SDOB7 – Submitted Abstracts

Tony Lynas-Gray

University of Oxford

2015 July 16$^{\mathrm{th}}$

ORAL CONTRIBUTIONS

GAIA, the 1 billion star astrometric satellite mission will revolutionise virtually all aspects of stellar and galactic science, including the study of hot subdwarfs. Since the mission is well underway, and first data will be published within the next two years, it is important for scientists working in these fields to prepare themselves for a wealth of data. I will give an overview of the current status of the mission 18 months after the launch, and will point out the potential of GAIA data has for hot subdwarf research, both for understanding the stars themselves, and using them as tools for galactic studies

A Circumbinary Planet in 2M1938+4603

A. Baran (Pedagogical University of Cracow)

I will talk about our discovery of a Jovian planet orbiting a binary system 2M1938+4603. The system consists of a pulsating sdB star and an M dwarf. The pulsations detected in the sdB star turned out to be be very complex and we were unsuccessful in using them to derive stellar parameters. Instead, we focus on a binary nature of the system and analyzed the stability of the orbital period. It shows a periodic variation and we interpreted it as a third body in the system. We derived its parameters to be characteristic of a Jupiter-like body.

Now You See It, Now You Do Not: The Disappearing Pulsations of CS 1246

B. Barlow (High Point University)

At the time of its discovery, CS 1246 was one of the largest-amplitude rapidly pulsating sdB stars known. Since then, its pulsations have decreased in amplitude dramatically. Here we present an analysis of six years of ground-based photometry obtained with SKYNET and discuss the implications of our findings.

The BlackGEM and MeerLICHT Telescopes: Future Facilities Ideally Suited to Search for Variable Subdwarf Stars

S. Bloemen (Radboud University Nijmegen)

Unfortunately, most existing and planned large scale synoptic surveys operate at cadences of several days or weeks, which is too long to efficiently search for variable hot subdwarf stars. This will change in 2016 and 2017, when the MeerLICHT (Sutherland, SA) and BlackGEM (La Silla, Chile) telescopes become operational. In total, these two facilities will host at least four 65-cm telescopes with a wide field of view of 2.7 square degrees each. The planned high-cadence (1 min) optical surveys that will be performed with these facilities will be ideally suited to detect pulsating hot subdwarfs and hot subdwarfs in eclipsing binary systems, as well as a variety of other transient and variable star systems that vary on timescales of minutes to days. In this talk, I will present the MeerLICHT and BlackGEM facilities, their main science goals and how their data can contribute to the hot subdwarf research field.

Uncertainties on Near-Core Mixing in Red-Clump Stars: Effects on the Period Spacing and on the Luminosity of the AGB Bump

D. Bossini (University of Birmingham)

Low-mass stars in the He-core-burning phase play a predominant role in stellar, galactic, and extragalactic astrophysics. However, the ability to predict accurately the proprieties of these stars depends on our understanding of convection, which remains one of the key-open questions in stellar modelling. One of the observational features related to the Horizontal-Branch and Asymptotic-Giant-Branch evolution is the AGB bump. Its luminosity strongly depends on the position in mass of the helium-burning shell at its first ignition, which is related to the extension of the formal mixed core. In our work we use the MESA, BaSTI, and PaRSEC stellar evolution codes to compute models of a typical galactic Kepler giant star. We explore how various near-core-mixing scenarios affect the predictions of the AGB bump luminosity, as well as of the period spacing of gravity modes. We present evidence for AGB-bump candidates among Kepler targets, which allow us to make a combined analysis of classical and seismic constrains.

Merger Rate of Low Mass White Dwarf Binaries

W. Brown (Smithsonian Institution)

I will discuss the merger rate of double degenerate binaries containing extremely low mass $< 0.3\ M_\odot$ white dwarfs (WDs) in the Milky Way. Low mass WDs are the signpost of ultra-compact binary systems; the Universe is not old enough to evolve such WDs through single star evolution. We have now discovered over 80 low mass WD binaries in our targeted spectroscopic ELM Survey. The median orbital period is 6 hrs, which means that half of the systems will merge in less than a Hubble time. We use new WD evolution tracks to infer space densities, and compare the observed merger rate with possible end products such as AM CvN stars, R CrB stars, and under-luminous supernovae.

Rotation Periods of White Dwarfs

M. Burleigh (University of Leicester)

Rotational broadening of white dwarf spectral lines is dwarfed by broadening by the high gravitational fields in these stars, and provides only limits on their rotation periods. Most white dwarf rotation periods are instead determined from photometric light curves of variable (and usually magnetic) white dwarfs, and through asteroseismology. I will present results from a large ground-based photometric survey of magnetic white dwarfs for their rotation periods, and results from the Kepler mission, in which a surprising number of apparently non-magnetic white dwarfs show low level photometric modulations as they rotate.

The Nature of Extreme Horizontal Branch Stars and Helium-Core White Dwarfs in the Galactic Bulge

A. Calamida (STSCI)

We detected for the first time a white dwarf (WD) cooling sequence in the Galactic bulge together with a dozen extreme horizontal branch (EHB) stars by using deep photometry collected with the Advanced Camera for Surveys on the Hubble Space Telescope. Observations at several epochs, spread over 9 years, allowed us to separate the disk and bulge stars down to very faint magnitudes, $F814W \approx 26 mag$, with a proper-motion accuracy better than 0.5 mas/yr (20 km/s). We were then able to select a pure sample of bulge WD and EHB stars. The comparison between theory and observations shows that a substantial fraction of the WDs ($\sim 30\%$) are systematically redder than the cooling tracks for CO-core H-rich and He-rich envelope WDs. This evidence would suggest the presence of a significant number of He-core WDs and WD - main sequence binaries in the bulge. This hypothesis is further supported by the finding of two dwarf novae in outburst, two short-period ($P \leqslant 1d$) ellipsoidal variables, and a few candidate cataclysmic variables in the same field. Multi-epoch medium-resolution spectra were collected with GMOS on Gemini for a sub-sample of the EHBs and a few blue horizontal branch stars.

The Nature of Extreme Horizontal Branch Stars and Helium-Core White Dwarfs in the Galactic Bulge – Continued

A. Calamida (STSCI)

These spectra will allow us to confirm the nature of these candidates through spectral classification and to determine the fraction of close binaries through radial velocity measurements. The true binary fraction of bulge EHBs, along with their abundances, will reveal if they share a similar origin as in the high-density, low-metallicity environments of Galactic globular clusters, in which stellar collisions and encounters play an important role in the formation of EHBs, or if they are more similar to the field disk population, where the binary scenario is favored and stellar environment is similar to the bulge.

The Potential of Pulsating SdB Stars for Probing Helium-Burning Cores

S. Charpinet (Observatoire Midi-Pyrénées), P. Brassard (Université de Montréal) V. Van Grootel (Université de Liège), G. Fontaine (Université de Montréal), S.K. Randall (ESO), E.M. Green (Steward Observatory)

The pulsations in evolved, core helium burning, extreme horizontal branch stars offer particularly favorable conditions for probing with asteroseismology their internal structure, thus constituting one of the most promising seismic window for this intermediate stage of stellar evolution. In particular, the gravity modes observed in the long period sdB pulsators have the power to probe deep inside these stars, down to the convective He-burning core boundary where uncertain physics (convection, overshooting, semi-convection) is at work. Space data gathered with CoRoT and Kepler these past years are indeed offering us opportunities to study these regions in detail and possibly shed new light on how these processes shape the core structure. I will discuss the potential of sdB asteroseismology for accessing the deeply hidden secrets of low mass star helium burning cores.

FUSE and STIS Observations of the SdO Star ROB 162 in NGC 6397

P. Chayer (Space Telescope Science Institute)

We present a spectroscopic analysis of the sdO star ROB 162, a UV-bright star in the globular cluster NGC 6397. With an effective temperature $T_{\rm eff} = 51,000$K and surface gravity $\log g = 4.5$, ROB 162 lies on a post-AGB (asymptotic giant branch) evolutionary track. Observations with the Far Ultraviolet Spectroscopic Explorer and the Space Telescope Imaging Spectrograph reveal a relatively small number of photospheric lines corresponding to elements such as C, N, O, Si, P, S, Fe, and Ni. Neither photospheric heavy elements nor P-Cygni features are detected.

