EXOPAG SAG 18 Draft Charter

Metrics for Direct-Imaging with Starshades

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The use of starshades for future direct-imaging missions is being studied and developed by various groups. Extensive testing of starshade performance has been conducted over a wide range of scales and test conditions. One missing piece has been a clear set of metrics to standardize the starlight-suppression performance of a test and requirements of a flight mission. There have been informal definitions of contrast as the amount of residual starlight at the location of an exoplanet of interest and of suppression as the total amount of residual starlight entering the telescope. But more precise definitions are needed to compare test results across groups and to then define flight requirements using these same definitions. An agreed-upon set of metrics would allow unbiased comparisons between separate tests and between tests and flight requirements.

A second SAG (SAG19, chaired by Dimitri Mawet) will be starting at the same time and working in parallel to answer similar questions but focused more on signal detection theory. We will coordinate closely with this SAG and develop compatible standards as much as possible.

We propose to form SAG18 to identify the areas of starshade performance where standardized metrics would be beneficial and to create rigorous definitions of key terms.

Some questions that may be answered by this SAG are list below. Refining these questions and goals will be the first task for the SAG group. We expect that the outputs from this SAG will be published so that the results can be used in the continuing starshade development work. The minimum outputs will be a glossary of terms as they are used in the community.

1. How can contrast or suppression be used as metrics of starshade performance (pros and cons)?
    - Contrast is directly linked to planet detectability, but is not flight-like if image is over-resolved.
    - Suppression is independent of telescope/ resolution, but it doesn't take into account the spatial distribution of light, so it's a very worst-case assessment.
2. How should contrast be defined?
    - The contrast should be calculated using a standard pixel location in the image, such as an annulus near the petal tips.
    - For test where there is no off-axis object in the field, a contrast limit must be calculated. This could be the average light in the chosen pixels, a statistical measure of the noise in the pixels (e.g. StDev), or a simulation of a point source detectability limit in the image.
    - If the test image is over-resolved compared to a flight-like configuration, the image could be post-processed to compensate. A method of compensation should be determined.
    - New starshade metrics should be based off of existing metrics where possible. Coronagraph groups have developed methods of defining contrast achieved in their testbeds and contrast required for planet detection. In additional, standard astronomical techniques for detecting faint sources will be referenced. The starshade metrics will be unique only where some aspect of the residual stray light from starshades requires a new approach.
3. How should suppression be defined?
    - If a test only measures the focal plane, then the suppression must be calculated by summing over an area in that image.

- Create a standard for what area of the image is included, including what features can be masked off and what radius the area should extend to
- If there is a smooth background present in the image, this could be subtracted either as a constant level or a smooth distribution.