"The dependence of orbital period on the mass of stars stripped in binaries"

Sepideh Abdollahihashjin; Ylva Götberg
Institute of Science and Technology Austria (ISTA)

Abstract:
Around one-third of massive stars are expected to lose their hydrogen-rich envelopes due to interaction with another star in a binary system. Most of the resulting "stripped stars" are expected to have masses predictable from the star's initial mass and the orbital period of the binary system. We explored the dependence of these two factors on the mass of the stripped star produced through mass transfer.
We used the MESA binary stellar evolution code to model a 12 solar masses star orbiting an 8.6 solar masses companion star on a twenty-day orbit. In this simulation, the most massive star in the system fills its Roche lobe, and mass transfer initiates. We focused on mass transfer during the main sequence when the helium core is not defined, and after the main sequence and during the Hertzsprung gap, when the helium core contracts towards central helium ignition. We chose these evolutionary phases prior to the long-lasting central helium burning as they produce long-lived stripped stars.
We found mass transfer initiates during a 12 solar masses star's main sequence creating lower-mass stripped stars if the orbital period is between 0.9 and 5.3 days. Longer orbital periods (up to 1600 days) produce similar-mass stripped stars as the mass transfer happens after the main sequence when the helium core is defined. Our next step is to model binary systems with a range of periods to help inform the stripped star mass distribution and binary properties in population synthesis codes.

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"Constraining stellar and orbital co-evolution through ensemble seismology of solar-like oscillators in binary systems"

Beck, P. G. [1,2]; Grossmann, D. H. [1,2]; Steinwender, L.[3]; Schimak, L. S.[4]; Muntean, N [5]; and the authors of Beck et al. (2024, A&A. arXiv:2307.10812)
[1] Universidad de la Laguna; [2] Instituto de Astrofisica de Canarias; [3] Technische Universität Graz; [4] Sydney University; [5] Universität Graz

Abstract:
The evolution of stars and their hosting binary systems is a highly interactive process and cannot be investigated in a segregated manner. Due to the constraints drawn by stellar binarity, oscillating red-giant stars in binary systems represent a unique opportunity to study the details of the structure and evolution of stars in the advanced phases of stellar evolution. Until recently, the number of known systems hosting solar-like oscillators was small.
In this poster, we present the joint analysis of space photometry from NASA Kepler and TESS, ground-based high-resolution spectroscopy such as APOGEE, and astrometry and orbital solutions from space with the ESA Gaia satellite (DR3). Our new approach delivered ~1000 new solar-like oscillators in binary systems with known orbital solutions and increased the sample size by an order of magnitude.
From the large sample, we can follow the evolution of the orbital eccentricity of a solar-like star as a function of age. Using asteroseismic techniques, we can distinguish between the various evolutionary phases and identify changes in the period and eccentricity of the orbit and stellar activity due to the accumulated effects of stellar evolution and tidal star-star interaction.

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"Electro-Motive Force in Heliospheric Magnetic Clouds"

Philippe-A. Bourdin
Institute of Physics, University of Graz

Abstract:
We use the electro-motive force to analyze the turbulence and dynamo action within or in front of shock waves passing the heliosphere. This requires us to take magnetic-field measurements, as well as plasma-velocity measurements from the solar wind, which we obtain from SolarOrbiter data. Typical events to analyze are of course inter-planetary coronal mass ejections that ultimately originate from energetic outbreaks on the Sun. Since SolarOrbiter flies within the Earth orbit at or below about 1 au, we obtain insights in regions where no stationary observatories are available and where such magnetic events have not yet interacted with any obstacle like a planetary megnetospehre. Our goal is to understand better how magnetic field might get amplified, how turbulence or reconnection slows down the propagation of these shoch fronts in inter-planetary space, and which component of the electro-motive force is a key her to cause dynamo action. Our first results indicate also that we may infer the magnetic helicity orientation from in-situ measurements in the inner heliosphere.

