

PREFACE

A strange field of speculation is opened by this phenomenon...here we have a star fitfully variable to an astonishing extent, and whose fluctuations are spread over centuries, apparently in no settled period, and with no regularity of progression. What origin can we ascribe to these sudden flashes and relapses? What conclusions are we to draw as to the comfort or habitability of a system depending for its supply of light and heat on so uncertain a source?

-- J.F.W. Herschel¹

We can imagine, at least, that the study of Luminous Blue Variable stars began 5000 years ago as the official court astrophysicists of Eridu speculated about a new first-magnitude star which persisted in their southern sky for several years.² After that the topic languished for a while, but now it has been renewed following recent observations by Blaeu (P Cygni, c.1600) and Herschel (η Argus, c.1840)...

-- More soberly, it is only within the past few years that we have begun to understand LBV's and to recognize their coherence as a class. Thus only a minority of astronomers are familiar yet with this relatively new topic, whose potential implications are of great interest (see below). One purpose of this book, we hope, will be to provide an accessible overview of the subject for interested astronomers and astrophysicists in general.

What is an LBV? One answer is that 'Very Luminous Blue Variable' would be more accurate and that S Doradus, η Carinae, and P Cygni are now thought to be examples. Their luminosities are of the order of $10^6 L_{\odot}$ and they lose mass sporadically in giant eruptions. They flirt with disaster near the Eddington Limit, and in so doing they exhibit a remarkable richness of physical behavior. They are near the observed Upper Luminosity Limit of stars in the Hertzsprung-Russell diagram, and their outbursts may be clues to why this Upper Limit exists. Opinions on the proper definition of 'LBV' are expressed by various people in this book, and Voltaire's quip about the Holy Roman Empire may apply: at times some LBV's may appear neither Luminous, nor Blue, nor Variable. Some authors prefer simply to call them S Doradus stars. But 'LBV' is pragmatically convenient here, just as a label.

Why are we interested in LBV's? The reasons embrace topics from spectral classification to galaxy evolution. Their dramatic eruptions are only beginning to be understood but apparently involve non-linear chaotic systems of hydrodynamics with radiative transfer. Their large, unsteady mass-loss rates appear to be crucial for evolution at the top of the H-R diagram. They may provide clues to interior processes relevant, for instance, to the progenitor of SN 1987A (whose blueward evolution was

¹*Results of Astronomical Observations...at the Cape of Good Hope* (London, 1847), p. 36.

²This is based on thoroughly unreliable but fascinating passages by P.C.A. Jensen (1890; *Die Kosmologie der Babylonier*, pp. 24–28) and Shklovsky & Sagan (1966; *Intelligent Life in the Universe*, ch. 33). Modern experts agree that the cuneiform texts do not really support Jensen's idea that η Car was seen and identified with *Īa*; but the story is so pertinent to LBV's that it should have been true!

acknowledged most readily by those astronomers who were most acquainted with very luminous stars). LBV's are thought to be crucial for understanding the formation of some types of Wolf-Rayet stars. They can be observed in other galaxies, even beyond the Local Group. They are suspected to be related, indirectly or perhaps directly, to any physical justification for using red supergiants as extragalactic distance indicators. They may be prominent in nearly-primordial dwarf galaxies, according to some speculations. And finally, they are sufficiently ill-understood, as yet, to provide scope for interesting surprises and reversals of consensus!

This book contains papers presented at IAU Colloquium 113, held at the Far Hills Inn near Val Morin, Quebec, on 15–18 August 1988. LBV's had played leading roles at the de Jager workshop in Lunteren, the Netherlands, in 1986 (see *Instabilities in Luminous Early-Type Stars*, ed. by Lamers and de Loore, 1987) and to a lesser extent they were discussed on other occasions such as IAU Symposia 105 and 116; but Val Morin was the first meeting devoted specifically to LBV's *per se*. Since other classes of very luminous stars are relevant to LBV's (e.g., B[e] stars, not to be confused with Be stars!), many or even most of the stars mentioned at Val Morin were strictly speaking not real LBV's; we have relied on the authors' own self-discipline to keep resulting centrifugal tendencies within reasonable bounds. The discussions following the papers have been edited; we have tried to make these clear and potentially useful, rather than aiming for a transcript of precisely what words each participant used.

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A note concerning multiple alternative star names and catalogs containing LBV's -- When one astronomer mentions HDE 326823 and another refers to He 3-1330, it is useful to know that these are the same star! Therefore *we have provided many cross-references in the object index at the end of this book*. We hope that these references to alternative star names will have a utility beyond this book. Moreover, preceding the index *we have listed a few catalogs* whence most commonly-cited LBV designations come; these may be useful if one must find the actual location of a given star.

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