IAU Symposium 357: White Dwarfs as Probes of Fundamental Physics and Tracers of Planetary, Stellar & Galactic Evolution. October 21-25, 2019. Hilo, Hawai'i

Sunday, October 20

17:00	Welcoming Reception and Registration (17:00-19:00)

Monday, October 21

8:00	Conference Registration (also available during Welcoming Reception)	
9:00	Welcome – Scot Kleinman	
9:15	Opening Intro – Martin Barstow	
9:30	Ashley Ruiter (Invited Talk)	***SN Ia Progenitors***
9:45	*Type Ia supernova sub-classes and progenitor origin*	*Chair: Scot Kleinman*
10:00	A. Cikota - *Investigating Progenitors of Type Ia Supernovae using Spectropolarimetry*	
10:15	E. Bauer - *Thermonuclear Supernovae and White Dwarf Pollution*	
10:30	Coffee Break	
10:45		
11:00	Carles Badenes (Invited Talk)	***SN Ia Progenitors***
11:15	*Binary White Dwarfs as Type Ia SN Progenitors*	*Chair: Scot Kleinman*
11:30	Y. Zenati - *The Origin of Standard Thermonuclear Supernovae from Hybrid White Dwarf Mergers*	
11:45	E. Wilson - *Convection in Common Envelopes and the formation of Double White Dwarfs*	
12:00	Lunch	
12:15		
12:30		
12:45		
13:00		
13:15		
13:30	N. Hallakoun - *Characterizing the local double white dwarf population*	*Chair: Sandy Leggett*
13:45	J.J. Hermes - *Paparazzi lightning: 68 million images of white dwarfs from space*	
14:00	J. Barnett - *Double Degenerates in the Open Cluster NGC 6633*	
14:15	C-H. Lee - *ANTARES: a community broker to digest the LSST firehose*	
14:30	T. Prince - *Observations of short period white dwarf systems with the Zwicky Transient Facility*	
14:45	S. Cheng - *The Delayed Evolution of High-mass White Dwarfs: a Cooling Anomaly and Double-White-Dwarf Mergers*	
15:00	Discussion	
15:15	*Moderator - Martin Barstow*	
15:30	Coffee Break	
15:45		
16:00	Eva Villaver (Invited Talk)	***Debris from Extrasolar Planetary Systems***
16:15	*Planetary Pieces: Putting All the Clues Together Using White Dwarfs*	*Chair: Sandy Leggett*
16:30	A. Doyle - *Exoplanetary Oxygen Fugacities from Polluted White Dwarf Stars*	
16:45	M. Kissler-Patig - *An HST imaging search for giant planets around the 7 white dwarfs in the Hyades cluster (H. Zinnecker)*	
17:00	T. Dupuy - *Orbit and Dynamical Mass of a White Dwarf in a Planet-Hosting Binary System*	
17:15	Discussion	
17:30	*Moderator - Lillia Ferrario*	
17:45	Bonus Talk	
18:00	A. Grace - *Maunakea and Hawaii Culture: Then and Now*	

