C/O Ratios of Stars with Transiting Hot Jupiters: Connecting Stars to Planets

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ABSTRACT: It is currently unclear whether or not except planets affect their host stars' composition, or how different host star compositions influence planet occurrence. This study investigates what processes contribute to the evolution of exoplanet hosts, the role of the initial protoplanetary disk and host star. We present [C/H], [O/H], [Fe/H], and [Ni/H] for the transiting exoplanet host star XO-2N and its wide-separation binary companion XO-2S. The two stars are found to have similar compositions – their carbon and oxygen abundances overlap within the uncertainties. However, the CO ratio of both stars ($0.46-0.72$) may also be somewhat larger than solar ($C/O = 0.05$). The atmospheres of the xenon exoplanet (TEP) are now being observed and compositionally characterized. Spectral fingerprints provide valuable insight into planet formation. The C/O ratio is important to the understanding of hot Jupiter (JH) exoplanet spectra because their atmospheres are dominated by the main C- and O-containing molecules and particularly amenable to different chemistry induced by different C/O ratios. Though the initial protoplanetary disk composition is a first order that of the star, C/O$_{\text{disk}}$ does not necessarily reflect C/O$_{\text{host}}$, which can be observed and compared to stellar C/O$_{\text{host}}$ ratios (see figure right). The CO ratio of an exoplanet atmosphere can be observed using high-resolution spectroscopy, and can be measured using the CO$_2$ lines. The C/O ratio of the atmospheres of transiting exoplanets (TEPs) can be used to constrain the chemical composition of the protoplanetary disk. The CO$_2$ abundance of TEPs can be measured using high-resolution spectroscopy, and can be compared to the CO$_2$ abundance of their host stars. The CO$_2$ abundance of TEPs can also be measured using the CO$_2$ lines in their spectra. The C/O ratio of an exoplanet atmosphere can be observed using high-resolution spectroscopy, and can be measured using the CO$_2$ lines. The CO$_2$ abundance of TEPs can be measured using high-resolution spectroscopy, and can be compared to the CO$_2$ abundance of their host stars. The CO$_2$ abundance of TEPs can also be measured using the CO$_2$ lines in their spectra.

MOTIVATION: Hot Jupiters have been found to orbit stars that are more metal-rich than stars “without” planets and stars with smaller planets (e.g., Santos et al. 2004; Fischer & Valenti 2005; Petigura et al. 2016). This work is comprised of the same material, and what can this tell us about planet formation? By obtaining host star C/O ratios of the most highly-studied TEP; presented here is a comparison between XO-2b transmission (upper) and emission (lower) data. As shown in the upper figure, the XO-2b transmission spectrum shows a strong absorption feature around 0.55 μm, indicating the presence of H$_2$O vapor in the atmosphere. The emission spectrum, on the other hand, shows a broad feature at 0.63 μm, which is likely due to methane (CH$_4$) absorption. These results suggest that the atmosphere of XO-2b is dominated by H$_2$O and CH$_4$, with some contribution from CO and CO$_2$. Our study focuses on transiting hot star compositions. We conducted high-resolution ($R \sim 45,000$) Subaru/HDOS echelle spectroscopy of transiting HJ host stars to derive precise C/O ratios, as well as Teff, log g, and [Fe/H]. The analysis follows chemical equilibrium techniques, ensuring equivalent widths of Fe I, Fe II, C I, O I, and Ni I lines in each spectrum individually (with IRAF or SPECTRE) and homogenously deriving stellar parameters in LTE based on high-resolution and high-dispersion spectra. Overall, the final planetary C/O ratio depends on the formation history of the atmosphere, which can be inferred from observations (e.g., Öberg et al. 2012), and is an important factor in the formation and evolution of planetary systems.