REALISTIC SIMULATIONS OF CORONAGRAPHIC OBSERVATIONS WITH FUTURE SPACE TELESCOPES.
M. J. Rizzo[1], A. Roberge[1], A. Lincowski[2], N. T. Zimmerman[1], R. Juanola-Parramon[1], L. Pueyo[3], M. Hu[4], A. Harness[4], [1]NASA Goddard Space Flight Center, 8800 Greenbelt Rd, Greenbelt MD 20771, maxime.j.rizzo@nasa.gov; [2]Dept of Astronomy, University of Washington, Box 351580, Seattle, WA 98195; [3]Space Telescope Science Institute, 3700 San Martin Drive, Baltimore, MD 21218; [4]Dept of Aerospace Engineering, Princeton University, Princeton, NJ 08544

We present a general framework to simulate realistic observations of future space-based coronagraphic instruments. This framework gathers state-of-the-art scientific and instrumental expertise and provides an end-to-end tool to simulate full observing scenarios, allowing robust characterization of future instrument concepts.

First, a spatially and spectrally resolved astrophysical scene is constructed with a star, a planetary architecture, and dynamically-consistent exozodiacal dust structure. It is superimposed to a background scene with stars and galaxies with realistic colors, which is based on the Hubble Ultra Deep Field galaxies. Several pre-computed scenes exist for different types of coronagraphs, and will be made publicly available. Scenes without exozodiacal dust can be constructed within the software.

The input science cube is processed with a coronagraph model, using pre-computed libraries of on- and off-axis point-spread funtions. Several instrument models can be chosen, including the WFIRST coronagraph, a starshade, and the LUVOIR coronagraph. These instrument simulations take into account time-varying wavefront errors that can degrade the contrast and decrease the performance of post-processing algorithms.

Various detector models are proposed to read out the focal plane, including the photon-counting EMCCDs baselined for WFIRST and LUVOIR. This generates realistic data products that can be used for post-processing.

Elementary post-processing methods, such as reference differential imaging (RDI), are also included as a set of basic post-processing routines. In the case of RDI, the user needs to run the code by also simulating the observation of a reference star, in addition to a target star.

We can also simulate using an integral field spectrograph as a backend instrument to the coronagraph. This allows to recover a full spatio-spectral datacube representing the input scene. The model for this instrument is the WFIRST integral field spectrograph, but it is simple to modify parameters in order to adapt them to other architectures.

This versatile simulation framework is written in Python and made publicly available to the community. It is aimed at helping the design of future coronagraph instruments by developing accurate sensitivity models, constructing realistic data products, and producing visually-appealing images to showcase the performance of these instruments (e.g. see Figure 1 for a WFIRST simulation).

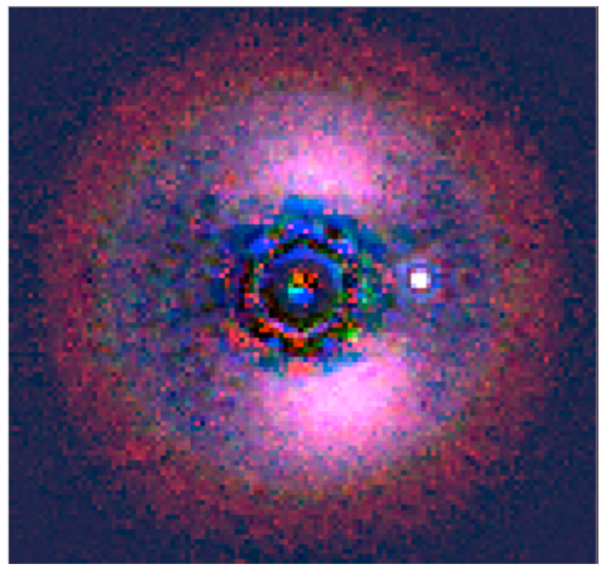

Figure 1: RGB composite of a simulated scene through the WFIRST Shaped Pupil coronagraph (Disk Mode). The scene represents a Jupiter-size planet at 2AU, seen in a system at 3pc. Two resonant dust structures can be seen at the Lagrange points of the system. The speckle noise floor is representative of a 10 picometer wavefront error. The composite image is from three filter bands, at 660nm, 720nm and 880nm, and simulates a total integrated exposure time of 24h across the three bands.