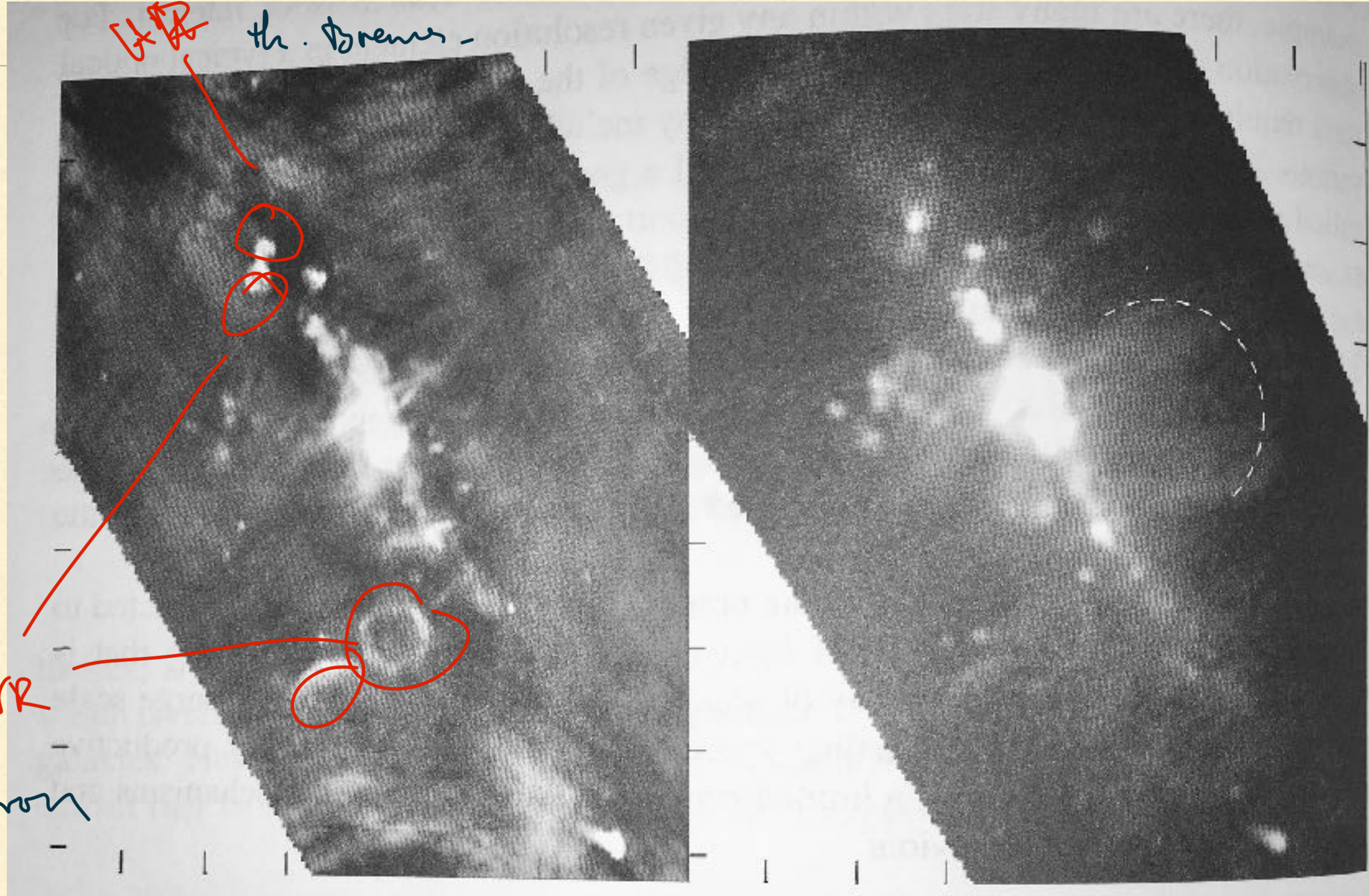
CHAPTER 10 - FORENSICS

Bringing it all together - “astro - intuition”

