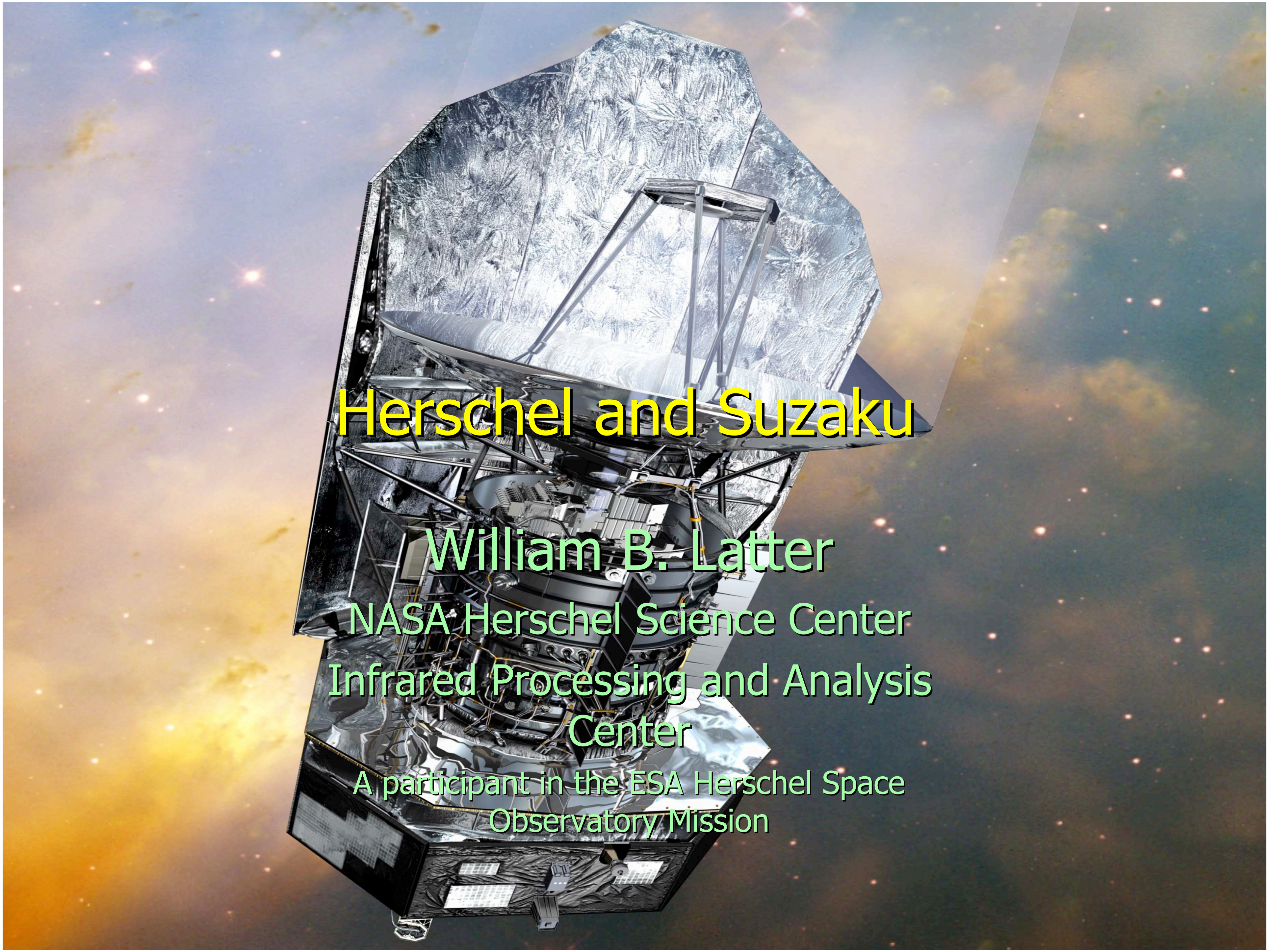


Herschel and Suzaku

William B. Latter

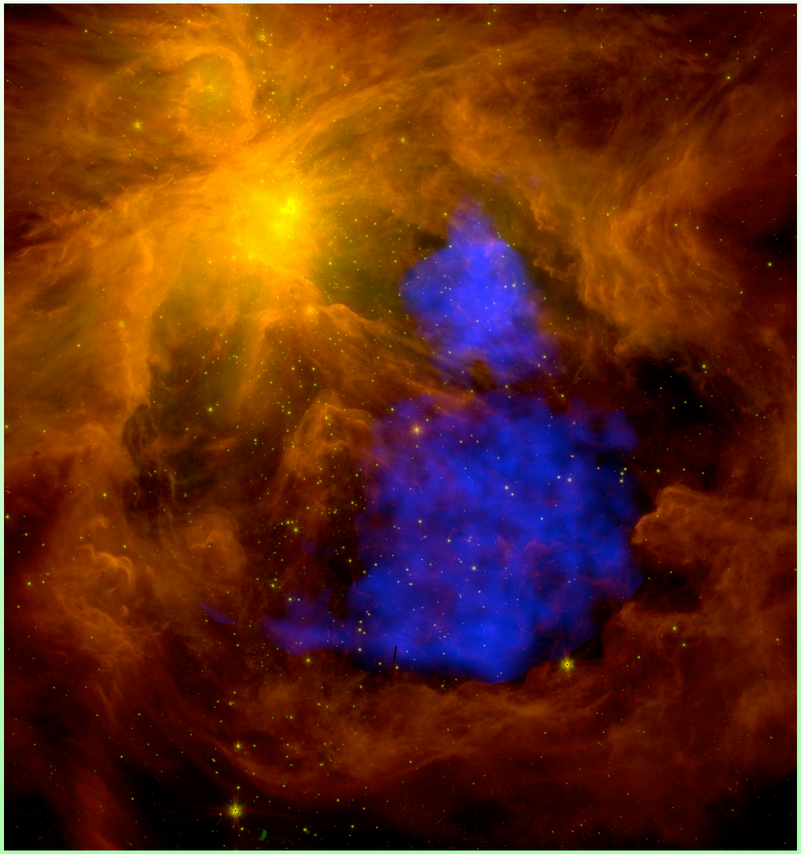
NASA Herschel Science Center

Infrared Processing and Analysis Center

A participant in the ESA Herschel Space Observatory Mission

Topics

- Basics and Overview of Herschel
  - The Observatory
  - Some Science Goals
- Herschel and Suzaku: Two Examples of Science Synergy
  - AGN
  - Star formation