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"Advancing solar coronal magnetic field modeling through a non-force-free approach in physics-informed neural networks"

M. P. K. Buchner [1]; R. Jarolim [1]; A. M. Veronig [1,2]
1: University of Graz, Institute of Physics, Graz, Austria; 2: University of Graz, Kanzelhöhe Observatory for Solar and Environmental Research, Treffen am Ossiacher See, Austria

Abstract:
While the solar magnetic field in the photosphere is commonly observed, its behavior in the upper atmospheric layers is difficult to assess observationally. However, observations support that magnetic field changes in the uppermost layer (the solar corona) are the primary source for solar eruptions. Therefore, modeling methods are used to reconstruct the coronal magnetic field from photospheric magnetic field maps. Recent methods for magnetic field extrapolations build on the force-free field assumption to reduce computational costs. While this approach can provide a realistic approximation of the solar magnetic field this assumption is not valid in the lower solar atmospheric layers. In this study, we expand on the physics-informed neural network (PINN) architecture developed by Jarolim et al. (2023). The adopted framework extrapolates photospheric vector magnetic field maps from the Helioseismic Magnetic Imager (HMI) onboard NASA's Solar Dynamics Observatory (SDO). Governed by the physical equations the training process tries to find a balance between the equations and observational data. To enhance the accuracy of the existing model and allow further investigations on the complex physical processes in solar active regions, our goal is to integrate non-force-free dynamics. Our method introduces the plasma pressure as a new quantity into the extrapolation process and experiments with force-free sub models which get pre-trained to a certain stage. This strategy is expected to yield a model that creates an improved representation of the solar magnetic field, particularly in active regions, which are the primary drivers of space weather impacts. By the refined coronal field model, we aim to contribute to a deeper understanding of solar atmospheric dynamics and its potential impacts on Earth.

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"Astro-cardiology: can binary-stripped stars be used to trace the spins of cores in evolved massive stars?"

Andrei-Alexandru Cristea
Institute of Science and Technology Austria (ISTA)

Abstract:
Stellar rotation is thought to be responsible for strong interior chemical mixing, especially in low-metallicity stars, and to directly relate with the spins of the black holes and neutron stars they result in. However, angular momentum transport inside stars and the formation of dynamo magnetic field structures remain poorly understood. Despite this, binary systems may provide valuable insight. In binary systems, stripping of the hydrogen-rich envelope will expose the helium core, thus providing the possibility to trace the core rotation of evolved massive stars directly from the surfaces of these stripped donor stars. We compare a series of single and He-rich stripped binary evolutionary models, that we computed with the 1D stellar evolution code MESA. The rotation profiles of single red super-giant (RSG) models employing the Tayler-Spruit dynamo are characterized by differential rotation, with a rapidly rotating rigid core (omega~2.158e-4 rad/s) and a slowly rotating rigid envelope (omega~4.13e-10 rad/s). This indicates that the core and envelope are magnetically weakly bound and rotationally decouple shortly after the main sequence. This is in agreement with our binary-stripped star models: their final spins are negligibly affected by the loss of their hydrogen-rich envelopes and their angular momentum profiles closely map those of the single RSG cores. This suggests that the surface rotation rates of binary-stripped stars may be used as proxies for core rotations of evolved massive stars. A comparison of our models with new observations of binary stripped stars could produce a first set of direct observational constraints on angular momentum processes happening inside evolved massive stars.

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"Runaway Stripped Stars in the Milky Way Galaxy: A Population Synthesis Study"

Aayush Desai
Institute of Science and Technology

Abstract:
Given the recent leaps in our ability to explore our Cosmic neighbourhood, one might expect that we know a great deal about it. But there is still a lot to learn. A study estimates that two-thirds of the most massive (brightest) stars should exist in binaries. A majority of these binaries should evolve through a mass transfer phase, creating hot, envelope-stripped helium stars. Astonishingly, such a system has not been observed in the Milky Way! To inform future observations of stripped stars, I used a binary population synthesis code that utilises single and binary stellar evolution models computed with the MESA code as an initial framework. Subsequently, the code interpolates between the models to ascertain the parameters of the particular systems. I found that roughly 6000 systems with atleast 1 stripped star with mass between $2 - 8M_\odot$ should exist in the Milky Way alone. These stars are ejected when the companion star collapses in a supernova explosion that disrupts the binary system. A promising method to identify these outlier stars is to compare its velocity with its immediate neighbours. Given the exquisitely high astrometric accuracy of the Gaia DR3, such high-velocity stars could potentially be recognised from the data. Although the model is simplistic and does require further improvements, the early results suggest that a sub-set of the runaway stripped star population in the Milky Way could be detectable. These populations could guide future observations and provide an interesting avenue for identifying stripped stars.

