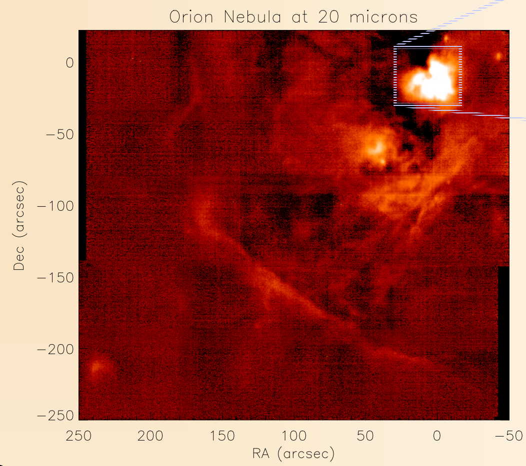
Mid-Infrared Observations of the Orion Bar with MIRSI

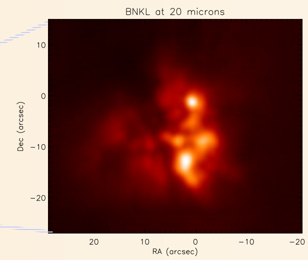
M. Kassis (BU), L.K. Deutsch (BU/CfA), E.L.O. Bakes (NASA/ARC), J.L. Hora (CfA), J.D. Adams (BU), and M.F. Campbell (Colby College)

http://mirador.bu.edu/mirsi/mirsi.html

ORION NEBULA

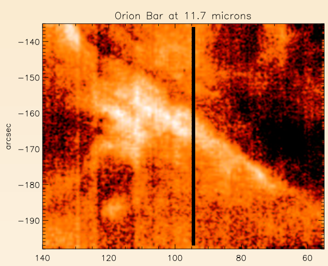
Mid-infrared images and spectra of the Orion Bar were acquired using MIRSI (the Mid-InfraRed Spectrometer and Imager) at the NASA InfraRed Telescope Facility (IRTF) in November 2002. The data acquired of the Orion Bar is part of a project to observe the emission from Polycyclic Aromatic Hydrocarbons (PAHs) in Photodissociation Regions (PDRs). Our goal is to compare observational results to predictions from state-of-the-art models of interstellar infrared emission and macromolecular chemistry (Bakes et al. 2001a,b). The models predict variations in the spectral features of PAHs, and can be used in combination with the observations to constrain the properties of the environment and compostion in the PDR in the Orion Bar.

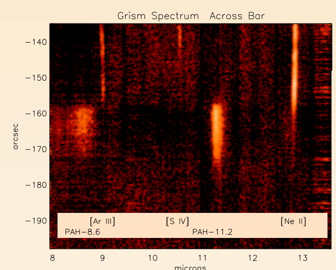




A 4x5 mosaic (left) taken at 20.9 µm contains the most prominent features of the Orion Nebula: the Bar, Trapezium, and the BN/KL region. Each position in the mosaic represents 40 s on-source integration time. Offsets in arcseconds are relative to the BN/KL object. The display in the mosaic is set to show the faint diffuse emission near Trapezium and the Bar. An enlarged section of the mosaic reveals the detail in the BN/KL region (above) that emerges in high resolution imaging with MIRSI.

ORION BAR



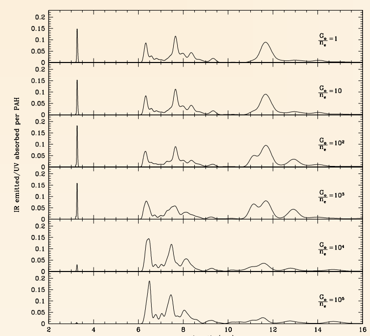


High resolution images were acquired of the Orion Bar at 8.7, 10.2, 11.2, 11.7, and 20.9 µm. In the 11.7 µm image (above), the Bar is a bright, clumpy, elongated structure. The 11.7 µm image has an on-source integration time of 20 s. and represents one full MIRSI field of view (85"x64"). The vertical line in the image represents the slit size and position used to take the spectrum of the Bar.

With our two dimensional array, we obtain spatial information along one dimension of the array and spectral information along the other dimension. Because of the Bar's favorable edge-on geometry, the spectroscopic observations trace the relative strengths of the PAH features as a function of depth into the Bar. Above, a spectrum of the Bar from 8-13 µm exhibits emission from both ionized gas and PAHs. The sharp transition between emission from [Ar III] at 8.99 µm and PAHs at 8.6 and 11.2 µm demonstrates that PAH emission peaks near the edge of the HII region. The emission from [Ar III], [S IV] 10.52 µm, and [Ne II] 12.81 µm will help constrain UV field strength, and the intensities of the 8.6 and 11.7 µm PAH features will be directly compared with the models of Bakes et al. 2001a,b.

