EP 14: Astrophysics: Stellar Astrophysics

Time: Friday 11:00–13:00 Location: HSZ/0004

Invited Talk EP 14.1 Fri 11:00 HSZ/0004
Unveiling the secrets of hot, massive stars with modern stellar atmosphere models — •Andreas A C Sander — Astronomisches Rechen-Institut, Zentrum für Astronomie der Universität Heidelberg, Heidelberg, Germany

Even in the time of multi-messenger astrophysics, it is the light from stars that mostly determines what we know about the Universe beyond our Earth. To decode the information that is imprinted in the starlight, we need to understand its origin in the outermost layers of the stars, the so-called stellar atmosphere. Modelling these transition layers allows us to translate our observations from small and big telescopes into a proper physical quantities, thereby enabling us to not just understand the stars themselves, but also their impact and interactions with their host environment and their role in the chemical evolution of the Universe.

My Emmy Noether research group at the ARI in Heidelberg focuses on the application and development of stellar atmosphere models for hot, massive stars. In my talk, I will briefly introduce the techniques and challenges of these expanding, non-equilibrium models as well as outline the concept for including a consistent hydrodynamic treatment. Afterwards, I will provide an overview about the observational and theoretical research efforts of my group, where we use the atmosphere models to unveil the secrets and impact of massive stars, ranging from the spectral analysis of individual stars and the theoretical investigation of radiation-driven winds to the prediction of stellar feedback in unresolved populations.

EP 14.2 Fri 11:30 HSZ/0004
Stellar oscillations in B supergiant stars. — •Julieta Paz Sanchez Arias[1], Matias Agustin Ruiz Diaz[2], and Peter Nemeth[1,3] — [1]Astronomical Institute, Czech Academy of Sciences. Ondrejov, Czech Republic — [2]Instituto de Astrofísica de La Plata. CONICET-UNLP. La Plata, Argentina — [3]Astroserver.org, Foter 1, 8533 Malomsok, Hungary

The evolution of massive stars depends on many stellar parameters and small changes in them during the evolution of the stars can yield widely diverging outcomes. Additionally, these parameters, such as the initial mass, metalicity, mass loss rate and the type and distribution of chemical mixing in their interiors are far from being firmly established. B supergiant stars are one peculiar group of massive stars that undergo stellar oscillations. These objects can be found in different evolutionary stages. The study of their spectra provides us with information on the surface chemical abundances left by their evolution and the current mass loss rate. On the other hand, the study of stellar oscillations is a powerful tool that allows to inspect the stellar interiors through the analysis of the light curves and numerical simulations of their evolution, interior and oscillations. In this work, we combine both tools to unveil the physical parameters involved in the evolution of 3 B supergiant stars in different stages of their evolution but sharing the same location in the Hertzsprung-Russell diagram.

EP 14.3 Fri 11:45 HSZ/0004
Super-kilonovae from Massive Collapsars as Signatures of Black Hole Birth in the Pair-instability Mass Gap — Daniel Siegel[1,2], •Aman Agarwal[1,2], Jennifer Barnes[3], Brian Metzger[3], Mathieu Renzo[3], and Ashley Villar[3] — [1]Perimeter Institute for Theoretical Physics, Waterloo, Ontario, N2L 2Y5, Canada — [2]Institute of Physics, University of Greifswald, D-17489 Greifswald, Germany — [3]Columbia Astrophysics Laboratory, Columbia University, New York, NY 10027, USA

The core collapse of rapidly rotating massive ~ 10 solar masses stars (collapsars), and the resulting formation of hyperaccreting black holes, comprise a leading model for the central engines of long-duration gamma-ray bursts (GRBs) and promising sources of r-process nucleosynthesis. Here, I will discuss the signatures of collapsars from progenitors with helium cores >~ 130Me above the pair-instability mass gap. The disk outflows can potentially generate a large quantity (up to >~ 50 solar masses) of ejecta, comprised of >~ 5-10 solar masses in r-process elements. Radioactive heating of the disk wind ejecta powers an optical/IR transient, with a characteristic luminosity ~ 10^42 erg/s and a spectral peak similar to kilonovae from neutron star mergers, but with longer durations >~1 month. These super-kilonovae herald the birth of massive black holes >~ 60Me and can populate the pair-instability mass gap from above. SuperKNe could be discovered through planned telescopes like Roman Space Telescope. Multiband gravitational waves of ~ 0.1-50 Hz from these systems are potentially detectable by proposed observatories out to hundreds of Mpc.