FUSE and STIS Observations of the SdO Star ROB 162 in NGC 6397 – Continued

P. Chayer (Space Telescope Science Institute)

The photospheric abundances are consistent with those of the red giant branch stars observed in the cluster. The star's low C abundance indicates that it left the AGB before the onset of third dredge-up, which brings the products of helium-burning into the convective envelope. Finally, the spectrum of ROB 162 reveals the presence of heavy elements such as Ga, Ge, and Sn in the interstellar medium along the line of sight.

The Formation of EL CVn-Type Binaries

X. Chen (Yunnan Observatory)

EL CVn type binaries are a new type of eclipsing binaries discovered by Maxted *et al.*, in which an A-type dwarf star eclipses the remnant of a disrupted red giant star and the remnant is in a rarely-observed phase i.e. pre-He-WD (it is evolving to higher effective temperature at nearly constant luminosity prior to becoming a very low-mass WD). A total of seventeen such binaries have been discovered and the companions of the A-type stars have been confirmed to have very low masses ($\sim 0.2 \mathrm{M}_{\odot}$) for six of these binaries. EL CVn-type binaries enable us to study the formation of very low-mass WDs in great detail. We propose that such binaries can be formed by stable mass transfer near the bifurcation point of binary evolution. We carried out more than 5000 binary runs to constrain the parameter space for forming such binaries. Based on this parameter space and employing binary population synthesis, we will give theoretical distributions of some properties of EL CVn-type binaries and compare them with observations.

Measuring the Orbital Decay of the Close sdB+WD Binary CD $-30^\circ 11223$ Caused by Gravitational Wave Emission

S. Dhawan (European Southern Observatory)

Short period binaries are predicted to be strong sources of gravitational waves. Here we aim to use time resolved FORS2 photometry of the bright, eclipsing, short-period sdB+WD binary CD $-30^\circ 11223$, to constrain the value of the orbital decay period, as indirect evidence of gravitational wave emission. We want to improve the signal-to-noise ratio on the shallow eclipses and improve the orbital parameter determination of this unique binary. Combining the new, high-precision eclipse times with archive data, we will be able to detect the predicted shrinkage of the orbit.

Planets in Post Common Envelope Binaries

S. Dreizler (Göttingen Universität)

Eclipse time variations in post common envelope binaries (PCEB) with white dwarfs and subdwarf-B stars as primaries have been interpreted as signatures from circum binary planets. Several of these interpretations have been questioned later on, either due to dynamical instability of the proposed planetary systems or due to non-detection of proposed companions. We will give an overview of our long-term monitoring of PCEB systems and the modeling in terms of Keplerian and Newtonian planetary orbits.

Asteroseismology as a Probe of Internal Rotation in Pulsating White Dwarf and Hot Subdwarf Stars

G. Fontaine (U. de Montréal), S. Charpinet (U. Toulouse), P. Brassard (U. Montréal), V. Van Grootel (U. Liège), N. Giammichele (U. Montréal)

A few years ago, Charpinet, Fontaine, & Brassard (2009, Nature, 461, 501) developed a new approach to test for solid body rotation (and deviations thereof) in pulsating stars. The method was successfully applied to the prototype of the GW Vir class of pulsating white dwarfs, PG 1159-035, for which the internal rotation profile was mapped over 99% of its mass (92% of its radius), a much better coverage than can currently be achieved from either helioseismology or asteroseismology of normal or giant stars. Similar results were obtained in the four other GW Vir pulsators with available and suitable seismic rotational data. These stars are all found to rotate rigidly but, more importantly, to rotate extremely slowly, not only at the surface but *globally*. Since the internal rotation profile is available over 99the mass of each of these pulsators, it is possible to compute the global rotation energy as well as the total angular momentum in each case. This leads to ratios of the global rotation energy to the internal thermal energy ranging from 1.E-08 to 1.E-06, which are extremely low values. In essence, these post-AGB objects have lost *all* of their initial angular momentum.

Asteroseismology as a Probe of Internal Rotation in Pulsating White Dwarf and Hot Subdwarf Stars – Continued

G. Fontaine (U. de Montreal), S. Charpinet (U. Toulouse), P. Brassard (U. Montreal), V. Van Grootel (U. Liege), N. Giammichele (U. Montreal)

This finding has a direct impact on the question of angular momentum transfer that must exist between the radiative core and the convective envelope in the red giant phases of stellar evolution. While the distribution of rotation kernels is exceptionally favorable for mapping the full structure of a GW Vir star, mode confinement below the outer envelope can also help in probing an unexpectedly large fraction of the mass in some cooler, more degenerate pulsating white dwarfs of the V777 Her and ZZ Ceti types. We briefly also discuss the application of this mapping technique in pulsating hot subdwarfs.

Hot Subdwarf Stars and their Connection to Thermonuclear Supernovae

S. Geier (European Southern Observatory)

Hot subdwarfs in close binaries with massive white dwarf companions are candidates for the progenitors of thermonuclear supernovae. As soon as the white dwarf explodes, the surviving hot subdwarf might be ejected from the binary and accelerated to velocities high enough to leave our Galaxy. Hypervelocity hot subdwarfs such as the prototype US 708 might therefore become important tools to study thermonuclear supernovae. I will present new results from our project searching for both the binary progenitors and the ejected donor remnants to SN Ia.

Forward Modelling of the Gravity-Mode sdB Pulsator KIC 10553698A

H. Ghasemi (Zanjan & KU Leuven), E. Moravveji (KU Leuven), C. Aerts (KU Leuven & Nijmegan), R. Østensen (KU Leuven), M. Vučković (Valparaíso), H. Safari (Zanjan)

Subdwarf-B (sdB) stars are core-helium burning objects situated at the extreme horizontal branch (EHB). Here we study one such star after it was observed with the NASA Kepler satellite: KIC 10553698A turned out to be a gravity-mode sdB primary in a short-period binary whose 3-year Kepler light curve revealed 156 significant frequencies identified as dipole and quadrupole modes (Østensen *et al.* 2014). Its period spacing patterns of high-order gravity modes deduced from the photometric data reveals deviations from a uniform spacing, offering a detailed fingerprint of its deep interior structure.

Forward Modelling of the Gravity-Mode sdB Pulsator KIC 10553698A – Continued

H. Ghasemi (Zanjan & KU Leuven), E. Moravveji (KU Leuven), C. Aerts (KU Leuven & Nijmegan), R. Østensen (KU Leuven), M. Vučković (Valparaíso), H. Safari (Zanjan)

In this study, we perform the first steps towards forward seismic modelling of KIC 10553698A using the stellar structure and evolution code MESA, in combination with the pulsation code GYRE in both its adiabatic and non-adiabatic linear approximation. We compute models with varying initial stellar mass, metallicity, helium core mass, and hydrogen envelope mass, while investigating the effects of extra diffusive mixing and convective core overshooting on the period spacings. Equipped with the measured period spacing pattern, we also address the combined role of gravitational settling and radiative levitation of heavy elements below the surface of KIC 10553698A. We provide constraints on these physical processes for this binary sdB pulsating primary.

The Search for the Shortest Period Binary White Dwarfs: The Latest Results from the ELM Survey

A. Gianninas (University of Oklahoma)

Extremely low mass (ELM) white dwarfs (WDs) represent the end point of the evolution of compact binary systems. They are the possible progenitors of type Ia supernovae, underluminous Ia supernovae, AM CVn systems, R Coronae Borealis stars, and single subdwarf O/B stars. In addition, they are among the strongest sources of gravitational waves in the mHz range. I will present the latest results from the ongoing ELM Survey, our targeted search for these short-period ($P < 1$ day) ELM WD binaries. I will present the latest set of twelve new binaries which we have identified over the course of the last year. I will also discuss the puzzling presence of metals in many ELM WDs. In addition, I will present the observed orbital period distribution as a function of effective temperature and discuss the membership of ELM WD binaries to the galactic disk and halo populations.

In this talk, I will discuss how the current observations of sdB binaries constrain binary evolution theory in general, and I will mainly focus on the common-envelope ejection efficiency derived from observations of sdB binaries and how helium is ignited.