Spitzer and XMM view of Orion

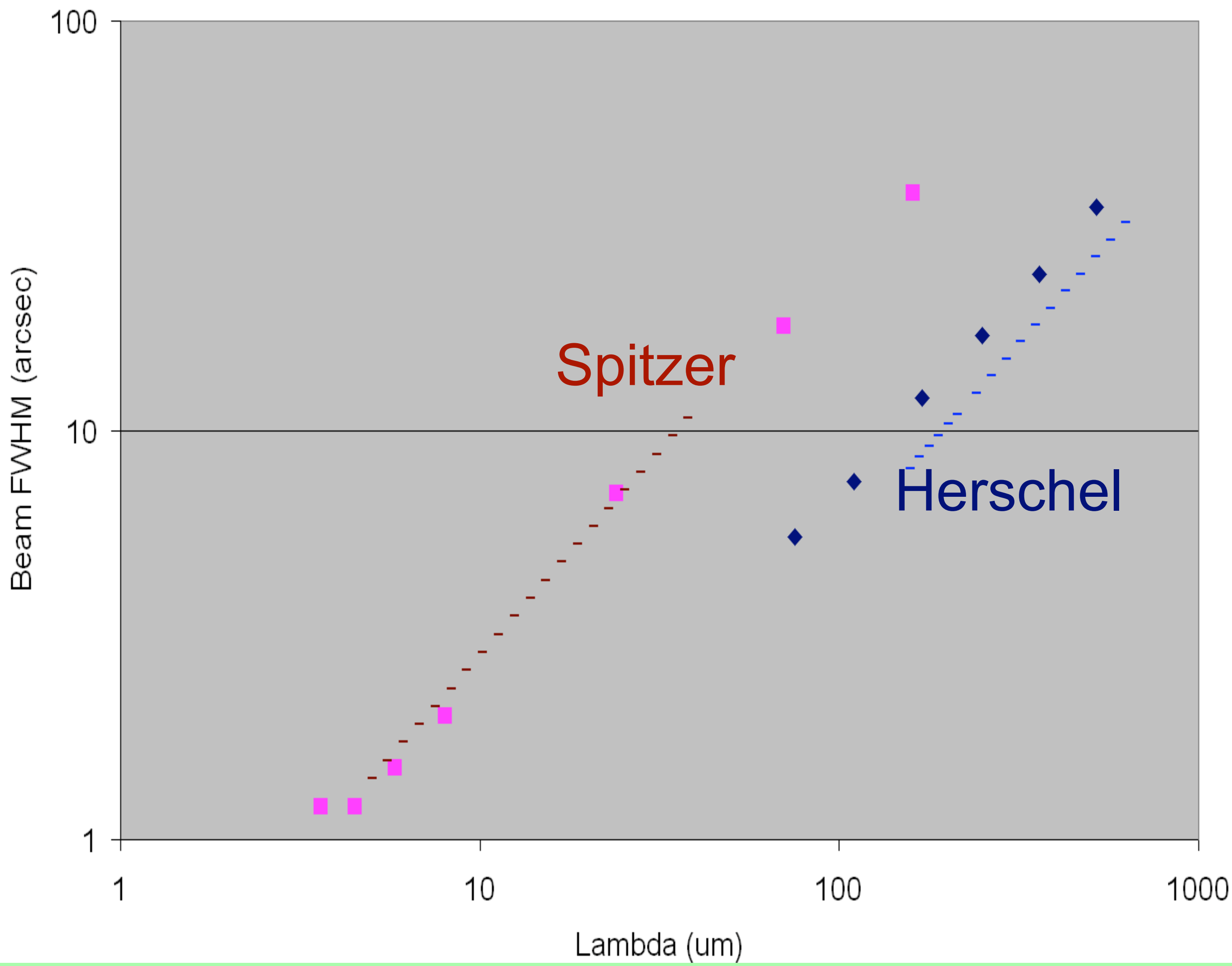
Herschel Overview

- **ESA cornerstone observatory**
  - instruments 'nationally' funded, int'l - NASA, CSA, Poland – collaboration
  - ~1/3 guaranteed time, ~2/3 open time
- **FIR (57 - 670 μm) space facility**
  - large (3.5 m), low emissivity (< 4%), passively cooled (< 90 K) telescope
  - 3 focal plane science instruments
  - 3 years routine operational lifetime
  - full spectral access
  - low and stable background
- **Unique and complementary**
  - for λ < 200 μm larger aperture than cryogenically cooled telescopes (IRAS, ISO, Spitzer, Akari,…)
  - more observing time (~7000hr/yr for Herschel) than balloon- and/or air-borne instruments (~1000 SOFIA flights per year)
  - larger field of view than interferometers
