Correction Factors for Habitable Exoplanet Direct Imaging:
Consider the Exozodiacal Dust inside Inner Working Angle

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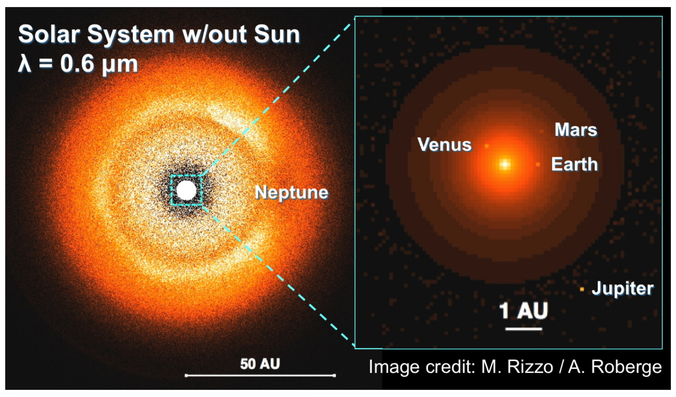
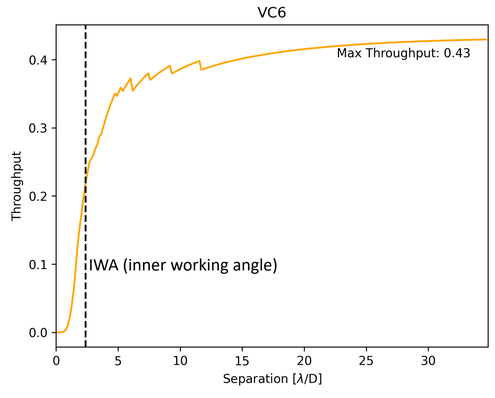
Introduction

•**Goal:** Directly imaging Earth-like exoplanets in habitable zones is a major goal of astronomy, as this technique could reveal crucial information about these planets.
•**Challenge:** Detecting these planets is extremely difficult due to their faint signals, which could be obscured by the presence of exozodiacal dust. This dust, analogous to zodiacal dust in our solar system, scatters starlight and creates a bright background glow.
•**Previous Studies Limitation:** Past research on exozodiacal dust's impact on exoplanet imaging often overlooked the dust within the Inner Working Angle (IWA) of coronagraphs.
•**Coronagraphs:** These instruments block the star's light to allow faint planets to be seen. The IWA is the central region where the coronagraph effectively blocks not only the starlight but also most of the off-axis lights.
•**This Study's Focus:** To quantify the impact of exozodiacal dust *within the IWA* on the detectability of habitable exoplanets and introduce a correction factor to account for its impact.
•**Methodology:**

- Using MCFOST radiative transfer code to simulate realistic exozodiacal dust disks around Sun-like stars at 10 pc.
- Simulating observations of these disks using two coronagraph types: Apodized Pupil Lyot Coronagraph (APLC) and Vortex Coronagraph (VC).
- Comparing simulations with and without considering the dust within the IWA to determine the correction factor that quantifies the underestimation of background noise when this inner dust component is ignored.

•**Key Finding:** Neglecting inner dust can lead to significant underestimates of background noise, negatively impacting the accuracy of predictions for future exoplanet imaging missions.





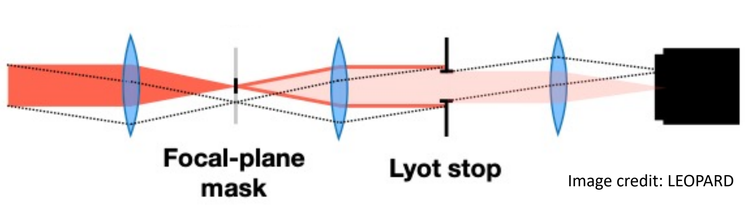
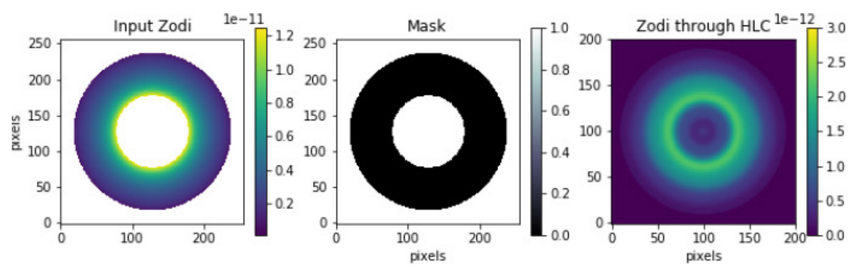
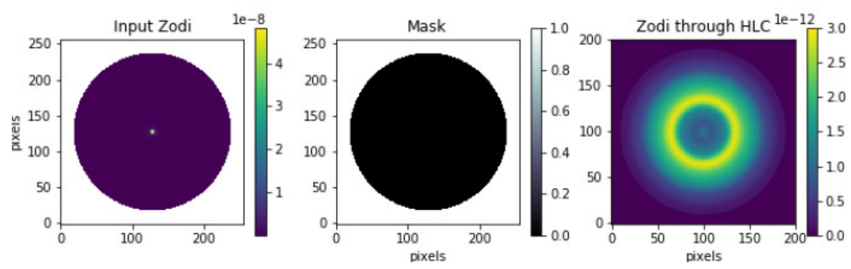


