

Scientific Report

Summary

The ESF funded workshop “Gaia and the end states of stellar evolution” was held at the University of Leicester on 11-13 April 2011. The workshop was attended by 27 people, and consisted of 18 presented talks and discussion sessions. The participants were mainly from European institutes, although 2 attendees were based in Chile and the USA. The main aim of the workshop was to develop plans for a white paper to be submitted to the Gaia GREAT working group on “the end states of stellar evolution” to be used to direct research and the acquisition of pre and post Gaia follow up data. This white paper is now in the process of preparation, and will be submitted to the ESF within 6 months of the start of the meeting. It will also be published on the Gaia GREAT wiki for the “end states of stellar evolution” working group and the arxiv pre-print server astro-ph.

The 3-day programme was designed to be informal, with everyone who wished to contribute presenting a talk. Sessions described the Gaia satellite and mission, discovery potential for new white dwarfs and additional information that would be available for known white dwarfs. Each presentation was 15 minutes long, with the exception of those on the mission itself which were 30 mins. The workshop schedule was designed to allow 15 minutes for questions and discussion after each talk. The last session of the workshop, after lunch on the 13 April, was devoted to an hour long discussion of the content and schedule for writing the white paper together with the need for future workshops on Gaia and white dwarfs.

The support provided by the ESF allowed lunch, evening meals in Leicester city centre and refreshments to be provided to the delegates free of charge for all 3 days of the meeting. Additionally, travel and accommodation support was provided to 5 delegates, two of whom were invited speakers, allowing them to attend the workshop.

Scientific content and description of discussion

The scientific content of the meeting was divided into 3 main sections; Gaia the mission, new discoveries with Gaia, and how Gaia will expand our knowledge of white dwarfs. The programme may be found below with hyperlinks to the talks. This information may also be found on the workshop website at http://www.star.le.ac.uk/great_workshop/prog.html and the workshop photograph at http://www.star.le.ac.uk/great_workshop/index.html

Monday 11 April

10:00: Registration and Coffee

11:30: Welcome - Martin Barstow

Chair: Matt Burleigh

11:35: [Gaia progress report and introduction](#) (Stefan Jordan)

12:25: Lunch and Discussion

14:30: [Using GAIA parallaxes to directly calibrate absolute GAIA and non-GAIA photometric systems](#) (Jay Holberg)

15:15: [Follow up with multi-fibre spectrograph](#) (Boris Gaensicke)

15:45: Coffee and Discussion

Tuesday 12 April

Chair: Boris Gaensicke

09:50: [White dwarf population tools for the GAIA and LSST era](#) (Jay Holberg)

10:20: [The nearby white dwarf population and what we can learn from a complete sample, which Gaia will give us!](#) (John Subasavage)

10.50: [The population of white dwarfs in our galaxy and their evolution](#) (Shenghua Yu)
11.20: Coffee
11.40: [White dwarfs as laboratories of Physics](#) (Jordi Isern)
12.10: [White Dwarf luminosity functions: current status, and prospects](#) (Nigel Hambly)
12.30: [Gaia observations of cluster WDs and expanding our knowledge of the IFMR](#) (Sarah Casewell)
13.00: Lunch
14.00: [GAIA and the Mass-Radius Relation](#) (Martin Barstow)
14.30: [Discovering new Sirius-type binaries](#) (Matt Burleigh)
15.00: [Evolution of hot white dwarfs](#) (Nathan Dickinson)
15.30: Coffee
16.00: [Gaia photometric system and performances](#) (Carme Jordi)
16.45: Discussion
19.00: Workshop meal at Kayal, Leicester

Wednesday 13 April

Chair: Stefan Jordan

10.00: [Search for the coolest white dwarfs in the Galaxy](#) (Silvia Catalan)
10.30: [GAIA's role in probing the outcomes of double white dwarf mergers](#) (Simon Jeffery)
11.00: [The local population of magnetic white dwarfs](#) (Katherine Lawrie)
11.30: Coffee
11.50: [Searching for planetary companions to White dwarfs with GAIA](#) (Roberto Silvotti)
12.20: [Ultracool Companions to White Dwarfs](#) (Paul Steele)
12.50: [Discovery and Characterisation of Eclipsing Post Common Envelope Binaries from Gaia](#) (Steven Parsons)
13.20: [Discussion: Planning the white paper](#)
13.30: Lunch/Discussion
14.30: Final discussion and decisions on white paper and Close (Martin Barstow)

The presentations on the mission began with the satellite itself, schematics and data products:

Gaia will map the Milky Way galaxy and measure distances, proper motions and obtain spectra (320-1000 nm) for some 1 billion stars down to $V \sim 20$. It will also obtain high-resolution spectra of Ca lines (847-874 nm) for the brighter objects to measure radial velocities. Among this billion objects will be many white dwarfs (both known, and newly discovered).