The results of spectroscopic analyses of the sample of hot subdwarf stars drawn from the northern Hamburg Quasar survey as well as from the southern Hamburg ESO Survey are reviewed in the light of new results from other samples.

Confronting the "Extreme Planetary Systems" claimed around sdBVs

J.J. Hermes (University of Warwick)

To date, there have been at least two claims of "extreme planetary systems" detected in Kepler space-based photometry of hot subdwarfs which were otherwise targeted for their g-mode pulsations. The authors argue that observed 5.2-19.5 hr periodicities in the power spectrum of the pulsating sdBs KIC 05807616 and KIC 10001893, below the claimed acoustic cutoff frequency, are best explained by illumination from multiple, irradiated, close-in planets (e.g. Charpinet *et al.* 2011, Silvotti *et al. 2014*). I will present evidence strongly complicating this planetary hypothesis, and argue that these claims undermine future detections of planets around hot subdwarfs and related objects.

Quantitative Spectral Analysis of the Stripped Red-Giant Star 1SWASP J024743.37-251549.2B

C. Heuser (Universität Erlangen)

We present preliminary results of a quantitative analysis of high-resolution UVES spectra of J024743.37-251549.2B - the stripped helium core of a red giant. The modelling is done with a hybrid approach, combining ATLAS12 LTE temperature-density stratification with NLTE statistical equilibrium and spectrum synthesis calculations for several elements with the DETAIL/SURFACE package to determine atmospheric parameters and the elemental abundances of elements such as He, O, Mg.

On the nature of the secondary star in AA Dor

D. Hoyer, T. Rauch, K. Werner (Universität Tübingen), P.H. Hauschildt (Hamburger Sternwarte), J.W. Kruk (NASA Goddard)

AA Dor is a close, totally eclipsing, post common-envelope binary with an sdOB-type primary star and an extremely low-mass secondary star, located close to the mass limit of stable central hydrogen burning. Within the error limits, the secondary may be either a brown dwarf or a late M-type dwarf. In January 2014, we measured its phase-dependent spectrum with XSHOOTER over one complete orbital period. Since the secondary's rotation is presumably synchronized with the orbital period, its surface divides strictly into a day and a night side. We report on the progress to extract the spectrum of its cool side during its transit and of its hot, irradiated side close to its occultation. We discuss the nature of the secondary.

Element Diffusion and Rotational Mixing: Their Effect on the Evolution of Proto-Helium White Dwarfs

A. Istrate (Argelander Institute Bonn)

Extremely low-mass helium white dwarfs are the result of binary interactions in close systems. Focusing on the remnant companion star in tight orbit LMXB systems, we aim at studying the effect of element diffusion coupled with rotational mixing on: (i) the lifetime of proto-helium white dwarfs and (ii) the hydrogen content at the beginning of the cooling track which determines its further cooling evolution. In this context, I present here the first preliminary results obtained with MESA. Rotational mixing in addition to element diffusion produces stronger hydrogen flashes compared to the case when just diffusion is considered. Consequently, the hydrogen envelope mass will be smaller at the end of the proto-white dwarf phase which will result in even further accelerated cooling of the white dwarf.

Common Envelope Evolution with Low-Mass Giants

N. Ivanova (University of Alberta)

Common envelope is a short-timescale phase in the lives of close binaries that takes place when one of the binary companions starts an unstable mass transfer. If the Roche lobe filling star is a red giant, the outcome of the common envelope phase can be formation of a compact binary where one of the stars is a subdwarf. This is one of the dominant formation channels for subdwarf binaries. I will talk about the recent progress in understanding the physics of the common envelope phase, in particular, about the role of recombination on the common envelope outcomes for low-mass giant donors. I will present 3D hydrodynamic studies that led us to a revision of the energy budget formalism. I also will discuss the role of the recombination during common envelope events that take place on a timescale significantly longer than the orbital timescale.

Dynamical Model Atmospheres and Emergent Spectra for Pulsating Proto-Subdwarfs

C.S. Jeffery (Armagh Observatory)

The pulsating extreme helium stars V652 Her and BX Cir are contracting rapidly and are likely to become helium-rich hot subdwarfs within about 10,000 years. Their pulsations can simply be described by a rapid outward acceleration at minimum radius followed by nearly linear inward acceleration (or free-fall) under gravity. Very high-resolution time-resolved spectroscopy of V652 Her has allowed us to carry out tomography of the surface layers, to resolve the passage of the outward shock through the photosphere, and to directly measure differential compression and expansion in the photosphere during passage through minimum and maximum radius respectively.

Dynamical Model Atmospheres and Emergent Spectra for Pulsating Proto-Subdwarfs – Continued

C.S. Jeffery (Armagh Observatory)

This empirical paradigm is supported by new hydrodynamical calculations for V652 Her, in which we use the dynamical properties (rather than stellar atmospheres) to constrain the mass, temperature and radius. The models reproduce the observed shock progression and the compression and expansion of the photosphere, and imply that spectral analysis techniques adopted hitherto are inappropriate. The hydro calculations are used to compute a new generation of model atmospheres in which the approximation of hydrostatic equilibrium has been relaxed, and from which the radiative transfer equations have been solved to compute the emergent spectrum around the pulsation cycle. The latter models reproduce well the observed behaviour of the spectrum of V652 Her, especially around minimum radius. The new models can mitigate one of the major sources of systematic error in determining the fundamental properties of pulsating stars, whilst the methods developed here are directly applicable to other radial-mode early-type pulsating stars including hot subdwarfs and β Cephei variables.

Learning from Fast and Slow Hot Subdwarfs About Type Ia Supernova Progenitors

S. Justham (National Astronomical Observatories, Chinese Academy of Science)

The inferred properties of US 708 strongly suggest that understanding unusual hot subdwarfs can provide information about the progenitors of thermonuclear supernovae. I will discuss the relationship between runaway hot subdwarfs and type Ia supernova progenitors, but intend to focus mainly on a different evolutionary path to the scenarios which may have produced such high-velocity hot subdwarfs as US 708. This channel would explain the characteristics of one known but puzzling candidate ex-donor star. If that star can be shown to further fit the model predictions, this would demonstrate clearly that the white dwarfs in single-degenerate type Ia supernovae can avoid exploding for a significant time after the end of accretion which is potentially very important for single-degenerate models but is currently unproven.

We report on our analysis of the Data Release 12 of the Sloan Digital Sky Survey, from which we found 55 sdBs and 52 sdOs, on top of the 636 we reported in DR10. Determining the mass of compact stars through spectral fitting has been hampered by the uncertain definition of the low mass - or surface gravity - we define as a subdwarf, a white dwarf, a blue straggler, or a low metallicity dwarf. We found thousands of such objects in the Sloan Digital Sky Survey spectroscopic survey, and we question their use to map the Galactic halo.

Planetary Remnants Around White Dwarfs

M. Kilic (University of Oklahoma)

Planets around white dwarfs may be common, and they may provide our best chance to detect bio-markers on a transiting exoplanet, thanks to the diminished contrast ratio between the white dwarf and its planets. Here we present results from a recent Spitzer Space Telescope survey of bright white dwarfs, and compare the frequency of remnant planetary systems around white dwarfs with planet formation models. We also present the first results from a minute-cadence transit survey for planets in the white dwarf habitable zone.

The Reliability of Period Detections in Regularly-Spaced Time Series.

C. Koen (University of the Western Cape)

Recently Baran *et al.* (2015) looked from a different angle at the problem of detecting periodicities in regularly sampled time series. The usual approach is to start from pure noise time series, and to obtain the statistical distribution of the highest spectrum peaks. Observed peak heights can then be compared to the reference distribution, and a significance level deduced. Instead, Baran *et al.* (2015) studied the probability of correctly recovering the frequency of a known signal which was superposed on a noise time series. It turns out that the signal-to-noise ratio required to correctly identify the signal frequency is higher than might have been anticipated. Results of further simulation experiments, aimed at studying these findings in more detail, are discussed.

