Science Applications of the coronagraph instrument

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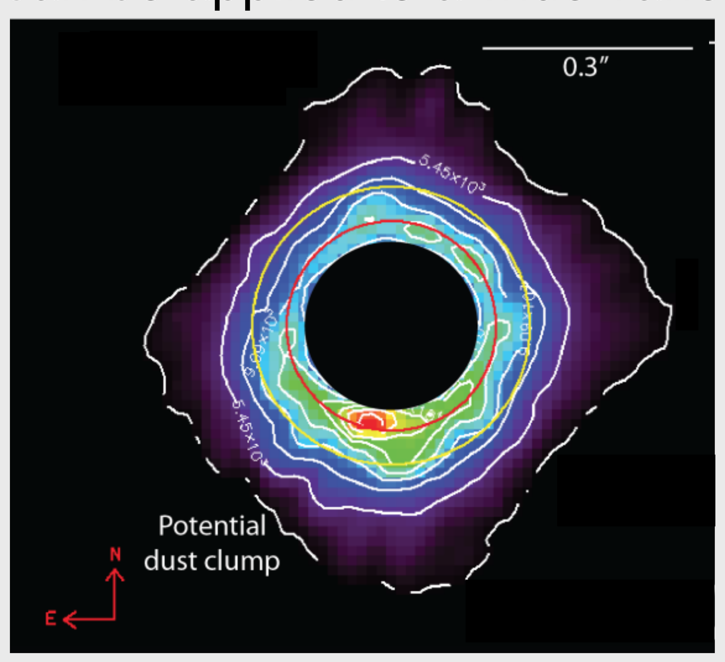
In addition to the discovery and characterization of exoplanets, the coronagraph instrument (CGI) on WFIRST has the potential for ground-breaking discoveries in other fields. The full capabilities of the WFIRST CGI will be invaluable for a broad range of scientific applications, including imaging of asteroids, Kuiper Belt objects, and comets; the circumstellar environments of evolved giant and supergiant stars; protoplanetary disks around young stars; and the circumnuclear regions of active galactic nuclei. In this poster we summarize some of the key compelling science gains that can be pursued with the WFIRST CGI.

Massive Stars

The circumstellar environments of evolved massive stars are excellent targets for coronagraphic imaging. With a large contrast ratio and small inner working angle it is possible to detect gas, dust, and companions at very close radii. This in turn can be applied to a wide variety of current questions on massive stellar evolution.



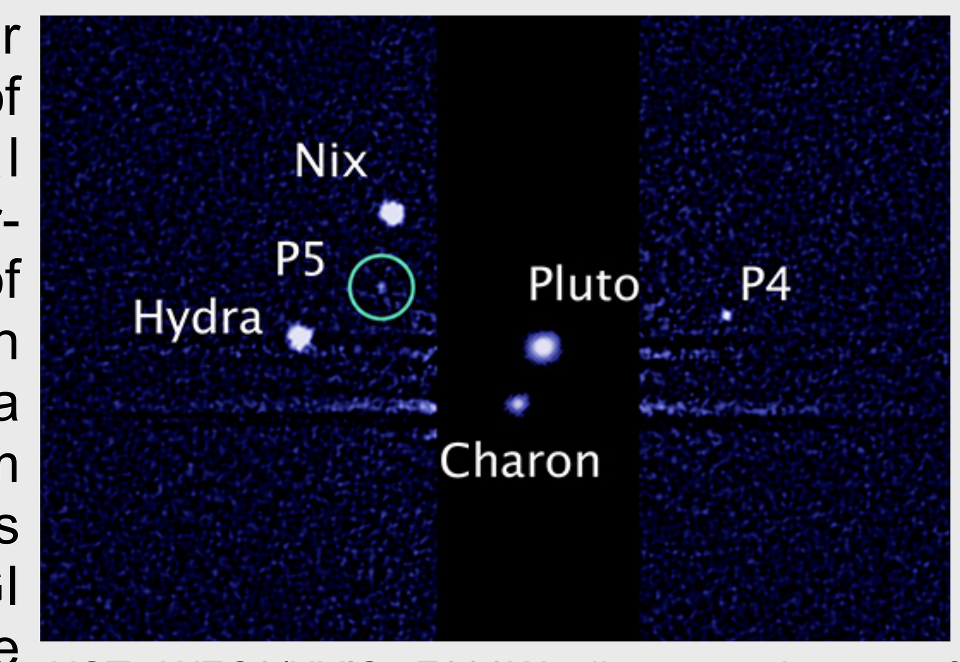
H-band GPI image of the circumstellar environment of Galactic RSG CD-31 4916 (Jamie Lomax; poster **#341.03**)

