Leveraging the Pandora SmallSat Mission for Exoplanet Science with HST and JWST

Thematic Areas (Check all that apply):

☒ (Theme A) Key science themes that should be prioritized for future JWST and HST observations
☒ (Theme B) Advice on optimal timing for substantive follow-up observations and mechanisms for enabling exoplanet science with HST and/or JWST
☐ (Theme C) The appropriate scale of resources likely required to support exoplanet science with HST and/or JWST
☐ (Theme D) A specific concept for a large-scale ($\sim$500 hours) Director's Discretionary exoplanet program to start implementation by JWST Cycle 3.

Summary: Spectral signals introduced by stellar photospheric heterogeneity represent one of the prime challenges for precise exoplanet transmission spectroscopy. The Pandora SmallSat Mission, a recently selected Pioneers-class mission, has been designed to address this challenge with long-baseline, multi-epoch, multi-wavelength (visible and near-infrared) observations of exoplanet transits that will be used to disentangle stellar and planetary spectral features. Pandora's notional target list includes 20 Earth-to-Jupiter-sized exoplanets orbiting M and K stars, with the flexibility to change targets during its 1 year of science operations. Pandora will operate simultaneously with HST and JWST in 2025–2026 and will be available for auxiliary science during a significant part of its mission. Here we advocate for coordination with the Pandora team to support HST and JWST exoplanet initiatives with (near-)simultaneous space-based optical photometry and near-infrared spectroscopy from this exoplanet-focused NASA mission.

Anticipated Science Objectives: Exoplanet transmission spectroscopy provides our most productive technique for probing the atmospheres of worlds beyond the Solar System with HST and JWST. However, stellar photospheric heterogeneity hinders accurate interpretations of precise transmission spectra, in many cases preventing us from fully leveraging the observational precisions of these facilities [1, 2, 3]. The Pandora SmallSat Mission [4], recently selected as part of NASA's Astrophysics Pioneers Program, has been designed specifically to disentangle stellar and planetary signals in transmission spectra and offers capabilities that are synergistic with HST and JWST (Figure 1). Using a 0.45-m primary, Pandora will observe exoplanet transits simultaneously with a photometric visible channel (wider than 0.45–0.65 μm) and a low-resolution near-infrared channel (wider than 1.0–1.6 μm). The target list includes 20 planets hosted by K and M dwarfs [for a notional target list, see 5]. Pandora's science objectives require at least 10 transit observations of each target, with each observation lasting roughly 24 hr. The spacecraft is expected to launch in 2025 for a nominal 1-yr mission, concurrent with HST and JWST operations. In addition to complimenting HST and JWST via its primary-mission observations, Pandora will have large availability for auxiliary science during its primary mission, which could further complement HST and JWST initiatives. In particular, coordination with the Pandora team to gather long-baseline optical photometry and near-infrared spectroscopy would complement infrared spectroscopy from JWST and be useful for disentangling the sort of stellar and planetary signals that have already been seen in transmission spectra of GJ 486b [2] and other small exoplanets (priv. comm.).

Urgency: Stellar contamination represents the primary challenge to interpreting precise transmission spectra, particularly for small planets transiting small stars, which have highly heterogeneous photospheres and remain active for gigayears.
Risk/Feasibility: Pandora's critical design review is planned for October 2023, and is currently on schedule for a launch in (no-earlier-than) March 2025.
Timeliness: Pandora's 1-yr primary mission will extend from mid-2025 to mid-2026, likely concurrent with HST Cycles 32 and 33 and JWST Cycles 3 and 4. An extended mission is feasible, if funded. Pandora's primary objective—mitigating stellar contamination—is identified in the NASA Exoplanet Exploration Program's Science Gap List, and is well-aligned with the Astro2020 Decadal.
Cannot be accomplished in the normal GO cycle: Pandora's unique observing plan, which includes repeated, 24-hr visits, can complement HST and JWST studies with observations that are not feasible with those high-demand facilities.

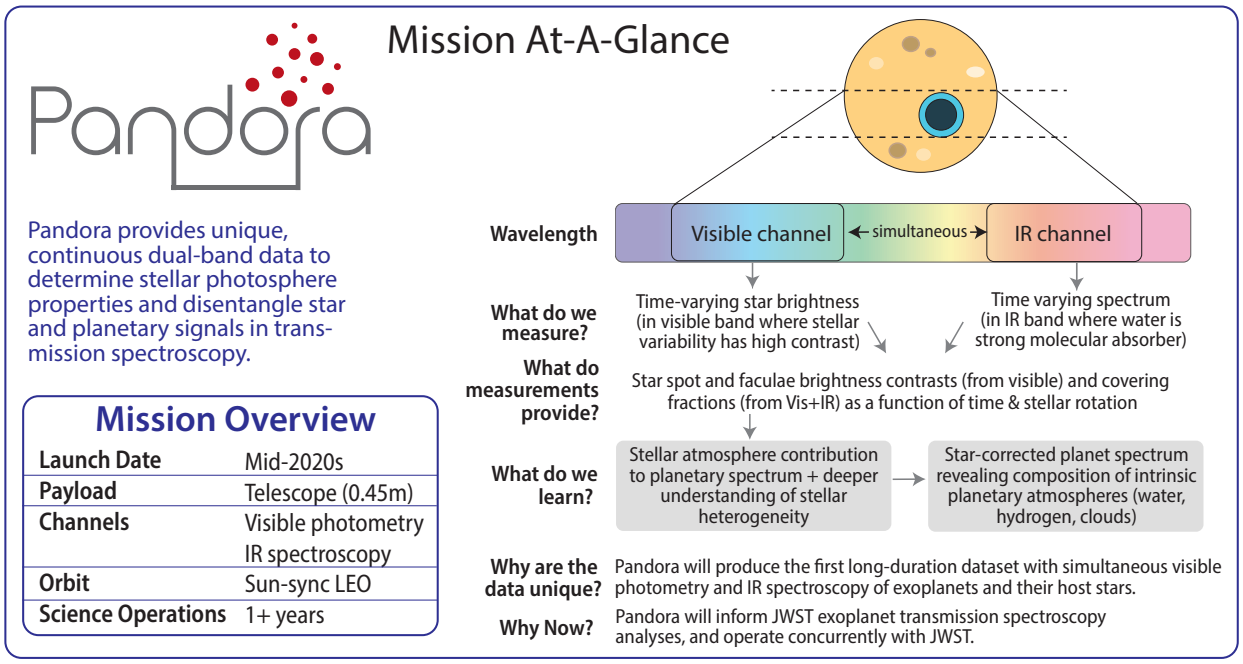

Figure 1: Overview of the Pandora Mission.

References

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