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"Unveiling complex magnetic field configurations in red giant stars"

L. Einramhof [1] ; S.B. Das [1,2] ; L. Bugnet [1]
1: Institute of Science and Technology Austria ; 2: Center for Astrophysics, Harvard & Smithsonian

Abstract:
Probing stellar internal magnetic fields is crucial in addressing the angular momentum transport problem in stars, which critically affects stellar evolution and age. Dipolar modes of stellar oscillation have very recently been used to make novel measurements of internal magnetic field strengths in red giant stars. This, however, relies on current state-of-the-art theory which can only infer the strength of the radial field component. Additionally, multiple magnetic field topologies may lead to the same signature in the dipolar oscillation frequencies, which we call topology degeneracy.
We show how a combined detection of magnetic signatures in dipolar and quadrupolar modes can significantly reduce the topology degeneracy. As a demonstration, we consider (a) purely dipolar, and (b) mixed dipolar and quadrupolar magnetic fields. We report how we can unambiguously infer essential topological parameters such as (i) the ratio between the dipolar and quadrupolar field strength and (ii) the inclination angles between the dipolar and quadrupolar fields with respect to the rotation axis.
Access to magnetic field topologies inside the core of red giants would result in a very strong impact on our understanding of angular momentum transport inside stars, and therefore on the current global picture of stellar evolution.

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"A high precision mass measurement of the central black hole in the massive elliptical NGC 2513 with ALMA molecular gas dynamics"

Shelley-Anne Harrisberg
Department of Astrophysics, University of Vienna

Abstract:
Supermassive black holes (SMBH) are believed to co-evolve with their host galaxies. Evidence for the co-evolution is found in the form of several tight correlations between the SMBH mass and various properties of the host galaxy, such as bulge stellar velocity dispersion (Ferrarese & Merritt 2000). In order to better understand the correlations more SMBH measurements are required in the low- and high-mass SMBH regime.
In this talk, I present my results of a SMBH mass measurement in the massive elliptical galaxy NGC 2513 obtained from cold molecular gas dynamics (Davis et al. 2013), using high resolution ALMA (Atacama Large Millimeter/sub-millimeter Array) observations.
I will first discuss the method, its advantages and its limitations.
Knowing the luminous mass of the galaxy is crucial for a precise SMBH mass measurement. I will then present how I derived the luminous mass of NGC 2513 using near-infrared images from the Hubble Space Telescope taking detailed dust masking into account.
In the final part of my talk, I will present kinematic maps obtained from the high-resolution observations (0.369'' x 0.325'') of the CO(2-1) lines obtained from ALMA.
These are then modeled using the KInMS (KINematic Molecular Simulation) routines developed by Davis et al. (2013). Applying the best-fit model to the ALMA data, the SMBH mass and its limits can finally be constrained.

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"Investigating the exoplanetary atmosphere of HAT-P-30b"

Nandini Jain
University of Potsdam

Abstract:
Characterizing the atmospheres of exoplanets is essential in order to understand their nature and provide clues about their formation and evolution. To this aim, transiting exoplanets are crucial in atmospheric studies as they allow very precise characterisation of the atmosphere due to the known planetary properties (planetary mass and radius). Transmission spectroscopy is a technique for the detection and characterisation of exoplanetary atmospheres. This method compares spectra taken inside and outside of transits to extract the planetary signal. Low-resolution transmission spectroscopy uses an instrument with low resolving power (R = 50, 000. The latter enables us to resolve the moving planetary motion during the transit. In addition, this technique allows to resolve planetary features from which information like planetary rotation, winds and chemical composition can be derived.
This project aimed at using archival data from FORS2 to study the atmosphere of HAT-P-30b, a hot Jupiter with a very small density and large scale height – and thus an ideal target for transmission spectroscopy as the expected signal is very high. In the ESO archive there were 1556 FORS2 spectra from two transit nights using the 600B and 600RI grisms. We analyzed the FORS2 data, following the method of sedaghati2017detection and nikolov2018absolute, to obtain the low-resolution transmission spectrum and identify the presence of strong absorbers and/or Rayleigh scattering. The calculated equilibrium temperature of HAT-P-30b puts this planet just between two sub-classes of hot Jupiters with different planetary chemistry and composition.
The (non-)detection of certain absorbers in the atmosphere provides strong constraints about temperature and detect eventual temperature inversion layers. This was done using theoretical models from the PetitRADTRANS.

