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On integrating light-curve modelling with atmospheric retrieval techniques

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Abstract

Characterising exoplanet atmosphere has been one of the major frontier in the field in recent decade. Thanks to many novel atmospheric retrieval techniques, we have detected a number of molecules that lives within various kinds of exoplanets' atmospheres, some of which are vital for life to exist. In the next decade, space missions such as JWST, ARIEL and PLATO will deliver measurements with unprecedented precision and completeness in terms of wavelength coverage. It is thus important for us to upgrade our current retrieval techniques in order to allow optimal exploitation of future instruments.

Contemporary atmospheric retrieval technique has focused on retrieving atmospheric components based on a planet's transmission spectrum, which was independently derived from fitting raw light-curves at different wavelengths. The process essentially compresses an entire light-curve into a single data point on a transmission spectrum, the compression inevitably affects uncertainty estimation and lowers the information gain. A way forward is to include geometric information of a light-curve within the atmospheric retrieval process. We demonstrated this concept by integrating Tau-REx, a fully Bayesian atmospheric retrieval framework , with PyLightcurve, a light-curve modelling routine.

This new approach provides 2 major advantages over the current approach, 1. A statistically more rigorous and more realistic estimation of the uncertainties involved in each retrieved parameters compared to the conventional approach. 2. The possibility to probe, for the first time, the correlation between various light-curve related parameters to atmospheric components. In this conference I will discuss the implication of these advantages using synthetic and actual observed data from Wide Field Camera 3 and the need for a dedicated end-to-end retrieval process that rigorously accounts for the uncertainties propagated from observation data all the way to atmospheric components.