Driving very long period pulsations in He-rich subdwarfs

presented by Tiara Battich

In the recent years a couple of He-rich subdwarfs (LS IV-14°116, KIC1718290 and UVO 0825+15) have been found to pulsate in very long periods between 1 and 12 hrs. These pulsations are expected to correspond to g-mode pulsations and cannot be explained by the standard $\kappa$-mechanism acting on the iron-group ionization opacity bump. In this poster we explore alternative explanations for the driving of pulsation in these stars.

Subaru and SALT observations of chemically-peculiar hot subdwarfs: UVO 0825+15 and friends

presented by Simon Jeffery

The majority of hot subdwarfs lie on or close to the helium main-sequence. Many have hydrogen-rich surfaces, but a substantial fraction of the hotter subdwarfs have hydrogen-depleted or hydrogen-deficient surfaces. Amongst the former, three were known to show extraordinary overabundances of heavy elements including zirconium and lead. Using Subaru/HDS in the north and SALT/HRS in the south, we commenced a high-resolution survey of hydrogen-depleted subdwarfs to discover new members of the class. The first major discovery, UVO 0825+15, was found to exhibit strong lead lines, to be an intrinsic variable in K2 field 5, and to have a relatively high space motion. This poster will discuss the observations of UVO 0825+15, the discovery of a new extreme helium star, results for other chemically-peculiar subdwarfs, and implications for our understanding of these stars.

Line-blanketed LTE spectra for O and B type subdwarfs

presented by Simon Jeffery

We present a grid of model spectra computed in hydrostatic, radiative and local thermodynamic equilibrium, including full line blanketing, and useful for the analysis of stars of spectral types O and B. The grid considers mixtures with helium-to-hydrogen ratios ranging from 0.01 to 100 (by number), and for metallicities $Z = 0, 0.1 Z_{\odot}$ and $Z_{\odot}$. It provides a reference to compare with more sophisticated model calculations (e.g. nLTE) as well as a tool for exploring spectra from large surveys. A major systematic error arising from the use of insufficiently blanketed model atmospheres is highlighted.

Detailed chemical composition analysis, and the hunt for stratification in two hot subdwarfs, PG0909+276 and UVO 0512-08

presented by James Wild

The formation of hot subdwarfs (sdO/B stars) is a standing problem in astronomy, with several proposed evolutionary tracks that provide possible solutions. Part of the problem is the general homogeneity of the chemical compositions of specimens so far observed. A small sub-class of hot subdwarfs that are enriched with heavy metals have been noted; understanding how and why these stars are different to their peers may provide new insight to the formation channel or channels of these stars. We make use of observations in three spectral regions of two stars, PG 0909+276 and UVO 0512-08 to derive the chemical composition of each at various optical depths in their atmospheres. By analysing in this way, we hope to test for stratification of the star into layers of lighter and heavier elements to explain the observed high abundance of Lead. We test the null hypothesis that all elements will, in all spectral regions, show the same abundances. We make use of the software package LTECODES to generate synthetic spectra that are then compared to the observations. The parameters of effective temperature, surface gravity and chemical composition are optimised to minimise chi-squared, and discuss the results in the context of other chemically peculiar hot subdwarfs.
New CCD photometry of seven successive years from 2010 is presented for the HW Vir-type eclipsing binary 2M 1533+3759. Using the $V$ light curves together with the radial-velocity data given by For et al. (2010), we determined the absolute parameters of each component to be $M_1=0.442\pm0.012\, M_{\odot}$, $M_2=0.124\pm0.005\, M_{\odot}$, $R_1=0.172\pm0.002\, R_{\odot}$, $R_2=0.157\pm0.002\, R_{\odot}$, $L_1=19.4\pm1.4\, L_{\odot}$, and $L_2=0.002\pm0.002\, L_{\odot}$. These indicate that 2M 1533+3759 is a detached system consisting of a normal sdB primary and an M7 dwarf companion. Detailed analyses of 377 minimum epochs, including our 111 timings, showed that the orbital period of the system remains constant during the past 12 yrs. Inspecting both types of minima, we found a delay of $3.9\pm1.0\, s$ in the arrival times of the secondary eclipses relative to the primary eclipse times. This delay is in satisfactory agreement with the predicted Römer delay of $2.7\pm1.4\, s$ and the result is the second measurement in sdB+M eclipsing binaries. The time shift of the secondary eclipse can be explained by some combination of the Römer delay and a non-zero eccentricity. Then, the binary star would have a very small eccentricity of $e\cdot\cos\omega=0.0001$.