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Tuesday, October 22

9:00	Chris Manser (Invited talk) *Remnant planetary systems around white dwarfs*	***Debris from Extrasolar Planetary Systems*** *Chair: Paula Szkody*
9:15		
9:30	L. Rogers - *Infrared variability around planetesimal-eating white dwarfs*	
9:45	K. Bell - *The Search for Transiting Planets and Planetesimals with the Zwicky Transient Facility*	
10:00	M. Kissler-Patig - *Planets around white dwarfs as seen by the TESS mission*	
10:15	M. Coleman - *White Dwarfs as Accretion disk laboratories*	
10:30	Coffee Break	
10:45		
11:00	D. Wilson - *Discovery of an Irradiated Brown Dwarf Companion to a White Dwarf*	
11:15	J. Krzesinski - *Searching for Low-mass Companions Around White Dwarfs and Subdwarfs from Kepler field.*	
11:30	Discussion *Moderator - Siyi Xu*	
11:45		
12:00	Conference Photo	
12:15		
12:30	Lunch	
12:45		
13:00		
13:15		
13:30	Susana Landau (Invited Talk) *Variation of fundamental constants*	***Fundamental Physics*** *Chair: JJ Hermes*
13:45		
14:00	D. Winget - *Understanding spectra from white dwarf photospheres: benchmarking the atomic physics*	
14:15	X. Chen - *Extremely low-mass white dwarfs in double degenerates: Formation and Significance for LISA*	
14.30	B. Dunlap - *Learning about Line Shapes and Masses from Gaia Parallaxes*	
14:45	L. McNeill - *Probing white dwarf structure with LISA: using gravitational waves for asteroseismology*	
15:00	L. Tchang-Brillet - *Laboratory studies of VUV emission spectra of heavy element ions*	
15:15	P. Tremblay - *Neutral Helium Line Profiles through the Simulation of Local Interactions in White Dwarfs*	
15:30	Coffee Break	
15:45		
16:00	Adela Kawka (Invited Talk) *The origin and properties of magnetic white dwarfs*	***Fundamental Physics*** *Chair: JJ Hermes*
16:15		
16:30	F. Hardy - *A New Look at Magnetic White Dwarfs*	
16:45	S. Kalita - *Continuous gravitational wave from magnetized compact objects*	
17:00	K. Burdge - *The shortest period eclipsing binary*	
17:15	P. Bera - *Quasi-periodic oscillations from post-shock accretion column of strongly magnetized accreting white dwarfs*	
17:30	Discussion *Moderator - S. O. Kepler*	
17:45		

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Wednesday, October 23

9:00	Alejandro Córsico (Invited Talk) — ***Precision Studies of White Dwarf Structure***
9:15	*White dwarf asteroseismology* — *Chair: Agnes Kim*
9:30	H. Shipman - *40 Years of Pulsating White Dwarfs*
9:45	F. de Geronimo - *Evolution and asteroseismology of ultra-massive white dwarfs.*
10:00	A. Kim - *Validation of Asteroseismic fitting with the new White Dwarf Evolution Code*
10:15	J. den Hartogh - *Using asteroeseismically obtained core rotation rates of low and intermediate mass stars to investigate slow neutron capture nucleosynthesis*
10:30	Coffee Break
10:45	
11:00	P. Skody - *Accreting, Pulsating WDs: Probing Heating and Rotation*
11:15	Z. Vanderbosch - *A Ground-Based Detection of an Outbursting DBV White Dwarf*
11:30	S. Charpinet - *The chemical structure of the hot pulsating DB white dwarf KIC 08626021 from asteroseismology*
11:45	B. Castanheira - *Asteroseismology of white dwarfs observed by Kepler and K2*
12:00	Excursion
19:00	Public Talk at 'Imiloa Astronomy Center M. Barstow - *What has space done for us?*

