"Galaxy archaeology - The quest for ancient mergers"

Christine Ackerl
Universität Wien - Institut für Astrophysik

Abstract:
The LCDM cosmological model requires that gravitational attraction continuously leads to mergers of dark matter halos. The galaxies and their halos we observe in the local universe, must have formed hierarchically over time, with smaller systems being accreted by larger ones. State-of-the-art cosmological simulations do reproduce the observed large-scale hierarchical clustering of galaxies. However, challenges concerning the assembly of galaxies and the interplay of baryonic processes and dark matter remain.
To bridge the gap between simulations and observations it is crucial to understand how the structure and observed properties of galaxy stellar halos are impacted by mergers. To achieve this we need detailed *observational* constraints on the hierarchical assembly of galaxies. Because the dominant epoch of galaxy assembly lies in the early universe, this is an extremely challenging task. Typically the stellar systems of the most significant mergers are well mixed by redshift ~0.
The aim of galaxy archaeology is to disentangle these accreted stellar populations from the stellar halo light of nearby galaxies using techniques such as stellar population fitting and dynamical modelling. With the advent of integral field spectroscopy, this research field has seen significant progress. However, the required mapping from spectra of the stellar halo light to full age and metallicity distributions is methodologically challenging. Interpreting merger signatures in the derived age and metallicity distributions adds an additional level of uncertainty. This cumulative build-up of systematic uncertainties makes it challenging to uncover ancient mergers with such a “top-down” and step-by-step approach.
In this talk I present a novel “bottom-up” approach, where we forward model the assembly of galaxy halos. In this manner we can condense the full assembly history into multiple model outputs suitable for comparison to raw/simpler observational data of galaxy halo light. Additionally we can, for the first time, produce simultaneous predictions for multiple complementary tracers of the assembly of a galaxy’s halo - globular cluster populations and chemical/age distributions of stars.
Our approach is as follows: we model accretion times, mass ratios and tidal stripping for each dark matter subhalo. We use agnostic/stochastic star formation histories, which are based on observations of galaxy population star formation rates at different redshifts to set the stellar mass growth for each galaxy - including chemistry and quenching. Additionally, we model the chemical properties of each galaxy’s star clusters self-consistently with the star formation and chemical evolution histories of their host galaxies.
The resulting library of models contains millions of self-consistent halo + baryon assembly histories for hundreds of different total stellar ex-situ fractions and host galaxy stellar masses. For each assembly history we have the flexibility to predict observables of:
- Composite (in-situ, mixed with ex-situ) spectra and spectral energy distributions of the galaxy stellar halo light
- Age-metallicity distributions with local ex-situ fraction predictions in different age bins (to assess merger times)
- Ages, merger times and chemical properties of all surviving ex-situ and in-situ globular clusters.
With our approach we can assess self-consistently whether two different tracers of merger histories (e.g., globular cluster colours, and age-metallicity distributions from stellar spectra of the host galaxy), are both consistent with observations. Furthermore, the method prevents the build-up of systematic errors known from existing step-by-step approaches. Additionally it is well suited to recover the ex-situ fraction and merger history in major merger cases, where the stellar population properties between the primary and secondary system may be very similar.
In this talk I will showcase the first results from applications of our method to stellar halo spectra and globular cluster populations of nearby galaxies.

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"Quantitative Spectroscopy of OB-type Stars with Machine Learning"

P. Aschenbrenner
Universität Innsbruck

Abstract:
OB-type stars are of great importance for a detailed understanding of galaxy formation and evolution. Due to their high luminosity, these stars can be observed not only in our own galaxy but even outside the local group. The only information we obtain from these objects is the light they emit. Nevertheless, it is possible via quantitative spectroscopy to study the spectra and to determine the physical and chemical properties of stars via a hybrid non-LTE (non-local thermodynamic equilibrium) method. I mainly focus on stars with spectral types ranging from B2 to O9. They have weak stellar winds and show strong metal absorption lines in the optical part of their spectrum. To handle the large amount of publicly available data nowadays, I employ different machine learning techniques to simplify and automate the analysis process.

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"Using red clump stars as probes of stellar interior dynamics: focus on overshooting and magnetism"

L. Barrault [1]; L. Bugnet [1]; S. Mathis [2]; A. Serenelli [3]
1: Institute of Science and Technology Austria (ISTA); 2: AIM, CEA, CNRS, Université Paris-Saclay; 3: Institute of Space Sciences (ICE, CSIC) Barcelona

Abstract:
Low-mass stars undergoing Helium burning in their core represent a well defined and populated feature of the HR diagram, the "red clump" (RC). RC stars are unique probes of their past-evolution stages, as their structure and hence seismic and photometric observables vary according to the modelling parameters chosen along the Main Sequence and the Red Giant Branch. Their study gives constraints on the dynamical processes mixing the internal stellar plasma. Namely, the overshooting phenomenon and magnetism are two cornerstones of the physics of stellar interiors. Overshooting brings more mixing, hence extending the lifespan of stars. Magnetism distributes plasma along the field lines, often inhibiting convection and mixing. Both processes are key to understand stellar dynamics and better constrain stellar evolution and ages in the Universe.