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"Star-formation rates of galaxies in the early Universe: new insights from JWST"

Ivan Kramarenko
Institute of Science and Technology Austria

Abstract:
The distribution of star formation rate among galaxies is one the most important observables in the studies of galaxy formation and evolution. Coupled with the halo mass function, it provides an estimate of the star-formation efficiency as a function of halo mass and redshift, shedding light on the impact of feedback mechanisms on galaxy evolution. However, measuring star formation rates at $z > 3$ has long been hampered as most sensitive results relied on the rest-frame UV light, which is subject to uncertainties in dust attenuation. To address this issue, we take advantage of the unique near-IR capabilities of the James Webb Space Telescope (JWST) to measure star formation rates among galaxies at $z > 3$ using rest-frame optical spectroscopy for the first time. In particular, we use the wide-field slitless spectroscopic (WFSS) data from JWST Cycle 1 & 2 observations to obtain a complete sample of H-alpha emitters at $3.8 < z < 5.0$. We put the results of our work in the context of the studies of galaxy evolution in the early Universe, as well as discuss some major challenges presented by the WFSS data.

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"Symmetry methods in galactic dynamics"

Edward Lilley
University of Vienna

Abstract:
Notions of symmetry and integrability are ubiquitous in physics, and this is especially true when considering the dynamics of self-gravitating systems (e.g. galaxies). A central problem is the calculation of the normal modes of an equilibrium dynamical model. This talk will look at the role played by symmetries in the classification of coordinate systems appropriate for both the dynamical (Hamilton-Jacobi) and gravitational (Poisson) parts of the problem. The focus will be on recent results in the latter case -- in particular, symmetry operators that give rise to appropriate bases of orthogonal functions to represent perturbations of spherically-symmetric, razor-thin disc, or slightly-thickened-disc galaxies (arxiv:2302.06944). Applications of the main mathematical results to other subfields of physics will also be discussed.

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"Red giant binaries as seen from TESS and Kepler"

Yannis Marx
Karl Franzens Universität

Abstract:
The Transiting Exoplanet Survey Satellite (TESS) has been observing more than 1.5 billion stars since it’s launch in 2018. Some of these stars have previously been observed by the Kepler Space Telescope. Kepler has delivered photometric data of the same stars for 4 years. This gives us an opportunity to compare the newly acquired data of TESS with the already well established data of Kepler. Aims: We aim to compare the photometric data of TESS with the successful data of Kepler, using the unique features of binary star systems, containing a red giant component. We also seek to calculate new periods for the binary systems, using the combined data of Kepler and TESS. We extracted the photometric flux from the target-pixel data and processed the photometric data of 17 different binary stars reported by Beck et al. (2014). For that we used the Lightkurve Python package and the Mikulski Archive for Space Telescopes (MAST) to download and process the data. The comparison was done by combining both data sets into one combined phase diagram for each binary system. The thesis presents phase diagrams of 17 eccentric binary systems, which contain a red giant component. These phase diagrams contain data from both Kepler and TESS telescopes. For 10 of them, the joint TESS and Kepler data contained either the eclipses or flux modulation of tidal distortion. This allowed us the calculation of 10 new precise periods for these systems. With the help of the combined phase diagrams we could compare the photometric data of both space telescopes. They show similarities in the observed features of the binary systems, but also strong differences in the quality of those observations due to their different telescope apertures. We analysed these differences in the data and gave possible explanations for them.

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"The effects of Solar Activity cycles on the asteroseismic parameters from 25 years of observations with GOLF and VIRGO on the ESA SOHO space telescope"

S. Michlmayer [1]; P. Beck [2,3]; R. A. García [4]; A. Jiménez [2,3]
1: University of Graz, Austria; 2: Universidad de La Laguna, Spain; 3: IAC, Tenerife, Spain; 4:CEA, Paris-Saclay, France