**Element abundance in the He-enriched sdO-stars HD 127943 and Hz 44**

HD 127943 and Hz 44 are two of the brightest subluminous O-stars with apparent V-magnitudes of about 10 and 12, respectively. Spectroscopic analysis found them to have similar parameters with $T_{\text{eff}}=42\, 500\, K$ and 39 000K, and the same $\log g=5.60$. Both stars have a moderately helium enriched atmosphere $N(\text{He})/N(\text{H})\sim+0.5$ as well as an optical spectrum rich in nitrogen lines. Using high resolution optical and UV spectra, we performed a non-LTE abundance analysis of metallic elements such as C, N, O, Si, S, Fe and Ni.

**Revealing the true nature of the binary nucleus of the planetary nebula Hen 2-428**

Identifying progenitor systems for the double-degenerate scenario is crucial to check the applicability of type Ia supernovae as cosmological standard candles. Santander-Garcia et al. (2015) claimed that Hen 2-428 has a double-degenerate core whose combined mass significantly exceeds the Chandrasekhar limit. Together with the short orbital period (4.2 hours), the authors concluded that the system should merge within a Hubble time triggering a type Ia supernova event. Garcia-Berro et al. (2016) explored alternative scenarios to explain the observational evidence, as the high mass conclusion is highly unlikely within predictions from stellar evolution theory. They conclude that the evidence supporting the supernova progenitor status of the system is premature. Using state-of-the-art non-LTE model atmospheres we aim to derive the temperature, surface gravity and helium abundance of Hen 2-428 in order to obtain spectroscopic masses for this binary system based on the latest stellar evolutionary models for the first time. This will allow us to derive a sound conclusion on the true nature of this system.

**Feige 86 - A forbidden fruit**

A new, combined ultraviolet (IUE/SWP) and optical (VLT/UVES) spectral analysis with Tlusty model atmospheres reveals hitherto unseen details of Feige 86. This star is a worthy prototype of blue horizontal branch stars and a flagship to the development of precision spectroscopy techniques involving atomic diffusion and vertical isotope separation, that are also relevant to sdB stars.

**A FEROS survey of hot subdwarf stars**

We recently completed a small survey of twenty hot subdwarfs using the Fiber-fed Extended Range Optical Spectrograph (FEROS) and the 2.2-m telescope at La Silla. The sample included apparently single objects as well as how subdwarfs paired with a bright, unresolved companion. As expected, the
fraction of radial velocity variables is close to 50\%, and, among these, we identified a long-period (62 d) sdO plus G III binary. The system should evolve into a close subdwarf plus white dwarf pair during the common envelope phase that should follow the second ascent of the giant branch. Newly discovered systems include short period binaries with periods ranging from 3.5 hours to 5 days and comprised of a sdB primary and an unseen companion. We will present a preliminary model atmosphere analysis of all objects in our sample.

**K2 observations of the p-mode pulsator PG0048+091**

presented by Mike Reed

K2's Campaign 8 observed PG0048 continuously for three months with one minute integrations. On this poster we show the results of our analyses of these data and compare them to what was published in 2007. With K2's amazing coverage, we have uncovered several interesting features, most in contrast to the 2007 publication.

**Examination of the full Kepler data set for Mungo: more meandering multiplets.**

presented by Mike Reed

Mungo was observed during the Kepler mission from Q6 until the end in Q17. The first year of data were analyzed and published in 2012, revealing a 10 day binary which was measured using three independent methods. That study found 166 periodicities with asymptotic period spacings and rotationally-induced frequency multiplets. The multiplets indicated subsynchronous rotation near 45 days. In examining the full Kepler data set, we detect over 250 periodicities and uncover some new features.

