Hydrogen-Deficient Stars in the Galaxy

Stars like our Sun convert hydrogen to helium, grow to become red giants, exchange mass with companions and ultimately run out of fuel and collapse to become a white dwarf, neutron star or black hole. The stellar evolution story is not simple; there are many pathways a star can take and only a few produce "helium stars". For example, a massive star can blow its hydrogen away, or a red giant can be stripped of its outer hydrogen by a companion. A contracting white dwarf can re-ignite and expel its outer layers, or a double white dwarf binary can merge to create a new helium-burning star, and so on. All these processes are rare and the products are short-lived, so there are relatively few "hydrogen-deficient stars" in the Galaxy, but they come in many different forms, from cool supergiants to hot subdwarfs and from single stars to interacting binaries.

In Armagh we are using the 11m Southern African Large Telescope (SALT) to make the largest multi-epoch survey of hydrogen-deficient stars in the Galaxy, including over 200 helium-rich hot subdwarfs and extreme helium stars. These observations will be combined with data from other large-scale surveys including Gaia, TESS, and LAMOST. Objectives include a full description of stellar properties, distribution and kinematics. The goal is to explore connections between subgroups of helium stars and hence to identify evolutionary pathways. Current projects include:

i) the SALT survey of chemically-peculiar subdwarfs,
ii) a SALT study of contraction in post-merger extreme helium stars
iii) SALT follow-up of candidate AM CVn stars and other potential GW sources

This is a collaborative project between Armagh Observatory and Planetarium (AOP), University of Cape Town (UCT) and the South African Astronomical Observatory (SAAO), with senior participants including Simon Jeffery and Gavin Ramsay (AOP), Itumeleng Monageng and Patrick Woudt (UCT) and Paul Groot (SAAO).
It addresses the nature and role of hydrogen-deficient stars in the Galaxy based on past and continuing observations with SALT. It will make use of a new generation of models for spectroscopic analysis, as well as new observations from SALT, Gaia, TESS and other surveys. A student participant would explore tools for automating data analysis, and for visualising the results. Facilities at Armagh include a new high-performance computer centre (for computing model atmospheres, data analysis and stellar evolution and pulsation calculations), and a new data visualisation center (for exploring distribution and kinematics).

A student might work on ensemble studies of the entire sample, and hence develop skills in data science for astronomy, or on focused studies of some of the extraordinary individual stars we are discovering, developing skills in stellar atmospheres and/or pulsations. In either case, enthusiasm for both programming and astrophysics will be desirable. A participant in the visitor programme would contribute to the completion of well-focused projects within the scope of the above programme.

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