- **Launch in late 2008**
- **www.ipac.caltech.edu/Herschel/nhsc.shtml**

A Comparison - Spitzer and Herschel: Basic Niche Differences

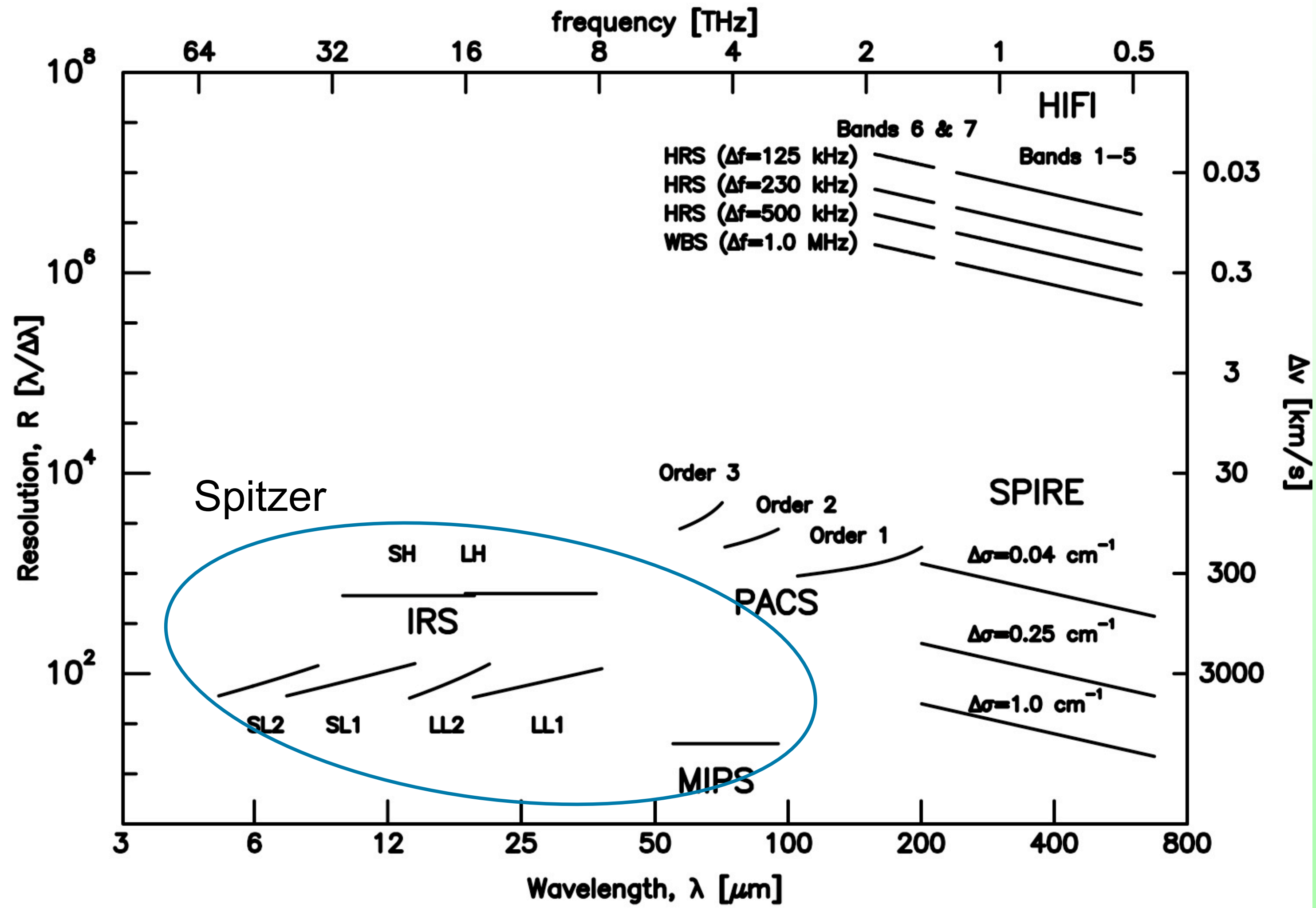
- Herschel will advance on questions that require
  - longer wavelengths
  - better spatial resolution at same wavelength
  - greater spectral resolution
- Herschel sensitivity to point source continuum is limited by warm telescope vs. confusion limited for Spitzer
  - Expected 1 hour 5_ sensitivity is a few mJy for targeted point sources
    - Significant improvement over confusion-limited 160μm of Spitzer
    - Still not well matched to Spitzer 24μm sensitivity for typical SEDs
- New for Herschel: Heterodyne capability from 157 to 625μm
  - Resolution in range 0.3 to 300 km/s

