Circumstellar Disk Studies with the Gemini Planet Imager: Simulations and Sensitivities

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The GPI team also includes members at UC Santa Cruz, JPL, AMNH, Universite de Montreal, NRC Herzberg Institute of Astrophysics & elsewhere.

GPI is a high-contrast AO system being built for the Gemini Observatory (Macintosh et al. 2008). GPI combines:
• high order AO wavefront control
• coronagraphic diffraction suppression
• precision IR wavefront calibration
• a speckle-suppressing science camera

GPI is well into its integration & test phase, and first light is planned for about 1 year from now.

GPI’s primary science goal is the direct imaging and characterization of young, low-mass exoplanets in thermal emission. GPI also seeks to image scattered light from debris disks with optical depths down to as low as $\tau \sim 4 \times 10^{-5}$.

GPI’s science camera is a near-infrared integral field spectrometer and polarimeter that can provide either $\sim$30-80 spectroscopy or broadband dual-channel polarimetry in 3 bands from 1.2-5 µm. Polarimetry mode is implemented via a novel "integral field polarimetry" optical design (Perrin et al. 2008, 2010) that will provide enhanced speckle suppression over prior high-contrast polarimeters by eliminating non-common-path WFE between the channels.

GPI is Nearing Completion

The 2.5 years since GPI passed its critical design review in 2008 have been very productive, and we’re eagerly looking forward to shipping it out later this year. The optomechanical structure, calibration interferometer, and coronagraph masks have already been delivered to UCSC. The science camera is undergoing pre-shipping test and review at UCLA for delivery this spring. And initial versions of a data pipeline, user tools, and analysis GLUs are all ready and awaiting science data. We expect to deliver to Gemini South in late 2011 and begin science operations in 2012.

Systematics & Calibration

GPI’s sensitivity to disk-scattered light relies on differential polarimetry to suppress PSF speckles. The achieved performance depends both on the science camera calibration (for which reason we developed a new polarimeter design optimized for high contrast) and also on our ability to calibrate instrumental polarization of the Gemini telescope plus GPI AO system.

Calibration accuracy of <0.3% in degree and <20º in phase is required to ensure that final uncertainties are not dominated by systematics. Monte Carlo simulations demonstrate that our in-lab and on-the-sky calibration plans should achieve accuracies at least ~0.5%. We conservatively estimate 1% residual post-suppression speckles, comparable to polarimetric performance achieved at Lick (Perrin et al., 2008, Hinkley et al., 2009). This factor includes systematic uncertainty from instrumental polarization, flat field uncertainties, and crosstalk between polarization channels on the detector.

Planned Science Observations

Gemini Observatory has recently released a call for proposals for campaign science with GPI starting in semester 2012B (see the Gemini web site for full details). The resultant science program is expected to contain observations of circumstellar disks as well as direct imaging of self-luminous low-mass exoplanets.

GPI will excel in both assembling large statistical samples via survey operations, and also detailed follow-up studies of particularly interesting objects. The improved contrast and image working angle lend themselves to investigations of the inner regions of bright, known disks (for instance see the simulation of HD141569 at left). The connection between circumstellar dust and giant planets will be a key area of investigation for the future. GPI’s鉴定 with warm dust that is potentially stirred by exoplanets. Detection of disk substructure such as gaps, clumps, and rings can provide evidence for unseen planets or provide dynamical constraints on planetary systems.

But GPI’s greatest impact on disk science may be imaging surveys of larger samples of more distant or fainter disks; the majority of nearby disks known from IR excesses remain unsaged (Rice et al. 2007). In conjunction with SED modeling and resolved imaging at other wavelengths with WISE, Herschel, and/or ALMA, GPI disk observations have the potential to greatly advance our understanding of disk architectures and evolution.

Acknowledgements

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References

Graham 2008 (GPI CCDD, Gemini)
Macintosh et al. 2006, SPIE 6272
Perrin et al. 2008, SPIE 7115
Maine et al. 2010, SPIE 7736

Perrin et al., 2008, PASP p. 555
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We also acknowledge support from the Natural Sciences and Engineering Council of Canada. Gemini Observatory is operated by the AURA, under a cooperative agreement with the NSF on behalf of the Gemini partnership: the NSF (USA), MINC (Chile), NRC (Canada), CONICYT (Chile), the Australian Research Council (Australia), CNPq (Brazil), and CONICET (Argentina).

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