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White Dwarfs as Probes of Fundamental Physics: Tracers of Planetary, Stellar and Galactic Evolution

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WHITE DWARFS AS PROBES OF FUNDAMENTAL PHYSICS: TRACERS OF PLANETARY, STELLAR AND GALACTIC EVOLUTION

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COVER ILLUSTRATION:

Rainbow over Hilo bay, Big Island, Hawai'i, viewed from the Grand Naniloa hotel (credit: Rachel Barstow).

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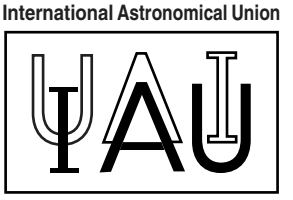

WHITE DWARFS AS PROBES OF FUNDAMENTAL PHYSICS: TRACERS OF PLANETARY, STELLAR AND GALACTIC EVOLUTION

PROCEEDINGS OF THE 357th SYMPOSIUM OF THE INTERNATIONAL ASTRONOMICAL UNION HELD IN HILO, HAWAII, USA 21–25 OCTOBER, 2019

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Foreword

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 makes it a wonderful location for a scientific meeting. Participants feel apart from the rest of the world and the effort of travel encourages long-duration visits. 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. The image chosen for the cover was fortuitously recorded by my wife Rachel at the opening of the meeting, when the whole audience was completely distracted from my opening remarks by that stunning rainbow – impossible to compete with... but also a fitting and encouraging start to the symposium.

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

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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 is also enormous. Thus, the time was ripe to bring together experts from different branches of science so that they could 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.

Martin Barstow – 31st March 2020

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