Poster Abstracts

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Exploring the Atmospheres of Exo-Venuses with JWST

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With the James Webb Space Telescope, we will soon be able to obtain transmission spectra of terrestrial planets, which has only been possible for gas giants so far. This group of rocky planets would possibly also contain hot and cloudy planets similar to Venus - whose atmospheres might be dominated by a spectrally active gas like CO_2, instead of H_2 and He as is the case for gas giants.

I will present the modifications required in the current retrieval methods to simulate such atmospheres using NEMESIS [1]. The prior used for the dominant gas needs to be heavily skewed, or priors such as Centred log-ratio [2] need to be used. Also, some factors that have a negligible impact on the spectra when gases are present in trace amounts, like the isotopologue abundance ratio, will need to be taken into consideration.

The current models of clouds on Venus indicate the presence of multiple particle sizes and variations with altitude [3]. Such complex models are hard to implement for retrievals and are also computationally expensive. I will discuss whether simpler parametric clouds can be used to retrieve atmospheric properties from data simulated using the complex cloud models.

[1] Irwin, P.G.J. et al, 2008, JQSRT, 109, 6
[2] Piette, A.; Madhusudhan, N.; Mandell, A.M., 2022, MNRAS, 511, 2
[3] Barstow, J. K., 2012, PhD Thesis, University of Oxford

Learning to detect RFI in radio astronomy without seeing it

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Radio Frequency Interference (RFI) corrupts astronomical measurements, thus affecting the performance of radio telescopes. To address this problem, supervised segmentation models have been proposed as candidate solutions to RFI detection. However, the unavailability of large labelled datasets, due to the prohibitive cost of annotating, makes these solutions unusable. To solve these shortcomings, we focus on the inverse problem; training models on only uncontaminated emissions thereby learning to discriminate RFI from all known astronomical signals and system noise. We use Nearest-Latent-Neighbours (NLN) - an algorithm that utilises both the reconstructions and latent distances to the nearest-neighbours in the latent space of generative autoencoding models for novelty detection. The uncontaminated regions are selected using weak-labels in the form of RFI flags (generated by classical RFI flagging methods) available from most radio astronomical data archives at no additional cost. We evaluate performance on two independent datasets, one simulated from the HERA telescope and another consisting of real observations from LOFAR telescope. Additionally, we provide a small expert-labelled LOFAR dataset (i.e., strong labels) for evaluation of our and other methods. Performance is measured using AUROC, AUPRC and the maximum F1-score for a fixed threshold. For the simulated data we outperform the current state-of-the-art by approximately 1% in AUROC and 3% in AUPRC for the HERA dataset. Furthermore, our algorithm offers both a 4% increase in AUROC and AUPRC at a cost of a degradation in F1-score performance for the LOFAR dataset, without any manual labelling.

Space Debris - Impact and novel approaches for detection

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Observations at a wide range of wavelengths are necessary to understand our universe. Therefore, telescopes on earth and in space are of cardinal importance, however the threat of space debris is a permanently growing problem not only for satellites but also for telescopes in space. The number of debris particles is constantly increasing. Actually, there are about 750,000 particles with a size of > 1 cm and a velocity of 20 to 40 km per hour. [1]

These space debris objects poses a threat for space based Infrastructure, as a collision can cause them to fail or even destroy them completely. Telescopes such as Hubble or James Webb are placed in a high orbit, where no debris should occur. But as the number of debris particles will increase in the future due to the increasing commercialisation of space, launching a new telescope becomes more critical. To counteract this risk, strategies are being developed to detect space debris, using different types of sensors such as LIDAR or RADAR. In this way, the orbits of the debris particles can be determined and catalogued so that they can be used, for example, to perform avoidance manoeuvres with satellites or dene launch windows. To further increase the performance of