First, we show using the stellar evolution code GARSTEC and the APOKASC-3 survey that the variation of the overshooting parameter plays a significant role in the relative size of the Helium core, hence in the morphology of the RC and the transition mass towards the Secondary Red Clump, formed of higher mass core Helium burning stars in which the onset of He burning would occur into non-degenerate conditions. We conclude on giving constraints for the overshooting parameter that are independent of previously derived estimations, and anticipate a mass dependence of such a parameter, that will be derived in the near-future.

Second, we use such corrected modelling prescriptions to evolve low-mass stars up to the RC with the stellar evolution code MESA, and investigate the persistence of a stable magnetic field previously detected in the radiative zone of early Red Giants. We use GYRE (state-of-the-art stellar oscillation code) coupled to the newly developed MAGSPLITPY code computing magnetic frequency splittings. We show that even for the expected weak amplitude of a stable magnetic field, the magnetic signature is non-negligible in the low-frequency range of the detectable mixed p-g modes and follow the overall tendency previously observed in RGB stars. However, unlike for the case of their younger counterparts, the magnetic splitting obtained is highly dependant on the discontinuities of the Brunt-Väisälä frequency near the convective core, arising primarily from the adopted prescription on extra-mixing. Such results in turn strengthen our interest in using RC stars as unique probes for stellar physics and prove that constraints in the modelling of dense core convection and overshooting will have an appreciable impact on the measurement of magnetic fields inside RC stars in the future, and therefore on our knowledge of stellar evolution.

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"Analyzing the substructures of Coronal Mass Ejection using WISPR"

Greta Cappello
University of Graz

Abstract:
Parker Solar Probe (PSP; launched in 2018) and Solar Orbiter (SoLO; launched in 2020) observe the Sun from unprecedented close-in and out-of-ecliptic orbits. This unique and high-resolution data will give us new insights about the initiation and early evolution of coronal mass ejections (CMEs) in the inner heliosphere. Especially the combination of remote sensing solar imagery in EUV and white-light together with in-situ plasma and field measurements is expected to reveal a better understanding about the nature of CMEs. The solar source region, the eruption characteristics and underlying magnetic reconnection process are expected to be reflected in the different CME substructures, e.g., showing shell-like structures and rays, which are not yet fully understood. To investigate the complexity of small-scale features belonging to coronal mass ejections (CMEs), we use high-resolution white-light image data from heliospheric imager WISPR, aboard Parker Solar Probe. We analyzed a CME case study using a multi-spacecraft approach to support the analysis and data interpretation.

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"Alignment of diffuse interstellar bands"

Alexander Ebenbichler
University of Innsbruck

Abstract:
Context. There have been many attempts to identify families of diffuse interstellar bands (DIBs) with perfectly correlating band strengths. However, although major efforts have been made to classify broadly based DIB families and important insights have been gained so far, no family has been identified with sufficient accuracy or statistical significance to prove that a series of selected DIBs originates from the same carrier. This can be attributed in part to the exclusive use of equivalent widths to establish DIB families.
Aims. In a change of strategy we search for DIBs highly correlated in both band strength and profile shape. This approach increases the chance that correlating DIBs are members of one family, and originate from the same carrier molecule. Subsequently, we search for correlations between DIB profile families and atomic interstellar lines, with the goal to further constrain possible DIB carriers.
Methods. We adapt the well known method of time-series alignment to perform spectral alignment, that is, DIB alignment. In a second step, we analyse the alignment results using clustering analysis. This method requires a statistically significant data set of DIB sight lines. The ESO Diffuse Interstellar Bands Large Exploration Survey (EDIBLES) data are perfectly suited for this application.
Results. We report eight DIB families with correlating strengths and profiles, as well as four previously unreported DIBs in the visual range using DIB alignment. All profile family members show Pearson correlation coefficients in band strength higher than 0.9.

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"SDSS J1741+8842: a gravitationally lensed binary quasar"

Leon Ecker
LMU Munich, Universitätssternwarte

Abstract:
The Hubble tension, a significant challenge in cosmology, has sparked extensive research efforts to come up with different methods of measuring the Hubble constant. One independent method based on time-delay cosmography uses strong lensed variables sources. The key to the success of this approach lies in the construction of a good strong lensing model. My research focuses on an intriguing system featuring two quasars, one lensed twice and the other four times. I will give an overview of strong lensing and talk about this particular system.