The discussion of the schematics of Gaia was followed by a talk on using Gaia parallaxes to calibrate non-Gaia photometric systems such as known wide white dwarf binary systems. These data will be used to acquire accurate physical parameters for the white dwarfs in the system, thus feeding into one of the most important empirical relations for white dwarfs – the relationship between mass and radius. This was then complemented by a talk on follow up data for objects observed by Gaia, namely the design of a prospective new spectrograph for the William Herschel Telescope on La Palma and how this may be optimised for white dwarfs. The proposed ESO large programme “the Gaia-ESO survey” was also discussed as it will target over 100 000 stars in various environments around the Galaxy. There were a number of co-authors of the proposal present at the workshop and there was debate as to the best way to select white dwarfs from the targets. The talks on Gaia were completed by an in depth invited presentation by Gaia team member Carme Jordi on the Gaia photometric system and its performance.

The session on expanding our knowledge of white dwarfs began on Tuesday 12 April 2011 with talks on the white dwarf population in general:

These talks covered topics as diverse as simulated populations of white dwarfs, white dwarfs in binary systems, white dwarf cooling models and complementarity between Gaia and the Large Synoptic Survey Telescope photometry and the prospects of a new spectrograph, Big BOSS for the KPNO 4m telescope. The spectrograph is designed for a dark energy survey by cosmologists, but will also use the wavelengths that are required for white dwarf observations. The discussion following this talk debated the possibilities of collaborating with other spectroscopic surveys to obtain spectra of the white dwarfs in their target fields.

The white dwarf luminosity function was also discussed in a talk describing the use of large area surveys and reduced proper motions to define luminosity functions for white dwarfs in the thin and thick disks and the bulge of the Galaxy. PanSTARRS was also discussed as a survey which, along with Gaia will provide much more data in this area.

The afternoon session began with contributions on empirical relations; the initial mass-final mass relation, and the mass-radius relation and how combining Gaia parallaxes with known and newly discovered white dwarfs will improve our knowledge and of these relations. There was also a talk on Sirius-type binaries and how high quality observations of them can be used improve our knowledge of these empirical relations. The session was finished by a presentation on hot white dwarfs and how the pollution of their atmospheres by heavy elements can be used to map the local interstellar medium.

The final day saw contributions about new discoveries with Gaia, beginning with searching for the coolest white dwarfs (population II white dwarfs) using the WFCAM transit survey and reduced proper motions. This survey will be greatly expanded by Gaia and the resultant new white dwarfs will be included in luminosity functions and initial mass functions for our Galaxy, filling gaps in the current parameter space. This was followed by a presentation on white dwarf-white dwarf mergers and the type of both pre-and post merger objects that Gaia will provide distances for. Magnetic white dwarfs were also discussed in a talk describing how Gaia space motions and parallax may allow us to determine their little understood origin.

These contributions were followed by 2 presentations on planets. The first of these discussed the likelihood of discovering planetary companions to white dwarfs and explained that Gaia should be able to detect planets with orbital periods between 1.5 months and 2.5 years which correspond to orbits of 0.2 to 1.6AU (the Earth is at 1 AU). There was also discussion on the synergy between the PLATO mission and Gaia regarding the identification and characterisation of white dwarfs and the discovery of previously unknown pulsating white dwarfs with PLATO. The second contribution described new discoveries of brown dwarf companions to white dwarfs using large area surveys and discussed how Gaia's parallax will increase the sample of white dwarfs to use in the search for low mass companions, but also described their scarcity, with only 1% of white dwarfs having a low mass companion. The session was rounded off by a presentation on post common envelope binaries, many of which are eclipsing. Gaia is predicted to discover many of these objects and determine their space motion and distances providing more targets with which to test the mass-radius relation for white dwarfs.

The final day also saw a discussion on the white paper and how it was to be structured, what scientific topics would be covered and who would contribute to each section. An editorial board was also created to oversee the production of the document.

The general programme was arranged to allow discussion after every talk, which then fed into the final discussion on the white paper. The white paper will be divided into 3 main chapters and the chapters further broken down into sections, and in some areas subsections. The sections were

determined in the final discussion session, and where no-one with suitable expertise attending the meeting, experts in the field were invited to contribute. The areas of science to be discussed will be; the mass-radius relation, the initial-final mass relation, luminosity function, the evolution and origin of magnetic fields, pulsating white dwarfs, binaries, planetary systems, other late stages of stellar evolution and synergy with other projects. Each section will consist of a brief introduction to the field and its importance to white dwarfs, as well as detailing our knowledge to date, before explaining just what the Gaia mission will provide and any additional data that is required to fully exploit the mission products.

Each section will be written by a collaboration of interested parties. The final document and introductions to the chapters will be completed by the editorial board consisting of 6 people; which include 3 of the meeting organisers and one of the co-facilitators of the Gaia GREAT working group on the end states of stellar evolution.