RADAR systems for the detection of space debris, even with sizes of < 1 cm, concepts inspired from radio telescope technologies can be adapted to the RADAR receiver. For future receiver systems, it will be investigated to what extend the sensitivity can be increased through the use of cryogenics, as is common in radio astronomy, and whether this technique can be applied to phased array receivers. The research was carried out on the basis of the German Experimental Space Surveillance and Tracking RADAR (GESTRA) system.[2] This is a phased

array RADAR demonstrator for the detection of space debris developed at Fraunhofer FHR. In addition to the performance analysis, the technical aspects of designing a scalable cryogenic phased array receiver will also be considered. The concept for a 38 element phased array in the L-band was investigated and the design verified by thermal and mechanical analyses.[3],[4]

How to Detect Postborn Rotation

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In a standard cosmology, the weak gravitational lensing signal to leading order is a 'curl free' field, i.e. it induces no rotational distortions to the background image. The curl has therefore been useful as diagnostic test for noise dominated experiments, and with improved sensitivities in the near future an excess of lensing rotation could signal new physics. However, postborn corrections to the deflection field will also produce a unique non-zero curl potential through a second order "lens-lens" effect. I will present an exploration into the detectability of this postborn rotation in the context of the Cosmic Microwave Background (CMB) lensing for the upcoming Simons Observatory (SO) and "Stage-4" (S4) experiments. I derive an optimal rotation estimator using cross-correlations with pairs of Large Scale Structure (LSS) tracers, and provide forecasts for observable combinations utilising the CMB lensing convergence, galaxy density, and the Cosmic Infrared Background (CIB). I will also provide the first analytical results for the reconstruction biases inherent in such an estimator due to cross-correlations of non-Gaussian fields.

Mapping accretion in intermediate-mass stars

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In earlier type Herbig Ae/Be stars the accretion mechanisms are not yet well understood because their magnetic fields are too weak to sustain magnetospheric accretion. These are the first steps in my study of time variability of accretion-related lines in young intermediate-mass stars, using the STAR-MELT code, combined with long- and short-cadence spectroscopic data. The targets chosen for study are promising sources as they have well-known protoplanetary discs, and evidence of extinction by circumstellar material. Emission and absorption lines with broad and narrow components, including metallic ones, are detected in these stars in a similar way to what is found in their lower-mass counterparts, and the STAR-MELT Python code assists in quantifying any variability found. By measuring the variability in velocity and relative intensity for different lines we aim to trace the structure of accretion columns and distinguish between different accretion mechanisms as they evolve over time.

SolARE - Solar Active Region Extractor

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Active Regions are areas with particularly intense and complex magnetic structures on the Sun. They are commonly linked to space weather and thus are an important feature to be tracked. Given the amount of data, this proves to be extremely difficult, leading to us applying a combination of computer vision, analysis of the underlying physics and machine learning to attempt to be able to detect these regions as they emerge.

We show that the version without convolutional neural net is capable of noticing a range of active regions, yet requires further improvements, possibly to be gained by planned additions to both the analytical part of the algorithm and the machine learning segment. We report a mean intersection-over-union (IoU) of 0.4 for the method presented.

These results should be improved before the pipeline build for this system is deemed useful, with a way to increase these metrics presented as well.

X-ray Emission from Pre-Main Sequence Stars with Multipolar Magnetic Fields

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In pre-main sequence (PMS) stars X-ray luminosities are observed to decrease with age. The large-scale magnetic fields of stars are also seen to evolve with age throughout the PMS with fields becoming less axisymmetric, more complex and less dipolar. In these works, we explore the connection between the two observations by modelling the X-ray luminosities of a solar-like PMS star with varying large-scale magnetic field geometries. The magnetic fields modelled are axisymmetric, of multipole fields or those with a combination of dipole and octupole components, which fit the description of many young PMS stars large-scale magnetic fields. To calculate X-ray luminosities, the extent of closed coronal magnetic field loops capable of containing X-ray emitting plasma is determined. Our models find a trending decrease in stellar X-ray luminosity as the degree of multipole field increases and as fields become less dipole dominant. The results agree with the observations of older PMS stars with typically more complex fields having lower X-ray luminosities and supports the idea that the change in large-scale magnetic field geometries of PMS stars impacts their X-ray emission trends.