EBERHARD KARLS UNIVERSITÄT TÜBINGEN

MATHEMATISCH-NATURWISSENSCHAFTLICHE FAKULTÄT

Stellar Atmospheres

T. Rauch, N. Reindl, V. Suleimanov, K. Werner

Institut für Astronomie und Astrophysik

Hot stellar remnants

Quantitative spectral analysis of evolved stars and stellar remnants allows us to conclude on nucleosynthesis processes in stars that drive the chemical evolution of galaxies. These objects also serve as stellar laboratories for atomic physics and the behavior of matter under extreme conditions. A basic requirement is the computation of atmosphere models. We focus on hot white dwarfs and their immediate progenitors, the central stars of planetary nebulae, as well as on neutron stars.

White dwarfs and central stars of planetary nebulae; novae

Caused by dredge-up, nuclear processed matter appears at the surface of central stars of planetary nebulae. In the most extreme cases, re-ignition of He-shell burning triggers deep envelope convection, ingestion and burning of the entire hydrogen layer, laying bare the stellar interior. We directly see the results of neutron-capture nucleosynthesis.

In hot white dwarfs (WDs), metals can be strongly enriched by radiative acceleration. Normally undetectable trace elements become visible. Hence these WDs are ideal laboratories for atomic physics. In particular, theoretical predictions of atomic data from highly ionized trans-iron group elements can be validated by their spectral lines (Fig. 1). Also, the physics of the acting diffusion processes – usually taking place invisibly deep inside of stars – can be studied.

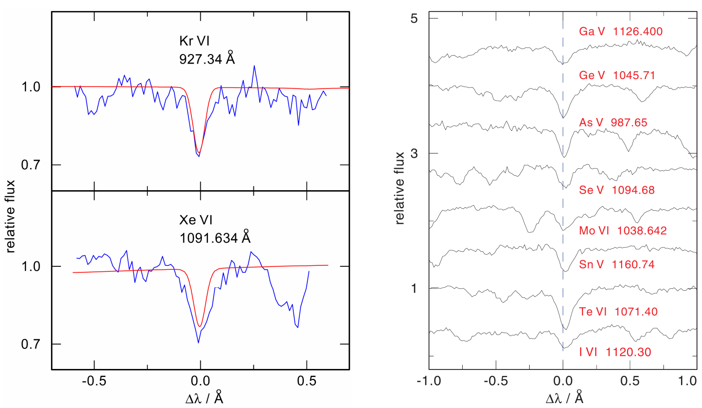

Fig. 1: First detection of krypton and xenon in a hot white dwarf (left) as well as other trans-iron elements (right). The abundances are several dex oversolar and are indicative of enrichment through radiative acceleration and nucleosynthesis (Werner, Rauch, Ringat, Kruk, 2012, ApJ, 753, L7).

Element abundance analyses of extremely hot WDs in supersoft X-ray sources reveal details of the thermonuclear explosions in novae (Fig. 2).

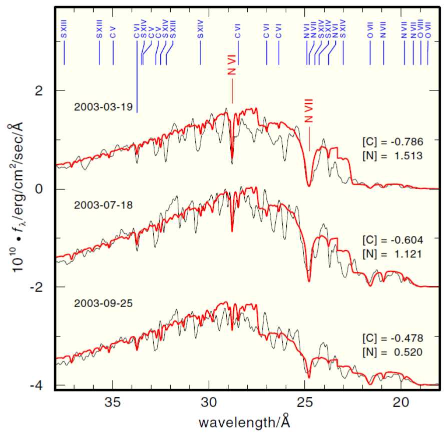

Fig. 2: Temporal evolution of temperature and chemical composition of the white dwarf in nova V4743 Sgr (Rauch et al., 2010, ApJ, 717, 363).

Neutron stars; X-ray bursters

A primary aim of neutron-star (NS) research is to constrain the equation of state of matter at super-nuclear densities by NS mass and radius measurements (Fig. 3). One prerequisite is the determination of the effective temperature from the thermal emission spectrum based on NS model atmospheres. Extreme conditions (temperatures, densities, magnetic field strength) pose particular challenges.

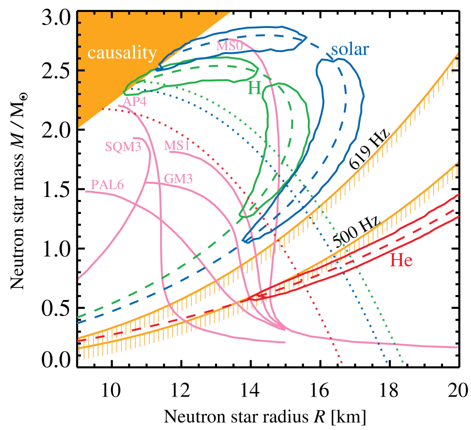

Fig. 3: Constraints on the equation of state derived from cooling phases of thermonuclear photospheric radius-expansion bursts of the neutron star 4U1724-207 observed with RXTE (Suleimanov, Poutanen, Revnitsev, Werner, 2011, ApJ, 742, 122)

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University of Tübingen · Faculty of Science
Kepler Center for Astro and Particle Physics
Institute for Astronomy and Astrophysics