Abstract:
The Solar and Heliospheric Observatory (SOHO) provides us with unprecedented short-cadence spectroscopic and photospheric data of the Sun-as-a-star for 27 years. Here the data from the GOLF and VIRGO/SPM instruments are used. This dataset completely covers the previous solar cycles (23 and 24) and contains the onset of the current solar cycle. The measurement of the solar activity cycle with instruments that integrate over the whole solar surface is important because then we can compare the results with asteroseismic studies of other solar-like stars on the main sequence, provided by the rich data of the space telescopes such as NASA Kepler, TESS or the forthcoming European PLATO mission. In this poster, we present the results of my master’s thesis project to study the influence of the solar activity cycle on asteroseismic parameters. We investigate the reported correlation of the shift of the radial and low-degree non-radial oscillation modes with the activity of the Sun. The level of solar activity is estimated from the SOHO time series data. Additionally, we obtain proxies for solar activity from the SILSO international sunspot number. We extend the analysis until 2023 and provide first insights into the behavior of solar-oscillation modes in the ongoing solar cycle 25.

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"Constraining the core-rotation rate along the red-giant evolution"

Nicolas Muntean [1]; P. G. Beck [1,2,3]; D. Grossmann [1,2]; L. Schimak [1]; R. A. Garcia [4]; S. Mathur [2,3]; A. Hanslmeier [1]
1:Karl Franzens Universität Graz; 2:Instituto de Astrofisica de Canarias; 3:Departamento de Astrofisica, Universidad de La Laguna, 4:Université Paris-Saclay, Université Paris Cité

Abstract:
The evolution of the core rotation rate of red giant stars is a key parameter in understanding the stellar behavior in the late phases of stellar evolution. Thanks to the mixed-dipole modes, we can constrain the core rotation and internal rotational gradient as a star advances through the red-giant phase.
This master thesis presents a pipeline performing a classical seismic analysis of the power-spectral density of oscillating red-giant stars and identifying the period spacing and coupling coefficient to describe the mixed mode pattern precisely. Using the MESA stellar evolution and the GYRE stellar oscillation codes, we calculate the representative models of the selected stars and derive the rotational kernels for the dipole modes. From the semi-automatically detected rotational splittings and the assumption of a two-shell rotation model for the stars, we constrain the rotational gradient in three different stages of the red-giant evolution.

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"Coronal dimming evolution and properties in soft X-rays as compared to EUV"

A. Razquin [1]; A. M. Veronig [1,2]
1: Institute of Physics, University of Graz, Universitätsplatz 5, Graz, 8010, Austria; 2: Kanzelhöhe Observatory of Solar and Environmental Research, University of Graz, Kanzelhöhe 19, Treffen, 9521, Austria

Abstract:
Coronal dimmings are regions of transiently reduced emissions observed in extreme ultraviolet (EUV) and soft X-ray (SXR) wavelengths interpreted as the decrease of coronal density and plasma evacuation due to the onset of coronal mass ejections (CMEs). CMEs are large structures of plasma and magnetic fields expelled from the Sun into the heliosphere. Solar CMEs are the main cause of space weather disturbances in Earth's atmosphere and magnetosphere. Thus, the development of diagnostic tools for coronal dimmings can yield additional information regarding CMEs, which can in turn be used for the detection of Earth-directed CMEs and stellar CMEs. We present a study of coronal dimmings associated with Earth-directed CMEs as observed in SXR by the XRT instrument onboard Hinode. We compare the derived characteristic quantities with those observed in EUV by AIA onboard the Solar Dynamics Observatory. By using these two instruments we observe how the solar corona restructures and refills with plasma after a CME eruption at different temperatures.

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"Relics from the Early Universe in Cosmic Voids"

J. Sanghavi
Ludwig-Maximilians-Universität München

Abstract:
Unlike halos, cosmic voids are anti-correlated with the dark matter, and the large-scale void bias can be negative. Thus, this work explores the information contained in voids, which complements the analysis using halos, and investigates the potential of cosmic voids to test local primordial non-Gaussianity and cosmological parity violation.
By utilizing a suite of 150 full N-body Quijote simulations, we analyze the void bias which exhibits scale-dependent corrections, like its halo bias counterpart. To enhance the analysis, we implement a unique weighing scheme, giving weightage to under-dense voids through compensation. Furthermore, we compare our results between voids identified in the halo density field and those in the dark matter distribution.
We also analyze 450 N-body Quijote simulations, divided into sets with different parity-violating parameter values. Intriguing signatures are found in the angular momentum of voids, exhibiting a non-zero correlation with the average velocity of the void. These findings suggest the potential for using pseudoscalars and other directional correlators to evaluate parity violation.
By utilizing cosmic voids, we can deep dive into the earliest moments of the Universe. Future surveys sensitive to voids might be able to confirm our findings and further constrain various models.