Spectral Decomposition of sdB Binaries

S. Kreuzer (Erlangen Universität)

We present a status report on our spectroscopic analysis of sdB binaries consisting of a subdwarf and a G/F-type main-sequence companion. These systems show significant excess in the infrared. As input, we use data provided by the SDSS and BOSS spectrographs. Standard stellar spectum model grids as well as a non-LTE subdwarf grid allows us to decompose the spectrum of a binary system and hence find the contribution of each star to the combined flux. In order to obtain the best fitting combination of parameters of both stars we use a standard Chi-square fitting routine. The analysis reveals T_{eff}, $\log g$ and the metal abundance for each single star and the relative radial velocity of both components. The long-term goal is to study technical possibilities in the spectroscopy of multiple-star systems and the development of a fast method for their decomposition, which would then be applied to a large number of stars.

We provide wind mass-loss rate estimates for hot subdwarfs as a function of their stellar parameters. For that purpose we apply our NLTE wind models with CMF line force. We show that besides the stellar luminosity the wind mass-loss rates are very sensitive to the surface metallicity of the subdwarf star. On the other hand, the helium abundance does not affect the wind mass-loss rate significantly. We also discuss the observational consequences of our models.

The Observational Short-Period Population of Hot Subdwarf Binaries

T. Kupfer (Radboud University Nijmegen)

Recent studies increased the number of hot subdwarf binaries with orbital periods less than 30 days and measured mass functions for 142 systems known today. Such compact systems faced at least one common envelope phase during their evolution. Companion types are either low-mass-main sequence stars, brown dwarfs or white dwarfs. I will present a detailed study of the known population of compact hot subdwarf binaries.

Spectral Analysis of HD 188112: a Metal-Poor Pre-Helium Core White Dwarf

M. Latour (Erlangen Universität)

HD 188112 is a bright sdB star with a mass too low to sustain core helium burning and is therefore considered as a pre-ELM white dwarf. I will present the detailed abundance analysis of HD 188112 based on high resolution HST UV spectroscopy. We used hybrid non-LTE model atmospheres to fit the observed spectral lines and derived abundances of more than a dozen elements, including two trans-iron elements: Gallium and Tin. The metallic abundances of HD 188112 indicates that the star is particularly metal-poor, thus contrasting with other sdBs and the few ELM WDs for which abundances have been measured. We also constrained the mass of the companion star (WD) to be between 0.9 and 1.3 $\mathrm{M}_\odot$, but we are limited by the assumption of synchroneous rotation and the uncertainty on the mass of the sdB itself.

Overshooting mixing beyond the convection zone is crucial for stars with convective cores or convective envelopes. When a low mass star evolves up along the red giant branch (RGB), it will develop much more extensive convection in its envelope. Such envelope convection penetrates rapidly inward into the stellar interior, and finally results in a composition discontinuity when it develops into the chemical gradient region. Subsequently, when the out-moving hydrogen burning-shell encounters the newly-formed composition discontinuity, the star will develops the so-called RGB bump on the HR diagram. Therefore, comparisons of characteristics of the RGB bump are crucial for the overshooting mixing below the base of the stellar convective envelope.

Overshooting Mixing in RGB and Horizontal Branch Stars – Continued

Y. Li (Yunnan Observatory)

In order to treat overshooting convection below the base of the convective envelope, we used the k-omega model of Li (2012) in RGB models of a $1M_{\odot}$ star. We solved equations of the k-omega model in the stellar envelope, and then obtained that the turbulent kinetic energy and the frequency of turbulence decay in the overshooting region according approximately to power laws of pressure. The decaying indices are found to be sensitive to the parameters of the k-omega model. We adopted a modified overshooting mixing model of Zhang (2013) to investigate the overshooting mixing below the base of the convection zone. We found that the RGB bump appears at a significantly lower luminosity when using the k-omega model than when using the standard mixing-length theory, and its duration is also considerably reduced.

When a low mass star burns helium in its center on the horizontal branch, it will develop a convective core. Therefore the overshooting mixing beyond the convective core significantly affects the fuel supply of the nuclear burning process. We tried to used the k-omega model to determine the overshooting mixing, and comparisons with observations can provide evidences of convection in the stellar core.

Sun-like oscillations have been discovered in five hundred main sequence and sub-giant stars and in more than twelve thousand red giant stars in the solar neighbourhood. In this talk, I will argue how this network of natural detectors could be used to probe fundamental physics, including dark matter and gravitational waves. Moreover, these star detectors can complement the experimental research done on Earth. This observational network of stars could be used to make other types of gravity tests, as unlike experimental detectors, it should be possible to follow the progression of gravitational waves throughout space. The continuous observation and monitoring of the oscillation spectra of the stars around us, within a sphere of up to one thousand parsecs, could help with the discovery of gravitational waves originating in our Galaxy or even elsewhere in the Universe.

The Coolest Extremely Low-Mass White Dwarf and an Astrophysical Conundrum

T.R. Marsh (University of Warwick)

I will report on follow-up HST spectroscopy of SDSS J1257 + 5428, an extremely low mass (ELM) white dwarf ($< 0.25\ M_\odot$) in a 4.6-hour binary with a massive ($> 1\ M_\odot$) white dwarf. HST FUV and SDSS data allow us to constrain the temperatures of both components, the gravity of the massive white dwarf and the ratio of the radii of the two components. The ELM component has a temperature of 6400 K, the coolest known for any ELM white dwarf. Models indicate that it would take such a star at least 5 Gyr to form, and yet its companion has a mass that suggests it formed from a short-lived, high-mass ($\sim 5\ M_\odot$) star and a cooling age of only 1 Gyr. We have no explanation for this remarkable system.

Subdwarf B stars are low-mass core helium burning stars with extremely thin hydrogen envelopes. Their atmospheres are generally helium deficient, however a minority of these stars have extremely helium rich surfaces. A small number have an intermediate surface helium abundance accompanied by peculiar abundances of other elements. We have studied a sample of 74 hot subdwarfs including 40 helium-deficient, 22 intermediate helium and 12 extreme helium stars. Radial velocity and proper motion measurements together with distances allow a calculation of the Galactic space velocities of these stars. We have investigated the kinematics of these three groups of hot subdwarfs to determine whether they belong to different Galactic populations. We confirm that the majority of helium deficient subdwarfs show a kinematic distribution similar to that of thick disk stars. Helium rich sdBs, however, show a more diverse kinematic distribution.

Kinematics of Helium-Rich Subluminous O and B Stars – Continued

P. Martin (Armagh Observatory)

Although the majority are probably disk stars, a minority show a much higher velocity dispersions consistent with membership of a Galactic halo population. It is noted that several of the high-velocity subdwarfs are members of the class of "heavy-metal" subdwarfs discovered by Naslim *et al.*

Stripped red giant stars are the rarely-observed precursors of very low mass white dwarfs. They are currently evolving at nearly constant luminosity towards higher effective temperatures as p-p shell burning erodes the thin hydrogen layer that surrounds their degenerate helium cores. We have discovered 18 such stars in bright eclipsing binary star systems with A-type companions (EL CVn-type binaries), more than doubling the known sample of such stars. The first such binary found was discovered to be a new class of pulsating star. In this talk I will summarize what is known about stripped red giants and describe the follow-up observations that have been obtained for the newly-discovered binaries.

Do all SNe Ia Have the Same Explosion Mechanism?

X. Meng (Yunnan Observatory)

I will present evidence which shows that all SNe Ia may explode with the same explosion mechanism, and the mechanism does not depend on the progenitor system.

Thanks to the high sensitivity of the XMM-Newton and Chandra satellites, X-ray emission has been now detected from five sdO stars and upper limits derived for several other interesting hot subdwarfs. This sample includes binaries, in which the X-rays result from accretion onto a white dwarf or neutron star companion, as well as single sdO stars, in which X-rays are probably due to shock instabilities in the wind. The latter can can provide useful information for our understanding of the radiation-driven winds of more luminous and massive stars, while the study of hot sd binaries with compact companions is relevant, among other things, in the context of evolutionary models. After a review of the properties of the X-ray emission from hot subdwarfs, I will report on recent observations of the three X-ray brightest sdOs (HD 49798, BD +37 442, and BD +37 1977), discuss the implications of the non-detections of sdB+WD binaries, and present the prospects for future X-ray observations of hot subdwarfs.

