Astronomy 288C

Special Projects in Astronomy:
Astronomy Research Techniques
Microwave & IR Detectors

- Heterodyne
- bolometers
- CCD like HgCdTe InSb
Heterodyne Detectors

- Single mode <~200 GHz
- Typically 30% band
- Direct to ~100 MHz
- Cooled GaAs
- Mixers
- Correlation receivers
- Power stability  1/f noise
Bolometers

• Broad Band
• Low heat capacity
• Cooled, typical .1 K
• Noise <10^{-20} W
• Thermometers doped Si, TES
• Single/Multi mode
Direct Detection Arrays

- ~millions of pixels
- HgCdTe (Hg/Cd ratio determines cutoff)
- Complex readout schemes
- Cooled 4-50K
- Limited to <20 um or >15 THz
- Dark current, quantum efficiency
Microwave & IR Satellites

- IRAS 1983  First
- COBE 1989-1990  CMB
- IRTS 1995  Japan
- MSX 1996-1997  Military
- SWAS 1998-2005  Small Explorer
- WMAP 2001-2010  L2
- Spitzer 2003-2009
- Akari 2006-2007
- Herschel 2009-2013
- Wise 2009-2013
- Planck 2010-2012  3rd gen CMB
Infrared Astronomical Satellite

IRAS
Infrared Astronomical Satellite
IRAS

- Sun Sync Orbit 900 km  1083 kg
- Helium cooled (hence 10 month life)
- Full Sky each 6 months
- 4 bands 12, 25, 60, 100 um
- .5-2 arcmin resolution
- Discovered 350,000 sources
Cosmic Background Explorer
COBE-DMR

3 frequencies:
  31.5, 53, 90 GHz

Differential Horns
60 deg apart

7 deg resolution

Rotates at .8 rpm

Magnetic signature
COBE FIRAS

Fourier Transform Spectrometer
Cold Detectors (1.4 K)
7 deg resolution
Frequencies 60-2850 GHz
Absolute measurement
External Calibrator
Galactic foregrounds
Cold Chopped Detectors
190 mm P, Cold calibrator
Ten bands 1.25, 2.2, 3.5, 4.9, 12, 25, 60, 100, 140, 240 \(\mu m\)
.7 deg resolution
Zodiacal Emission
Bolometer detectors
Cross Calibration
Lunacy
IRTS

- LEO
- 150 mm Primary
- Liquid Helium cooled 1.5 K
- NIRS 1.4-4 um spectrometer
- MIRS 4.5-11.7 um spectrometer
- FILM CII 158 um OI 63 um
- FIRP 150, 250, 400, 700 um .5 deg resolution
Infrared Space Observatory

1-70 Mm orbit
  2400 kg, 600 mm
2 Spectrometers
2 Cameras
2.5-240 um
Cooled Optics 4K
1-90 Arcsec Resolution
MSX

- Sun sync orbit 900 km 2700 kg
- 330 mm primary
- Solid $\text{H}_2$ cooling
- 8.28, 12.13, 14.65, 21.3 um
- Calibration balls...
SWAS

- LEO 285 kg
- 550 mm primary
- 487-556 GHz
- Observed Molecular lines
- Pegasus launch
Wilkinson Microwave Anisotropy Probe

At L2 1.5 Gm from Earth
  840 kg, 900 mm primaries
10 differential receivers
22, 30, 40, 60, 90 GHz
  140 deg apart
Resolution .25-1 deg
Spin .464 rpm, Precess 1 rph, Orbit 1 year
Spitzer

- Drift Orbit 950 kg
- 850 mm primary
- IRAC 3.6, 4.5, 5.8, 8 μm $256^2$ arrays
- IRS 5.3-37 μm
- MIPS 24, 70, 160 μm $128^2 32^2 2\times20$

Andromeda 24μm
• Sun sync Orbit 525 km
• 400 mm primary
• Solid H$_2$ cooled
• HgCdTe 1024$^2$ detectors
• 3.4, 4.6, 12, 22 um
• 6” resolution
Akari

- Sun sync orbit, 700 km, 952 kg
- 685 mm primary
- Liquid Helium cooled 6 K
- 1.7-180 μm
Herschel

- At L2, 3300 kg
- 3500 mm primary
- Liquid He Cooled
- PACS spectrometer 55-210 um
- Spire spectrometer 194-672 um
- HFI spectrometer R=$10^7$ 157-625 um
Planck

- L2 orbit
- Cooled He$^3$ to .1 K
- Frequencies 30, 44, 70, 100, 143, 217, 353, 545, 857 GHz
Pixelization

- Natural: Easy, hard to compare to others
- Ra, Dec: Standard, non uniform size, noise
- Quadcube $6\times4^n$: Hard to spherical transform
- HealPix $12\times4^n$: New standard, equal size pix, Spherical Transforms
SCHEDULE – subject to revision

- Sep 9 Introduction and Overview, Astronomy Basics
- Sep 16 Astronomical Sources and Backgrounds
- Sep 23 IR & Microwave Astronomy
- Sep 30 Gamma-ray Generation and Detection
- Oct 7 IR & Microwave Data Analysis
- Oct 14 Gamma-ray Sources and Signatures
- Oct 21 The Research Process
- Oct 28 Foreground Subtraction
- Nov 1 Gamma-ray data analysis
- Nov 11 Microwave Ballooning
- Nov 18 Multi-wavelength Astronomy
- Nov 25 Science Communication and Paper Writing
- Dec 2 Dedicated Time for Research Projects
- Dec 9 Dedicated Time for Research Projects