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"Planet Vetting of TESS data"

Laura Schöller; Arno Riffeser; Luis Thomas; Juliana Ehrhardt
University Observatory, Ludwig-Maximilians Universität München

Abstract:
The cornerstones of our current understanding of exoplanets undoubtedly rests on the groundbreaking missions of TESS and Kepler, which have discovered over 5000 exoplanet candidates. With the help of automated pipelines, the data is reduced and the lightcurves are inspected for transit signals. Despite attempts of filtering out conspicuous False Positive candidates such as eclipsing binaries, blended systems, or nearby transiting events, a significant number of them get reported as potential planets. The following confirmation process traditionally involves highly expensive ground-based photometric and spetroscopic observations. To be as efficient as possible with the limited observing resources, several techniques are available to validate transit signals before starting further surveillance. The goal is to create a secondary analysis "pipeline", which first employs the available methods and later examines the phasefolded lightcurve using a Python tool called Triceratops. This approach aims to identify specific False Positives, providing a nuanced perspective and guiding subsequent follow-up observations.

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"Unsupervised Classification of RR Lyrae Stars"

L. Steinwender [1], P. G. Beck [2,3], K. Hambleton [4], A. Hanslmeier [5]
1: Graz University of Technology; 2: Instituto de Astrofísica de Canarias; 3: Universidad de La Laguna; 4: Villanova University; 5: University of Graz

Abstract:
Big Datasets are becoming increasingly important in the field of astrophysics due to new powerful telescopes and surveys continuously observing our night sky, producing giant datasets. A prominent example of such large data streams is Vera C. Rubin LSST, designed to simultaneously monitor the variable southern night sky in 6 colors down to a limiting magnitude of r~24. Unsupervised machine learning (ML), a method of learning from patterns within the data, is key for gaining insight into this expected excess of photometric data.
We present our prototype classifier dedicated to classifying RR Lyrae variable stars into their relevant subclasses (RRab, RRc, and RRd), optimized for the expected needs of Rubin LSST. Using the classification from the RR Lyrae Catalog of the ESA Gaia mission, we constructed training sets containing ~30000 lightcurves using data from the Zwicky Transient Facility Catalog of Periodic Variable Stars (ZTF CPVS) and lightcurves extracted from Full-Frame-Images of the NASA TESS space telescope. We further preprocessed and analyzed these lightcurves using a custom-built Python package. Subsequently, using a Variational Autoencoder (VAE), we created a deep generative model to project the lightcurves into a low-dimensional representation, which quantitatively describes the characteristic shape elements of the lightcurves. In preparation for the Rubin LSST data, we apply our pipeline to the data of the Zwicky Transient Factory (ZTF), a precursor facility for Rubin LSST. We show how the results are improved with the inclusion of physical features such as period and variational amplitude. Through unsupervised clustering of this data representation, we identify the RR Lyrae subclasses in the ZTF data, which we anticipate to be easily adaptable to the Rubin LSST data.

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"Chemical Properties, Age- and Metallicity Gradients of Simulated Galaxies"

J.Stoiber; L. Valenzuela; L. Kimmig; R.-S. Remus
Universitäts-Sternwarte München

Abstract:
Photometric and integral field unit observations of the stellar component have shown galaxies to come in a large variety of morphologies and kinematics. By applying population synthesis techniques, it is possible to determine spatially resolved age and metallicity distributions.
Using the hydrodynamical cosmological simulation Magneticum, we analyze the global age properties of galaxies and investigate their correlations with the radial distribution of metallicity.
We classify the galaxies as disks, intermediates, and spheroids via the b-value, which is a proxy for a galaxy's position in the stellar mass - stellar specific angular momentum plane. Global properties of the galaxies are determined and radially binned to analyze age and metallicity gradients. Their stellar content is subdivided into an old, middle-aged, and young population. Correlations of the radial distribution of metallicities with global properties are then calculated, while their slopes are taken from a fit to radially binned data. The results are compared to observations from the SAMI, CALIFA, MaNGA, ALHAMBRA and TYPHOON surveys.
I will show that, while age correlates with morphology, metallicity correlates stronger with mass. As expected, disks are more rotationally supported than spheroids. In agreement with observations, I demonstrate the general trend that the age of galaxies increases with mass and that spheroids, on average, are older than the disks, at a fixed mass. The mass-size relation stays consistent with observations when split into the different age populations. Another important relation, the mass-metallicity relation is in general agreement with observations.
A slightly positive average age gradient in spheroids suggests an "outside-in" formation scenario, while disks, on average, have a negative central age gradient, suggesting an "inside-out" growth. Also, on average, the young and old stellar populations exhibit a different slope of the radial metallicity distribution. Our investigation reveals that the metallicity of the old population is rather loosely correlated with the radius, but always negatively. The young population’s correlations range from tight to loose and critically can be both negative or positive.

