Exploring Complex Chemistry in Exoplanet Atmospheres at High Spectral Resolution

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High resolution spectroscopy (HRS) is a powerful and highly versatile, ground-based technique for exoplanet atmospheric characterisation. New HRS instruments and statistical frameworks have accelerated the field dramatically in recent years, producing results on par with JWST e.g. elemental ratios for the study of planet formation, and at the same time opening new parameter space such as the 3D dynamical nature of exoplanets winds and rotation. The unique sensitivity of HRS to spectral line shape holds a wealth of information and we are only just beginning to scratch the surface of what we can learn. In this talk, I will showcase the most recent advances that will enable HRS studies of rocky exoplanets with the Extremely Large Telescopes (ELTs). I will discuss the extension to M-band wavelengths with CRIRES+ and its potential for exploring the surface composition of lava planets with existing telescopes. I will also demonstrate new results that push HRS into the warm (sub-)Neptune regime for the first time, constraining metallicity and aerosols, both in thermal emission and reflected light. I will end with a discussion on the importance of HRS in the context of robust confirmation of complex molecular species in sub-Neptune atmospheres and the necessary laboratory experiments and calculations needed to support this.