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"Nucleosynthesis in black hole accretion disks: a channel to form enriched stars in globular clusters?"

Laurane Fréour
University of Vienna

Abstract:
Considered as a prototype of simple stellar populations for a long time, globular clusters are now known to host multiple stellar populations. In addition to stars with “pristine” chemical abundances, “enriched” stars have been found, showing enhancement in light element abundances. Many scenarios have been suggested to shed light on the origin of these multiple populations, but none of them can reproduce all the observations. Most of these scenarios involve a mixing between pristine and “enriched” material coming from a polluter. Breen (2018) suggested that black hole accretion disks could be a possible source for the polluted material, which can then be ejected through outflows and mix with pristine material. We investigated the feasibility of producing “enriched” material in black hole accretion disks by means of a 132-species reaction network, varying the temperature of the gas and the timescale for the accretion. Given an accretion disk model, we explored the values of mass, mass accretion rate, viscosity, and radius of the black hole-accretion disk system that would allow for the creation of elements of interest, before the gas is accreted by the central object.
Our findings reveal that there is only a very limited region where the formation of some of the relevant elements to explain the presence of multiple populations is plausible; this region corresponds to black holes masses and viscosity parameters that are highly unlikely, based on current observations, thus leaving the puzzle on the origin of multiple stellar populations remains unsolved.

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"KIC 9163796 - Age determination by asteroseismic grid modelling for an oscillating red giant binary"

D. H. Grossmann; P. G. Beck; L. S. Schimak; N. Muntean; C. Johnston; J. Zinn; S. Mathur; A. Hanslmeier
Instituto de Astrofisica de Canarias, Tenerife, Spain

Abstract:
The age of a star cannot be measured but only inferred from observational quantities related to age. A well-known stellar age greatly impacts our understanding of evolution on much larger scales, such as exoplanetary systems or the history of the Milky Way. For stars in the red-giant phase, comparison of observations with evolutionary models delivers ages that are typically determined with statistical uncertainties between 30 and 50%. These uncertainties originate from ill-constrained intricacies of the stellar input physics and related parameter degeneracies that cannot be resolved from modeling single stars.
Double-lined spectroscopic (SB2) binaries, where certain spectroscopic lines are available for both components, provide a unique opportunity to constrain stellar physics, potentially leading to better stellar ages. Additionally, detectable oscillation-power excesses in one or both components in a binary system enable an independent calculation and confirmation of stellar properties, such as mass, radius, and composition. In this talk, we present the in-depth analysis of KIC9163796, a double-lined oscillating red-giant & red-giant binary system. Although having a mass ratio of almost unity, both components vary significantly in effective temperature, luminosity, radius, and lithium abundance. We use the differences observed in the stars to constrain the two combined models for the primary and secondary. By creating a multi-dimensional model grid for the combined modeling approach of both components, we used the stellar evolution code MESA and the theoretical frequency spectrum of the stellar oscillation modes to evaluate the best values of the masses, the convective parameters, and initial helium, at the constraints of identical ages and metallicity.
This modeling approach also allowed us to determine the age of the system with a 20 % precision (tau = 2.5 ± 0.5 Gyr). In conclusion, this binary system provides an important benchmark for improved age determination on the red-giant branch.

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"The influence of accretion bursts on methanol and water in massive young stellar objects"

Rodrigo Guadarrama
Universitat Wien

Abstract:
The effect of accretion bursts on massive young stellar objects (MYSOs) represents a new research field in the study of young stars and their environment. The impact of such bursts on the disc and envelope has been observed and plays the role of a "smoking gun" providing information about the properties of the burst itself. We aim to investigate the impact of an accretion burst on massive disks with different types of envelopes and to study the effects of an accretion burst on the temperature structure and the chemistry of the disk. We focus on water and methanol as chemical species for this paper.
The thermochemical code of Prodimo (PROtoplanetary DIsk MOdel) is used to perform simulation of high mass protoplanetary disk models with different types of envelopes under the presence of an accretion burst. The models in question represent different evolutionary stages of protostellar objects. We calculate and show the chemical abundances in three phases of the simulation (pre-burst, burst, and post-burst).
More heavily embedded disks show higher temperatures. The impact of the accretion burst is mainly characterized by the desorption of chemical species present in the disk and envelope from the dust grains to the gas phase. When the post-burst phase starts, the sublimated species freeze out again. The degree of sublimation depends strongly on the type of envelope the disk is embedded in. An accretion burst in more massive envelopes produces stronger desorption of the chemical species. However, our models show that the timescale for the chemistry to reach the pre-burst state is independent of the type of envelope.
The study shows that the disk's temperature increases with a more massive envelope enclosing it. Thus, the chemistry of MYSOs in earlier stages of their evolution reacts stronger to an accretion burst than at later stages where the envelope has lost most of its mass or has been dissipated. The study of the impact of accretion bursts could also provide helpful theoretical context to the observation of methanol masers in massive disks.

