HK 33: Nuclear Astrophysics II

Time: Tuesday 16:00–17:30 Location: HK-H10

Group Report HK 33.1 Tue 16:00 HK-H10

Electromagnetic Counterparts of Neutron Star Mergers: Signatures of Heavy r-Process Nucleosynthesis — •Andreas Flörs[1], Luke Shingles[1], and Gabriel Martínez-Pinedo[1,2] — [1]GSI, Darmstadt, Germany — [2]TU Darmstadt, Darmstadt, Germany

It has long since been established that observable actinides in the universe originate from the r-process. In 2017, the electromagnetic counterpart to the gravitational wave detection of two merging neutron stars was observed. From the light curve alone it was possible to characterise two ejecta components: one that contains low-Y_e material such as lanthanides and possibly actinides, and a high-Y_e component with low lanthanide abundances. The dividing characteristic between the two components is the opacity of the material: lanthanides have a $\sim$100 times higher opacity than iron-group material. The opacity of actinides is expected to be on a similar level as that of the lanthanides, or, possibly, even higher.

To identify specific elements, spectroscopic information is required. However, so far no clear detection of individual lanthanides or actinides has been made in the only observed neutron star merger. A great challenge for spectroscopic modelling of kilonovae using radiative transfer codes is the almost non-existent atomic data currently available for lanthanides and actinides. I will present converged and, where possible, calibrated atomic structure calculations from Zr to U. I will then use this collection of atomic data to show how we can use radiative transfer simulations to identify signatures or place constraints on the amount of heavy r-process material synthesized in kilonovae.

HK 33.2 Tue 16:30 HK-H10

Long Term Evolution of Neutron Star Merger Ejecta — •Christian Schwebler[2,1], Gabriel Martínez-Pinedo[1,2,3], Andreas Bauswein[1], Oliver Just[1], and Ninoy Rahman[1] — [1]GSI Helmholtzzentrum für Schwerionenforschung, Planckstraße 1, 64291 Darmstadt, Germany — [2]Institut für Kernphysik (Theoriezentrum), Fachbereich Physik, Technische Universität Darmstadt, Schlossgartenstraße 2, 64298 Darmstadt, Germany — [3]Helmholtz Forschungsakademie Hessen für FAIR, GSI Helmholtzzentrum für Schwerionenforschung, Planckstraße 1, 64291 Darmstadt, Germany

Binary neutron star mergers (BNS) are at the moment the most promising events for r-process nucleosynthesis. We simulate the long term properties of the dynamical merger ejecta, which are crucial for the nucleosynthesis, by three dimensional numerical-relativity simulations. Starting with initial data from BNS merger simulations, which typically cover timescales of milliseconds, our goal is to investigate the ejected material up to several days or weeks, the timescale in which the kilonova, the electromagnetic signal of a BNS merger, is detectable. We focus on the dynamical evolution and the impact of r-process heating on the material.

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HK 33.3 Tue 16:45 HK-H10

Neural network reconstruction of the dense matter equation of state from neutron star observables — •Shriya Soma[1], Lingxiao Wang[1], Shuzhe Shi[2], Horst Stoecker[1], and Kai Zhou[1] — [1]Frankfurt Institute for Advanced Studies, Frankfurt am Main, Germany — [2]Stony Brook University, Stony Brook, New York, USA

The equation of state (EoS) of strongly interacting cold and ultra-dense matter still remains a major challenge in the field of nuclear physics. With the advancements in measurements of neutron star masses, radii and tidal deformabilities from electromagnetic and gravitational wave observations, neutron stars play an important role in constraining the EoS. In this work, we present a novel method that exploits deep learning techniques to reconstruct the dense matter EoS from mass-radius (M-R) observations of neutron stars. We employ neural networks (NNs) to represent the EoS in a model-independent way, within the range 1-7.4 times the nuclear saturation density. In an unsupervised manner, we implement the Automatic Differentiation (AD) framework to optimize the EoS, so as to yield an M-R curve that best fits the observations. We demonstrate the rebuilding of an EoS on mock data, i.e., M-R pairs derived from a generated set of polytropic EoSs. We show that it is possible to reconstruct the EoS with reasonable accuracy, using just 12 mock M-R pairs, which is nearly equivalent to the current number of observations. We finally deploy the NNs in the AD scheme on real M-R data, including the recent measurements from NICER, to infer the neutron star EoS and present the results hereof.

HK 33.4 Tue 17:00 HK-H10

Core-collapse supernova simulations with reduced nucleosynthesis networks — •Gerard Navo[1], Moritz Reichert[2], Martin Obergaulinger[2], and Almudena Arcones[1,3,4] — [1]Institut für Kernphysik, Technische Universität Darmstadt, Darmstadt, Germany — [2]Departament d'Astronomia i Astrofísica, Universitat de València, Burjassot (València), Spain — [3]Helmholtz Forschungsakademie Hessen für FAIR, GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany — [4]GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany

Core-collapse supernovae play a critical role in the chemical history of the universe. In recent years, huge advances have been reported about multidimensional simulations, magnetic fields, neutrino treatment and reactions, high-density equations of state, nucleosynthesis, and long-time evolution connecting to observations. Here we focus on the nucleosynthesis and their treatment within the simulations. Including large nuclear networks in multidimensional simulations is not feasible because of the computational expense. Therefore, often a simple treatment is used for the composition at temperatures where the nuclear statistical equilibrium can no longer be applied. We have now included reduced networks into state-of-the-art supernova simulations (Obergaulinger & Aloy 2017) to account for the composition and energy generation from nuclear reactions. I will present, the impact of several reduced networks based on multidimensional core-collapse supernovae simulations for different progenitors.

HK 33.5 Tue 17:15 HK-H10

Reevaluation of the cosmic antideuteron flux from cosmic-ray interactions and from exotic sources — •Laura Serksnyte[1], S. Königstorfer[1], I. Vorobyev[1], L. Fabbietti[1], D. M. Gomez Coral[2], P. von Doetinchem[2], J. Herms[3], A. Ibarra[1], T. Pöschl[1], A. Shukla[2], and A. Strong[4] — [1]TUM — [2]University of Hawaii at Manoa — [3]MPI für Kernphysik — [4]MPI for Extraterrestial Physics

The studies of antinuclei cosmic rays are of great interest as they represent one of the most promising indirect probes of exotic phenomena in our Galaxy such as dark matter annihilation and primodial black hole evaporation. However, the antinuclei cosmic rays also contain a background contribution from antinuclei produced in cosmic-ray collisions with the interstellar gas. In order to interpret any future measurement of the cosmic ray antinuclei fluxes, it is imperative to have a full understanding of the uncertainties involved from production to propagation. This requires a data driven estimation of the production and annihilation cross sections of antinuclei, as well as a state-of-the-art propagation model. We studied the antideuteron cosmic-ray flux using the GALPROP propagation model and we obtained the fluxes stemming from exotic sources and from cosmic-ray interactions. We used the most up-to-date antideuteron production cross sections and for the first time included a data-driven estimation of the inelastic antideuteron cross sections. In this talk we will present our results including an in depth study of the prevailing uncertainties such as antideuteron production modeling, propagation parameters and others.