The curious case of high-metallicity and high C/O atmosphere of the hot Jupiter tau Bootis b

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The chemical abundances of gas-giant exoplanet atmospheres hold clues to the formation and evolution pathways that sculpt the exoplanet population. Novel advancements in atmospheric retrieval methods for ground-based high-resolution cross-correlation spectroscopy have enabled the measurement of atmospheric C/O and metallicity of gas giant exoplanets at precisions comparable to that of solar system gas giants. To date, only three gas-giant exoplanets have had their atmospheric chemical abundances constrained via this route. One of them is the particularly puzzling hot-Jupiter tau Bootis b. SPIRou observations of the planet in the 0.9 to 2.5-micron range indicate an atmosphere depleted in water and a high C/O and high metallicity, which is at odds with the standard core-accretion model of planet formation. On the other hand, recent observations using CARMENES in the 0.9 to 1.7 micron detect an atmosphere with solar abundance water. One hypothesis behind these seemingly contradicting results could be that the core of the water and CO lines forming at different pressure levels probe different atmospheric dynamics. To investigate this, we revisit the archival CRIRES observations of the secondary eclipse of tau Bootis b. I will present revised analyses of these data using PCA-based systematics detrending coupled with Bayesian atmospheric retrieval framework for high-resolution spectroscopy. In the context of these results, I will demonstrate the effect of divergent dynamical information contained in the lines of different C and O-bearing molecules on their respective Doppler signatures and retrieved abundances. In summary, the varying dynamical origins of CO and water lines at high-resolution are necessary to account for to measure the C/O and metallicity of gas-giant atmospheres accurately.