Coronagraphy of cool massive stars such as red supergiants and yellow supergiants will make it possible to identify small companions at close radii and directly test different mass loss scenarios. For hot evolved massive stars such as Wolf-Rayet stars and luminous blue variables, coronagraphic imaging could reveal the detailed morphology of circumstellar environments impacted by strong wind interactions or eruptive mass loss events.

See poster #341.03 today for more on current and future work with massive star coronagraphy!

Asteroids, KBOs, and Comets

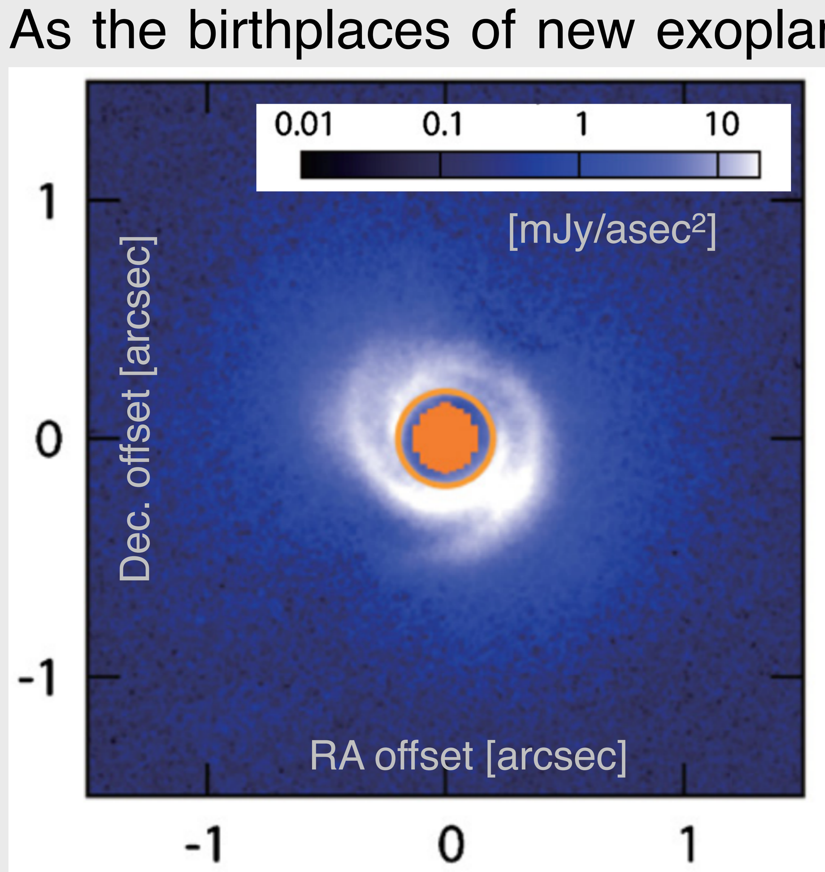
Objects within our own solar system, including binary asteroids, Kuiper belt objects, and asteroid moons, would benefit enormously from optical coronagraphy. Imaging binary or multiple systems at several epochs (see below) will make it possible to estimate masses and densities, which in turn can be used to infer bulk composition and porosity for these objects. Coronagraphic imaging of "active" asteroids can also reveal outgassing and the presence of near-surface volatiles, while observations of distant comets that have not yet been exposed to solar UV emission could offer a glimpse of primordial early solar system materials. Carrying out such observations with a space-based instrument like the CGI on WFIRST would allow us to combine improved PSF stability with deep sensitivity limits at small inner working angles.