Spatial Resolution: Spitzer vs. Herschel

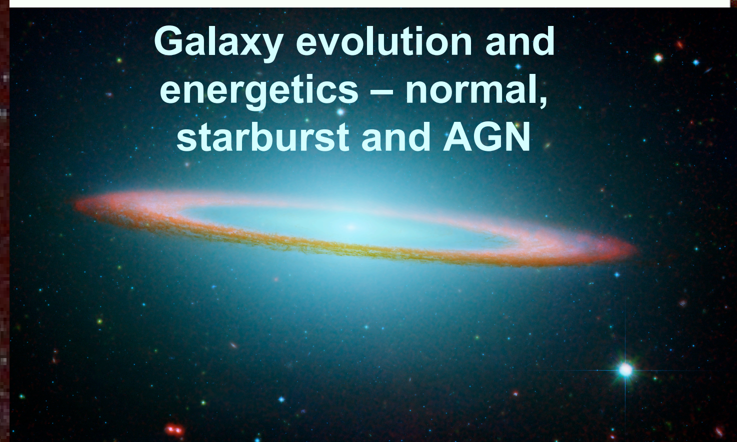


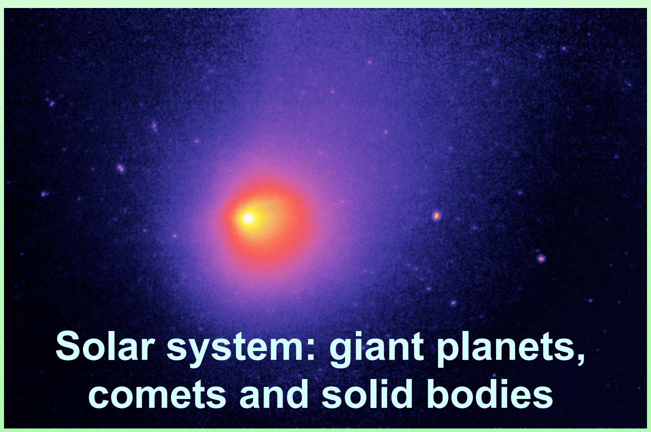
- Herschel offers same spatial resolution at ~4 times the wavelength
- Surface brightness sensitivity suffers proportionately