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"How the environment impacts the properties of galaxies in the early Universe"

Gauri Kotiwale
Institute of Science and Technology Austria

Abstract:
The Epoch of Reionisation marks the phase transition from a dark universe with neutral hydrogen to an ionised universe through which UV photons can pass. Young star-forming galaxies are considered to be the key sources responsible for the reionisation of the Universe, but the details are unclear. It is particularly unclear how to separate the properties of the individual ionising sources from their large-scale environment. I will present results using JWST/NIRCam wide field slitless spectroscopy and imaging observations in several fields centred on bright quasars at $6 < z < 7$ from the EIGER survey and a bright galaxy in the COSMOS field. I perform stacking of rest-frame optical spectra of [OIII] emitting galaxies to understand how the environment impacts the properties of the galaxies, especially analysing the galaxies in overdensities around the bright quasars.
This work will help shed new light on the properties of sources that contribute to the tail-end of the epoch of reionisation of the Universe and help understand the environments in which luminous quasars form.

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"Statistics of Coronal Bright Points and Preparation of a CBP Simulation with Hinode and SDO data"

Isabella Kraus; Philippe-A. Bourdin
Institute of Physics, University of Graz

Abstract:
The exact coronal heating mechanism remains a riddle, but magnetically active regions are known to trigger extreme-UV emission along coronal loops. Also at much smaller scales, there are small bipolar regions that can be associated with evenly sized coronal bright points (CBPs). We study the statistical properties of CBPs with continuous data from the SDO spacecraft to track the lifetime of CBPs. We aim to verify if the lower corona co-rotates with the photosphere. From 346 CBPs we extract information on their lifetime, size, shape, polarity, etc. We then compare the CBP lifetime with its shape and EUV visibility. From the CBP tracking algorithm we confirm a strict co-rotation of the CBPs with the photospheric differential rotation. Furthermore, we like to reproduce one CBP in a 3D magneto-hydrodynamic simulation. A vertical Poynting flux is created from horizontal advection motions in the photosphere that perturb the magnetic field. We verify if the coronal heating is from Ohmic dissipation of direct currents. The observational data for the CBP simulation is obtained from the Hinode/SOT instrument and is complemented with SDO/HMI data. This allows us to enlarge the field-of-view, so that the simulation is driven fully by observed photospheric magnetic fields. The bottom and top model boundaries are fully closed for mass and heat flows. The hottest and brightest CBPs seem to exist for significantly longer time, up to 24 hours, than compared to fainter CBPs. The merging of two CBPs has no influence on the overall size of the persisting CBP. We also find that the merging of two CBPs is a relatively rare phenomenon. Loop-like CBPs are usually bipolar and their merging probability is low. Weaker magnetic polarities produce fainter and cooler CBPs. This supports that the CBP heating is mainly based on magnetic energy dissipation.

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"The gas and stellar content of the LSB galaxy MCG+00-03-004 as seen by MUSE"

Federica Mauro
University of Vienna

Abstract:
A low surface brightness galaxy (LSB) has a surface brightness magnitude lower than the night sky. The LSB galaxy MCG+00-03-004 has been recently observed with the MUSE spectrograph. The data revealed an irregular morphology and a plethora of HII regions heterogeneously distributed. The final goal of this project has been to gain insight into the properties of the galaxy's baryonic matter. At first, we characterised the overall stellar populations to subtract the stellar continuum. Then we determined the number and properties of its HII regions, including distribution, Hα luminosity, extinction, density, temperature and metallicity. Finally, we studied the internal kinematics of the galaxy, in particular, looking for regular motions of gas and comparing its rotational curve to other studies on LSB galaxies.

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"Co-evolution of disk and bulge components in spiral galaxies since the cosmic noon"

Federica Mauro
University of Vienna

Abstract:
Over the past two decades, there have been quantitative investigations into the evolution of galaxies through measurements of physical properties. However, these studies have only derived global values of the characteristic properties of distant and faint galaxies, ignoring the fact that the two distinct but intertwined components of bulge and disk have very different star formation and chemical enrichment histories, which result in a different spectral energy distribution (SED) and mass-to-light (M/L) ratio. This PhD project aims to explore the growth of the two primary structural components of spiral galaxies, the disk and bulge, using innovative methods to shed light on the differential evolution of the main structures of disk galaxies up to 4 Gyr after the Big Bang. It will quantitatively investigate the influence of CMOD (Papaderos, Östlin & Breda 2023) on previous determinations of the Tully-Fischer relation (TFR) since $z \approx 2$ and develop semi-empirical prescriptions to overcome its impact. CMOD is the differential chromatic modulation due to different SFHs of co-existing galaxy components bulge and disk. The work will employ spatially-resolved analysis of the physical properties of the bulge and disk, utilizing MAGPI high-quality integral field spectroscopy (IFS) data for a representative survey of rotationally supported galaxies at $z \approx 0.3$. Population spectral synthesis codes (FADO and Starlight) will infer the spatially resolved star formation and the chemical enrichment history of the galaxy sample, focusing on the bulge-to-disk age contrast at $z \approx 0.3$. Additionally, this comprehensive treatment of CMOD effects would allow for a precise determination of M/L(z, filter), incorporating spatially resolved k-correction and ε evolutionary corrections from our simulations and compute the effects on the integral magnitude and colour considering an evolutionarily consistent context. Finally, the focus will shift to constructing kinematic scaling relations, like TFR, and comparing them with simulations.