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Thursday, October 24

9:00	M. Tucker - *Gone But Not Forgotten: A Decade of Archival GALEX Data Reveals a Multitude of Variable White Dwarfs*
9:15	O. Vincent - *Searching for ZZ Ceti white dwarfs in the Gaia survey* — *Chair: Elizabeth Jeffery*
9:30	J. Provencal - *White Dwarfs and Convection*
9:45	Discussion
10:00	*Moderator - Barbara Castanheira-Endl*
10:15	
10:30	Coffee Break
10:45	
11:00	Paola Marigo (Invited Talk) — ***Stellar Physics and Galactic Evolution***
11:15	*What can we learn from the initial-final mass relation of white dwarfs?* — *Chair: Elizabeth Jeffery*
11:30	M. Hajduk - *Real time evolution of post-AGB stars*
11:45	L. Löbling - *(Pre)-white dwarf stars as measuring tools for yields of asymptotic giant branch nucleosynthesis*
12:00	Lunch
12:15	
12:30	
12:45	
13:00	
13:15	
13:30	Jordi Isern (Invited Talk) — ***Stellar Physics and Galactic Evolution***
13:45	*White dwarfs as Advanced Physics laboratories: the axion case* — *Chair: Patrick Dufour*
14:00	T. Oswalt - *The Completeness of Gaia-Selected Samples of White Dwarfs—Are We There Yet?*
14:15	K. Williams – *Ensemble Evolutionary Studies of White Dwarfs*
14:30	N. Lagarde - *New population synthesis approach: the golden path to constrain*
14:45	T. von Hippel - *White Dwarfs, Gaia, and the Age of the Galactic Disk*
15:00	Coffee Break
15:15	
15:30	E. Jeffery - *A Bayesian Analysis of White Dwarfs in Open Clusters Observed with Gaia*
15:45	N. Fantin - *Measuring the Star Formation of the Milky Way Using its Stellar Graveyard*
16:00	S.O. Kepler - *Mass distribution of white dwarfs*
16:15	T. Heintz - *Comparing the Total Ages of Wide Double White Dwarfs in Gaia DR2*
16:30	Discussion
16:45	*Moderator - Judi Provencal*
17:00	Break before dinner
17:15	
17:30	Leave for dinner

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Friday, October 25

9:00	V. Suleimanov - *Statistics of white dwarf properties in intermediate polars*	*Chair: Atsuko Nitta*
9:15	P. Muralimohan - *Geometry of nova ejecta*	
9:30	N. Finch - *What can ISM and non-photospheric highly ionised lines in WD spectra reveal about the beta CMa tunnel?*	
9:45	A. Bedard - *The spectral evolution of hot white dwarfs*	
10:00	T. Rauch - *Heavy-metal white dwarfs*	
10:15	N. Gentile Fusillo - *Cool white dwarfs as standards for infrared observations*	
10:30	Coffee Break	
10:45		
11:00	S. Blouin - *The Spectral Evolution of Cool White Dwarfs*	
11:15	P. Dufour - *Origin and evolution of carbon atmosphere white dwarf stars*	
11:30	H. Richer - *The White Dwarf That Has Everything*	
11:45	K. Masuda - *Discovery of four white dwarfs in self-lensing binaries*	
12:00	Lunch	
12:15		
12:30		
12:45		
13:00		
13:15		
13:30	B. Kayastha - *Dynamical Evolution of Globular Clusters with White Dwarfs, Neutron Stars and Black Holes using the GPU supercomputer*	*Chair: Gerald Handler*
13:45	M. Hollands - *A white dwarf of spectral type DAQ*	
14:00	E. Cukanovaite - *Calibration of the mixing length parameter for DB and DBA white dwarf based on 3D atmospheric models*	
14:15	T. Cunningham - *From hydrogen to helium: the convectively driven spectral evolution of white dwarfs*	
14:30	Closing Review	
14:45		
15:00	Discussion *Moderator - Lillia Ferrario*	
15:15		
15:30		
15:45	Coffee Break	
16:00		

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Invited Speakers

Ashley Ruiter
Carlos Badenes
Eva Villaver
Chris Manser
Susana Landau
Adela Kawka
Alejandro Corsico
Paola Marigo
Jordi Isern

F/M/non-specified – 5/4/0

Session Chairs and Discussion Moderators

Scot Kleinman
Sandy Leggett
Martin Barstow
Lilia Ferrario
Paula Skody
Siyi Xu
JJ Hermes
S.O. Kepler
Agnes Kim
Elizabeth Jeffery
Barbara Castanheira-Endl
Patrick Dufour
Judi Provencal
Atsuka Nitta
Gerald Handler