Hot UV Bright Stars in Globular Clusters - The Sequel

S. Moehler (European Southern Observatory)

UV bright stars are stars brighter than the horizontal branch and bluer than the red giant branch. Due to the high bolometric correction for hot stars, optical photometry provides mostly luminous cool UV bright stars evolving away from asymptotic giant branch. UV photometry on the other hand adds the missing hot UV bright stars (see Moehler *et al.* 1998, A&A 335, 510), some of which follow other evolutionary paths. Almost two decades later we continued and extended our investigation, and will report on new optical spectroscopy of UV-bright stars in M 4, M 22, M 30, NGC 6712, and ω Cen.

We present an overview of our on-going project to characterize hot subdwarf stars and binaries in the Sloan Digital Sky Survey. We derived atmospheric parameters for 860 stars that were selected from Data Release 10 based on color criteria. The bulk of our selection is fainter than 15 (SDSS g) magnitudes. They are at high galactic latitudes, therefore most stars belong either to the old Thick Disk or Halo populations. In line with the different population membership, the atmospheric parameters show fundamental differences when compared to bright, most likely Thin Disk subdwarfs.

Kepler Observations of sdB Pulsators – New Diagnostics for Asteroseismology

R. Østensen (KU Leuven)

Recent analysis of four-year-long light curves from the Kepler spacecraft has finally revealed that trapped modes are certainly present in hot subdwarf stars as predicted by theory. Furthermore, the unprecedented duration of the observations has permitted us to detect the e-folding time scale of the pulsation modes for the first time. This yields important new diagnostic tools that promises improved constraints when comparing observations to non-adiabatic pulsation models.

The Puzzle of Angular Momentum Distribution in Red Giant Stars

R.-M. Ouazzani (Århus University)

Transport of angular momentum in stars is one of the major issues in stellar structure and evolution. The space-borne missions CoRoT and Kepler have toppled our current understanding of redistribution of angular momentum in late stages of stellar evolution allowing for the measurement of core rotation from rotational splittings of mixed modes. Contrary to the predictions of current evolutionary codes, the core of red-giant stars is shown to slow down along evolution. This calls for a very efficient physical mechanism which enables to transport angular momentum from the inner to the outer layers, still yet to be found. In this context, I will report on recent observational constraints on the inner rotation of red giants and discuss the puzzle that it represents to theoreticians together with potential solutions.

The Extreme Horizontal Branch Stars in ω Cen: A Population Apart?

S. Randall (ESO)

Extreme Horizontal Branch (EHB) stars in globular clusters such as ω Cen appear to have quite distinct observational properties compared to their sdB/sdO counterparts in the Galactic field. As a population, the ω Cen EHB stars are distributed differently in $\log g - T_{\rm eff} - {\rm He}$ abundance space, have different binary properties and show different pulsation characteristics than observed for field stars. Over recent years, we carried out an extensive survey of the EHB in ω Cen, obtaining light curves, atmospheric parameters, and radial velocities for a significant sample. Here, I will present the latest results of our study and discuss the implications for our understanding of hot subdwarfs in different environments.

Interesting features in Kepler-observed sdB stars

M.D. Reed (Missouri State University)

In this talk I will discuss, hopefully with feedback from the expert audience, observed features in the lightcurves of Kepler-observed pulsating sdB stars. Many of these features are revealed through detailed sliding Fourier transforms, which show how pulsations evolve with time over the three-years of Kepler data. The overall goal is to understand the underlying structure and physical conditions within sdB stars. The peculiar features observed by Kepler must reflect conditions, and their changes, within these stars.

Recent Progress on our Understanding of He-Dominated Stellar Evolution

N. Reindl (Tübingen Universität)

About 20% of all hot pre-white dwarfs in the post-AGB region of the HRD are H-deficient. While late thermal pulse scenarios can account for the C-dominated atmospheres of PG 1159 stars and [WC]-type central stars, the origin and evolution of He-dominated stars is hitherto still a mystery. In the last year, the number of the extremely hot, He-dominated O(He) stars doubled and first hints for close binaries amongst these stars were found. Here, we will present the latest discoveries and review on our current understanding of their evolution, including possible evolutionary links to He-sdO stars and other He-dominated objects.

Subdwarf B stars (sdB) are the counterpart in the galactic field of extreme horizontal branch stars found in globular clusters. They are compact objects, with stellar masses below $\sim 0.5 M_{\odot}$, at the core helium burning stage, that have been left with an hydrogen envelope too thin to be able to sustain a stable hydrogen burning shell. Recently with the Sloan Digital Sky Survey (SDSS) a large amount of spectroscopically identified sdB stars have been found, increasing the number of known sdB to 647 objects, in DR10. Given the number of stars a spread in metallicity is expected for the progenitors of the sdB stars, in particular towards low metallicity values. As is known, the metallicity parameter is important to determine the age, as much as the position of the star in effective temperature and gravity diagram.

Exploring the Dependence of Hot Subdwarf Star Evolution on Metallicity – Continued

A. Romero (Universidade Federal do Rio Grande do Sul)

In this work we compute a grid of horizontal branch models, for different metallicity values, from Z=0,0001 to 0,01, characteristic of globular clusters and solar neighborhood stars. We employ our model grid to characterise the sdB sample obtained from SDSS. In addition we pretend to separate sdB stars from other possible classes of stars that are close in effective temperature and gravity, like Main Sequence and extremely low mass white dwarf stars.

The EREBOS project - Studying the Influence of Substellar Objects on the Late Stages of Stellar Evolution

V. Schaffenroth (Innsbruck Universität)

Planets and brown dwarfs in close orbits will interact with their host stars, as soon as they evolve to become red giants. However, the outcome of those interactions is still unclear. Recently, several brown dwarfs have been discovered orbiting hot subdwarf stars in very short orbital periods of 0.065 - 0.096 d. More than 3% of those stars might have close substellar companions. This shows that such companions can signicantly affect late stellar evolution and that sdB binaries are ideal objects to study this influence. Thirty-six new eclipsing sdB binary systems with cool low-mass companions with periods from 0.05 to 0.5 d were discovered based on their lightcurves by the OGLE project.

The EREBOS project - Studying the Influence of Substellar Objects on the Late Stages of Stellar Evolution – Continued

V. Schaffenroth (Innsbruck Universität)

We want to use this unique and homogeneously selected sample to derive the mass distribution of the companions, constrain the fraction of substellar companions and determine the minimum mass needed to strip off the red-giant envelope. We are especially interested in testing models that predict hot Jupiter planets as possible companions. Therefore, we started the EREBOS (Eclipsing Reflection Effect Binaries from the OGLE Survey), which aims at analysing all newly discovered HW Vir systems based on a spectroscopic and photometric follow-up of all targets. Here we will introduce this new project and give the current status together with first results.

Stellar evolution calculations have had great success reproducing the observed atmospheric properties of different classes of stars. Asteroseismology of subdwarf B stars allows for a rare test of the internal structure of stellar models and suggests convective cores of $0.22 - 0.28 M_{\odot} > 45\%$ of the total stellar mass. We evolved subwarf B stellar models with MESA (Modules for Experiments in Stellar Astrophysics) to test how well their interior structure reproduces the results inferred from asteroseismology. We show that our qualitative evolutionary paths, position in the $\log g - T_{\mathrm{eff}}$ diagram and model timescales are consistent with previous results. SdB masses from our full evolutionary sequences fall within the range of the empirical sdB mass distribution, but are nearly always lower than the median.

MESA Stellar Evolution Models of sdB Stars – Continued

J.-T. Schindler (Steward Oservatory)

Using standard MLT with atomic diffusion we find convective core masses of $\sim 0.17 - 0.18 M_{\odot}$, averaged over the entire sdB lifetime. We can increase the convective core sizes to be as large as those inferred from asteroseismology, but only for extreme values of the overshoot parameter (overshoot gives numerically unstable and physically unrealistic behavior at the boundary). High resolution three-dimensional (3D) simulations of turbulent convection in stars suggest that the Schwarzschild criterion for convective mixing sytematically underestimates the actual extent of mixing because a boundary layer forms. We plan to implement an improved formulation of mixing into MESA that is set up to account for the boundary layers and thus would decrease the errors in both sdB total and convective core masses.