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"Settling motions in 1D stratified models of stellar coronae"

Vartika Pandey; Philippe-A. Bourdin
Institute of Physics, University of Graz

Abstract:
1D MHD simulations are important to understand plasma's response to heating. They have provided us with important results in solar and stellar physics, e.g. inversion studies, spectro-polarimetric studies, loop models for flares etc. And of course 1D models provide better spatial resolution with less computational and time demands. Most of these 1D simulations require a model atmosphere to start and the ones available are not exact to our current understanding of the Sun and other stars.
Here, we present a 1D sample atmospheric model that spans from the solar interior to the outer corona of the Sun. We investigate the effect of resolution/grid distance on the numerical stability of a simulation and also emphasize the importance of parametric studies to get the simulation setup as realistic as possible. We also talk about various heat/energy transfer mechanisms and which one suits best to maintain realistic temperature and density profiles.
When a stratification is transferred to a new simulation setup the numerical and analytical derivatives are not identical so, the initial hydrodynamic equilibrium is inexact. To find an equilibrium, pressure imbalances need to settle and later, shock waves are generated. These observed motions in the vertical direction have amplitudes up to 10 km/s. This effect would stop us from comparing our model output with realistic observed Doppler shifts of about 2 km/s. Therefore, we settle our initial stratification with 1D-MHD simulation under realistic solar parameters, like mass diffusion, heat conduction, viscosity, radiative losses, upwards decreasing magnetic field pressure, and Spitzer heat conduction along the magnetic field. We implement an artificial heating function for the corona that resembles the heating in a self-consistent 3D model driven by observations. This way, we avoid the collapse of solar corona due to insufficient heating in the 1D case. We are able to maintain the high temperatures in the corona with our artificial heating function. Generally, it might sound right to use lower diffusion constants for finer grid resolutions, but we find actually more diffusion is needed to maintain stratification models numerically stable.
Thus we present a complete atmospheric stratification that spans from the interior to the outer corona and can be used as the initial condition for 3D-MHD simulations and is able to replace older stratifications like the VAL-C and FAL-C that have shortcomings like too low spatial extent or insufficient methods.

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"The molecular gas perspective on the growth and death of Hα emitters in the Spiderweb protocluster at z=2.16"

Jose Manuel Perez Martinez
Instituto de Astrofisica de Canarias (IAC)

Abstract:
Galaxy clusters at low redshift are dominated by massive quiescent galaxies hosting stellar populations >10 Gyrs old, indicating that they were formed in the early universe when clusters were still in the process of being assembled (i.e., protoclusters). The rapid growth of galaxies within protoclusters is driven by the efficient transformation of the cold gas reservoir into stars until the sudden shutting down of star formation. However, the exact mechanisms governing this phase of accelerated galaxy evolution remain unsettled, with both supermassive black hole growth and environmental effects as the main contenders. To shed light on this question, we obtain CO(1-0) molecular gas information with the Australia Telescope Compact Array on a sample of >30 spectroscopically confirmed Hα emitters in the Spiderweb protocluster at z = 2.16, and investigate the link between their star formation, AGN activity, and molecular gas reservoirs as a function of environment. We discuss the relative importance of in-/outflow processes in regulating the accelerated evolution of star-forming galaxies at the early phases of cluster assembly and propose a combination of AGN feedback and overconsumption as the main mechanisms leading to the onset of the red sequence in this massive cluster in formation at the cosmic noon.

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"Deep Learning & Philosophy - On the epistemic role of Deep Learning in science"

I. Piantschitsch
1: Institute of Physics, University of Graz, Austria ; 2: Department of Physics, University of the Balearic Islands (UIB), Spain

Abstract:
Deep learning networks are ubiquitous in many branches of science and engineering, however, not all the details of their underlying mathematical structure is comprehensively understood. This fact undoubtedly raises questions regarding the use of deep learning as a valid scientific method but also regarding its relation, its differences, and its similarities to computer simulations, experiments, and observations. The interdisciplinary project “DeLPhi – Deep Learning & Philosophy”, which is funded by the Styrian government, aims to analyse benefits, challenges, and risks of applying deep learning networks in science. The international team working on this analysis includes experts in the fields of mathematics, physics, cognitive science, philosophy, law, and art. The objective of the project is the mutual exchange of expertise in the different fields, such as the mathematical background of deep learning, its application in astrophysics, its epistemic content but also its implications on technology law for instance.

