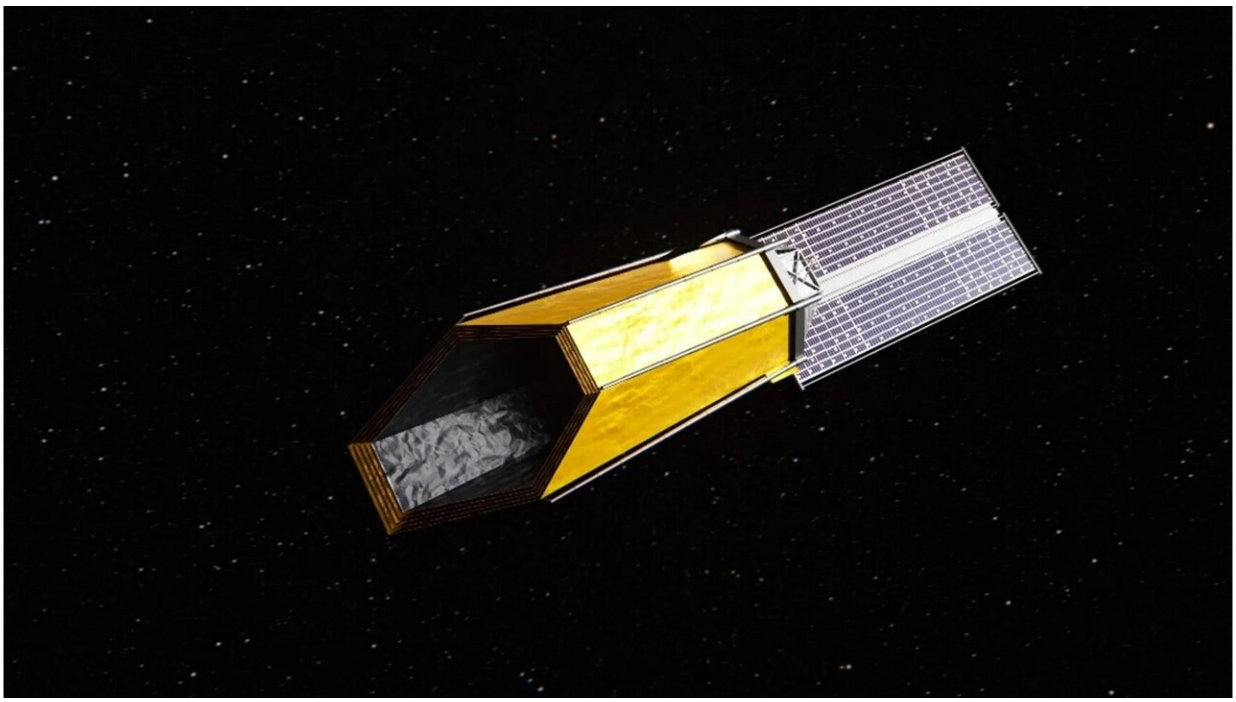
How to SUPPPPRESS light from a star that is ten billion times brighter than its habitable exoplanet

July 31 2024, by Andy Tomaswick



This artist's concept features one of multiple initial possible design options for NASA's Habitable Worlds Observatory. Credits: NASA's Goddard Space Flight Center Conceptual Image Lab

Searching for Earth 2.0 has been an obsession of almost all exoplanet hunters since the discipline's dawn a few decades ago. Since then, they've had plenty of technological breakthroughs help them in their quest, but so far, none of them have been capable of providing the clear-cut image needed to prove the existence of an exo-Earth.

However, some of those technologies are undoubtedly getting closer, and one of the most interesting is utilizing a system called a multi-grated vector vortex coronagraph (mgVVC). Researchers think it may hold the optical properties to enable space-based telescopes like the Habitable Worlds Observatory (HWO) to finally capture the holy grail of exoplanet hunting—and it may be ready for prime time as early as next year.

The work is published on the *arXiv* preprint server.

That's the timeline provided by the project team for the Substantiating Unique Patterned Polarization-sensitive Polymer Photonics for Research of Exoplanets with Space-based Systems (SUPPPPRESS) project, based out of Leiden University. Its primary focus for two years will be building and testing a mgVVC designed to eliminate one of the biggest challenges related to its implementation—polarization leakage.

To understand why that's a problem, it's best first to understand what a vector vortex coronagraph is. A standard coronagraph uses some optical mask or physical disk to block out a star's light. This allows the light from that star's exoplanets to shine directly onto its optical system, allowing even relatively standard optics to make out details of the planet, like whether it has water in its atmosphere.

A vector vortex coronagraph uses a type of liquid crystal mask that shifts the phase of the starlight, essentially eliminating it. However, light from objects slightly off the mask's axis, such as an exoplanet, isn't affected by the phase shift, allowing it to pass through directly to the accompanying telescope's detector.

Polarization leakage happens because of manufacturing defects in the liquid crystal mask used by VVCs. These could result from alignment errors, deformities in the liquid crystals, or stress or strain on the mask. Ironically, the way to fix this might be to make more masks.

The concept of a multi-grated vector vortex coronagraph is to layer multiple masks on each other. Since many of the defects are created in the manufacturing process, they should be unique to each individual mask, and as such, they shouldn't stack but cancel each other out when placed in series with one another. And the more grates there are, the more effective this solution is.

According to the paper, a single-grated VVC could capture light from an exoplanet that is about 10,000 times dimmer than its host star. In contrast, a triple-grated VVC would be capable of capturing light from exoplanets that are 10 billion times dimmer than their stars.

More information: Iva Laginja et al, Prototyping liquid-crystal coronagraphs for exo-Earth imaging, *arXiv* (2024). DOI: 10.48550/arxiv.2407.14723

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