A New HW Vir Binary From the Palomar Transient Factory: PTF1 J072455.75+125300.3 - An Eclipsing Subdwarf-B Binary with a M-Star Companion.

M. Schindewolf (Erlangen Universität)

We report the discovery of an eclipsing binary – PTF1 J072456+125301– composed of a subdwarf B (sdB) star (g'=17.2) with a faint companion. Subdwarf B stars are core helium-burning stars, which can be found on the extreme horizontal branch. About half of them reside in close binary systems, but few are known to be eclipsing, for which fundamental stellar parameters can be derived. We conducted an analysis of photometric data and spectra from the Palomar 60" and the 200" Hale telescope respectively. A quantitative spectral analysis found an effective temperature of T=33900K and a surface gravity of $\log g = 5.74$, typical for an sdB star. The companion does not contribute to the optical light of the system, except through a distinct reflection effect.

A New HW Vir Binary From the Palomar Transient Factory: PTF1 J072455.75+125300.3 - An Eclipsing Subdwarf-B Binary with a M-Star Companion – Continued

M. Schindewolf (Erlangen Universität)

From the light curve an orbital period of 0.09980(25)d and a system inclination of $83^{\circ}.56$ were derived. The mass for the M-type dwarf companion is about 0.155 solar masses. PTF1 J072456+125301 has similar atmospheric parameters to those of pulsating sdB stars (V346 Hya stars). Therefore it could be a high-priority object for asteroseismology, if pulsations were detected such as in the enigmatic case of NY Vir.

I will describe a set of simulations of the long-term outcomes of white dwarf mergers, focusing on remnants that produce sdBs and RCBs. Beginning with the results from simulations of the evolution of the short-lived viscous disk initially present in these remnants, I map these remnants into the MESA stellar evolution code and follow their long-term thermal evolution.

Omega Centauri is the most massive globular cluster in our galaxy. The peculiarities many authors have discovered classify it as an anomalous globular cluster, since it possess a large spread of light and heavy elements, multiple main sequences and a very extended horizontal branch. The very blue end of its HB has a peculiar shape, which contributed to give this blue tail the name of blue hook. However the peculiarities of this group of stars do not end to the shape they have. From a spectroscopic point of view many of them are helium dominated, and possess a high surface carbon abundance, as high as 3%.

On the Blue Hook of the Most Massive Globular Cluster in our Galaxy – Continued

M. Tailo (University “La Sapienza” of Rome)

The current models used to explain this feature involve mixing during the red giant branch phase or the occurrence of the late helium flash mixing during the evolution toward the horizontal branch. However the number of stars populating this part of the HB and its magnitude extension suggest that we are missing something in the description of these stars. In this talk I will present a new model, including newly calculated late helium-flash mixed stellar evolution models, to explain all the features we observe in the blue hook of Omega Centauri and will provide some insight on its role in the evolution of this category of object.

Hot subdwarf-B stars in long period binaries are found to be on eccentric orbits, even though current binary evolution theory predicts those objects to circularise before the onset of Roche-lobe overflow. We aimed to find binary evolution mechanisms that can explain these eccentric long period orbits, and reproduce the currently observed period-eccentricity diagram. Three different processes are considered; tidally enhanced wind mass loss, phase dependent RLOF on eccentric orbits and the interaction between a circumbinary disk and the binary. To test these processes they were implemented in the binary module of the stellar evolution code MESA.

Of the tested eccentricity pumping processes, phase dependent RLOF can cover the short period - intermediate eccentricity region of the period-eccentricity diagram ($P = 600 < 1000 days$) while the addition of a circumbinary disk allows orbits with higher eccentricities and higher orbital periods ($e < 0.35 \text{ and } P < 1600 days$) to be populated. A remaining problem is that these models favour a distribution of higher eccentricities at lower periods, while the observed systems show the opposite trend. A problem that can be solved by finding the connection between several model parameters, as for example accretion fraction, and the initial and current binary configuration.

Testing the Planetary Hypothesis of the Post-Common-Envelope Binary HW Virginis

M. Vučković (Universidad de Valparaíso)

About a dozen close eclipsing binaries with compact primaries that have evolved through a common-envelope (CE) stage have been found to show periodic eclipse timing variations. The most common interpretation for this phenomenon is the presence of light-travel-time variations caused by one or two circumbinary planets orbiting the tight binary system. If these planets are indeed confirmed, then they must have either survived the red-giant and CE stage of the compact star, or they must have formed from the material ejected at the end of the CE stage. However, for some systems the proposed planetary systems turned out to be dynamically unstable, while in others the orbital parameters and masses of the proposed planets disagree drastically with more recent high-precision eclipse timings. It is therefore of critical importance to combine eclipse-timing measurements with experiments that independently test the planet interpretation. In this talk I will present the recent efforts to monitor the system velocity of the most promising PCEB system HW Vir to directly compare the changes in the system velocity and the eclipse timings.

The Hybrid CONeWD + He star Binaries as the Progenitors of Type Ia Supernovae

B. Wang (Yunnan Observatory)

The hybrid CONe white dwarfs (WDs) have been suggested to be possible progenitors of type Ia supernovae (SNe Ia). In this work, we systematically studied the hybrid CONe WD + He star channel for the progenitors of SNe Ia, in which a hybrid CONe WD increases its mass to the Chandrasekhar mass limit by accreting He-rich material from a non-degenerate He star. According to a series of detailed binary population synthesis simulations, we obtained the SN Ia birthrates and delay times for this channel.

The Hybrid CONeWD + He star Binaries as the Progenitors of Type Ia Supernovae – Continued

B. Wang (Yunnan Observatory)

The SN Ia birthrates for this channel roughly accounts for 1%-18% of all SNe Ia. The estimated delay times are 28Myr-178Myr, which are the youngest SNe Ia predicted by any progenitor model so far. We suggest that SNe Ia from this channel may provide an alternative explanation of type Iax SNe. We also presented some properties of the donors at the point when the WDs reach the Chandrasekhar mass. These properties may be a good starting point for investigating the surviving companions of SNe Ia, and for constraining the progenitor channel studied in this work.

Origin of Hot Subdwarfs at High Velocity

E. Ziegerer (Erlangen Universität)

Hypervelocity stars (HVS) move so fast that they are unbound to the Galaxy. The spatial and velocity distribution of HVSs provides significant constraints on the shape and density distribution of the Galactic dark matter halo. When they were first discovered in 2005, dynamical ejection from the super massive black hole in the Galactic Centre (GC) was suggested as their origin. The two dozen of HVS known today are young massive B stars of 3-10 solar masses. Some highvelocity subdwarfs have attracted interest because of their high RVs, most notably, the sdO star US 708, for which an origin in the GC can be excluded, is the fastest unbound star in our Galaxy. We embarked on a kinematic analysis of further subdwarfs based on proper motion measurements using the full 6D phase space information. Their orbital properties can then be derived by tracing back their trajectories in different mass models of our Galaxy. We discuss their origins and their way of acceleration.

Amplitude and Frequency Variations of Oscillation Modes in the Hot B Subdwarf Star KIC 10139564: First Evidence of Nonlinear Resonant Mode Coupling in SdB Stars?

W. Zong (IRAP)

The Kepler spacecraft offers new opportunities to search for long term variations of oscillation modes in pulsating stars. These mode variations in amplitude and frequency could be caused by the mechanism of resonant mode coupling described by the amplitude equation (AE) formalism. We analyse 38-month of uninterrupted Kepler short cadence data gathered on KIC 10139564 and found clear signatures of nonlinear effects in mode multiplets caused by stellar rotation. The p-mode triplet at 5760 μHz shows quasi-periodic modulations in frequency and amplitude that can be associated with the intermediate regime of the resonant mode coupling mechanism in which modes show periodic or irregular (sometimes even chaotic) modulations.