HST WFC3/UVIS F606W discovery image of Styx, illustrating detection of KBO multiple system (NASA, ESA, & M. Showalter/SETI Institute)

Protoplanetary Disks

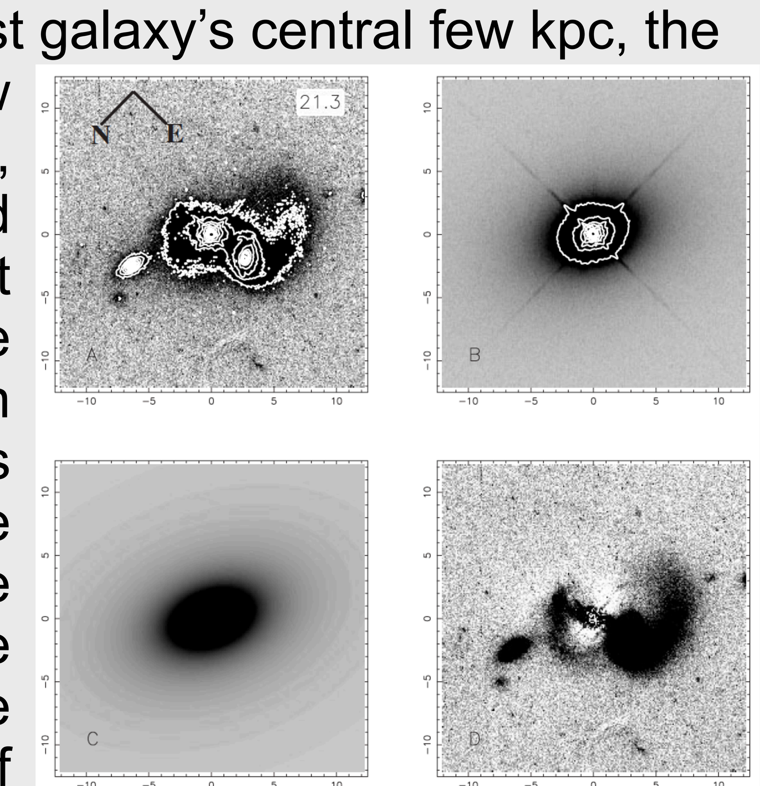
As the birthplaces of new exoplanets, protoplanetary disks are crucial observing targets for understanding the mechanisms and timescales of planet formation. Protoplanetary disks are brighter than debris disks with fainter central stars. ALMA observations can determine total mass and study large dust grain morphology, while near-infrared polarimetric images have begun to reveal structure. However, visible-light observations with the improved angular resolution and inner working angle offered with a space-based coronagraph such as the WFIRST CGI will observe the scattered light, probing the small grain properties and spatial distribution of the disk as a whole, identifying asymmetries and spiral arms in unprecedented detail.



From Muto+ 2012; Subaru/HiCAO H-band polarized intensity image of SAO 206462; mask size and errors in orange.

Active Galactic Nuclei

Active galactic nuclei (AGN), in particular Seyfert 1's and QSOs, are excellent targets for coronagraphic observations. Their bright nuclei (exposed along a clear line of sight) inhibit detailed observation of the host galaxy's central few kpc, the same area that is crucial for understanding how these AGN are fueled. Coronagraphic imaging, combining PSF fitting with host modeling and subtracting, allows us to determine the host morphology and brightness profiles of these galaxies' circumnuclear regions. This in turn makes it possible to identify key features such as bright star-forming regions and jets from the central source. Optical coronagraphy will sample older stellar populations at z~0-2 and rest-frame UV emission from the formation of young massive stars at z>2; WFIRST could be capable of carrying out an unprecedented coronagraphic survey of AGN at 0<z<6.



From McLure+ 1999; HST images, 2D model fits, and model-subtracted images of the radio-quiet quasar PG 1012+008

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