Mid-Infrared H$_2$ Imaging of the Nearest Twisted Protostellar Outflow: Spitzer IRS Spectral Mapping of IRAS 16253-2429


Background: The IRAS 16253 Outflow

At a distance of just 125 pc in the Ophiuchus clouds, the outflow from the Class 0 source, IRAS 16253-2429, is unique in its proximity, isolation, and beautiful hourglass shape. The protostar was first discovered as a strong millimeter source in a mapping survey of the cloud [1]. Its near-infrared, shock-excited H$_2$ emission and CO (3-2) bipolar outflow were mapped soon thereafter [2].

IRAC image (blue = 3.6 μm, green = 4.5 μm, red = 5.8 μm) of the protostar, the bipolar outflow cavity (seen via scattered light, mostly in the 3.6 μm channel) and regions of shocked emission (seen mostly at 4.5 μm and 5.8 μm) in the outflow.

IRAC 8.0 μm image of IRAS 16253-2429: The 8.0 μm filter encompasses two strong PAH emission features; one at 7.7 μm and the other at 8.6 μm. The ρ Ophiuchi cloud core is backlit by the UV radiation of the Sco OB2 association behind it, providing a bright background to reveal the infall envelope in absorption.

The 2.12 μm 1-0 S(1) Line (red) overlaid on the K-band continuum image (greyscale) of the protostar and its outflow. These data were obtained with the Wide-field Infrared Camera (WIRC) on the Hale 5-meter telescope [3].

IRS Spectral Line Maps

The inner 2.25′ x 1′ (0.081 pc x 0.036 pc) region of the twisted, point-symmetric outflow driven by IRAS 16253 was mapped with the Infrared Spectrometer on-board Spitzer Space Telescope in March of 2007. Maps were obtained in SLI (Short Wavelength) mode, covering the 3.2 μm – 14.7μm spectral range at low-resolution (R=64 – 128).

The outflow is detected in all of the pure rotational H$_2$ transitions that fall within the instrumental bandpass, but in no other spectral features. The integrated line intensity maps are displayed to your right in units of W m$^{-2}$ sr$^{-1}$.

Upcoming Data Analysis

Estimating extinction and using excitation diagrams (e.g. [4,5]), we plan to derive the local temperature (assuming LTE conditions) in different portions of the flow. Such excitation diagrams are constructed by plotting the values of ln(N$_{H}_2$/μ) against E$_{up}$, where N$_{H}_2$ is the column density of the population in the upper energy level of each transition, and E$_{up}$ and $\mu$ are the level energy and statistical weight, respectively. The slope of the straight line fit to these points then yields the temperature of the emitting region. Derivation of the density structure of the protostellar envelope from the absorption profiles, and of jet properties derived from the outflow cavity shape will be the subject of a separate work.

Ortho H$_2$ Lines

- The 5.5 μm 0-0 S(7) Line
- The 6.91 μm 0-0 S(5) Line
- The 9.67 μm 0-0 S(3) Line

Para H$_2$ Lines

- The 6.1 μm 0-0 S(6) Line
- The 8.0 μm 0-0 S(4) Line
- The 12.27 μm 0-0 S(2) Line

References