Starshade concepts

Markus Janson

Image credit: NASA
General concept

External opaque mask casts a shadow on the telescope, providing high contrast with good IWA.

Pros: Easier than coronagraphy to reach very high contrasts

Cons: Limited directability; lack of “stepping stones”

Seager et al. (2015)
Some basic parameters

Larger separation between telescope and starshade is better, but more expensive.

Short wavelengths are easier than long wavelengths.

=> UV is easy, while mid-infrared is essentially hopeless.

There is partially a trade-off between contrast and bandwidth.

\[ \mathcal{R} = \left[ \frac{n!}{r^{2n}} \left( \frac{s\lambda}{2\pi} \right)^n \right]^2 \]

(Not optimal, but conceptually useful)
Examples of concepts

Path 1: Design mission with a telescope-occulter pair

E.g. HabEx: ~4m telescope, ~72m starshade
Examples of concepts

Path 2: Design occulter for an ‘existing’ telescope

E.g. Starshade rendezvous: WFIRST telescope, ~20m starshade
The CESO concept

A starshade in space casts a shadow on a telescope on Earth

Janson (2007) examines an orbital configuration to accomplish a fixed shadow at minimal delta-V constraints
The CESO concept

A co-rotating orbit at appropriate distance will give a shadow motion that instantaneously matches Earth’s rotation at some latitude.

=> Minimal delta-V required to maintain shadow fixed on a telescope around that time.

Janson (2007)
The CESO concept

An orbital solution exists that matches the celestial equator across the year (well enough)

Target-to-target motion very cheap, though restricted within +/-5 deg latitude

Janson (2007)
The CESO concept

Large sample available even within +/-5 deg, thanks to the small IWA
Notable developments

Thin, opaque materials are becoming increasingly manufacturable
Notable developments

Extreme adaptive optics: >50% Strehl at visible wavelengths! (e.g. ZIMPOL)

Requires bright guide star
Telescopes of increasingly larger sizes are becoming available from the ground.