Image credit: LEOPARD



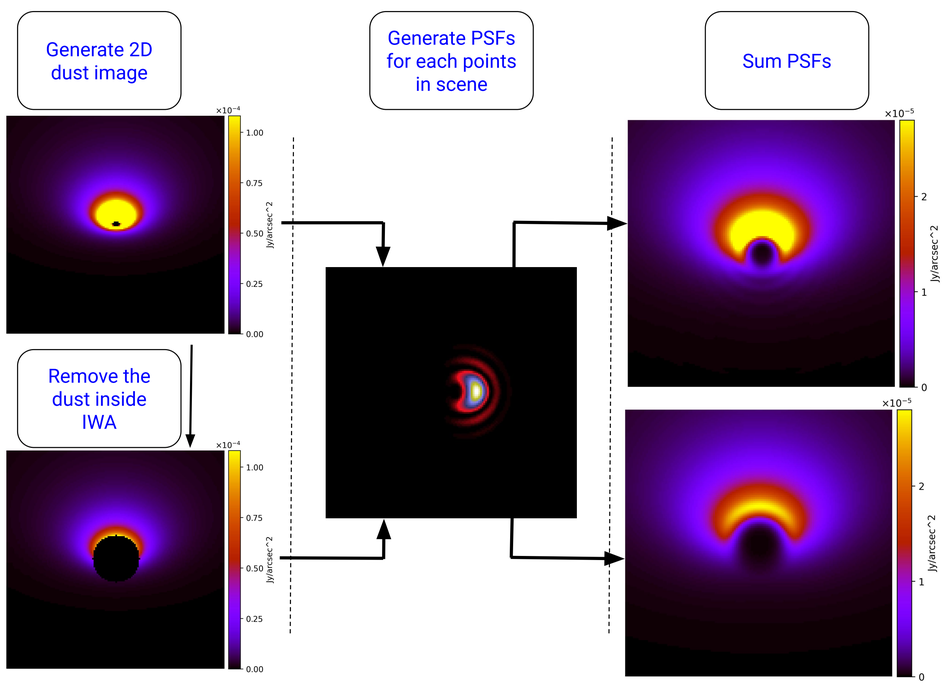
(a) Ignore the dust inside IWA



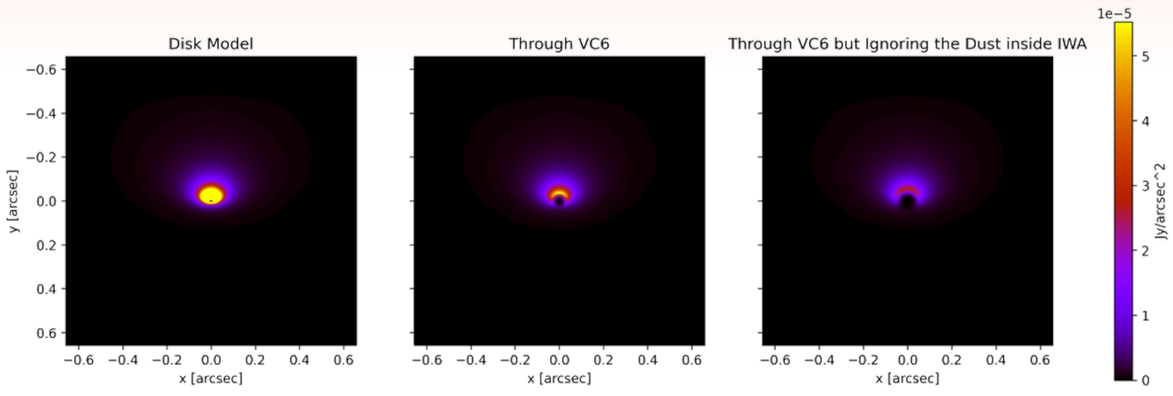
(b) Consider the dust inside IWA

Image credit: Douglas et al. (2019)

