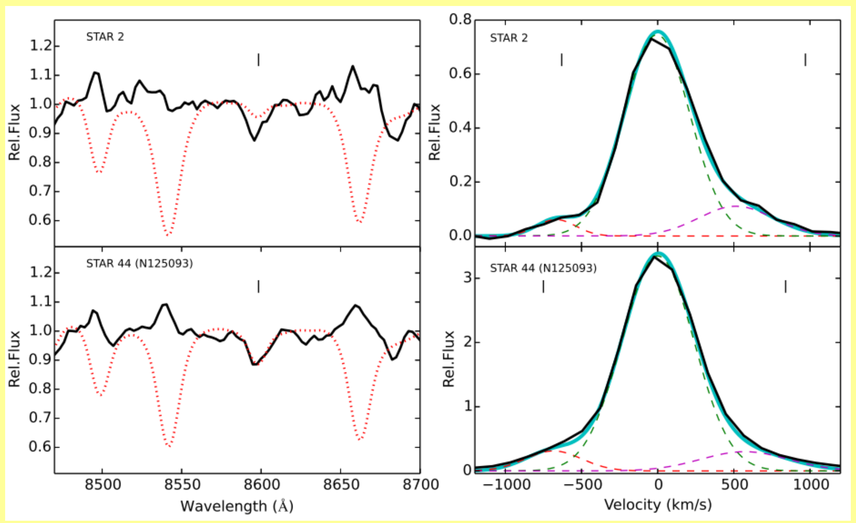
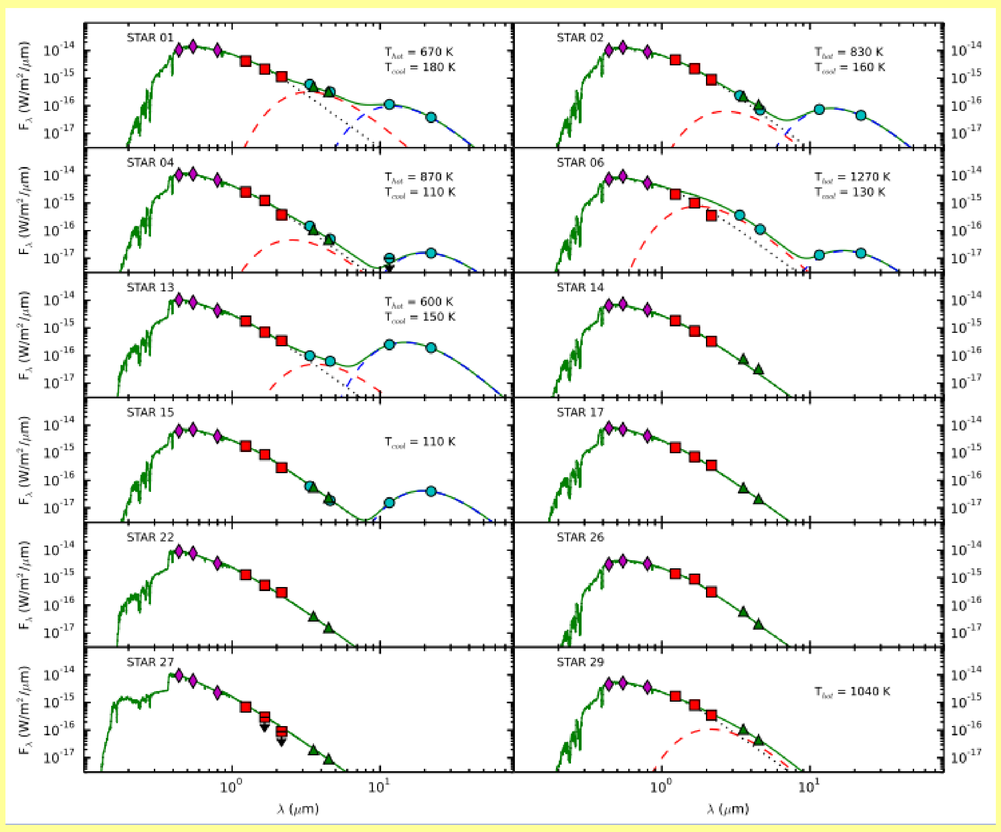
Abstract : The evolution of massive stars surviving the red supergiant (RSG) state remains unexplored due to the rarity of such objects. The yellow hypergiants (YHGs) appear to be the warm counterparts of post-RSG classes located near the Humphreys-Davidson upper luminosity limit, which are characterized by atmospheric instability and high mass-loss rates. We aim to increase the number of YHGs in M33 and thus contribute to a better understanding of the pre-supernova evolution of massive stars. For our goal, we employed infrared photometry from *Spitzer and* 2MASS of the most luminous yellow supergiants (YSGs) to report objects with circumstellar dust evidence resulting from mass-loss events. We undertook optical spectroscopy of five dust-enshrouded YSGs and employed optical time-series photometry spanning nine years of 21 YSGs, to explore the properties of the dust and report variability in the spectral type that is typical of the few well known YHGs. We report three luminous candidate YHGs in M33 and five less luminous dusty YSGs as post-RSG candidates.