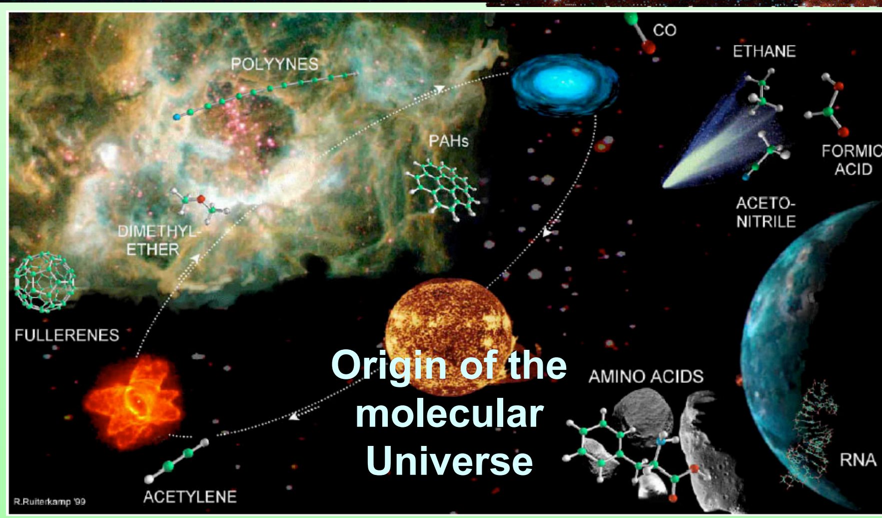
Spectroscopic Capability



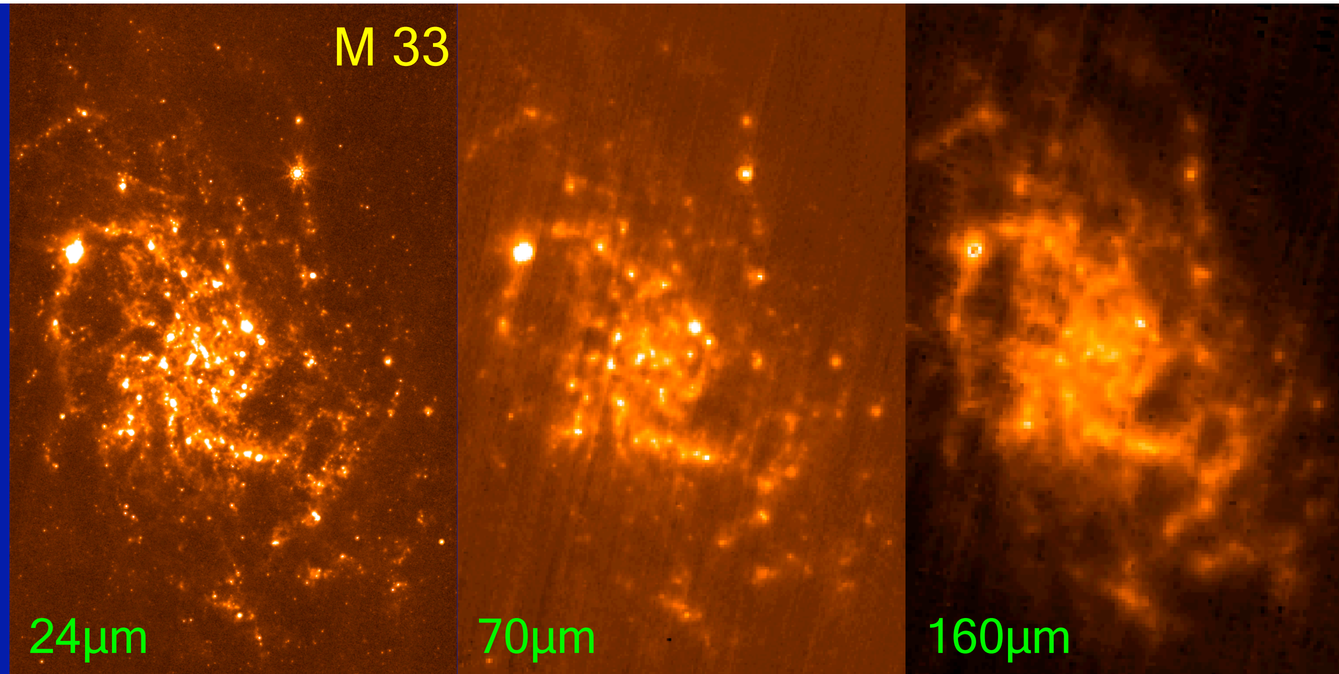
Some Herschel Science Goals



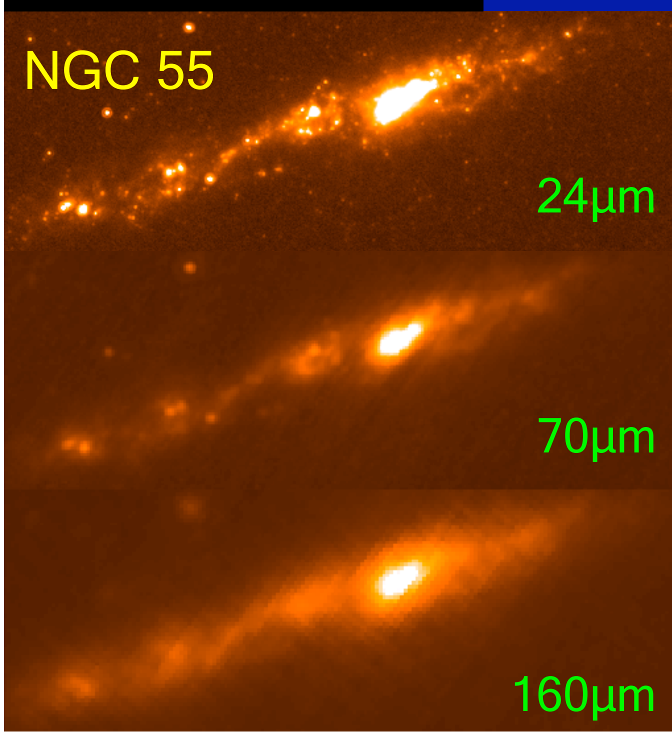


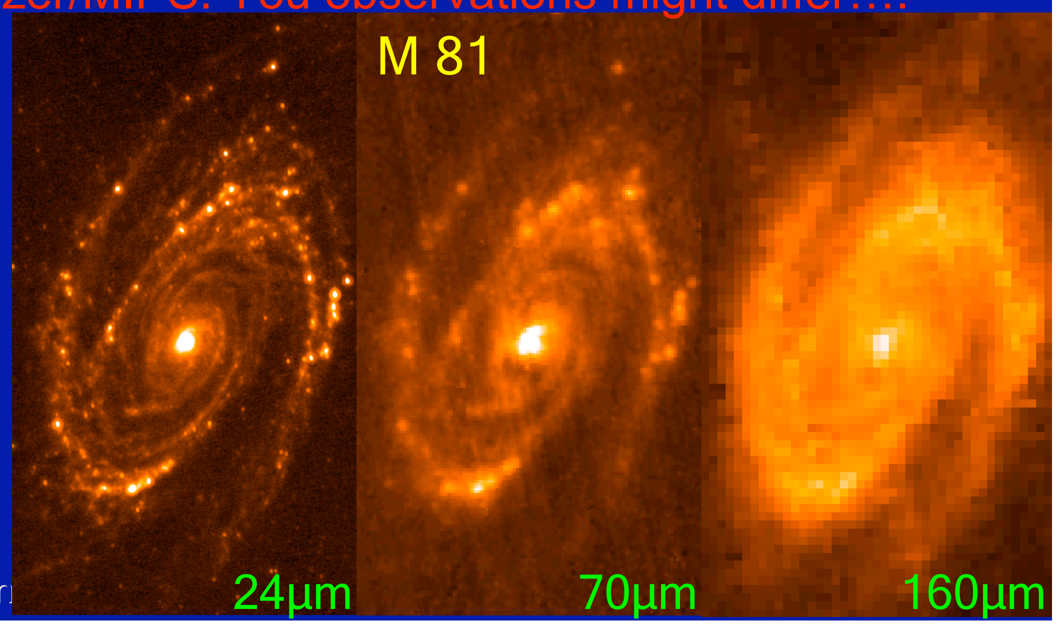


Spatial Resolution Example: Galaxies in all 3 MIPS bands



Because of warm telescope, Herschel will have limited surface brightness sensitively compared to Sptizer/MIPS. You observations might differ….



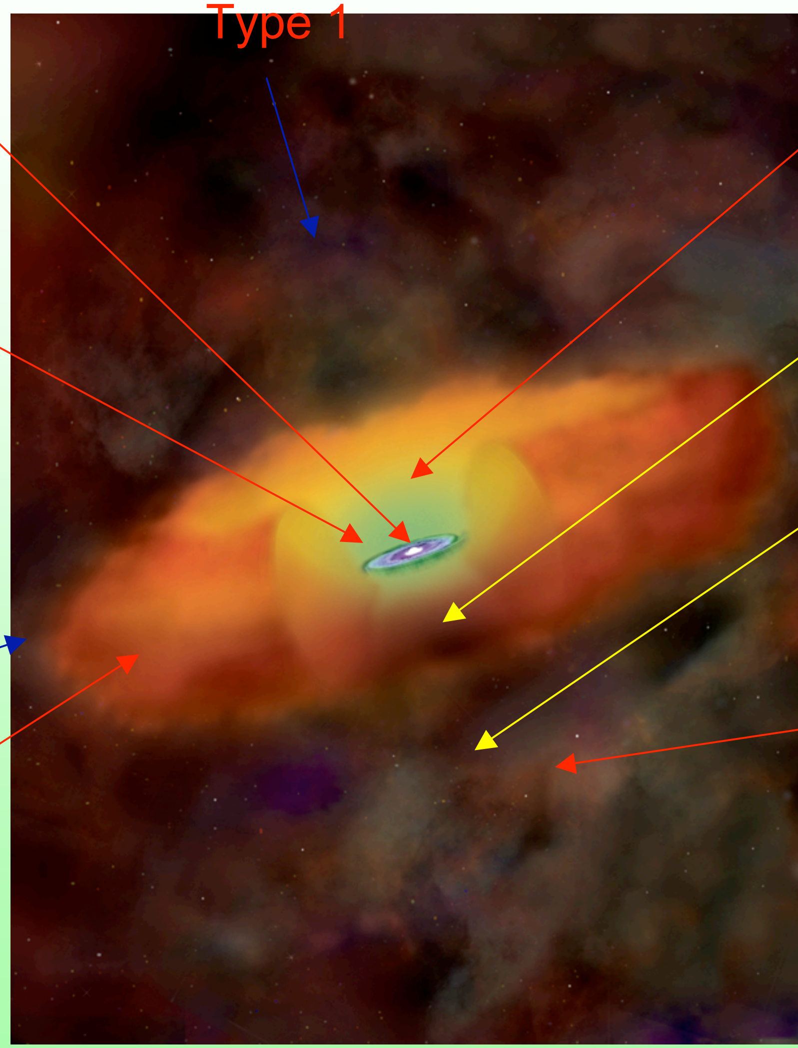


Suzaku, San

Herschel/Suzaku: One Example -- AGN

- View of AGN depends on inclination
- Optical/UV light: obscured when edge-on
- Traditional surveys: optical/UV, soft X-ray
- Hard X-ray/IR/radio surveys see all

AGN Unification Model: nuclear regions



Example -- Obscured AGN: $N_H \sim 10^{21} - 10^{24}$ cm^{-2}

- The AGN Basics:
  - Numbers: geometry of central regions
  - Properties: information on obscuring material
  - Insights: ULIRG power source (AGN or SF?), origin of background, history of Star Formation and Accretion
  - Tools: Fluxes and spectral slopes, IR fine-structure lines
- No single AGN population *(Alexander et al. 2003, Rosati et al. 2002):*
  - Type 2 AGN/QSOs *(Norman et al 2002, Kim et al. 2006)*
  - Compton-thick AGN *(Polletta et al. 2006)*
  - XBONGS *(Fiore et al. 2000, Kim et al. 2006)*
  - Obscured type 1 AGN *(Wilkes et al 2002)*
  - Optically Highly Polarized Type 1 AGN *(Smith et al. 2002)*

- "Unbiased" Survey - Chandra/SWIRE (*Polletta et al 2006*)
  - Spitzer: Lockman Hole region of SWIRE 11 sq.deg.
    - 5, 9, 43, 40, 230 μJy 5 σ limits at 3.6, 4.5, 5.8, 8.0, 24 μm
  - Chandra: 0.6 sq.deg. contiguous, 70 ksecs, Centered on Deepest VLA image
    - X-ray flux limit: 2×10^{-16} erg cm^{-2} s^{-1}
  - Find: 25 Compton-thick AGNs deg^{-2}; two most luminous Compton thick AGN at high *z*.

