

# *Sub-millimeter Astronomy*

*Monday, Wednesday 11-12:15pm*

*January 13<sup>th</sup> –February 19<sup>th</sup> 2003*

## **1. Introduction**

- what is sub-millimeter astronomy?
- what do you see at sub-millimeter wavelengths?
- what kind of science can you do?

## **2. Signal detection**

- detection techniques: heterodyne & bolometers
- spectrometers
- noise, sensitivity

## **3. Single-dish telescopes**

- observing techniques
  - position/frequency switching
  - on-the-fly mapping
- sensitivity/time estimation
- data reduction
  - spectral line datacubes
  - the Emerson algorithm
- science
  - solar system studies
  - ISM
  - cosmology
- application to the JCMT & CSO

## **4. Interferometry**

- theory
  - the two-element interferometer
  - Fourier transforms and the uv-plane
- practice
  - incomplete uv-coverage
  - phase noise
- observing techniques
  - phase and amplitude calibrators
  - fast switching
  - water line monitors
- sensitivity/time estimation

- data reduction
  - uv weighting
  - dirty maps
  - deconvolution: clean and maximum entropy
  - self-calibration
  - combining with single-dish data
- science
  - solar system studies
  - ISM
  - cosmology
- application to the SMA

## 5. Future instrumentation

- ground: LMT/CARMA/ALMA/SCOWL
- space: SOFIA/FIRST
- Terahertz astronomy

Seminar attendees will be asked to lead a 20 minute discussion on a topic concerning sub-millimeter astronomy. Some suggested topics are listed below. Single question, generally open ended, problem sets will be given aperiodically and discussed in class.

### *Some suggestions for student led discussions:*

- Measuring the size of KBOs ([www.ifa.hawaii.edu/~jewitt/varuna.html](http://www.ifa.hawaii.edu/~jewitt/varuna.html))
- Large dust particles in comets ([www.ifa.hawaii.edu/~jewitt/scuba.html](http://www.ifa.hawaii.edu/~jewitt/scuba.html))
- Debris disks (Holland et al. 1998, Nature, 392, 788)
- Submillimeter observations of protoplanetary disks
- Protostellar surveys in molecular clouds (e.g. Motte et al. 1998, A&A, 336, 150)
- Interstellar chemistry
- Measuring the dust opacity at 850 $\mu$ m (Kramer et al. 1998, A&A, 329, L33)
- The Submillimeter Wave Astronomy Satellite ([cfa-www.harvard.edu/swas](http://cfa-www.harvard.edu/swas))
- Observations of CI at 492 Ghz
- (Sub)millimeter observations of the Sunyaev-Zeldovich effect
- Submillimeter observations of protogalaxies (Hughes et al. 1998, Nature, 394, 241; Barger, Cowie et al.)
- Science with ALMA ([www.alma.nrao.edu](http://www.alma.nrao.edu))
- BOOMERANG observations of the CMB
- Similarities and differences between optical and radio interferometry
- A potential project for the SMA