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"Extragalactic Stream Models based on 1D Gaussian Slices"

Jan-Niklas Pippert
Max Planck Institute for Extraterrestrial Physics

Abstract:
From the ΛCDM paradigm it is expected that galaxies merge and grow in extreme and violent environments. These processes form tidal features of various shapes and properties depending on the merger mass ratio, orbital parameters, and gas richness. We use 170 archival g ′ band observations of local ($z \leq 0.08$) galaxy clusters, captured with the Wendelstein Wide Field Imager (WWFI) to identify tidal features around galaxies in these fields. Of the features that were discovered, 15 have been selected for more detailed photometric studies. A fast and innovative technique was developed for determining the photometric characteristics of tidal streams and tails. It utilizes a Gaussian distribution with higher-order moments to describe the light profile of such features perpendicular to their elongation direction. Apertures are generated directly from a FWHM criterion. It can be utilized for large samples, which are produced by upcoming surveys, e.g., EUCLID (not only for low but perhaps for higher redshifts). The deep Wendelstein images allow measuring the surface brightnesses inside one FHWM down to ∼ 27 g ′ mag arcsec−2 . The streams have on average ∼ 26.1 g ′ mag arcsec−2 and are dimmer than the tails in our sample (∼ 25.2 g ′ mag arcsec−2). Structural parameters, such as the effective radius Re and the effective surface brightness µe are compared to various galaxy types. From that, we suggest, from our small sample size, that streams originate most likely from ellipticals and spirals, whereas dwarfs are excluded due to their faintness.

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"Dynamical inference for orbit distributions of galaxies - case study of NGC 4550"

Stefanie Reiter
University of Vienna, Department of Astrophysics

Abstract:
A key aspect in studying galaxy evolution is the stellar dynamics, within which a galaxy's formation history is encoded. To disentangle the different dynamical components of observed galaxies, it is possible to construct orbit distributions from observations using orbit-based dynamical modeling. This requires the accurate extraction of the stellar kinematics from observed integrated light spectra. The most commonly used software for kinematic extraction, pPXF, results in a parametric description of the line of sight velocity distribution (LOSVD) using Gauss Hermite models. These have difficulty recovering the bimodal LOSVDs of counter-rotating galaxies, and we therefore expect as of yet unchecked biases in the dynamical inference. We test this by comparing the dynamical models of well-known counter-rotating galaxy NGC 4550 inferred from stellar kinematics extracted with pPXF to those inferred from an alternative approach using a non-parametric description of the LOSVD, Bayes-LOSVD. This talk will focus on the significant differences we find in the dynamical inference, as well as our ongoing work to address open questions concerning regularization on the orbit space.

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"Modeling CMEs as Large Scale Magnetic Flux Ropes"

Hannah Theresa Rüdisser
Austrian Space Weather Office, GeoSphere Austria Graz, Graz, Austria

Abstract:
Accurate forecasting of space weather impacts from coronal mass ejections (CMEs) demands a profound understanding of their structure and evolution. New observations, facilitated by rising solar activity and missions such as Parker Solar Probe and Solar Orbiter, provide unprecedented insights into the global shape and structure of CMEs. The 3D Coronal Rope Ejection Model (3DCORE) assumes an empirically motivated torus-like flux rope structure that expands self-similarly within the heliosphere, influenced by a simplified interaction with the solar wind environment, and carries along an embedded analytical magnetic field. We utilize an approximate Bayesian computation sequential Monte Carlo algorithm to fit the in situ magnetic field observations, which allows us to generate estimates on the uncertainty of model parameters. This model can be used to quickly determine physical parameters of an event, advancing research on the global magnetic structure of CMEs. Anticipated contributions from upcoming missions like PUNCH, Vigil, and potential future constellation missions further promise advancements in space weather forecasting.

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"Influences of data processing techniques on the interpretation of atmospheric spectra from JWST"

S. Schleich [1]; S. Boro Saikia [1]; C. Changeat [2]; M. Güdel [1]; A. Voigt [1]; I. Waldmann [3]
1: University of Vienna; 2: European Space Agency - STScI; 3: University College London

Abstract:
The characterisation of exoplanet atmospheres through spectroscopic observations is the next step in advancing our understanding of exoplanetary systems. The field of exo-atmospheres is at a turning point thanks to the recent launch of the James Webb Space Telescope (JWST). However, the combination of increased sensitivity and wavelength coverage requires significant care in the reduction and interpretation of these observations, as the resulting data products determine the conclusions drawn by retrieval algorithms. We present an analysis of a JWST near-infrared observation of the Hot Jupiter WASP-39 b, comparing atmospheric characterisation results obtained from transmission spectra produced with varying data reduction assumptions. Investigating the impact of these assumptions on retrieved atmospheric parameters provides us with important insights into best practices for investigating the extensive amount of exo-atmosphere spectra expected from JWST.