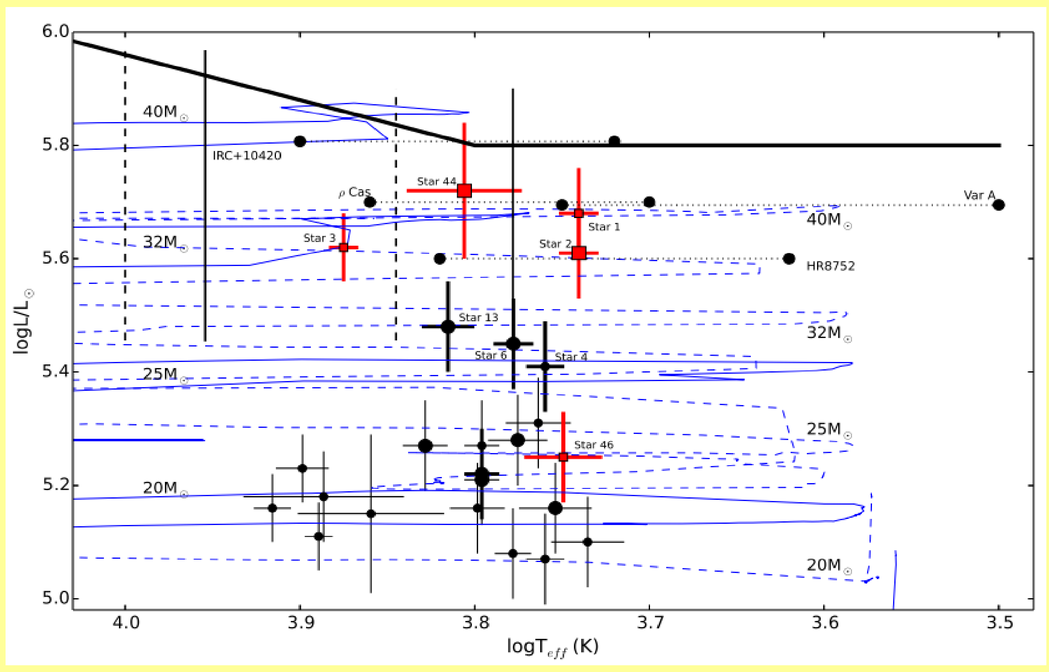
We undertook optical long-slit spectroscopy with OSIRIS/GTC of the five most dusty and luminous YSGs in M33 selected from mid-infrared criteria. We report Hα emission in three of these, two of which additionally display CaII in emission. Classification of the three absorption spectra was done from the strength of the CaII triplet and of the adjacent Paschen hydrogen series. All but one spectra display a strong OI feature at 7774 Å confirming their high luminosity with $\log L/L_{\odot}>5.3$.



A close-up view of the CaII triplet (left) of the two emission-type spectra of stars 2 and 46, superposed on two ATLAS9 models of YSGs at a consistent temperature. Emission of CaII feature is supportive of an expanding gaseous shell. Both stars display a broad Hα broad emission followed by broad wings that are blended with [NII] emission and are explained by outflow velocities. (Humphreys et al. 2013)



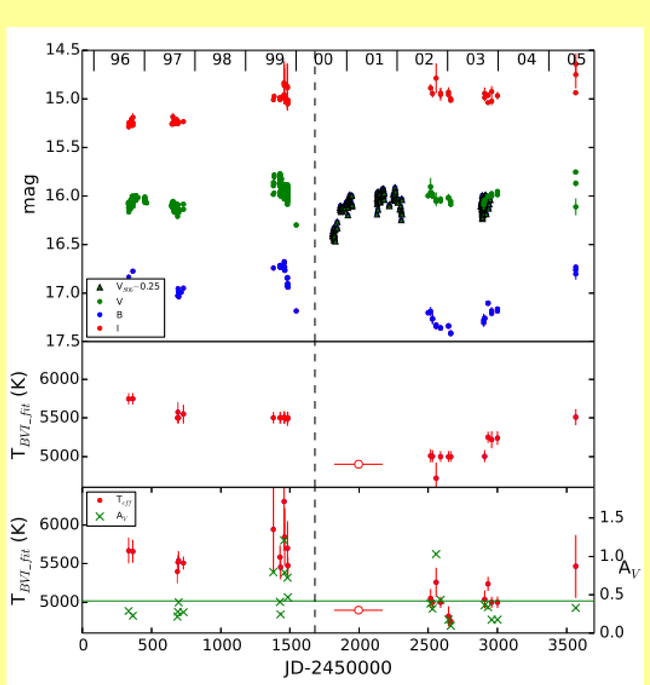
We built the spectral energy distributions (SEDs) of 21 YSGs in M33 with log $L/L_{\odot}>5$ using photometry from DIRECT (magenta diamonds), 2MASS (red squares), *Spitzer (*black triangles) and WISE (cyan circles). The SEDs were optimally fit with ATLAS9 models for the photospheres and modified black bodies for the dust components in the infrared. Discrepancies in the fit of different surveys (e.g. for star 06) could be indicative of their variant circumstellar environment.



The SED-fit parameters of the 21 luminous YSGs in M33 along with those of the dusty spectroscopic targets (red) were plotted on the Hertzsprung-Russell diagram. Comparison with the Geneva evolutionary tracks (Ekström et al. 202) assigns initial masses between 18-20 to 35-40 $M_{\odot}$. We find that the upper diagram is occupied by seven YSGs, which all show infrared excess that arises from both hot and cool dust (thick lines). Of these, three are suggested as candidate YHGs for follow-up high-resolution spectroscopy. Five less luminous dusty YSGs are proposed as candidate post-RSGs (large dots).

REFERENCES

- Ekström, S., et al. 2012, A&A, 537, 146
- Humphreys, R., et al. 2013, ApJ, 773, 46
- Kourniotis, M., et al. 2017, A&A, 601, 76



Star 2 constitutes a rather promising YHG candidate supported by long-term variability that partly resembles the "bounce" of a YHG against the cool border of the 'Yellow Void'. We report a decrease in temperature of more than 500 K that followed a dimming of amplitude larger than 0.5 mag in the V band light curve of the star. We attribute the observed variability to a modification in the atmospheric structure and/or in the wind optical depth that followed a possible outburst that occurred in mid 1999.