F/M/non-specified – 9/6/0

Scientific highlights

White dwarf stars are interesting in their own right, as the end stage of the evolution of most stars ($M > \sim 8M_{solar}$). However, they are also very important players in other branches of astrophysics. White dwarfs are clearly implicated in the mechanism(s) of Type Ia Supernovae, although proven progenitors have yet to be identified. Measurement of the ages of the oldest white dwarfs provides a limit on the age of the galaxy and its components, while the white dwarf luminosity function can be used to trace episodes of historical star formation. Study of their cooling rates and pulsations can shed light on the behaviour of matter under the extreme physical conditions found in their envelopes and cores. Several decades of studies of their photospheric composition have concluded that many are accreting material from the debris of past planetary systems. Therefore, currently, they provide the **only** way of exploring the range of bulk compositions of extra-solar planetary material. The presence of large numbers of absorption lines of highly ionised elements such as iron and nickel provides an opportunity to search for tiny differences between laboratory and observed line wavelengths that might indicate variation in the fine structure constant. Similar anomalies in the wavelengths of molecular H_2 lines could, if present, point to a gravitational dependence of the fundamental proton-electron mass ratio. White dwarfs can also act as background sources for observation of absorption lines which can be used to probe the structure and state of interstellar and circumstellar gas across a wide range of temperatures and densities.

It is clear that the “exotic” and interesting white dwarfs that might provide the strongest evidence for, or constraints on, a particular physical phenomenon are often small in number, even in the current samples (~10,000 stars) that have been expanded by recent surveys such as SDSS, Pan-STARSS and LAMOST. For example, the potential channels for SN Ia may be more diverse and complicated than we thought. Although there is a regular stream of candidates, it is still the case that no clear progenitor system has so far been identified. We do need to find the progenitor systems. Similarly, in studying accretion of exotic-planetary material, we need to observe active systems with transiting debris to test the models and mechanisms proposed. However, we currently have only a single example where transiting orbiting debris is detected.

Over a period of more than 20 years, spectroscopic observations of several hundred white dwarfs have been carried out with a variety of ground- and space-based telescopes to understand their composition. However, these observations are trying to address many variables across the white dwarf temperature and mass range, besides the many elements detected. Therefore, the observational statistics often limit any strong conclusions from being drawn. The Gaia DR2 catalogue contains an estimated 200,000 white dwarfs, more than a factor 10 increase on current numbers. It is gratifying to see, as a member of the Gaia Data Processing and Analysis Consortium (DPAC), that Gaia data appears in almost every paper in these proceedings, from large scale surveys to studies of small groups and individual objects. However, to make use of this increase, a significant dedicated follow-up effort from both ground- and space-based telescopes is required. While this might be feasible on the ground with multi-object spectroscopy, the limited time available on space telescopes is an insurmountable problem.

Photometry with space telescopes such as Kepler and Tess has dramatically increased the number of pulsating white dwarfs known. However, several presenters demonstrated that understanding the complexities of an individual objects is very time-consuming. Therefore, there is a need to focus on the pulsators that are already known and well-studied to provide follow-up data and detailed analysis for these.

Executive Summary

IAU Symposium 357 - White Dwarfs as probes of fundamental physics and tracers of planetary, stellar and galactic evolution – was held in October 21st to 25th 2019, at the Grand Naniloa hotel in Hilo on the Big Island of Hawai'i, USA. At the time of writing this foreword, approximately 5 months later, the World is in the middle of the COVID-19 crisis. Many communities are confined to their homes, with many of us, working remotely. It is sobering to realise how our usual privilege and freedom to travel the World to meet fellow scientists can be brought to a halt in such a short space of time. It also brings into focus discussions we had in Hawai'i about how to organise remote meetings to reduce costs and the travel-related carbon footprint of our community.

Hawai'i is among the most remote and beautiful places on the planet. This made it a wonderful location for a scientific meeting. Participants felt apart from the rest of the world and the effort of travel encouraged participants to stay for the whole meeting. I am very grateful to the Local Organising Committee for an exceedingly well-organised, fruitful and enjoyable meeting. Thanks also go to my co-chairs and other members of the Scientific Organising Committee for helping with the original symposium application and devising a vigorous scientific programme. All the organisers and participants are grateful to the IAU for selecting the symposium and supporting the attendance of early career scientists. We would also like to thank the Association of Universities for Research in Astronomy (AURA), the Royal Astronomical Society (RAS) and the University of Leicester for financial support for the meeting organisation and travel.