**Exposing white dwarf core structures: towards observational constraints on nuclear burning and chemical mixing of He-Core-Burning sdB stars**

presented by Noemi Giannichele

White dwarf stars can be seen as stellar fossils that keep buried in their interior many features from their past evolution. By studying their internal chemical compositions, and more precisely the carbon-oxygen profiles, we can place constraints on key processes in stellar physics such as nuclear burning, convection, and mixing, that shape this stratification over time. Better constraining these physical processes, that are still occurring for sdB stars, will unravel interesting perspectives on better understanding core helium-burning phases.

**Trapped Modes in an sdB pulsator: KIC10001893**

presented by Murat Uzundag

KIC10001893 is a V1093 Her type pulsating subdwarf-B star, which was observed extensively by the Kepler spacecraft. An amplitude spectrum of the star demonstrates a rich content of g-modes. We have found 110 significant frequencies. The g-mode region contains 104 frequencies, whilst the p-mode region includes six of them. Using an asymptotic period spacing we have identified modal degrees and radial orders of 32 dipole and 18 quadrupole modes. The echelle diagrams of l=1 and 2 modes show trapped modes in accordance with the theoretical predictions (Charpinet et al. 2000, 2013).

**Further Evidence of a Brown Dwarf Tertiary Component of the Post-Common Envelope Eclipsing Binary V470 Cam (HS 0705+6700)**

presented by Tony Lynas Gray

In many cases, post-common envelope binaries have orbital periods which show small increases or decreases when observed over a decade or more; these may originate as a consequence of light-travel time changes caused by the binary centre of mass being perturbed by a third body although it is not clear how such a body might have survived the subdwarf B star progenitor mass-loss at the top of the Red Giant Branch or formed subsequently. Thirty-nine primary eclipse times for V470 Cam were secured with the Philip Wetton Telescope during the period 2016 November 28th to 2017 January 26th; these provide
further evidence of a brown dwarf tertiary in the system although additional observations would need to confirm this interpretation and investigate other possible origins for the period change. All available eclipse timings suggest a tertiary mass of at least 0.0236(40) solar masses and an orbital period of 11.77(67) years about the binary centre of mass; these would be consistent with a hybrid formation hypothesis for the brown dwarf, in which some ejected material from the subdwarf B star progenitor is accreted on to a precursor tertiary component.

An Expansion of the Mass-Orbital Period Relation for sdBs from Stable RLOF
presented by David Brown

Hot Subdwarf B (sdB) stars are thought to be core-helium burning stars (field equivalents to extreme horizontal branch stars in Hertzsprung-Russell diagrams of globular clusters) with core masses of about 0.5 Ms surrounded by thin inert hydrogen envelopes of less than 0.02 Ms. The precise mechanisms by which they are formed are not entirely determined, and explanations that posit their origin from either single-star progenitor mechanisms or from binary star interactions have been proposed. Using binary population synthesis methods, Han et al. (2002, 2003) were able to model observed field sdB stars well and also potentially EHB stars in globular clusters (Han 2008). The Han et al. (2002, 2003) binary model for the origin of sdB stars suggests three binary channels for the origin of hot subdwarfs: 1) as the result of one or two episodes of common envelope (CE) evolution which yield short-period sdBs in binary systems; 2) as the result of one or two phases of stable Roche love overflow which result in sdB stars in binaries with long periods; and, 3) as the result of the merger of two helium white dwarfs (WD) to produce a single sdB star. Recent observations have started to discover long-period sdB binaries, which given previous difficulties in detecting them, have only just begun to allow the testing of the validity of the stable (first episode) RLOF channel which yields sdB binaries with MS companions in long-period binaries. These observations suggest that the distribution of long-period sdB binaries with MS companion masses peaks at around 500 d-1000 d, which is in contrast to orbital period peak of 100 d as suggested by the ‘best-fitting’ binary model of Han et al. (2003) for Z=0.02. Recent improvements by Chen et al. (2013) to the treatment of stable RLOF in the binary population synthesis methodology of Han et al. (2002, 2003), focusing on atmospheric RLOF in sdB progenitors, have yielded a unique mass-orbital period relation (for a given Z) for sdB stars, a direct consequence of the core mass-radius relation of giant stars at the end of RLOF, which yields a wider range of long-period sdB binaries of up to about 1100 d for sdBs produced via the first stable RLOF channel. This is consistent with the observed sdB orbital period distribution of long-period sdB binaries. In the results presented here, the work of Chen et al. (2013) is expanded to include a greater range of metallicities (Z=0.0001, 0.001, 0.02, 0.03, 0.04, 0.05) that builds on the work already done in an effort to obtain the mass-orbital period relation for each metallicity. This is part of the study, done at various metallicities by Brown, that expands on the original work of Han et al. (2002, 2003) for Z=0.02.

