Doing The Tango: Enhancing JWST with an Occulter

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Abstract:

Spatially resolving an exoplanet from its host star allows spectral separation of the planet's reflected starlight and thus characterization of its atmosphere and orbital parameters. This poster outlines a method of direct planet detection which has the distinct advantage of relaxing the very demanding tolerances on the telescope optics that are required by traditional coronographic designs. This approach is based on using a free-flying occulter spacecraft in conjunction with a space-based telescope, such as the JWST. Here we discuss the potential advantages of using an external occulter with JWST and showcase some of the recent ground test data illustrating the feasibility of using an occulter-space telescope system.

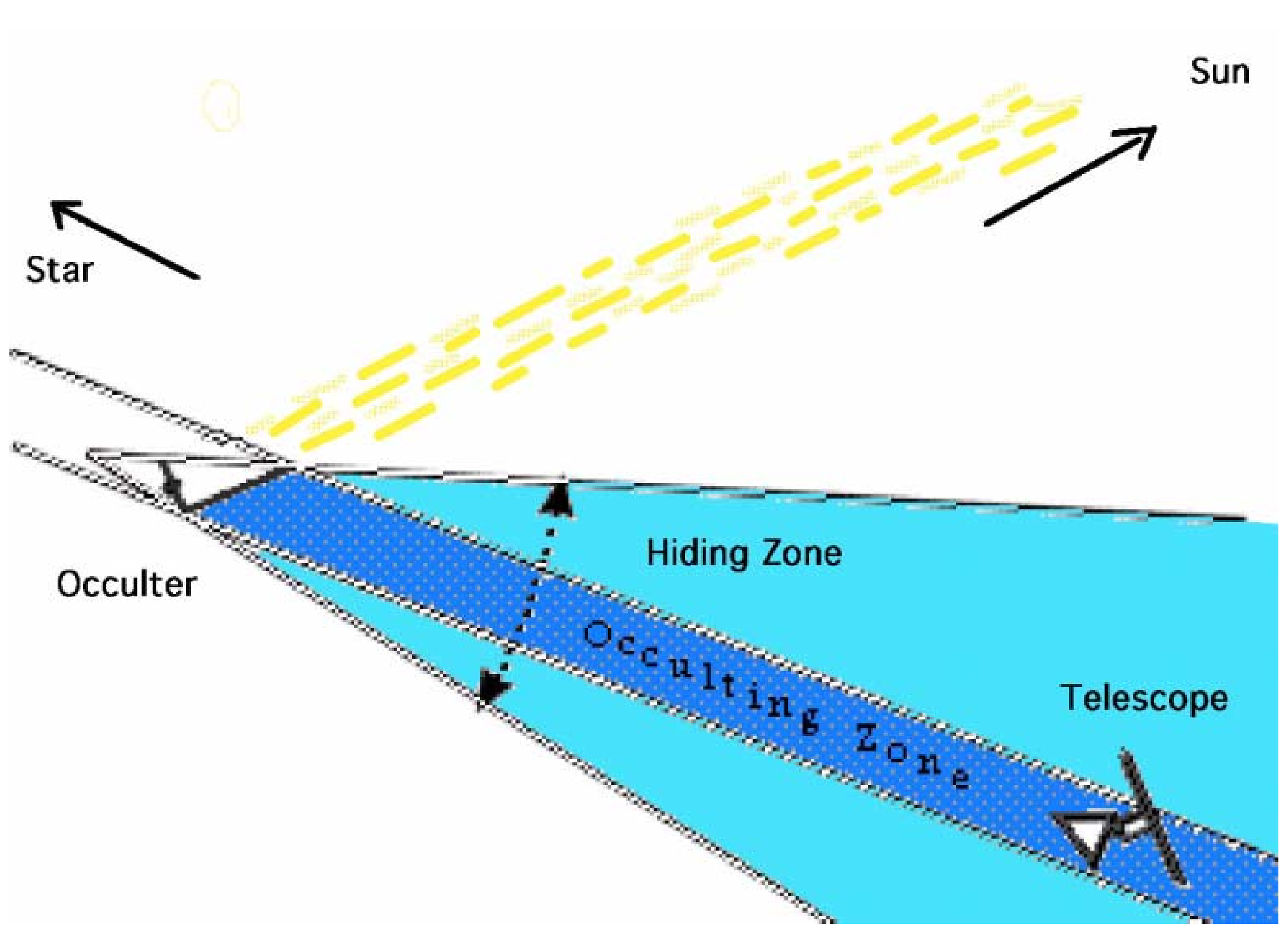


Figure1: Telescope-occulter configuration (not to scale)

Introduction to External Occulters:

An external, free-flying occulter is a spacecraft designed to fly tens of thousands of kilometers from a space-based observatory. The occulter is interposed between the telescope and the target star in order to reduce the light from the star, enabling the telescope to image any faint companions in orbit about that star. A 5-year occulter mission designed to perform extrasolar planet detection, orbit determination, and atmospheric characterization about 50-100 or more stars within 15-40 parsecs could be conducted in concert with JWST. Simulations show that an apodized 4-meter telescope and a 20-meter occulter system could optically detect terrestial sized planets about stars out to approximately 7 parsecs.

