Mid-IR Polarimetry and Spectropolarimetry with SOFIA

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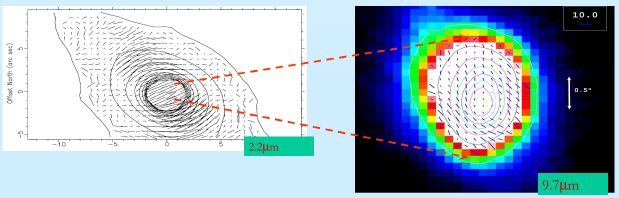
Goals

The SOFIA observing platform offers a unique opportunity to make polarimetric and spectropolarimetric observations at mid-infrared wavelengths without the complications from atmospheric absorption that plagues ground based efforts at these wavelengths. Potential targets include dust emission features in comet comae, dust emission features in protoplanetary disks, silicate absorption and emission features in evolved, cool, luminous stars and AGN. Spectropolarimetry (see the poster on **SMIRPh**) will allow us to determine the wavelength dependence of polarization in emission, extinction and scattering through spectral features from different mineral species, and mineral species at different locations along the line-of-sight. The broad wavelength coverage of SOFIA will allow us to work both through, and well outside of the silicate features.

AGN

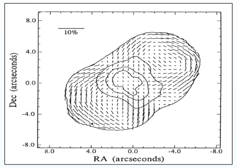
MIR polarimetric observations hold the promise of investigating the torus, the cornerstone of unified theories of AGN. Geometrically and optically thick torus of gas and dust obscures accretion onto supermassive black hole from some lines of sight. The torus intercepts a significant fraction of the flux from the central engine and re-emits this energy in the MIR.

MIR observations are potentially the most useful wavelength range for investigating the torus. Dust grains in the central regions of the AGN could be aligned through radiation pressure from the central engine (Elitzur & Scloshman, 2006), or magnetic fields, which in some models is necessary for torus formation and stability (Krolik & Begelman 1988; Konigl & Kartje 1994). Observations such as those for NGC 1068 can establish the continuity between the torus and host galaxy's nuclear environments. Without large wavelength coverage, the silicate feature can complicate more than enhance the observations.

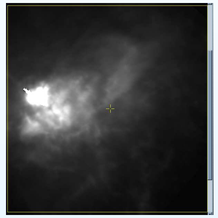


NIR to mid-IR polarization in NGC 1068 (Packham et al. 1997, 2007) shows 90º PA of polarization flip, consistent with aligned dust grains North of the nucleus, a central minimum due to a compact torus, and dust infall to the East, South and West.

Evolved Stars



N band polarimetry of Eta Carina (Aitken et al. 1995)



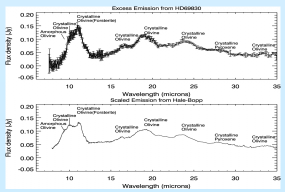
VY CMa showing arc-like features in the mass loss wind with morphology reminiscent of Solar prominences (Smith 2001).

Grains can become aligned on surprisingly short time scales. Grains in the ejecta of Eta Carina, for example, show alignment on shorter than century time scales. If magnetic fields are responsible for the alignment, we can explore the magnetic field geometry in circumstellar shells. For example, are the large arcs seen in VY CMa and IRC +10420 analogous to Solar prominences, only many orders of magnitude more energetic? Are magnetic fields a fundamental part of the mass loss process in luminous cool stars?

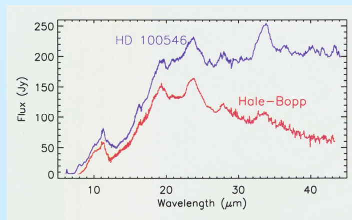
Mid IR imaging polarimetry and spectropolarimetry, with wavelength coverage through and well outside the Si feature (which can be both in absorption and emission) can help explore these questions.

Comets and Protoplanetary Disks

There is evidence for aligned grains in comet comae (e.g. Rosenbush et al. 2007) and it is likely that grains will be aligned in protoplanetary disks as well. The MID-IR offers a wealth of spectral features due to specific mineral species in both crystalline and amorphous forms. If these minerals are in aligned grains, then spectro-polarimetry through the emission features can be used to investigate relationships between these species. For example, if amorphous and crystalline olivine are in separate grain/grain aggregates, then the polarization through the spectral features could be very different. If the silicates are in separate grain/grain aggregates than carbon, the polarization may show a change between the continuum and the emission features.



SPITZER SPECTRA OF A KO V STAR "SUPERZODI" vs. SOLAR SYSTEM COMET
(*adopted from Biechman et al. 2005, ApJ 626, 1061)*



ISO SPECTRA OF A HERBIG DEBRIS-DISK SYSTEM AND SOLAR SYSTEM COMET *(adopted from Crovisier et al. 1996, Science 275, 1904 and Malfait et al. 1998 A&A 332, 25)*