PDR THEORY

Both the UV field flux (G_o)and the electron density will vary with depth (as a function of A_v) into the PDR. The emergent IR emission spectrum from the PAHs will depend on their charge, size, molecular structure, degree of hydrogenation, and erosion, which are determined by their UV powered photochemical evolution within the PDR (Bakes et al. 2001a,b). The figure below illustrates how the ratio of G_o/n_e affects the PAH charge, which has a major effect on the resulting PAH emission profile (Bakes et al. 2001a). The surface of a PDR corresponds to relatively high G_o/n_e, which decreases with depth into the PDR. Comparisons of our observations with the models will allow us to determine important physical parameters for the Bar, such as their UV flux, gas and electron density, and gas temperature for regions at successive depths into the Bar.



Bakes, E., Tielens, A., & Bauschlicher, C. 2001a, ApJ, 556, 501

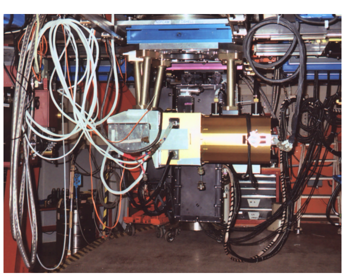
Bakes, E., Tielens, A., Bauschlicher, C., Hudgins, D., & Allamandola, L. 2001b, ApJ, 560, 261

MIRSI

Mid-InfraRed Spectrometer and Imager

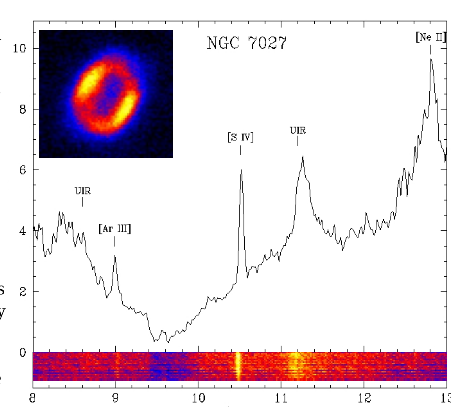
MIRSI is the Mid-InfraRed Spectrometer and Imager which utilizes a Raytheon/SBRC 320x240 Si:As high background IBC array. Off-axis reflective optics in the camera liquid-helium cryostat yield achromatic diffraction-limited imaging with a pixel scale on IRTF of 0.27 arcsec and a field of view of 85x64 arcsec. MIRSI offers complete spectral coverage over the 8-14 µm and 17-26 µm atmospheric windows for both imaging (discrete filters and circular variable filter) and spectroscopy (10 and 20 µm grisms with resolutions of 100 and 200). A SUN PC with a PCI bus interface communicates over a fiber optic link with the Digital Signal Processor-based timing board which receives, processes, and responds to commands from the host computer. The host computer initiates telescope nod and offset commands over the network while the DSP acquires data and controls the telescope chopping secondary. All data files are stored in FITS format. For a more complete description of the camera see Deutsch et al. 2002, SPIE, Astronomical Telescopes and Instrumentation, 4841,13.

MIRSI is available for collaborative observations at the IRTF. Interested parties must contact MIRSI P.I. Dr. L. Deutsch (ldeutsch@cfa.harvard.edu) regarding the submission of collaborative proposals.



MIRSI on the IRTF. MIRSI was designed to look upward when attached to the IRTF's Cassegrain focus in order to eliminate intermediate, warm optics from the optical path.

Observations of the Planetary Nebula NGC 7027 demonstrate MIRSI's capabilities in imaging and spectroscopic modes. At a resolution of 200, the composite spectrum of NGC 7027 (right) exhibits lines of ionized gas and emission from PAHs at 8.6 and 11.2 µm. At the bottom, the spectrum of one of the PN lobes used to develop the composite spectrum is presented and shows that the lobe is resolved spatially along MIRSI's slit. An 11.7 µm false color image of the PN is presented at the upper left of the spectrum and shows the bright lobes. The spectrum and the 11.7 µm image contain continuum as well as PAH emission.



AAS January 2003

Acknowledgements: Funding for MIRSI construction was provided by the NSF and Boston University. We thank E. Tollestrup (BU) for his lab assistance and J. Polizotti (SAO) for his contributions to the telescope interfacing hardware and fabrication. MIRSI team members were visiting astronomers at the Infrared Telescope Facility, which is operated by the University of Hawaii under a cooperative agreement with the National Aeronautics and Space Administration.