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SUBDWARF B STARS IN HW VIR SYSTEMS

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Abstract. Subdwarf B stars (sdB) dominate the populations of faint blue stars and are found in both the old disk (field sdBs) and halo populations (globular cluster members) of our own Galaxy. The origin of sdB stars remains largely a puzzle, but evidence is accumulating that close binary evolution is fundamental to the problem. With interferometric methods, we expect to detect and learn about close cool companions to derive further insight in the evolution of sdB stars.

1 What are sdB stars? Spectroscopic analysis and asteroseismology

Subdwarf B stars represent a fairly uniform class of faint blue stars. They are evolved objects populating the blue extension of the horizontal branch (HB). Normal HB stars correspond to the stage of stable helium core burning with simultaneous hydrogen burning in a shell. In contrast to these, extreme HB (EHB) stars can be identified with models burning helium in their cores but with hydrogen layers too thin to sustain nuclear burning. In the limit of a vanishing hydrogen layer, the EHB meets the helium main sequence at 0.5 $M_\odot$. Since the EHB evolutionary stage is a very long-lived one (10^8 yr), these stars are sufficiently common to be the most likely source for the "UV upturn" phenomenon observed in elliptical galaxies and galaxy bulges. While the future evolution of an sdB star can be predicted by model calculations as leading more or less directly to the white dwarf graveyard, thus avoiding a second giant phase, the question of how they have formed in the first place is still an issue very much under investigation.

An important step towards a deeper understanding of sdB stars was made possible when a fraction of them were discovered to be variable, on timescales of minutes with amplitudes of typically a few mmag. Pulsations in sdB stars, driven by the κ-mechanism due to an opacity bump caused by iron, had been predicted shortly before the first pulsator was discovered (see Charpinet 2001 for a review including a compilation of known pulsators). While the fact that even within the so-called sdBV instability strip most of the sdB's are stable (within the

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observational limits) adds to the mystery, there has nevertheless been considerable progress: Both the theoretical modelling of the driving mechanisms as well as the combined observational and theoretical task of mode identification for the observed pulsations recently have started to yield convincing results. Mode identification has turned out to be rather non-trivial for sdB's and is currently being further tackled by a coordinated spectrophotometric monitoring approach. Once successfully applied, asteroseismology yields precise results for stellar parameters such as the luminosity, mass, inner structure and chemical composition, rotation or magnetic fields of an object.

2 Why do sdB stars exist? Evolution scenarios and HW Vir systems

The main question to be answered is how the progenitor star manages to remove all but a tiny fraction of the hydrogen envelope at exactly the same time as the helium core has attained the mass of 0.5 $M_{\odot}$, which is required for the helium flash. Single star evolution with enhanced mass loss has been proposed as a possible explanation. A competing scenario evokes binary evolution. It is supported by the finding from photometric, radial velocity and infrared excess surveys that many sdB's do indeed reside in binary and often even close binary systems. Yet there will remain considerable doubts about the validity of this approach as long as this cannot be shown for all of the objects. Binarity alone is not all that is needed to explain the formation of sdB stars; the additional requirement of a past common envelope ejection seems to be essential and is certainly harder to prove. Possible pairs that would fit into this picture are the combinations [sdB + cool main sequence star] and [sdB + white dwarf star]. A particularly noteworthy kind of systems are the HW Vir variables which consist of a cool main sequence star orbiting an sdB in a plane oriented in such a way that eclipses can be witnessed from earth. They permit to extract a wealth of information about their components (see e.g. Drechsel et al. 2001); two more such systems are known so far.

To settle the question whether all sdB's reside in close binary systems, high angular resolution techniques in combination with binary frequency and separability simulations provide another important approach. In addition to work done with the HST (Heber et al. 2002, resolution: 0.1" in the R band), interferometric results with VLTI will be of great value to probe the spatial separation regime occupied by the very close systems. The search technique can be calibrated against and will complement the accurate results from either asteroseismology or eclipsing binary analysis; then it can be extended to constrain possible companions to sdB's which neither show pulsations or eclipses, and in particluar test for companions to those sdB's which do not show any signs of binarity so far.

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