Luminous Blue Variables in M33: The Extended Hot Phase of Romano’s Star (GR 290)

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ABSTRACT
Romano’s Star (GR290) is an LBV in M33. Recently, the star underwent a dramatic change in the visual, that was accompanied by a marked increase of the spectral line excitation. Presently, GR 290 appears to be in the hottest phase ever observed in an LBV. More than 100 emission lines have been identified in the 3100–10000 Å range covered by the WHT spectra, including the hydrogen Balmer and Paschen series, He I and He II, C II, N II-N III, Si II-Si IV, and many forbidden lines of [O III], [N II], [S II], [A III] and [Fe III]. Many lines, especially the He I triplets, show a P Cygni profile with an E-A radial velocity difference of ~400 km/s. The 2008 spectrum appears quite similar to that of a typical WN8-9 star. During 2003–2009 GR 290 varied between the WN11–WN8 spectral types, with the hottest spectrum corresponding to a fainter visual magnitude. This temperature–visual luminosity anticorrelation suggests variation at constant $M_{bol}$. GR 290 might just present the key evidence that will help to bridge the LBV and WNL evolutionary phases.

The December 2008 Spectrum of GR290

More than 100 emission lines have been identified in the 3100–10000 Å spectral range covered by the WHT spectra, belonging to different species, including the hydrogen Balmer and Paschen lines, He I and He II, C II, N II-N III, Si II-Si IV, and forbidden lines of [O III], [N II], [S II], [A III] and [Fe III]. The presence of the [O III] doublet indicates the presence of a massive low density, high temperature circumstellar envelope. Many lines, especially the He I triplets, show a P Cygni absorption with an E-A radial velocity difference around 400 km/s. Especially interesting is the 4630–4700 Å emission feature which is a line blend of at least N III, C III, He II and [Fe III] (top of Figure 4). After subtraction of the other components we found that the He II 4686 Å line also displays a broad component (bottom of Figure 4) that can be attributed to the WNL spectrum. The overall spectrum resembles that of WN8-9 stars according to the classification of Crowther & Smith [8]. The shape of the 4630–4700 Å blend is similar to that of the September 2006 spectrum, reported by Massey et al. [9], probably taken when the star had already reached the minimum phase.

Spectral Variations of GR 290

During 2003–2009 we have collected many low resolution spectra covering the different luminosity phases of GR 290. As observed in other LBVs, the spectrum appeared hotter during minimum, with a marked strengthening of the ionization level of the emission line spectrum. This is best illustrated in Figure 5 where we show the blue spectral region of GR 290 during 2003–2009. For comparison we show the spectra of ours of the Of/WN9 star UIT 3 in M33 [1], and of AG Car during a visual minimum [10]. The WHT spectrum has been resampled to the resolution of the other spectra. The 4630–4700 Å blend was weak in 2004 when the star was more luminous ($V = 17.17 ± 0.5$), and very strong from December 2006 to 2008 when the star was very faint ($V = 17.5 ± 0.5$) and very strong from December 2006 to 2008 when the star was very faint ($V = 17.5 ± 0.5$). In Figure 6 we show the variation of the equivalent width of some emission lines: it is evident in the figure the anticorrelation between the visual luminosity and the equivalent width of the He II line and of the 4630–4700 Å blend, while the hydrogen and neutral helium lines displayed smaller changes.

Evolutionary considerations

The time scale and amplitude of the light variations of GR 290 are typical of the strong-active S Dor variables (van Genderen [12]), such as AG Car, R 127 and S Dor itself. The anti-correlation between visual luminosity and strength of the f-feature suggests that in GR 290 the variations took probably at constant (or nearly constant) bolometric luminosity [6]. In Figure 7 we show the representative points of GR 290 during 2003–2009 in the log equivalent width diagram of He I 5876 Å versus He II 4686 Å line. In the figure the approximate boundaries of the WN6-WN11 spectral classes proposed by Crowther & Smith [8] are drawn. As also indicated by the comparison of our spectra with the WNL-WN11 spectra illustrated by Crowther & Smith, GR290 after January 2006 has moved to the WN9-WN8 region, and presently its spectrum appears virtually indistinguishable from the classic late-WN stars.

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