Amplitude and Frequency Variations of Oscillation Modes in the Hot B Subdwarf Star KIC 10139564: First Evidence of Nonlinear Resonant Mode Coupling in SdB Stars? – Continued

W. Zong (IRAP)

The g-mode triplet at 519 μHz has three stable modes and is likely in the frequency lock regime. The doublet at 394 μHz shows amplitude variations even with large amplitude uncertainty, which is predicted by the AE theory. Additionally, two multiplets with $\ell \geqslant 2$ also show amplitude and frequency variations, but the theoretical framework for higher degree modes has not been investigated so far since more modes interact requiring a full numerical treatment of the AEs. These observed modulations could be the first signatures of nonlinear resonant couplings occurring in hot B subdwarf stars.

POSTERS

Searching for Planets Around Pulsating Subdwarf-B Stars

S. Bachulski, A. Baran (Pedagogical University of Cracow, Poland)

We present the results of our search for companions to g-modes pulsating subdwarf B stars. We selected a number of targets while we present only two in this poster. The stars, KIC 3527751 and KIC 10670103, were observed by the Kepler spacecraft for more than 3 years. We analyzed stability of the periods of the pulsation modes which may bear a signature of the Romer effect. This effect is an indication of a presence of a companion. For KIC 3527751 the amplitudes of the modes are to low leading to low precision in the O-C diagram, while for KIC 10670103 we did not detect any planet down to Jupiter-mass.

The Blue-Edge Problem of the V1093 Herculis Instability Strip Revisited Using Evolutionary Models with Atomic Diffusion

S. Bloemen, H. Hu, C. Aerts, M.A. Dupret, R. Østensen, P. Degroote, E. Müller-Ringat & T. Rauch

We have computed a new grid of evolutionary subdwarf B star (sdB) models from the start of central He burning, taking into account atomic diffusion due to radiative levitation, gravitational settling, concentration diffusion, and thermal diffusion. We have computed the non-adiabatic pulsation properties of the models and present the predicted p-mode and g-mode instability strips. In previous studies of the sdB instability strips, artificial abundance enhancements of Fe and Ni were introduced in the pulsation driving layers. In our models, the abundance enhancements of Fe and Ni occur naturally, eradicating the need to use artificial enhancements. We find that the abundance increases of Fe and Ni were previously underestimated and show that the instability strip predicted by our simulations solves the so-called blue edge problem of the subdwarf B star g-mode instability strip. The hottest known g-mode pulsator, KIC 10139564, now resides well within the instability strip even when only modes with low spherical degrees ($\ell \leqslant 2$) are considered.

Close-in Planets Around SdB stars: A Step Towards Constraining Their Masses?

S. Charpinet (Observatoire Midi-Pyrénées), A. Grandjean (Université de Toulouse), V. Van Grootel (Université de Liège), G. Fontaine (Université de Montréal)

In Charpinet *et al.* (2011), we presented first evidence of the presence of a very compact planetary system orbiting the sdB star KIC 05807616. The configuration of the system and the estimated radii for the planet candidates suggested that these nearly earth-size objects could be the remnants of one or more giant planets engulfed and partially disrupted in the expanding envelope of the former red giant star. In this scenario, only their dense core would have survived the event, leaving the small objects that we see. Testing further this hypothesis would require a mean to constrain the masses of the planet candidates in order to estimate their average densities. In this work, we introduce an interesting new approach that could potentially fulfill this objective.

Photoionization Heating of Nova Ejecta by the Post-Outburst Supersoft Source

T. Cunningham (Kings College London)

The expanding ejecta from a classical nova remains hot enough ($\sim 10^4\mathrm{K}$) to be detected in thermal radio emission for up to years after the cessation of mass loss triggered by a thermonuclear instability on the underlying white dwarf (WD). Nebular spectroscopy of nova remnants confirms the hot temperatures observed in radio observations. During this same period, the unstable thermonuclear burning transitions to a prolonged period of stable burning of the remnant hydrogen-rich envelope, causing the WD to become, temporarily, a super-soft X-ray source. We show that photoionization heating of the expanding ejecta by the hot WD maintains the observed nearly constant temperature of $(1 - 4{\times}10^4\mathrm{K})$ for up to a year before an eventual decline in temperature due to either the cessation of the supersoft phase or the onset of a predominantly adiabatic expansion.

Photoionization Heating of Nova Ejecta by the Post-Outburst Supersoft Source – Continued

T. Cunningham (Kings College London)

We simulate the expanding ejecta using a one-zone model as well as the Cloudy spectral synthesis code, both incorporating the time-dependent WD effective temperatures for a range of masses from $0.60 M_{\odot}$ to $1.10 M_{\odot}$. We show that the duration of the nearly isothermal phase depends most strongly on the velocity and mass of the ejecta and that the ejecta temperature depends on the WDs effective temperature, and hence its mass.

Kinematics of Binary sdB Stars

S. Eichie, A. Irrgang, E. Ziegerer, U. Heber (Dr. Remeis-Sternwarte / Erlangen University)

We present a kinematically analysis of more than 100 binary sdB stars, for which the orbits and system velocities, spectroscopic distances are known. Proper motions are taken from three astrometric catalogs. Galactic orbits in a Galactic potential are calulated and kinematic diagnostic diagrammes are constructed: U-V, Jz-e diagram and classification of the orbit following Pauli et al. In particularly interested cases, proper motions are measured from archival astrometric data. We discuss the Galactic population.

The Period-Effective Temperature Relation for DBV White Dwarfs

G. Fontaine (Montréal), V. Van Grootel (Liège), P. Bergeron (Montréal), P. Dufour (Montréal), E.M. Green (Steward Observatory), D. Kilkenny (Western Cape), and A. Nitta (Gemini Observatory)

We use archived as well as new spectroscopic data to provide a fresh look at the empirical instability strip for pulsating V777 Her (DBV) white dwarfs. In particular, we uncover a period-effective temperature that had escaped detection so far, even though such a relation is expected from theory and has been known in the cooler ZZ Ceti white dwarfs for some 30 years. The sense of the correlation is that the cooler the star, the larger the excited periods. In the details, we find convincing evidence in favor of the fact that instabilities in the current models (with fixed convective efficiency) develop faster than observed in the empirical data. One exciting explanation may be that we are actually seeing, in DBV stars, the actual proof that the convective efficiency decreases with decreasing effective temperature as predicted by the 3D hydro work of Pier-Emmanuel Tremblay.

Heavy Metals in a Light White Dwarf: Abundances of the Metal-Rich, Extremely Low-Mass GALEX J1717+6757

J.J. Hermes (University of Warwick)

Using the Hubble Space Telescope, we detail the first abundance analysis enabled by far-ultraviolet spectroscopy of a low-mass ($\sim 0.19 M_\odot$) white dwarf, GALEX J1717+6757, which is in a 5.9-h binary with a fainter, more-massive companion. We see absorption from nine metals, including roughly solar abundances of Ca, Fe, Ti, and P. We detect a significantly sub-solar abundance of C, and put upper limits on N and O that are also markedly sub-solar. We demonstrate that ongoing accretion of rocky material that is often the cause of atmospheric metals in isolated, more massive WDs is unlikely to explain the observed abundances in GALEX J1717+6757. Using new radiative levitation calculations, we determine that radiative forces can counteract diffusion and support many but not all of the elements present in the atmosphere of this WD; radiative levitation cannot, on its own, explain all of the observed abundance patterns, and additional mechanisms such as rotational mixing may be required.

I present a detailed analysis of the entire Kepler data set for the pulsating sdB star KIC 2697388.

Analysis of the Hot SdO Star BD $+28^\circ 4211$: The Optical Spectrum

M. Latour (Erlangen Universität)

Following the abundance analysis of the UV spectrum of BD $+28^\circ 4211$, we attempted to derive atmospheric parameters of the star on the sole basis of high-quality optical spectra by applying a simultaneous fit of all available H and He lines present in the spectra. This method is the widely used for determining fundamental parameters in hot subdwarfs and white dwarfs, though for very hot stars, it is often unreliable, because of the Balmer line problem and the fact that H and He are only weakly sensitive to a change of parameters.

Analysis of the Hot SdO Star BD $+28^{\circ}4211$: The Optical Spectrum – Continued

M. Latour (Erlangen Universität)

This poster will present our investigation of the effect of increasing model atmospheres metallicity on spectral lines for a wide range of temperatures, as well as our successful fits of BD $+28^{\circ}4211$ optical spectra. However these successful fits required metal-enriched model atmospheres (10x solar). This is unrealistic given the slightly sub-solar metallicity of the star, but probably indicate a significant lack of opacity in our model atmospheres.