EP 14.4 Fri 12:00 HSZ/0004
General relativistic radiation hydrodynamics simulations of hypermassive star evolutions — •Ninoy Rahman, Andreas Bauswein, and Gabriel Martínez-Pinedo — GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany

We investigate the evolutions of hypermassive neutron stars (HMNSs) formed by the mergers of binary neutron stars (BNSs) with initial gravitational masses of 1.35-1.35$M_\odot$, 1.362-1.362$M_\odot$, 1.292-1.4362$M_\odot$, 1.143-1.633$M_\odot$, and 1.37-1.37$M_\odot$ by 2D general relativistic hydrodynamical simulations. We employ the general relativistic hydrodynamics code NADA-FLD with energy-dependent three-flavor flux-limited diffusion neutrino transport to study the transiently formed HMNSs until their collapse to black holes (BHs). The newly born rapidly rotating HMNS with high temperatures and densities above nuclear saturation density is supported by the nuclear force, the thermal pressure, and the centrifugal force against gravity. We study the impact of the thermal and rotational properties of HMNSs on their lifetime. Additionally, we investigate the influence of viscous transport on the HMNS evolution. The lifetimes of HMNSs consider in this work vary from $\sim$50 ms to $\sim$150 ms. At Darmstadt, funding by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (ERC Advanced Grant KILONOVA No. 885281) is acknowledged.

EP 14.5 Fri 12:15 HSZ/0004
Weak Field Approximation of HAT-P-11s Magnetic Field via Stokes Polarimetry — •Andrew Rosenswie[1,2], Klaus Strassmeier[1,2], Silva Jaervinen[2], Thorsten Carroll[2], Martina Baratella[2], and Ilya Ilyin[2] — [1]Institut fuer Physik und Astronomie, Universitaet Potsdam, D-14476 Potsdam, Germany — [2]Leibniz-Institut fuer Astrophysik Potsdam (AIP), An der Sternwarte 16, D-14482 Potsdam, Germany

Presented in this work is the discovery of the magnetic field strength of the K dwarf star, HAT-P-11, which we measured in polarized light of the Stokes parameter V. The magnetic field was discovered to be 2.73 G. Our methodology can be applied to future polarimetric analyses of magnetically active stars via Stokes V polarimetry. Usage of echelle spectrographs with high spectral resolution allows for the determination of magnetic fields of stars and other celestial objects. We utilize the Potsdam Echelle Polarimetric and Spectroscopic Instrument (PEPSI), with spectral resolution R = 130 000. Due to the effects of orbital parameters of HAT-P-11 b, we predicted the detectability of a change of magnetic field strength of HAT-P-11 during the primary transiting eclipse of HAT-P-11 b, detected with PEPSI, consigned in the Large Binocular Telescope (LBT). By our discovery, it provides conclusive evidence via SVD profiles for deducing the magnetic field of a star known to be magnetically active for the past decade.

EP 14.6 Fri 12:30 HSZ/0004
An exact analytical solution for the weakly magnetized flow around an axially symmetric paraboloid, with application to magnetosphere models — •Jens Kleimann[1] and Christian Röken[2,3] — [1]Theoretische Physik IV, Ruhr-Universität Bochum, Germany — [2]Department of Geometry and Topology, Faculty of Science, University of Granada, Spain — [3]Lichtenberg Group for History and Philosophy of Physics, Institut für Philosophie, Universität Bonn, Germany

Rotationally symmetric bodies with parabolic cross sections are frequently used to model astrophysical objects such as magnetospheres immersed in interplanetary or interstellar plasma flows. We discuss a simple formula for the potential flow of an incompressible fluid around an elliptic paraboloid whose axis of symmetry coincides with the direction of incoming flow. Prescribing this flow, we derive an exact analytical solution to the induction equation of ideal magnetohydrodynamics, obtaining explicit expressions for an initially homogeneous magnetic field of arbitrary orientation being passively advected in this flow. Our solution procedure employs Euler potentials and Cauchy's integral formalism based on the flow's stream function and isochrones. Furthermore, a novel renormalization procedure allows us to generate more general analytic expressions modeling the deformations experienced by arbitrary scalar or vector-valued fields embedded in the flow as they are advected towards and then past the parabolic obstacle. Finally, both the velocity field and the magnetic field embedded therein are generalized from incompressible to mildly compressible flow.

EP 14.7 Fri 12:45 HSZ/0004

Emulation of density and temperature structures in front of astrospheres: an incompressible approach — •Dieter H. Nickeler — Astronomical Institute, Czech Academy of Sciences, Ondrejov, Czech Republic

Stars with their winds traveling through the interstellar medium (ISM) can form stellar wind cavities called astrospheres, separating the ISM gas from the inner stellar wind material by the astropause. By using the Grad-Shafranov equation (GSE) formalism, based on the stream function method of Langrange and Stokes for incompressible hydrodynamics, we compute possible density and temperature profiles in the vicinity of the astropause. We start with a simple, single X-type stagnation point. By variation of the density function, where the density depends on the stream function only, it is possible to construct a huge variety of temperature profiles, with fixed pressure, automatically guaranteed by the fulfillment of the GSE. These profiles in density and temperature are essential for calculating expressions, with which synthetic radiation profiles from the regions in front of the astropause nose can be computed and compared to observations.