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"Determination of the Luminosity of Stars at the Tip of the Red-Giant Branch from Gaia Observations as Proxy for the Effectiveness of Axion Cooling"

Suntinger T. [1], Beck P. G. [1,2], Camalich Jorge Martin [2], Hanslmeier A. [1]
1: Institut für Physik, Institutsbereich Geophysik, Astrophysik und Meteorologie, NAWI Graz, University of Graz, Universitätsplatz 5/II, 8010 Graz, Austria; 2: Instituto de Astrofísica de Canarias, E-38200 La Laguna, Tenerife, Spain

Abstract:
The Tip of the Red Giant Branch (TRGB) of a Globular Cluster (GC) marks the point of helium ignition in a star. Neutrinos, produced by plasma oscillations in the degenerate core of a red-giant branch (RGB) star , are cooling its core. Consequently, the star requires longer to reach helium's ignition temperature, allowing it to continue its evolution on the RGB. Consequently, the cooling of the core leads to an increased luminosity at the TRGB. This opens a possibility to test for the existence of an additional exotic cooling channel based on axions - hypothetical particles and dark matter candidates.
The challenge in determining such a precise luminosity at the TRGB evaluation lies in the sparse population of the upper RGB and its contamination by AGB stars. Moreover, the statistical probability of finding a star at the TRGB is infinitesimally small. Approximations based on statistical RGB distributions and the brightest found RGBs in the GCs are used as a solution. Variable RGBs pose yet another challenge to these approximations. Additionally, systematic uncertainties as reasons for the slight TRGB brightness increase need to be excluded.
To date, the Gaia satellite mission provides the largest coherent star catalogs (including high-precision astrometry, photometry, and spectroscopy).
In this poster, we present methods for deriving the bolometric absolute GC TRGB brightness as a proxy for the effectiveness of axion cooling on GC M5 (NGC5904) using recent Gaia DR3 catalogs. With Gaia DR3 catalogs, we derived the bolometric TRGB brightness of GC M5 (NGC5904). Using epoch photometry from Gaia DR3 for the four brightest RGs on the branch led to identifying one member as a long-period variable with a brightness range spanning over 0.9 mag, and a maximum brightness range of 0.2 mag for the remaining three members. Thanks to the epoch photometry, long-period brightness variability was also considered in the uncertainty estimation, leading to the bolometric GC TRGB brightness (-3.50 ± 0.31) mag for GC M5.
Methodologies based on axion-electron interactions via bremsstrahlung and provided by Straniero et al. (2020) were applied to the bolometric TRGB brightness, yielding an even lower stringent upper bound on the axion-electron coupling constant of 2.22, compared to the result of 2.30 from Straniero et al. (2020). A re-investigation of interstellar extinction, bolometric correction, and the use of future Gaia data releases 4 and 5 will lead to a significant quality increase of the TRGB brightness and most likely to an even tighter stringent upper axion-electron coupling bound.

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"Differentiable cosmological hydrodynamics"

Katyayani Trivedi
University of Vienna

Abstract:
Numerical simulations are an important tool for studying the formation and evolution of structures in our universe. Increasingly, we are interested in understanding how predictions depend on parameters or specific initial conditions. These questions can be answered by codes that are auto-differentiable. DISCO - DJ is a differentiable package for cosmological simulations implemented in JAX. In a quest to extend the currently available module and to include baryon hydrodynamics, a finite volume Godunov scheme is implemented in this code. Some first results of this effort are presented here.