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"Asteroseismology: Unveiling Stellar Nature Through Oscillation Pattern Recognition"

Kanah Marie Smith
Institute of Science and Technology Austria (ISTA)

Abstract:
Solar-like stars oscillate as a result of sound and gravity waves that propagate through the sphere; the waves allow us to then probe the stellar interior for information on its physical properties. These stars will evolve off the main sequence to the red giant branch (RBG) and subsequently either to the red clump or secondary red clump stages depending on their mass. Additionally, some solar-like stars, that we have yet to understand, have low-amplitude (ℓ=1) oscillation modes, dubbed “depressed” stars. Asteroseismology allows us to disentangle the classifications of these stellar evolutionary stages as red giant star populations, on the Hertzsprung-Russell diagram, tend to overlap between these regions. With the amount of currently available data, it is necessary to automate the classification process. Using a machine learning-based method, I worked to automate this disentanglement by using seismic data from stellar oscillations, since oscillatory patterns are characteristic of stellar age, to further sort these stars according to their evolutionary history. In this research, I have performed the classification of about 18,000 evolved stars, observed during the Kepler mission, based on their oscillation patterns; this is the largest sample of red giants that has been classified automatically and will allow for better studying of the interior dynamics of evolving solar-like stars.

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"Exoplanet Detection with the FOCES spectrograph"

Luis Thomas[1,2]; Juliana Ehrhardt [1]; Hanna Kellermann [1]; Arno Riffeser[1]; Frank Grupp[1,2]; Roberto Saglia [1,2]
1: University Observatory, Ludwig-Maximilians-Universität München; 2: Max-Planck-Institute for extraterrestrial Physics

Abstract:
We present the FOCES spectrograph and its results from the first two observing programs. FOCES is a fiber-fed, optical, high-resolution (R 60,000) Echelle spectrograph that is installed at the 2.1m telescope on the Wendelstein Observatory in the German Alps. The main goal is to perform precise mass measurements of new exoplanet candidates. To achieve the target stability of ~ 1 m/s the spectrograph is placed inside a temperature and pressure stabilized tank (<0.01 K and <0.1 hPa) and uses a laser-frequency comb for precise wavelength calibration. The first two observing programs started in May 2022. One is dedicated to the detection of hot-Jupiter candidates and the exploration of the magnitude limit for FOCES. The second program aims to detect intermediate sized super-Neptunes (4 - 8 $R_\oplus$) in and around the Neptune desert. The main results are the confirmation of six new exoplanets including 4 hot-Jupiters and 2 super-Neptunes.

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"The Dynamical Evolution of Planets Orbiting Interacting Binaries"

Santiago Torres
Institute of Science and Technology Austria (ISTA)

Abstract:
15% of solar-type stars are in such close binaries that interaction is bound to occur as the stars evolve and swell. Only ten planets have been detected orbiting binary systems. This suggests that dynamical processes play a key role in the evolution of circumbinary planetary systems. Understing the interaction between the bodies in such complex systems is important for planet formation and binary evolution. The tightest orbit binaries should host the most stable and, therefore, long-lived circumbinary planetary systems. Still, they are also the systems that are expected to experience mass transfer, common envelope evolution, or stellar mergers. Subdwarfs are one of the most common types of products resulting from binary evolution. They are both long-lived and easy to recognize. Understanding the impact of subdwarf formation on the surrounding planetary system, therefore, constitutes one of the most promising avenues for revealing how binary evolution, in general, affects planetary systems.
In order to disentangle the dynamic evolution of planets around evolved and interacting binaries, we developed an integration framework that seamlessly integrates the binary evolution data from the stellar evolution code MESA into a detailed N-body simulation code REBOUND. To ensure numerical robustness, we constructed a binary star model and introduced a recalibration method to mitigate errors from updates of binary properties during dynamical computations. We reveal that the nearest stable orbital separation for circumbinary planets is roughly 2.5 times the binary separation after mass transfer. In this talk, I will present our new method, model and latest results of the evolution of planets whose host binary evolves into a subdwarf system.