Additional pulsation mode (7.35 mHz) of PG 1613+426 and its amplitude variation
presented by Tomomi Otani

We present the detection of an additional pulsation mode (7.35 mHz) of a subdwarf B star, PG 1613+426. PG 1613+426 is near the hot end of the sDB instability strip, and one pulsation mode (6.94 mHz) was detected so far by Bonanno et al. Also, another pulsation mode candidate (7.05 mHz) was proposed with a confidence level above 90 % by Kuassivi, Bonanno, and Ferlet. To constrain sdB star evolutionary scenarios, this star was monitored in 2010, 2011, and 2015 as part of a project for searching companions to sdB stars using pulsating timing method. The photometric analysis of those data shows an additional 7.35 mHz pulsation mode as well as the previously detected 6.53 mHz mode, however the 7.05 mHz mode was not detected. Also, nightly amplitude changes of 7.35 mHz mode were observed, which may be due to the unresolved rotation splitting. Further analysis of unresolved frequencies is needed for performing the timing method for searching companions.
An Update on the Amplitude and O-C Diagram of CS 1246
presented by Zackary Hutchens

CS 1246 is an sdB star which was discovered in 2009 to have a single large-amplitude oscillation in its light curve. An O-C diagram constructed from this pulsation mode revealed the presence of a low-mass stellar companion in a 14.1-day orbit, which was later confirmed with radial velocity measurements. We have continued to monitor CS 1246 over the past eight years with the Skynet Robotic Telescope Network, over which time the pulsation amplitude has decreased nonlinearly. Here we present our most recent photometry on the star, along with an updated O-C diagram and pulsation amplitude analysis.

NY Vir System Revisited in the Light of New Data
presented by Ozgur Basturk

NY Virginis is an eclipsing binary system with a subdwarf B primary and an M type dwarf secondary. Recent studies suggested two circumbinary planets with Jovian masses (Qian et al. 2011, Lee et al. 2014). Lee et al. 2014 performed an orbital stability test using the best-fit parameters for the circumbinary planets derived from eclipse timing variation analysis. They found that the outer companion should be ejected from the system in about 800 000 years, while the neighbourhood of the best-fit parameters yields stable orbital configurations over 106 years. This suggests that more observations spanning a longer time base are needed to have better constraints on the best-fit parameters, especially the eccentricity of the outer companion. An observation report from Pulley et al. (2016) pointed out that the recent mid-eclipse times of the binary deviate significantly from the suggested models of Lee et al. 2014. With this perspective, we are performing an eclipse timing variation analysis of the NY Vir system, using new mid-eclipse times that we are obtaining together with that recently published ones in the literature to understand the nature of the system and constrain its parameters with the help of new data.

The iPTF high cadence survey in the Galactic Plane
presented by Thomas Kupfer

Ultracompact hot subdwarf binaries are short period binaries with orbital periods so short that the subdwarf will fill its Roche Lobe before the turning into a white dwarf. The study of these systems are important for our understanding of topics such as supernova Ia progenitors or binary evolution. Some of them might be detectable as Galactic gravitational wave sources with eLISA. However, the number of known systems is still limited.

In summer 2016, we have have conducted a high cadence R-band survey (~90 sec) at low Galactic latitudes (|b|<5 deg) covering 200 sqd. to identify detached white dwarf/hot subdwarf binaries with periods well below 2 hours. We extracted 1.9 Mio individual variable sources from the difference images to prevent crowding. The variability data will be compared to colors extracted from PanSTARRS DR1 as well as the IPHAS survey to identify blue objects. In this poster we present first results of the survey. Besides the identification of individual interesting objects, the survey will also act as a testbed for the fast and the furious survey which will cover the entire northern Galactic Plane.