NIRCam Coronagraphic PSF Estimation

Estimating the coronagraphic point spread function (reference PSF) is essential to achieving the deepest possible contrast and recovering faint astrophysical signals in the vicinity of a bright central object.

Introduction

Parent page: NIRCam Operations
See also: NIRCam Coronagraphic Imaging , JWST High-Contrast Imaging

The purpose of PSF subtraction is to achieve limiting contrast between a bright host (star, AGN, etc.) and reveal the faintest detectable astrophysical signal or "companion" in its vicinity. For more information, please refer to NIRCam-Specific Treatment of Limiting Contrast.

The companion may be an extended source, such as a circumstellar disk, a jet, or a point source, such as an exoplanet. The PSF reference image may be a composite of multiple images obtained after pointing changes—either a roll or an offset. To perform PSF subtraction, the reference image is scaled and subtracted from science images.

The idea is to subtract the closest 3-dimensional PSF (X, Y and intensity) profile of an unresolved star to a given scientific observation.

NIRCam PSF subtraction strategies

See also: JWST Coronagraphy in ETC

The most critical and consequential step in the post-processing of NIRCam coronagraphic images is subtracting the estimated wing of the point spread function (PSF) of a target centered on a coronagraphic mask (occulter).

Currently, NIRCam supports three PSF subtraction strategies, each with its own pointing operations, which vary in complexity and performance.

1. In the "reference star strategy" (RSS), coronagraphic images are obtained for both the host and reference targets. The reference image is to be scaled and subtracted from the host image to reveal any companion features, which are now as free as possible of residual light from the host.

2. The "angular differential imaging strategy" (ADIS) is self-referenced, involving only the host target. Two coronagraphic images are obtained that differ only in a small (5°–10°) roll maneuver, which must be sufficient to fully separate the two positions of the companion-feature image. Observatory roll is highly restricted, to ±5°, and observation planning is supported by the JWST Coronagraphic Visibility Tool.
3. The "small grid dither strategy" (SGDS) involves a *library* of reference-target images, obtained in a pattern of small, highly accurate, subpixel offsets (dithers). The library comprises samples of the slight variations in the PSF wing as a function of position relative to the occulter. Because the range of the SGDS pattern is larger than the expected error in TA, the optimal reference PSF for subtraction is a careful interpolation in the SGDS library. A variety of algorithms are available to perform the optimal subtraction, such as LOCI or KLIP.

References

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