White dwarfs are the most numerous members of the stellar graveyard. Over 90 percent of all stars currently on the main sequence will end their lives as white dwarfs. As such, they are important laboratories for fundamental studies of the evolution of stars, the formation and history of the Milky Way Galaxy and of planetary systems. Furthermore, white dwarfs give us crucial insights on the behavior of matter at extreme temperatures and densities. Surveys such as SDSS, SPY and ELM have given us access to an unprecedented wealth of information on the white dwarf population. Recent studies incorporating these databases have initiated a revolution in our understanding of its global properties that will continue to grow with the *Gaia* data releases and upcoming LSST results.

Once a white dwarf is formed, its evolution is only dominated by cooling. As white dwarfs cool over billions of years, determinations of the age of the oldest and therefore coolest white dwarfs place limits on the ages of the components of the Galaxy, such as the thin disk, and the thick disks, the halo, and the system of open and globular clusters. The characteristics, such as temperature and mass, of the white dwarf population contain invaluable information on the star formation history of the Galaxy.

White dwarfs are also extremely important indicators for cosmology. Type Ia supernovae are the standard candles that allow us to study the acceleration history of cosmic expansion. However, although it is crucial to identify the progenitor systems, the evolutionary paths leading to these explosions are still poorly understood. Recent surveys have begun to reveal the properties of single and double degenerate progenitors, but the picture is still very unclear and more work is needed.

In the past few years, white dwarfs have also begun to influence our understanding of the evolution of planetary systems. We have strong evidence that some white dwarfs harbour planets. We now know that white dwarfs can disrupt terrestrial planets, asteroids and other minor bodies and the resulting debris is accreted onto the white dwarf. White dwarfs have a unique atmospheric characteristic. The high surface gravity ($\log g \sim 8$) naturally leads to chemically pure hydrogen or helium photospheres. This means that the spectral features produced by the accreted material are not contaminated by original abundances. The observed features provide a unique opportunity to study the bulk composition of extrasolar planetary material. A subset of accreting white dwarfs contains spectral features of highly ionized heavy elements. Furthermore, accurate measurements of observed wavelengths can be compared with laboratory measurements to probe the possible variation of the fine structure constant in a strong gravitational field.

White dwarf research is fascinating in its own right, since it requires developments in atomic data and the study of properties of matter under extreme conditions. However, the impact that these studies have on other areas of astrophysics are also enormous. Thus, the time was ripe to bring together experts from different branches of science so that they can share their knowledge and provide feedback to each other.

The Symposium was highly interdisciplinary, bringing together not just astronomers working on white dwarfs, but also astronomers with expertise in a wide range of relevant disciplines. Such a gathering presented an opportunity to formulate the direction of white dwarf studies for the next decade.

The programme consisted of sessions organized around a number of key themes: SN Ia progenitors, debris from extrasolar planetary systems, fundamental physics, precision studies of white dwarf structure, stellar physics and galactic evolution. Each session included one or two invited keynote talks plus a number of contributed papers. Time was set aside for extensive discussion following the sessions associated with each them. These were moderated by members of the SOC, posing a number of questions of the audience to stimulate the discussion. The nature of such discussions makes them hard to record in detail, but a number of key points have been extracted and incorporated into a short concluding paper in these proceedings.

Scientific Organising Committee

Martin Barstow, Barbara Castanheira-Endl, Lilia Ferrario, S.O. Kepler, Pierre Bergeron, Zhanwen Han, Daniel Maoz, Jayant Murthy, Judi Provencal, Lydia Tchang-Brillet, Siyi Xu, G. C. Anupama, Shazreen Mohamed.

Local Organising Committee

Siyi Xu, Atsuko Nitta, Scot Kleinman, Sandy Leggett, Sarah Casewell, Chris Stark, Terry Lee, Erik Dennihy, Trent Dupuy, Peter Michaud, Ben Shappee, Andre-Nicolas Chene