Results

The final session of the workshop was an in depth planning session for the planned white paper.

The white paper will comprise 3 main chapters, detailing the scientific work that will be carried out using Gaia data. An important part of the document is to define what supplementary data will be required (both pre and post Gaia data releases) and what theoretical and modeling support is required.

The science chapter will comprise nine sections which contain an introduction to the science as well as information on what data exists, what additional data is required, what Gaia will do for the science, what data Gaia will not provide and any modeling requirements. Each section is to be written as collaboration by interested parties, overseen by an editorial board. Detailed below is the author list for the science section:

Editorial board – Martin Barstow, Matt Burleigh, Sarah Casewell, Boris Gaensicke, Jordi Isern, Stefan Jordan

Mass-Radius Relation – Martin Barstow, Jay Holberg, Steven Parsons

Initial-final mass relation – Sarah Casewell, Silvia Catalan, Paul Dobbie

Luminosity function – Nigel Hambly, Jordi Isern, Enrique Garcia-Berro, John Subasavage, Silvia Catalan, Ralf Napiwotzki

Evolution and origin of magnetic fields – Katherine Lawrie, Stefan Jordan, Matt Burleigh, Boris Gaensicke

Pulsating white dwarfs – Roberto Silvotti, Stefan Jordan

Binaries – Boris Gaensicke, Matt Burleigh, Jay Holberg, John Subasavage, Ralf Napiwotzki

Planetary systems – Matt Burleigh, Paul Steele, Roberto Silvotti, Boris Gaensicke, John Subasavage, Jay Farihi

Other late stages of stellar evolution – Tony Lynas-Gray, Uli Heber, Simon Jeffrey, Ralf Napiwotzki, Tom Maccarone, Pete Wheatley, Tom Marsh

Synergy with other projects – Roberto Silvotti

The chapter on supplementary data, in particular the section describing what data that will be required pre launch will direct the “end states of stellar evolution” working group in applying for telescope time over the next few years. We will also become involved in the design of new telescopes and instruments that could be optimised for white dwarf observations with the expansion of wavelength ranges, or additional filters/grisms. We will also explore the possibility of involvement with large area spectroscopic surveys, such as those required for cosmology, where a few optical fibres per field (in large multi-fibre surveys) might be spared to observe the white dwarfs located near the target.

The white paper, not only collates the ideas of people in the white dwarf field and what scientific results they hope to obtain from Gaia data, but will also allow us to have a coherent picture of what we require from other instruments and surveys, and in some cases may allow us to influence new instrument designs and become partners in large spectroscopic surveys designed for different science e.g. cosmology galaxy surveys.

This white paper will be presented at the Gaia GREAT plenary meeting to be held in Brussels on 21-23 June 2011 as evidence of the direction the “end states of stellar evolution” working group is moving. In 2012 the biennial European white dwarf workshop will be held in Poland, where there will be an additional opportunity to present our roadmap for study of white dwarfs using Gaia and present it to the worldwide community. This will also assist the authors revise and improve our strategy for future work in the field, and plan further workshops based on Gaia and its resulting science.

Participant list

Martin Barstow (University of Leicester)
Matt Burleigh (University of Leicester)
Sarah Casewell (University of Leicester)
Silvia Catalan (University of Hertfordshire)
Chris Copperwheat (University of Warwick)
Nathan Dickinson (University of Leicester)
Duncan Fyfe (University of Leicester)
Boris Gaensicke (University of Warwick)
Sandra Greiss (University of Warwick)
Nigel Hambly (University of Edinburgh)
Jay Holberg (University of Arizona)
Jordi Isern (Institut de Ciencies de l'Espai)
Richard Jameson (University of Leicester)
Simon Jeffery (Armagh Observatory / Trinity College Dublin)
Stefan Jordan (Astronomisches Rechen-Institut am Zentrum fuer Astronomie Heidelberg)
Carne Jordi (Universitat de Barcelona)
Katherine Lawrie (University of Leicester)
Tony Lynas-Gray (University of Oxford)
Tom Marsh (University of Warwick)
Ralf Napiwotzki (University of Hertfordshire)
Steven Parsons (University of Warwick)
Roberto Silvotti (Osservatorio Astronomico di Torino)
Paul Steele (MPI für extraterrestrische Physik)
John Subasavage (Cerro Tololo Inter-American Obs)
Jonathan Tedds (University of Leicester)
Pete Wheatley (University of Warwick)
Shenghua Yu (Armagh Observatory)

List of Speakers

Martin Barstow (University of Leicester)
Matt Burleigh (University of Leicester)
Sarah Casewell (University of Leicester)
Silvia Catalan (University of Hertfordshire)
Nathan Dickinson (University of Leicester)
Boris Gaensicke (University of Warwick)
Nigel Hambly (University of Edinburgh)
Jay Holberg (University of Arizona)
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