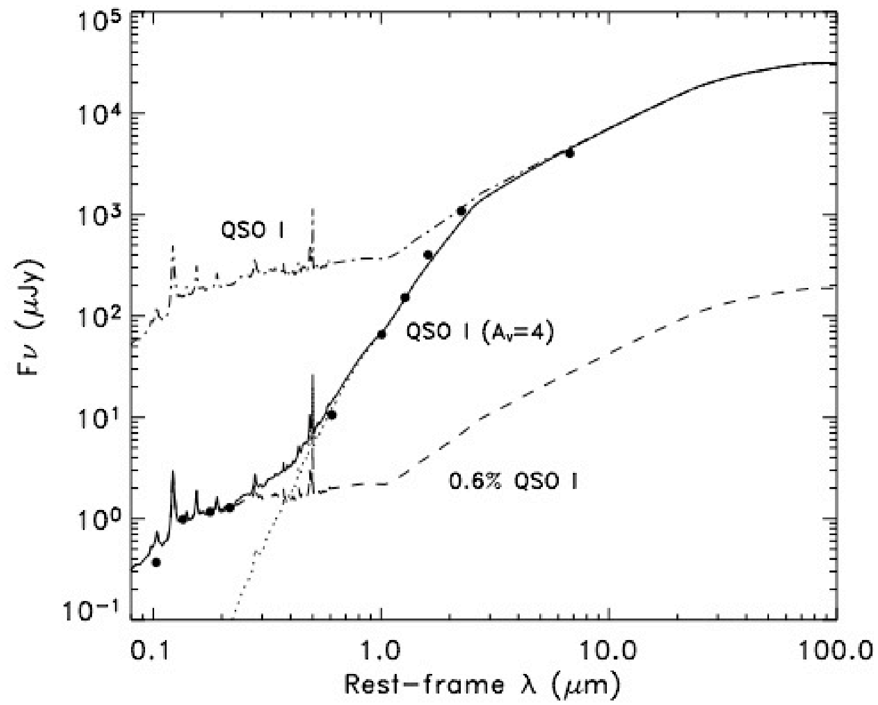
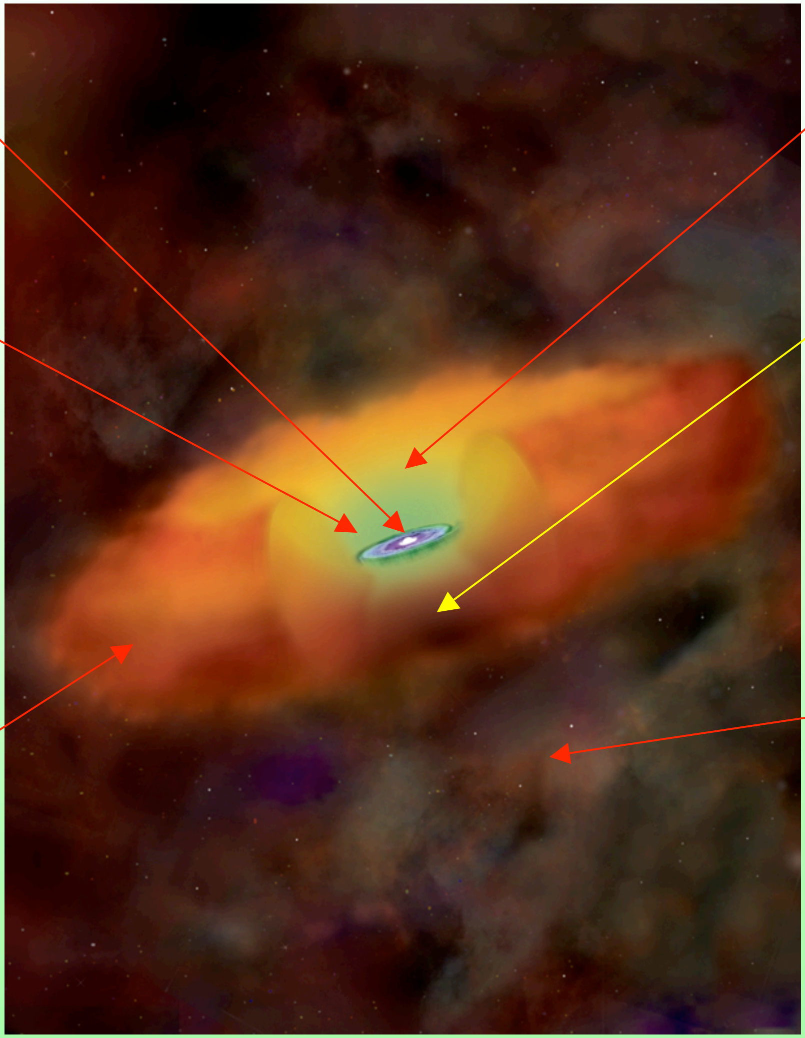


FIG. 9.—Observed SED of SW 104409 (*filled circles*) compared to an unobscured QSO template: (1) normalized to the mid-IR flux of SW 104409 (*dot-dashed line*), (2) scaled to match the optical flux of SW 104409 (*dashed line*), and (3) extinguished by $A_V = 4$ to fit the IR data points (*solid line*; see § 4.1). The solid line corresponds to the sum of the extinguished (item 3) and the scattered components (item 2).

