Fast Machine Learning for Science
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Machine Learning in Exoplanet Characterisation

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The exploration of extrasolar planets, which are planets orbiting stars other than our own, holds great potential for unravelling long-standing mysteries surrounding planet formation, habitability, and the emergence of life in our galaxy. By studying the atmospheres of these exoplanets, we gain valuable insights into their climates, chemical compositions, formation processes, and past evolutionary paths. The recent launch of the James Webb Space Telescope (JWST) marks the beginning of a new era of high-quality observations that have already challenged our existing understanding of planetary atmospheres. Over its lifetime, the JWST will observe approximately 50 to 100 planets. Furthermore, in the coming decade, the European Space Agency's Ariel mission will build on this progress by studying in detail the atmospheres of an additional 1000 exoplanets.

In this talk, I will outline three fundamental challenges to exoplanet characterisation that lend themselves well to machine-learning approaches. Firstly, we encounter the issue of extracting useful information from data with low signal-to-noise ratios. When the noise from instruments surpasses the signal from exoplanets, we must rely on self-supervised deconvolution techniques to learn accurate instrument models that go beyond our traditional calibration methods. Secondly, in order to interpret these alien worlds, we must employ highly complex models encompassing climate, chemistry, stellar processes, and radiative transfer. However, these models demand significant computational resources, necessitating the use of machine learning surrogate modelling techniques to enhance efficiency. Lastly, the Bayesian inverse problem, which traditionally relies on methods like Markov Chain Monte Carlo (MCMC) and nested sampling, becomes particularly challenging in high-dimensional parameter spaces. In this regard, simulation-based inference techniques offer potential solutions.

It is evident that many of the modelling and data analysis challenges we face in the study of exoplanets are not unique to this field but are actively investigated within the machine learning community. However, interdisciplinary collaboration has often been hindered by jargon and a lack of familiarity with each other's domains. In order to bridge this gap, as part of the ESA Ariel Space mission, we have successfully organized four machine learning challenges hosted at ECML-PKDD and NeurIPS (https://www.ariel-datachallenge.space). These challenges aim to provide novel solutions to long-standing problems and foster closer collaboration between the exoplanet and machine learning communities. I will end this talk with a brief discussion of the lessons learned from running these interdisciplinary data challenges.

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Session Classification: Invited Talks

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