Modelling the Reflection Effect with Irradiated Stellar Atmospheres in the SdO+dM Eclipsing Binary AA Dor

P. Németh (Erlangen Universität)

We present our struggle and first results to model the effects of irradiation from the hot sdO primary on the cool companion in AA Dor.

New Asteroseismic Analysis of the Subdwarf-B Pulsator PG 1219 + 534

M.-J. Péters, V. Van Grootel, M.-A. Dupret (Liége), E.M. Green (Steward Observatory), G. Fontaine (Montréal), S. Charpinet (Toulouse), P. Brassard (Montréal)

We present a new asteroseismic modeling of the short-period sdB pulsator PG 1219 + 534, based on the most recent stellar models (third generation) and new observations obtained during a 6-month campaign with the Mont4K/Kuiper combination at Mt Bigelow (Arizona). We derived the atmospheric parameters from high S/N low and medium resolution spectroscopy also gathered in Arizona and we obtained $T_{\rm eff} = 34258 \pm 170$ K and $\log g = 5.838 \pm 0.030$. To extract pulsation periods of PG 1219+534 from time-series photometry, we used Fourier analysis and pre-witening techniques. The 10 independent pulsation periods extracted are *p*-mode oscillations in the 80–175 s range. Then, the optimal model that leads to the best simultaneous match of these 10 periods observed in PG 1219+534 is searched in parameter space by applying the forward approach in asteroseismology.

New Asteroseismic Analysis of the Subdwarf-B Pulsator PG 1219 + 534 – Continued (1)

M.-J. Péters, V. Van Grootel, M.-A. Dupret (Liége), E.M. Green (Steward Observatory), G. Fontaine (Montréal), S. Charpinet (Toulouse), P. Brassard (Montréal)

On this basis, we carried out a seismic analysis using the latest (the third) generation of models and assuming that the observed modes have a degree $l = 0, 1, 2$ or 4. Considering the spectroscopic analysis and mode identification from observed rotational multiplets, the optimal third generation model is isolated matching the observed and theoretical periods with an average dispersion of 0.50%. The inferred structural parameters of PG 1219+534 are $T_{\rm eff} = 34093 \pm 300$ K, $\log g = 5.81 \pm 0.06$, $M_*/M_\odot = 0.442 \pm 0.003$, $\log M_{\rm env}/M_* = -4.25 \pm 0.06$, $\log M_{\rm core}/M_* = -0.36 \pm 0.07$ and $X_{\rm core}(C + O) = 0.92 \pm 0.02$. Moreover, by the presence of a fine structure (frequency multiplets), we tried also to characterize the rotation and determine the rotation rate of the surface and the core of the star.

New Asteroseismic Analysis of the Subdwarf-B Pulsator PG 1219 + 534 – Continued (2)

M.-J. Péters, V. Van Grootel, M.-A. Dupret (Liège), E.M. Green (Steward Observatory), G. Fontaine (Montréal), S. Charpinet (Toulouse), P. Brassard (Montréal)

Finally, we derived properties on the convective core from evolutionary tracks. We inferred that the sdB pulsator PG 1219+534 is located in an advanced stage on the evolutionary track (contraction phase), at the end of He-burning in the core.

The Extremely Rapid Evolution of SAO 244567 Through the Region of Hot Subdwarfs

N. Reindl, T. Rauch, (Tübingen Universität), M. Parthasarathy (Indian Institute of Astrophysics), K. Werner (Tübingen Universität), J.W. Kruk (NASA Goddard) & H. Todt (Universität Potsdam)

Within twenty years only, SAO 244567 turned from a B-type supergiant into the central star of the Stingray nebula. For the first time we performed a comprehensive spectral analysis based on all available spectra from 1988 until 2006 to derive the temporal evolution of its surface parameters. We confirm previous findings, that SAO 244567 must be a low-mass star ($M < 0.55 M_{\odot}$) and, thus, the observed fast evolution and the young planetary nebula with a kinematical age of only about 1000 years is in strong contradiction with canonical post-AGB evolution. We speculate, that the star could be a late He-shell flash object or, alternatively, it could be the outcome of close-binary evolution, being a low-mass ($0.35 M_{\odot}$) He pre-WD after a common-envelope phase, during which the PN was ejected.

Spectral Energy Distributions of Binary SdB Stars

J. Schaffenroth, A. Irrgang & U. Heber (Dr. Remeis-Sternwarte, Univ. Erlangen)

We present an analysis of the SEDs of more than 100 binary sdB stars based on UV, optical and infrared photometry with the aim to determine atmospheric parameters and to search for infrared excesses.

Searching for Hot Subdwarf + Dwarf-M (brown-dwarf) Binaries in APOGEE Data

H.T. Sener-Satir (KASI)

In this project, I aim to find hot subdwarf stars with late M-dwarf (brown-dwarf) companions. An inverse method will be applied for this: I will look at the APOGEE spectra of late type stars in order to find a trace of an sdB companion; not only because few hot subdwarfs are observed in APOGEE but also there has been some ancillary projects specifically for late type stars. More than two dozens of sd + dM systems are already known. Obtaining a high quality spectra for such systems would allow to learn the physical parameters of the companions by disentangling the spectra. Also the light curves of such systems can be obtained as follow-up observations and would help us to figure out the mass of the components. Despite there are many scenarios to form both single and binary hot subdwarf stars, binarity in these stars is not well understood, yet thought to be very common and there are theories being discussed in the favour of the idea that hot subdwarfs are essentially components of binary systems. Additionally, formation theories of these substellar components in such systems are still unknown, which makes the formation and evolution of hot subdwarfs in binary systems even more of a mystery.

Driving Pulsation Modes in Models of the Two Pre-ELM Helium-Core White Dwarfs WASP 0247-25B and WASP 1628+10B

V. Van Grootel (Liège), G. Fontaine, P. Brassard (Montréal), M. Latour (Erlangen), and A. Gianninas (Oklahoma)

Multi-periodic pulsations have recently been detected in two pre-ELM white dwarfs, which constitute a new class of pulsating stars. Standard adiabatic calculations quickly revealed that the observed modes have periods corresponding to low-degree, mid-order p-modes (probably including radial modes). However, the question of the driving mechanism has been left open, and we address that issue in this contribution. We thus present some preliminary results of a detailed study of the nonadiabatic properties of models of these stars. Among other results, we find that modes with periods closely comparable to the observed ones can indeed be excited in these models. A non-negligible abundance of He must be present in the driving/damping region, however.

Evolution of Double Helium White Dwarf Mergers: The Origin of He-rich Hot Subdwarfs

X. Zhang & C. S. Jeffery (Armagh Observatory)

Hot subdwarfs are traditionally classified into three types on the basis of their spectra: subdwarf B (sdB) stars, subdwarf O (sdO) stars, and subdwarf OB (sdOB) stars. These objects are located below the upper main sequence in the Hertzsprung-Russell (HR) diagram. The majority of hot subdwarfs are nearly naked helium stars, with helium-burning cores and low-mass ($< 0.02 M_{\odot}$). hydrogen-rich envelopes (Heber 2009). However, about 10the spectra of these He-rich stars can be divided into carbon-strong-lined (C-type) and nitrogen-strong-lined (N-type) or both (CN-type). Such features pose a challenge to the theory of stellar evolution. One possible channel to the formation of He-rich hot subdwarfs is the merger of two helium white dwarfs. Several close detached He+He WD binary systems have been observed. Owing to orbital decay by gravitational wave radiation, some of these systems are expected to merge within a Hubble time. The immediate merger products of He+He WD mergers are believed to be He-rich subdwarf stars (Saio & Jeffery 2000; Han *et al.* 2002, 2003). Owing to strong mixing during the merger process, the atmospheric abundances of the merger products are expected to match those observed (Zhang & Jeffery 2012). In this poster we present a model population of post-WD merger objects. We compare our model to the observed population of C-type, N- type and CN-type He-rich subdwarfs.