JWST Science:

* Planned optimization for 1-5 micron region, capable to 20 microns (current plan).
* Planned filters useful for photometry of extrasolar giant planets (1.6, 4.5, 5.1, and 12.8 microns).
* 6.5-m mirror gives 0.03 arcsec resolution at 1 micron.
* Occulter intended for observing in non-thermal wavelengths (up to 1.6 microns) or will require active cooling.

External Occulter Advantages:

* Star light blocked before entering telescope.
* No secondary coronographic optics to reduce throughput or introduce scattering.
* Can use any imaging or spectroscopic instrument without redesign.
* EGP detection less sensitive to polarization effects of optical surfaces.
* Can be added without redesign of current instruments.
* Only modest telescope enhancements would be necessary to operate with occulter, see next section.

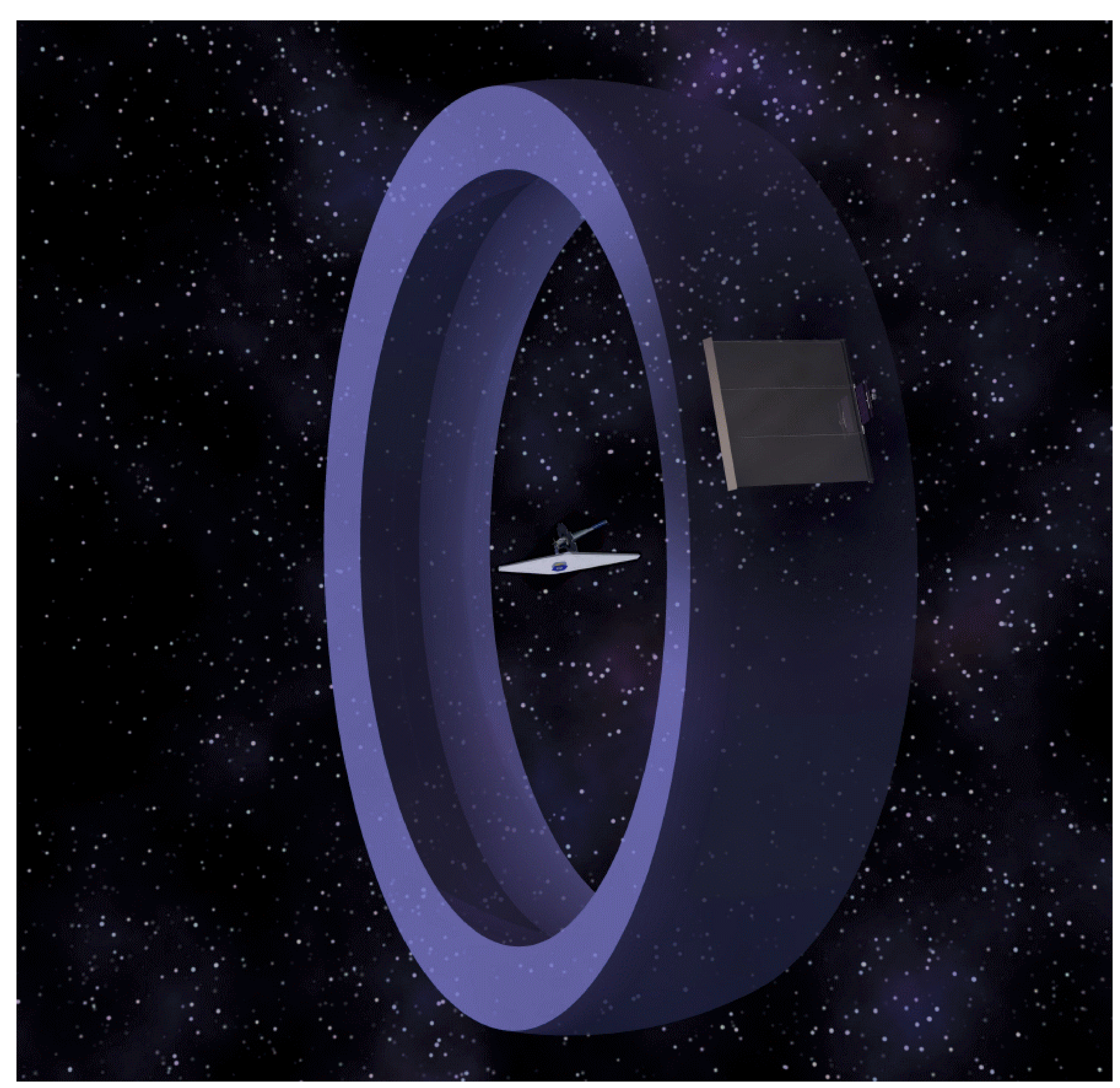
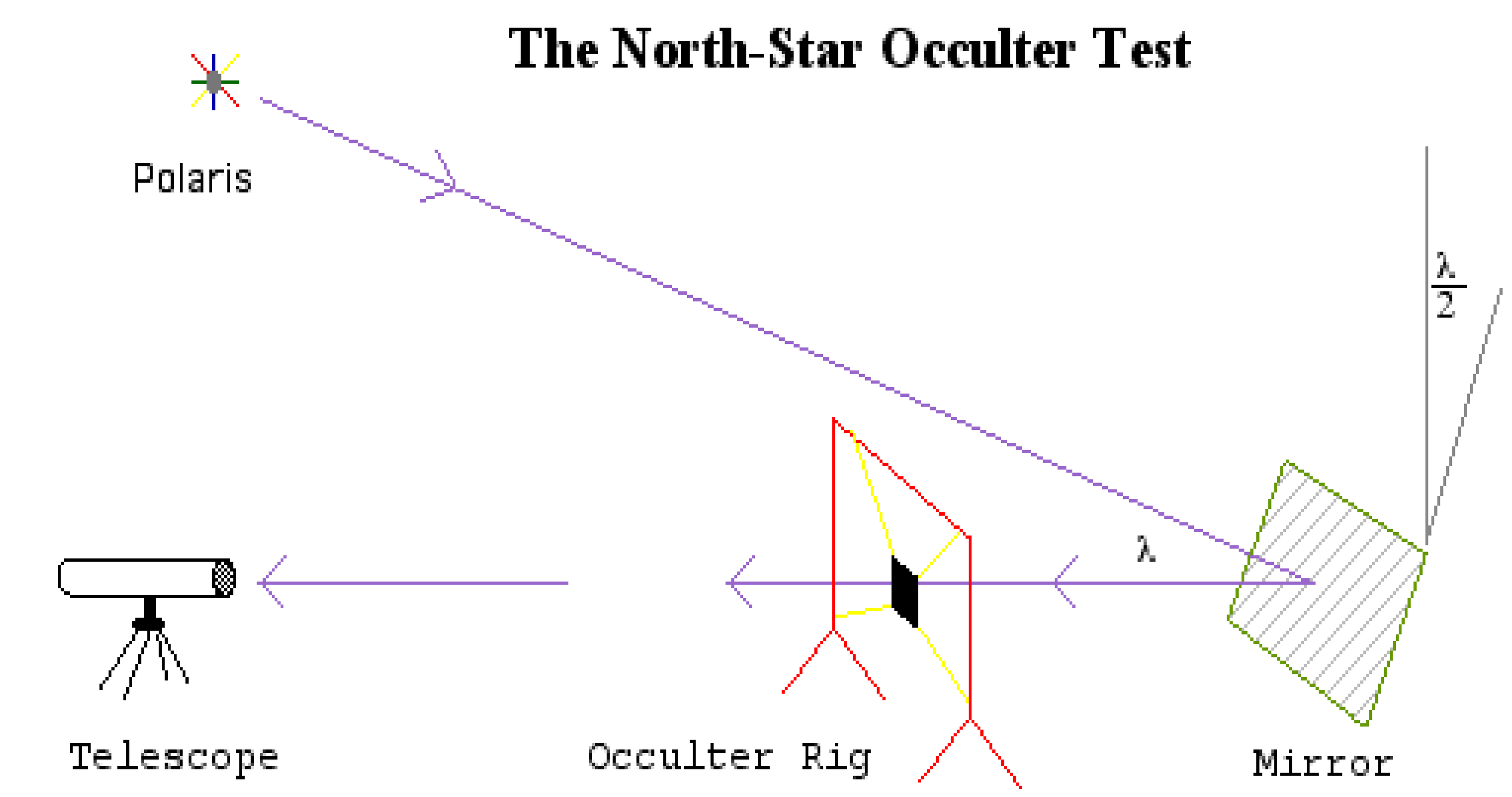


Figure 2: The *Quadrature Ring* representation (not to scale)

Operational Constraints and Requirements:

