A WEEK IN THE LIFE: AN ASTROBIOLOGY-FOCUSED STRATEGY FOR A LUVOIR (LARGE UV-OPTICAL-IR) TELESCOPE.
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Plans for a large UV-Optical-InfraRed (LUVOIR) space-based observatory are currently underway [1]. The LUVOIR telescope will support major advances in astrophysics, and among the main science drivers for such a mission is the search for life beyond our solar system [2]. This search for life on extrasolar planets will necessitate the spectral characterization of these worlds. Preliminary yield estimates (see [3], also Mandell et al. abstract at this meeting) demonstrate that a LUVOIR telescope ≥10m in diameter would be capable of finding dozens of potential Earth-like worlds. In this presentation, we will discuss how a spectral observation of such worlds would proceed, according to an observational strategy aimed at maximizing the chances of finding biosignatures. Search strategies optimized for other science goals (*e.g.*, comparative planetology) are beyond the scope of this discussion. The strategy outlined here includes system imaging, planet identification, preliminary habitability assessment, biosignature detection, and false positive discrimination.

The first observation such a mission would make is an image of the entire system. A near-immediate determination of the level of light from dust in that system would be made, and would be used to determine how long it would take to make the ensuing observations. (Higher dust levels would mean a greater contribution of background light and therefore a greater integration time.) If the integration times for planet detection are not prohibitively long, the mission would continue to observe that system. Integration for the sake of planet detection would continue on that system until one of three conditions is met: 1) potentially habitable planets are detected; 2) potentially habitable planets are deemed impossible due to dynamical constraints imposed by other planets found in the system; or 3) the integration has proceeded so long that observations of other systems would be more beneficial for optimizing the exo-Earth yield (see [1] for details).

For planets brighter than candidate exo-Earths (*e.g.*, planets closer to the star than the habitable zone or larger than rocky planets), spectra would be obtained as the telescope searches for the dimmer exo-Earth candidates. This would result in moderate resolution ($50<R<1000$) spectra of these worlds.

For exo-Earth candidate planets, the spectral retrieval would meet several "gates" as the observation proceeds and the spectral resolution of the observation increases. This increased resolution would deliver more complete information about the planet, refining the assessment of the planet's "astrobiological value."

First, at fairly low resolutions ($R\gtrsim10$) the observation will assess habitability based on whether the planet has abundant water, by searching for a broad feature at ~0.95 μm. If the target planet is "dry," the mission would move to another target. If the planet contains water, observation would continue until potential biosignatures are detected, or found to be absent.

The first biosignature that might appear is ozone (O_3), which has a broad feature with a high absorption cross-section in the UV. If O_3 is detected, observations would continue until oxygen (O_2) concentrations at the level of modern-day Earth could be detected or ruled out, by searching for features at 0.67 and 0.76 μm.

For planets with O_3 or O_2, a false positive discrimination strategy would follow. The known abiotic sources of these gases are: 1) oxidation of the bulk planet through a history of H loss; and 2) photochemical production in atmospheres rich in carbon dioxide (CO_2) and without much methane (CH_4). O_2-dominated atmospheres caused by oxidation of the planet could be identified by features that do not appear at lower O_2 pressures. Photochemical O_2/O_3 sources could be identified by low CH_4 concentrations, and high CO and CO_2 concentrations. This discrimination requires high-resolution IR spectroscopy, which has implications for the mission's architecture.

References:

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