Exoplanet Atmospheres at High Spectral Resolution

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High resolution spectroscopy is a powerful tool for exoplanet characterization. At high spectral resolution (R>20,000) the lines in a molecular band are resolved into a dense forest of numerous individual lines, with the line positions and strengths being unique to each molecular species. It is thus more difficult to mimic these signatures by random chance or instrument systematics, and makes it easier to distinguish overlapping molecular bands, when comparing to lower resolution spectroscopy. For close-in planets, we can use their significant change in Doppler shift during their orbit to disentangle their spectrum from their bright host star. Consequently, the technique works on transiting and non-transiting systems. For wide-orbit planets, we can instead use their spectrally distinct and strongly localised spatial position to dispensable them from their host stars. The extracted planet spectrum typically has very low signal-to-noise and requires template matching, e. g. cross-correlation, with models to derive the planet properties. The technique is sensitive to the shape and shift of the line, making it sensitive to measuring the planet's true mass, atmospheric composition and structure, day-to-night winds, rotation, heat circulation, clouds, and potentially even its atmospheric surface features. I will overview the advances of this technique since its first successful detections in 2010 as well as its limitations. I will highlight its future directions with the upcoming ELTs, and its complementary to other characterisation techniques and missions such as JWST and ARIEL.

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