EP 1: Astrophysics

Time: Monday 14:00–15:45 Location: EP-H1

Invited Talk EP 1.1 Mon 14:00 EP-H1

Asteroseismology of red-giant stars — •Saskia Hekker — Centre for Astronomy (ZAH/LSW), Heidelberg University — Heidelberg Institute for Theoretical Studies (HITS) — Stellar Astrophysics Centre, Aarhus, Denmark

Over the past decades we experienced a revolution in asteroseismology of red-giant stars. In this talk, I will discuss this revolution and first insights gained from asteroseismology into the stellar structure of red-giant stars.

EP 1.2 Mon 14:30 EP-H1

Finite time singularities and their relations to eruptive stellar mass loss events — •Dieter Nickeler and Michaela Kraus — Astronomical Institute, Czech Academy of Sciences, Ondrejov, Czech Republic

In recent years rings, spiral and arc structures have been detected around massive stars with strong stellar winds. These structures are proposed to be a result of stellar mass ejections. Taking a (fast) stationary stellar wind as initial condition, the time-dependent amplitude modulation is analyzed with respect to eventually occurring finite-time instabilities. These so called blow-up solutions can be interpreted as non-linear instabilities in the stellar wind, leading to eruptive mass loss of the star. We analyze under which circumstances such blow-up solutions can exist.

EP 1.3 Mon 14:45 EP-H1

Molecular environment of the yellow hypergiant HD 269953 — •Michaela Kraus[1], Maria Laura Arias[2], and Lydia Cidale[2] — [1]Astronomical Institute, Czech Academy of Sciences, Ondrejov, Czech Republic — [2]Instituto de Astrofisica de La Plata, CONICET-UNLP, Argentina

Yellow hypergiants are massive stars, most likely in post-red supergiant evolutionary state. Stars in this phase can undergo multiple outbursts, and the ejected material might enshroud the stars in gaseous and dusty shells or envelopes. The object HD 269953 has been suggested to be a candidate yellow hypergiant. Although no historic outburst has been reported for that object, its environment hosts a substantial amount of warm CO gas. To unveil the dynamics within the molecular gas we obtained a high-resolution (R $\sim$ 45 000) K-band spectrum of HD 269953 with IGRINS at GEMINI-South. We find that the spectrum is rich in emission features. In particular, we detect emission from the ^{12}CO and ^{13}CO molecular bands. The latter are strongly enriched, in agreement with the hypothesis that the environment contains processed matter that has been released from an evolved object. Moreover, we identified emission of hot water vapor, which is, to our knowledge, the first detection of water in the vicinity of an evolved massive star. We will present first results from our analysis of the circumstellar molecular gas and discuss scenario for its origin.

EP 1.4 Mon 15:00 EP-H1

Kilonovae, gamma-ray bursts, and heavy elements from neutron star mergers — •Oliver Just[1], Andreas Bauswein[1], Thomas Janka[2], Stephane Goriely[3], Ina Kullmann[3], Shigehiro Nagataki[4], Hirotaka Ito[4], and Christine Collins[1] — [1]GSI, Darmstadt, Germany — [2]MPA, Garching, Germany — [3]ULB, Brussels, Belgium — [4]RIKEN, Tokyo, Japan

The collision of two neutron stars, which was first observed in 2017, is one of the most luminous astrophysical explosions, in which not only electromagnetic radiation from radio to gamma-ray frequencies is emitted, but also huge amounts of energy in the form of neutrinos and gravitational waves. In order to decipher these multi-messenger events, e.g. for inferring the mass and composition of the material thrown out in the course of such a merger, one needs to build detailed theoretical models of the processes that lead to matter ejection and the emission of radiation. In this talk I will present our recent efforts to model the merger and its remnant using multi-dimensional hydrodynamics simulations including the transport of neutrinos. Moreover, I will outline how these simulations were used to predict the optical/near infrared signal, called kilonova, the flash of gamma-radiation, called short gamma-ray burst, as well as the amount of heavy elements, such as Gold, produced in the ejecta by means of the rapid neutron-capture (or r-) nucleosynthesis process.

EP 1.5 Mon 15:15 EP-H1

Core-Collapse Simulations of Very Massive Star: Gravitational Collapse, Black-hole Formation, and Beyond — •Ninoy Rahman — GSI Helmholtz Centre for Heavy Ion Research

We investigate the final gravitational collapse of rotating and non-rotating pulsational pair-instability supernova progenitors with zero-age-main-sequence masses of 60, 80, and $115\,M_\odot$ and iron cores between $2.37\,M_\odot$ and $2.72\,M_\odot$ by 2D (axi-symmetric) hydrodynamics simulations. Using the general relativistic NADA-FLD code with neutrino transport allows us to follow the evolution beyond the moment when the transiently forming neutron star (NS) collapses to a black hole (BH), which happens in all cases. Because of high neutrino luminosities and mean energies, neutrino heating leads to shock revival before BH formation in all cases except in the rapidly rotating $60\,M_\odot$ model, where centrifugal effects support a higher NS mass but reduce the neutrino-heating rate by roughly a factor of two compared to the non-rotating counterpart. After BH formation the neutrino luminosities drop steeply but continue on a 1–2 orders of magnitude lower level for several 100 ms because of aspherical accretion of neutrino and shock-heated matter, before the ultimately spherical collapse of the outer progenitor shells suppresses the neutrino emission to negligible values. In all shock-reviving models BH accretion swallows the entire neutrino-heated matter and the diagnostic explosion energies decrease to zero within a few seconds latest. Nevertheless, the shock or a sonic pulse move outward and may trigger mass loss, which we estimate by long-time simulations with the Prometheus code.

EP 1.6 Mon 15:30 EP-H1

Modeling disk fragmentation and multiplicity in massive star formation — •Rolf Kuiper[1] and André Oliva[2] — [1]Universität Heidelberg — [2]Universität Tübingen

There is growing evidence that massive stars grow by disk accretion in a similar way to their low-mass counterparts. Early in evolution, these disks can achieve masses that are comparable to the current stellar mass, and therefore the forming disks are highly susceptible to gravitational fragmentation. We investigate the formation and early evolution of an accretion disk around a forming massive protostar, focussing on its fragmentation physics.

We used a grid-based, self-gravity radiation hydrodynamics code including a sub-grid module for stellar evolution and dust evolution. We purposely do not use a sub-grid module for fragmentation such as sink particles to allow for all paths of fragment formation and destruction, but instead we keep the spatial grid resolution high enough to properly resolve the physical length scales of the problem, namely the pressure scale height and Jeans length of the disk.

The cloud collapses and a massive (proto)star is formed in its center surrounded by a fragmenting Keplerian-like accretion disk with spiral arms. The fragments have masses of ~1 Msol, and their continuous interactions with the disk, spiral arms, and other fragments result in eccentric orbits. Fragments form hydrostatic cores surrounded by secondary disks with spiral arms that also produce new fragments. Based on this, we study the multiplicity from spectroscopic multiples to companions at distances at 1000 au.