Herschel/Suzaku: A 2nd example -- star formation

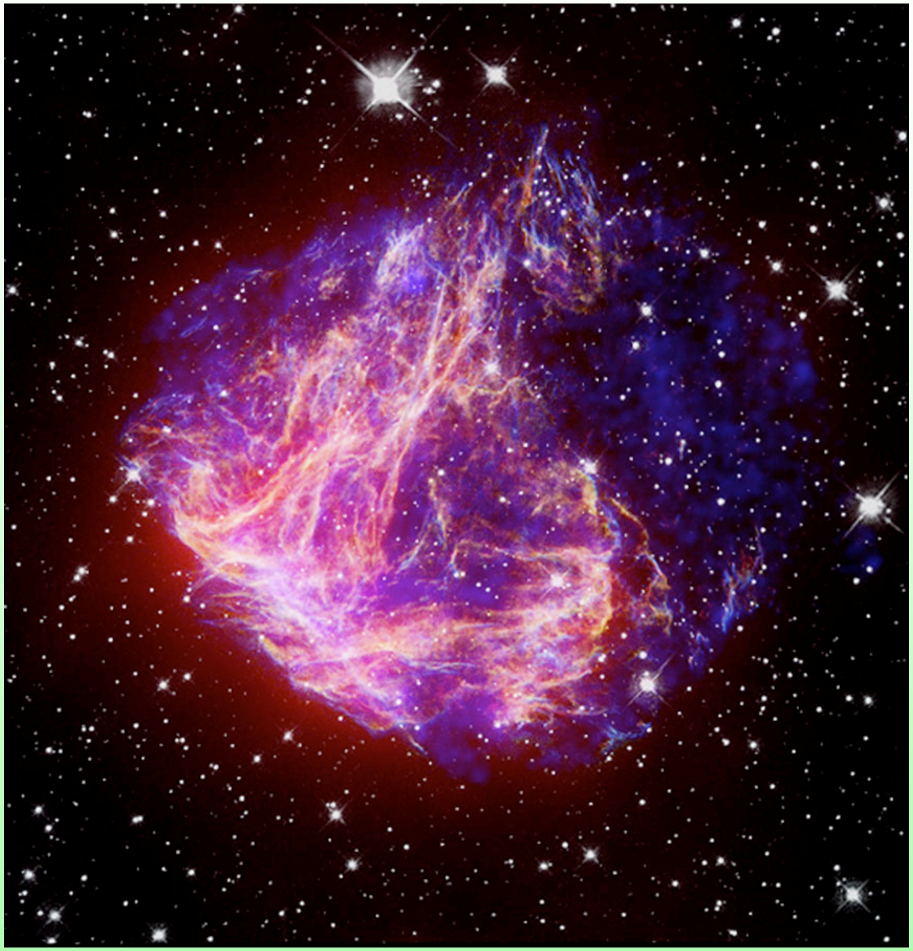
- Formation of stars in various environments and ultimately of planetary systems, is still very much one of the fundamental problems in astrophysics
  - primary goals of Spitzer, Herschel, ALMA, 2nd generation VLTI instruments, JWST, etc
- Young stellar objects (YSOs) are powerful and highly variable X-ray emitters. Origin of X-Ray emission remains uncertain:
  - evidence indicates that X-rays can efficiently irradiate the disks
  - theory says that this will have major effects on disk thermodynamics, chemistry, stability and evolution. X-rays may thus be an important regulator of planetary formation processes. Far-IR and submm provide strong diagnostic power: SED (dust), lines (gas, chemistry)
  - Suzaku and Herschel working together might be crucial to fully understanding the formation of stars and of planetary disks.
- Herschel and Suzaku can give unprecedented insights into the accretion and outflow processes and role played by magnetic fields. Also, ALMA will provide complementary views on the effects of stellar radiation on proto-planetary disks.
- E.g. Casanova et al 1995; Getman et al 2002; Winston et al 2007

A YSO Model: Same picture, different scale?



Prospects Summary - Herschel

- Herschel will provide high-resolution maps of nearby galaxies, PNe, star formation regions, SNR, and the local ISM in the FIR Fine-Structure lines
  - PDR structure and evolution
  - Disk evolution
- Herschel will detect lines at 0.5% of 10^{12} L(sun) galaxies at z~1, requiring ~3 10^{-18} W/m^2
- Herschel will decipher ISM chemistry with heterodyne precision
- All of that will connect Galactic and extragalactic ISM diagnostics, relate them to metallicity, age, evolutionary state, ISRF, solar system evolution, and numerous other topics *limited only by the imagination of the investigators….*



And SNR, too!

LMC SNR N49 - Chandra/Spitzer