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AI for astronomical spectroscopy: current challenges and future prospects for the WST

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WST will deliver datasets of such staggering volume and complexity that conventional analysis methods will be rendered obsolete.
Much faster, precise and independent of our models, artificial intelligence emerges as the indispensable engine of discovery.

The current landscape of machine learning in astronomy, particularly in spectroscopic analysis, faces two critical limitations. The first concerns interpretability: while neural networks demonstrate superior speed and precision compared to traditional methods, their 'black box' nature obscures the reasoning behind their predictions. The second limitation involves uncertainty quantification: current implementations typically fail to provide reliable errors. To overcome these challenges, I will present OssicoNN, a conditional Invertible Neural Network (cINN), through two concrete applications. First, using the Gaia-ESO Survey dataset, I will demonstrate OssicoNN's capability to derive stellar parameters with well-characterized uncertainties. Second, applying OssicoNN to simulated SDSS spectra, I will show how this approach exceeds the accuracy of classical Bayesian methods while providing insights into the features driving the network's decisions.

In the final section, I will outline two pillars of AI-driven astronomy by 2040: foundation models and autonomous agents. Foundation models trained on vast astronomical datasets will act as discovery engines. These models will directly cross-match WST's data with multi-wavelength surveys, creating unified frameworks to test theories. Second, autonomous agents will execute real-time decision-making: adjusting WST's focal plane to prioritize transient events, optimizing survey strategies, and coordinating follow-ups with other facilities.

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