The Importance of Ozone and UV Capability in Detecting Biosignatures on Planets With Intermediate Oxygenation States

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The strongest remotely detectable signature of life on our planet today is the photosynthetically produced oxygen (O2) in our atmosphere. However, recent studies of Earth’s geochemical proxy record suggest that for all but the last ~500 million years, atmospheric O2 would have been undetectable to a remote observer—and thus a potential false negative for life [1]. During an extended period in Earth’s middle history (2.0 – 0.7 billion years ago, Ga), O2 was likely present but in low concentrations, with PO2 estimates of ~ 0.1 – 1% of present day levels [2, 3]. Although O2 has a weak spectral impact in reflected light at these low abundances, O3 in photochemical equilibrium with that O2 would produce notable spectral features in the UV Hartley-Huggins band (~0.25 µm), with a weaker impact in the mid-IR band near 9.7 µm. Thus, taking Earth history as an informative example, there likely exists a category of exoplanets for which conventional biosignatures can only be identified in the UV. Here we emphasize the importance of UV capabilities in the design of future space-based direct imaging telescopes to detect O3 on planets with intermediate oxygenation states. We use a coronagraph instrument model to show that the Hartley-Huggins O3 UV band is detectable in reflected light for a low-oxygen exoplanet (PO2=0.5% PAL) orbiting a Sun-like star. This example highlights the broad implications of studying Earth history as a window into understanding potential exoplanet biosignatures [4].