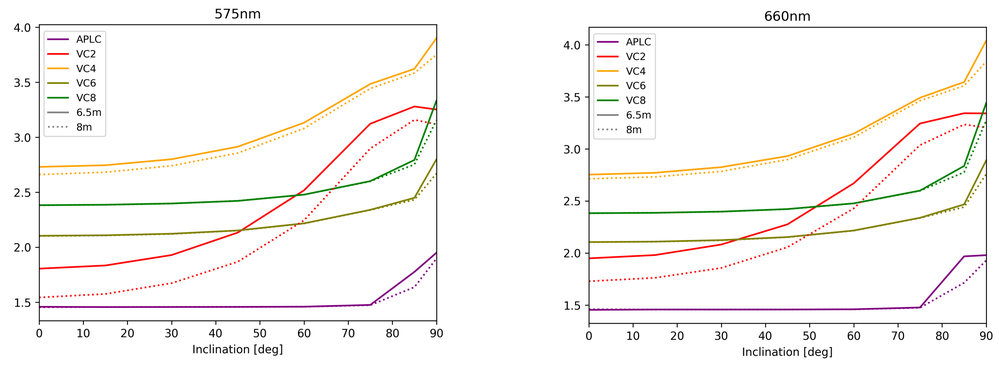
Modeling Flow

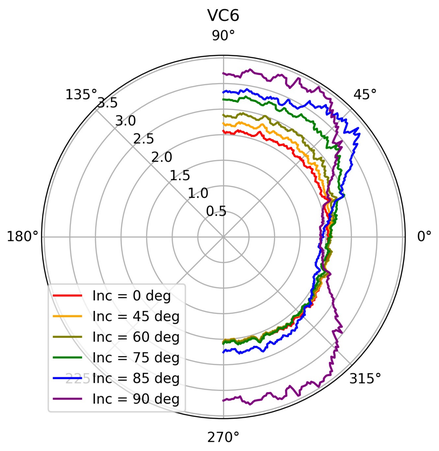


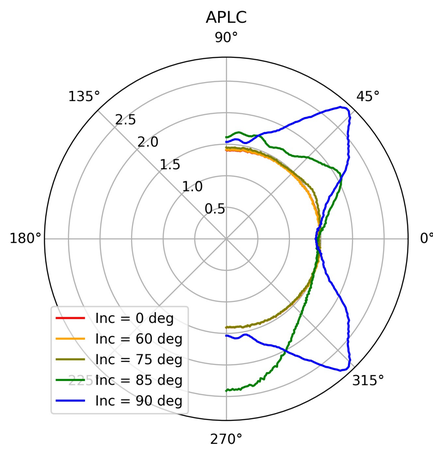
Results

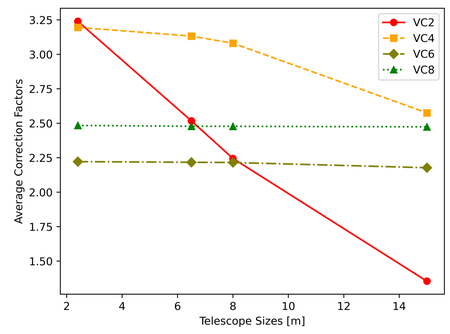


Analysis









Summary

- We highlight the often-overlooked impact of exozodiacal dust within the IWA on direct imaging observations.
- Our simulations demonstrate that neglecting this inner dust component can significantly underestimate background noise, particularly near the IWA.
- We introduce a correction factor to account for this underestimation, providing a valuable tool for optimizing future exoplanet imaging missions.
- Accurately modeling and mitigating the impact of all exozodiacal dust, especially within the IWA, is crucial for realizing the full potential of direct imaging in the search for habitable worlds.

Future works

- Incorporate realistic noise models into the simulated images.
- Estimate the yield rate of detectable exoplanets using simulation software like EXOSIMS and/or EXOVISTA.
- Evaluate the effectiveness of post-processing algorithms in mitigating the impact of exozodiacal dust within the IWA.

Reference

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