HCN VUV absorption cross section measurement at high temperature for hot exoplanets atmosphere photochemical modelling

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Close orbit exoplanets possess highly irradiated atmospheres at high temperatures, making high temperature photochemistry a major process that drives their atmospheres away from thermochemical equilibrium. Including photochemistry into exoplanet atmosphere modelling is essential to interpret observations. With the new generation of telescopes such as JWST (and future missions like ARIEL and PLATO) atmospheric characterization has reached a new level. Consequently, atmospheric models, especially their physico-chemical data inputs, must keep pace with these advances. A key physico-chemical parameter essential for photochemistry modelling is the absorption cross section, especially at high temperature. In this study, we provide new temperature-dependent VUV absorption cross sections of hydrogen cyanide (HCN), a key C/H/N species in exoplanetary atmospheres.
We measured the VUV absorption cross section of HCN between 115 and 200 nm at 300, 500, and 700 K using a vacuum ultraviolet spectroscopic setup at the LISA laboratory. Then, we implemented these data into the 1D thermo-photochemical model FRECKLL to quantify their impact on atmospheric physico-chemical processes. The absorption cross section of HCN increases with temperature, especially at wavelengths longer than 160 nm, with an enhancement up to an order of magnitude near 200 nm. Photochemical simulations show that using the high-temperature cross section instead of the one measured at 300 K leads to a decrease in HCN abundance in the upper atmosphere. Other species are also significantly affected, in some cases even more than HCN itself including key atmospheric species (e.g., H_2S, H_2O, C_2H_2). The enhanced absorption also modifies the opacity of the atmosphere, affecting the energy budget in the different layers of the atmosphere leading to variations in photodissociation of various species. Our results demonstrate that temperature-dependent VUV absorption cross sections are crucial for realistic modelling of hot exoplanet atmospheres. The new HCN data provide improved inputs for kinetic and radiative models. They also highlight the need for further high-temperature laboratory measurements of key atmospheric species, critical for supporting current and future missions such as JWST, ARIEL, and PLATO, and more generally, for expanding comprehensive physico-chemical datasets for exoplanet atmosphere modelling.