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"Numerical simulations of Ohmic heating of a coronal loop above a sunspot group"

Johannes Tschernitz; Philippe-A. Bourdin
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Abstract:
The high coronal temperatures of above 1 MK are not fully explained yet. A promising candidate among the various heating models is Ohmic dissipation of direct currents. Advective motions in the photosphere cause disturbances in the magnetic field, which propagate along the field and eventually reach the corona. The Poynting flux indicates the transport of energy into the corona. Due to the stresses, current sheets will form in the corona, where the energy is dissipated and heat the plasma.
We perform an observationally driven simulation of the heating of a coronal loop above a bi-polar active region via Ohmic heating. The simulation uses a grid of 1024×1024×256 grid points and covers a domain of 237×237×156 Mm^3. Magnetograms from the Narrowband Filter Imager (NFI) instrument on board of the Hinode satellite serve as boundary conditions and are also used to initialize the magnetic field in the simulation box. A photospheric velocity driver provides the necessary motions and consists of a large-scale velocity field derived from the magnetograms and an artificial granulation driver, which provides the small-scale motions generated by the granulation. The driver and the magnetic field create the vertical Poynting flux, indicating energy transport to the corona. The simulation is allowed to evolve self-consistently for a time period of ~3800 seconds.
After some time, the disturbances in the magnetic field become strong enough so that Ohmic heating sets in and starts to heat up the loop, counteracting the energy losses. The loop reaches coronal temperatures. With the increasing temperature, energy losses get also larger and after ~3600 s the losses balance the heating in the loop. We observe a maximum temperature of around 1.8 MK in the loop. We use the CHIANTI atomic database to calculate synthetic EUV emission and Doppler shifts with the values for temperature, density and velocity obtained from the simulation. The calculated synthetic emission and the Doppler shifts are then compared to co-temporal and co-spatial observations of the active region made with the EUV imaging spectrometer (EIS) on board of the Hinode satellite in the Fe XII spectral line at 195.12 Å. The comparison shows a hot loop at the same time and place above the active region and also the Doppler shifts show agreement with the observations.

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"Solar Magnetic Flux Ropes and their Early-Stage Evolution"

Andreas Wagner [1,2]
1: University of Helsinki; 2: KU Leuven

Abstract:
Solar eruptions can affect our technology and life on Earth significantly. The fundamental, underlying structure is a magnetic flux rope – a bundle of magnetic field lines which wraps around a common axis. Since we cannot measure the magnetic field in the solar atmosphere, numerically modelling the magnetic field, based on the conditions observed on the solar surface has become the standard approach. However, accessing the fundamental magnetic structures in the simulation data and tracking their evolution is not trivial. To deal with this problem, we developed a semi-automatic flux rope extraction and tracking tool, complemented by a graphical user interface. The method utilizes the twist parameter, which measures the field line twist, together with mathematical morphology algorithms. We apply our method to time-dependent data-driven magnetofrictional simulations of solar active regions AR11176 and AR12473. In doing so, we show the methods performance, as well as study the resulting flux ropes' trajectory through the simulation domain. In particular, we are investigating the deflection of these magnetic structures, as this is a crucial aspect in predicting if and how strongly they will impact Earth.

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"Reconstructing cosmological parameters using fast N-Body simulations"

Lukas Winkler
University of Vienna

Abstract:
One of the most fundamental questions in cosmology is how structure formed in our universe from primordial perturbation to the objects we can observe today. The current standard model ΛCDM is mostly consistent with this, but next generation observational efforts using instruments like JWST, Euclid, LSST and DESI will be able to test its predictions with unprecedented accuracy.
The primary tool to compare the influence of different cosmological parameters and models on structure formation are large-scale N-Body simulations. Recently fully differentiable simulations allow sampling the initial properties of the universe more efficiently. Combining this with better time integration methods that allow significantly faster simulations without sacrificing accuracy, it is now possible to reconstruct the initial properties of our universe more accurately than ever before.

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"Dark Matter Collapse Models"

Agata Wislocka
University of Vienna

Abstract:
The most accurate description of the formation of dark matter (DM) structures comes from N-body simulations. However, running simulations is not only a costly method, but also, one that is limited by resolution. Due to this shortcoming simulations cannot provide us with predictions about the smallest structures and their statistics. A powerful alternative to N-body approaches comes in the form of analytical or numerical framework describing the evolution of DM, without the need to follow complex, non-linear dynamics in detail. Such methods, like the excursion set formalism coupled with DM collapse models, can resolve the smallest scales, hence allowing for making such predictions. To date this method proves to make accurate statistical predictions (i.e. halo mass functions, progenitor distributions and the merger rate histories).
However, the collapse models make other detailed predictions for the DM fluid particles (i.e. collapse times, densities, morphology class), which have not yet been investigated against simulations. The aim of this project is to test these models thoroughly. For this purpose we use a simulation code, which outputs many parameters suitable for this comparison. We do this by evolving a grid of particles with the collapse models and excursion sets and comparing our results to 16 simulations all ran with different cut-off scales imposed on the initial power spectrum.