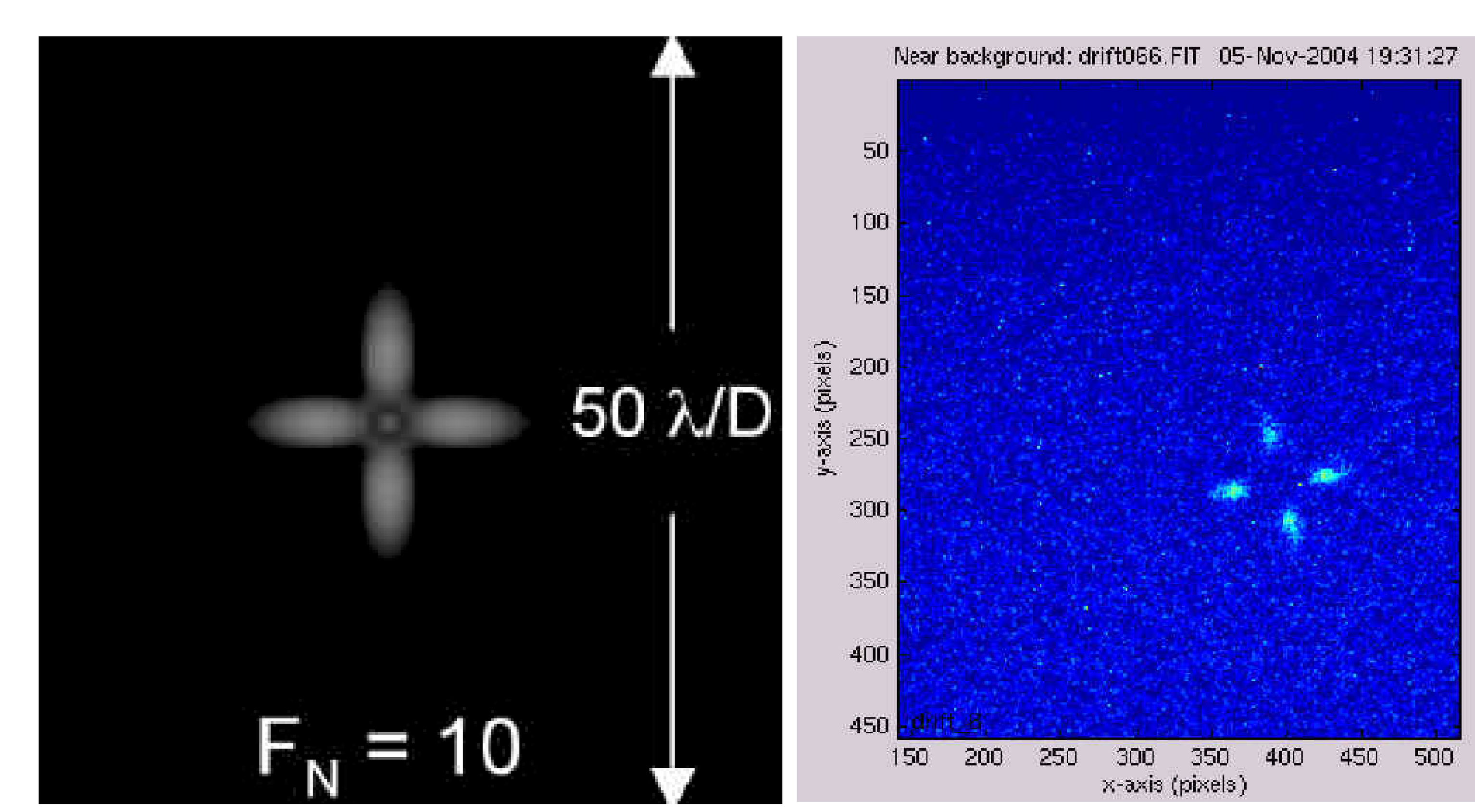
* Dual spacecraft formation flying.
* Communication link between telescope and occulter.
* Telescope software to enable formation flying.
* Occulter will operate 10-20,000 km from the telescope on a vector within 10-30 degrees of the plane perpendicular to the JWST-Sun vector, a zone called the "Quadrature Ring" (QR) (see Figure 2).



The Ground Test Configuration:

The scaled ground test configuration, illustrated above and in images below, used a 540-mm focal length refractor masked down to 11 and 24 mm (below left) separated by 100 meters from an occulter, a 12-inch diameter light shroud tube with removable 1- and 2-inch square occulters and a mirror cell (below right). Optical alignment of the system was carried out by using a green laser pointer. The star Polaris was allowed to drift across the field of view and behind the occulter.

Figure 4: The ground test hardware



Is It Real?:

Above left is a computer simulation of a star behind an occulter compared with actual ground test data of Polaris (above right) taken on November 5, 2004. The diffraction lobes are distinctly visible in the computer simulation and in the image of Polaris.

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