45 Years of Infrared Astronomy at the Air Force Laboratory

Dr. Stephan Price
Space Vehicles Directorate
First Near IR Surveys

- Freeman Hall conducted the first IR survey (1962)
- TMSS (1965 – 1967) by Neugebauer and Leighton
- Southern sky (1966 – 1967) by Price
Infrared Celestial Backgrounds Program

• Define the nature & detailed character of the infrared celestial background

• Probe-rocket based experiments (1970 – 1985)
  – 20 successes out of 23 attempts

• Satellites
  – Midcourse Space Experiment (1996 – 1997)
  – Observations with ISO and Spitzer

• 2MASS
  – Supported proof of concept study
First AFCRL Experiments

- Two proof of concept flights in 1970
  - Piggy-backed on an atmospheric experiment
  - Detected Orion Nebula
  - Lessons learned

- ARPA & AFCRL also provided funds for
  - Four Cornell rocket-based experiments (1970 – 1976)
  - Caltech & U. of Ariz. for 5 and 10 µm ground-based surveys.

- Sensor (top left)
  - Double folded optics
  - 4” primary mirror
  - Linear array of 6 Mid-IR detectors
HISTAR & HIStar South

• First successful mid-IR survey
  – HISTAR from White Sands
    • April 1971 – Dec 1972 (7 flights in 20 months)
  – HI Star South (Woomera)
    • 1974
    • Southern sky survey

• Results
  – 4, 11, 21 and 27 µm point source catalog
  – First large scale maps of the diffuse IR emission from the galactic plane & the zodiacal background
Cygnus X – HISTAR vs MSX

- HISTAR had ac coupled electronics
  - Extended emission extracted by digitally inverting the high frequency attenuation
  - A comparison of the HI STAR Cygnus X map to a higher resolution MSX image is shown
Background Measurements Program

- 35 cm diam. telescopes
- SPICE (left)  
  - 11-, 20- & 27 µm
- FIRSSE (above)  
  - 20, 27, 50 & 90 µm
- X10 HISTAR sensitivity
Launch of CB Experiment

- T-3 day rehearsal above
- Launch at left
BMP Results
Midcourse Space Experiment (MSX)
The IR Galactic Center

MSX (left) and Spitzer (right): IR 3 color images of the Galactic center
MSX Cygnus X 3-color Image
Current Activities

• Extend the absolute spectral fluxes of the calibration network stars into SWIR & visible to support system calibration at these wavelengths

• Upgrade entire calibration network
  – Create 0.4 – 30 μm spectral templates
  – Apply templates to all tertiary standards
  – Include additional spectral types
  – Add best characterized stars from the Bright Star Atlas to calibration network

• Thermo-physical lunar model
**Application: Spitzer Space Telescope**

*Spitzer* Infrared Array Camera calibration paper*:
Systematic bias between K star calibrators and A star calibrators in the 3.6 and 4.5 µm bands – K stars rejected

Original CWW spectrum of $\alpha$ Tau: bias at wavelengths <5 µm

New SWS+MSX K star spectra remove the bias allowing use of K star calibrators

*Reach et al. 2005*
The Moon for Calibration

- Extended ~0.5° source
  - Only celestial object beside the Sun for radiance calibration
  - Radiance comparable to that from the Earth – within dynamic range of Earth looking sensors

- Irradiance calibration for low resolution and low sensitivity instruments

- Complicated model needed
  - Complex viewing geometry due to lunar orbit
  - Complex albedo distribution
  - Thermo-physical model

- USGS products
  36 narrow spectral bands 0.35 µm < λ < 2.39 µm