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Variable C – "a typical" LBV in M 33?

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Abstract. One of the original Hubble-Sandage variables, Variable C in M33 is thought to be a very typical Luminous Blue Variable (LBV). An observational signature of LBVs is a variable brightness which is coupled to a change in spectral type. We compiled a 110 year long light curve of Var C and a set of spectra covering several decades. Analyzing both data sets, various astonishing changes of Var C, some very recent, emerged. Is Var C a typical or an atypical LBV?

Keywords. stars: variables: other, evolution, mass loss

1. Luminous Blue Variables

LBVs are characterized being luminous evolved massive stars with photometric and spectral variabilities on various timescales and magnitudes. Intrinsic to LBVs is the S Dor variability/cycle in which the spectral type changes from O-B to A-F and back within a few years. V magnitude and colors change, the star being faint in the hot and bright in the cool phase. More violent are the giant eruptions in which the brightness rises spontaneously by several magnitudes and larger amounts of mass are ejected. Giant eruptions have even been mistaken for supernovae (e.g. SN1954J). For further details see Humphreys & Davidson (1994). High mass loss by winds and/or giant eruption forms small ($< 4\,$pc) circumstellar LBV nebulae, a large fraction ($> 50\%$) being bipolar (Weis 2011). LBVs is a transition phase from main sequence to Wolf-Rayet state. Observations and theoretical stellar evolution models with rotation lowered the mass limit for LBVs to $M_{\rm ini} \gtrsim 22\,M_{\odot}$ (Meynet & Maeder 2005). Therefore LBVs are characterized by variability, high mass loss and possibly giant eruptions. However at least temporarily LBVs can appear simply as 'well behaved' normal supergiants! Note that **no** unique classification scheme exists to pinpoint a LBV with just a single observation!

2. Var C in M 33

Compiling several years of photometric and spectroscopic observations with data from the literature, archives and our own observations a lightcurve covering more than 110 years was generated. For several epochs spectral and photometric observations were synchronized. The lightcurve (Fig. 1) reveals variations on various time scales together with a secular brightening. As typical for LBVs the variability appears more irregular, still two prominent maxima (1946 & 1986) are present. Checking for periodicities, Fourier transformation analyses were done, yielding a long term(semi-)periodicity of 40.7 years. The last major maximum was 1986, the next is expected for 2027. A detailed analysis of the lightcurve and spectra of Var C was submitted to A&A by Burggraf *et al.*

What's it's doing now? The 2010 spectrum was dominated by absorption lines (plus some hydrogen lines with P Cygni profiles), and compatible with a B1 to B2 supergiant.

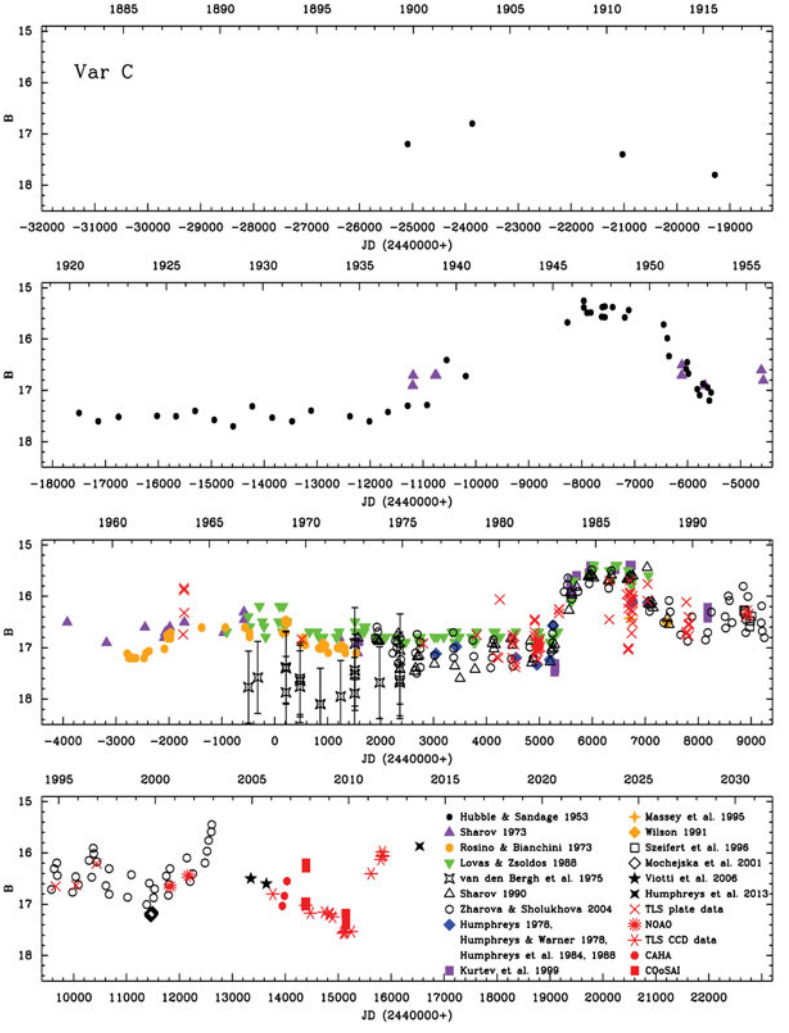

Figure 1. Var C lightcurve in B, starting in 1899

After that Var C started to brighten and a spectrum taken during maximum light in 2013 showed it changed into a late A-type supergiant (confirmed in LBT observations January 2014). It's going through a S Dor cycle! In the last hot phase the stellar wind velocities of Var C were $\sim 30\%$ lower as expected. This manifests either a criteria for the LBV class or that Var C has shed already a large amount of mass. Fur further details on this topic, the data sets and analyses see (Humphreys *et al.* 2013, 2014a,b) and references therein.

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