Mapping the magnetic field structure of white dwarfs

Research Field
Stellar Astrophysics

Project Suitability
PhD
Honours

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White dwarfs represent the final stage of stellar evolution for the majority of stars and they provide one the most sensitive probes into the history of stellar formation in the Milky Way due to their predictable cooling rates. A significant fraction of these stellar remnants harbours a magnetic field ranging from a few 100 G up to several 100 MG and it can affect the evolution and atmosphere structure of the white dwarf, as well processes such as accretion flows. The origin of magnetic fields in white dwarf stars remains unknown. Currently two leading theories have been proposed to explain the presence of magnetic fields in white dwarfs. The first is the fossil field origin, which means that the white dwarf has inherited the magnetic field from its progenitor, which is usually assumed to be a magnetic peculiar A and B star (Ap and Bp star). However, this scenario fails to explain the paucity of magnetic white dwarfs in close but non-interacting orbit with low-mass main-sequence stars. This leaves magnetic cataclysmic variables without direct progenitors, and as a result, a second origin was proposed. In this second scenario, a magnetic field is created within binary systems, either during a common envelope phase or in the merger of two white dwarfs. The two theories predict different magnetic field structures and rotational velocities. A study of the strength of the magnetic field, its surface structure and whether it is correlated with the white dwarf mass and/or cooling age will provide clues to the origin of the magnetic field. To understand the origin of magnetic fields and the role it plays in white dwarf atmospheres and evolution, we must first know the field strength and structure.

The European Southern Observatory (ESO) operates several 4m to 8m optical telescopes in the Chilean Atacama Desert which provides the best observing conditions on Earth. These telescopes are equipped with state-of-the-art instruments covering a vast range of the electromagnetic spectrum from the near ultraviolet and optical to the infrared. Therefore, ESO provides the ideal tools that are needed to carry out detailed studies of white dwarf stars.

The aim of this project will be to study the magnetic field structure of white dwarfs known to show variability in photometry, spectroscopy or spectropolarimetry. You will calculate magnetic model spectra and develop fitting programmes to find a unique solution to the field structure through mapping the magnetic field on the surface of the white dwarf. The model spectra will be compared to photometric, spectroscopic and spectropolarimetric data. Since Australia has access to 8m class telescopes of the ESO and its vast range of instruments, this project will primarily use data obtained with ESO.

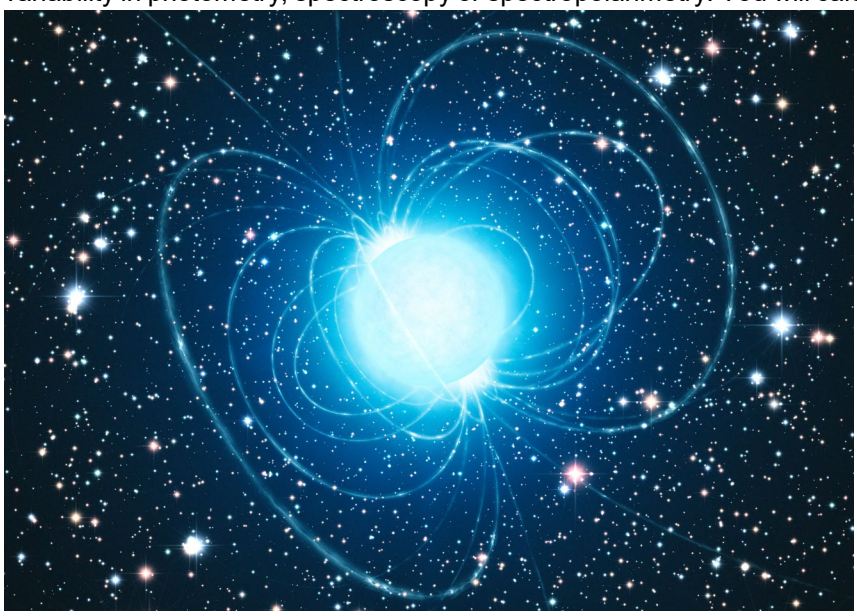

Figure 1: Artist's impression of stellar magnetic field lines (Credit: ESO/L. Calcada)