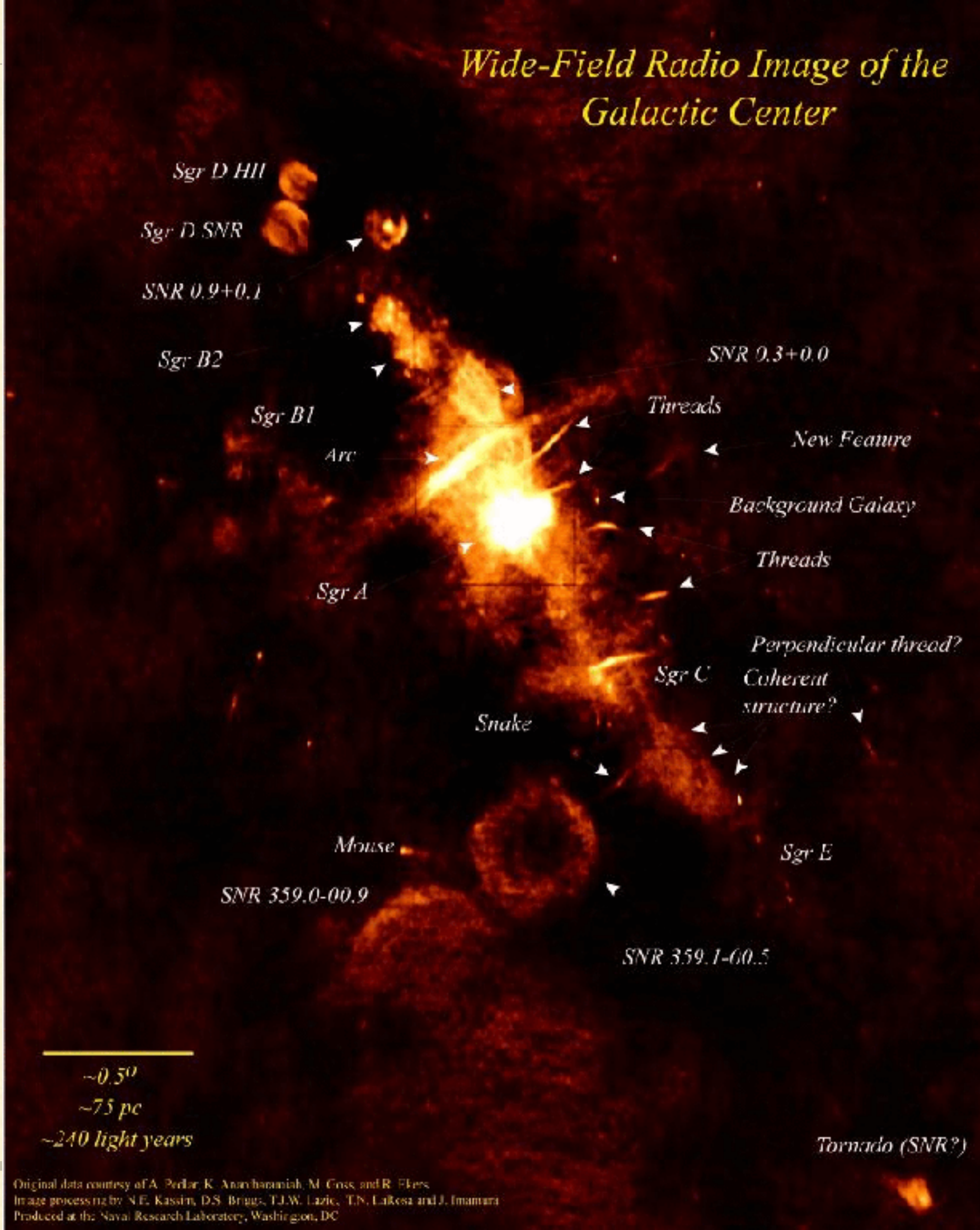


VLA 90cm

3 cm higher ν

continuum — thermal Bremsstrahlung — flat

— non-thermal synchrotron — α



Wide-Field Radio Image of the Galactic Center
Sgr D HII
Sgr D SNR
SNR 0.9+0.1
Sgr B2
Sgr B1
Arc
SNR 0.3+0.0
Threads
New Feature
Background Galaxy
Threads
Sgr A
Perpendicular thread?
Sgr C
Coherent structure?
Snake
Mouse
Sgr E
SNR 359.0-00.9
SNR 359.1-00.5
~0.5°
~75 pc
~240 light years
Tornado (SNR?)
Original data courtesy of A. Pedlar, K. Anantharamaiah, M. Goss, and R. Ekers
Image processing by: N.E. Kassim, D.S. Briggs, T.J.W. Lazio, T.N. LaRosa and J. Imamura
Produced at the Naval Research Laboratory, Washington, DC

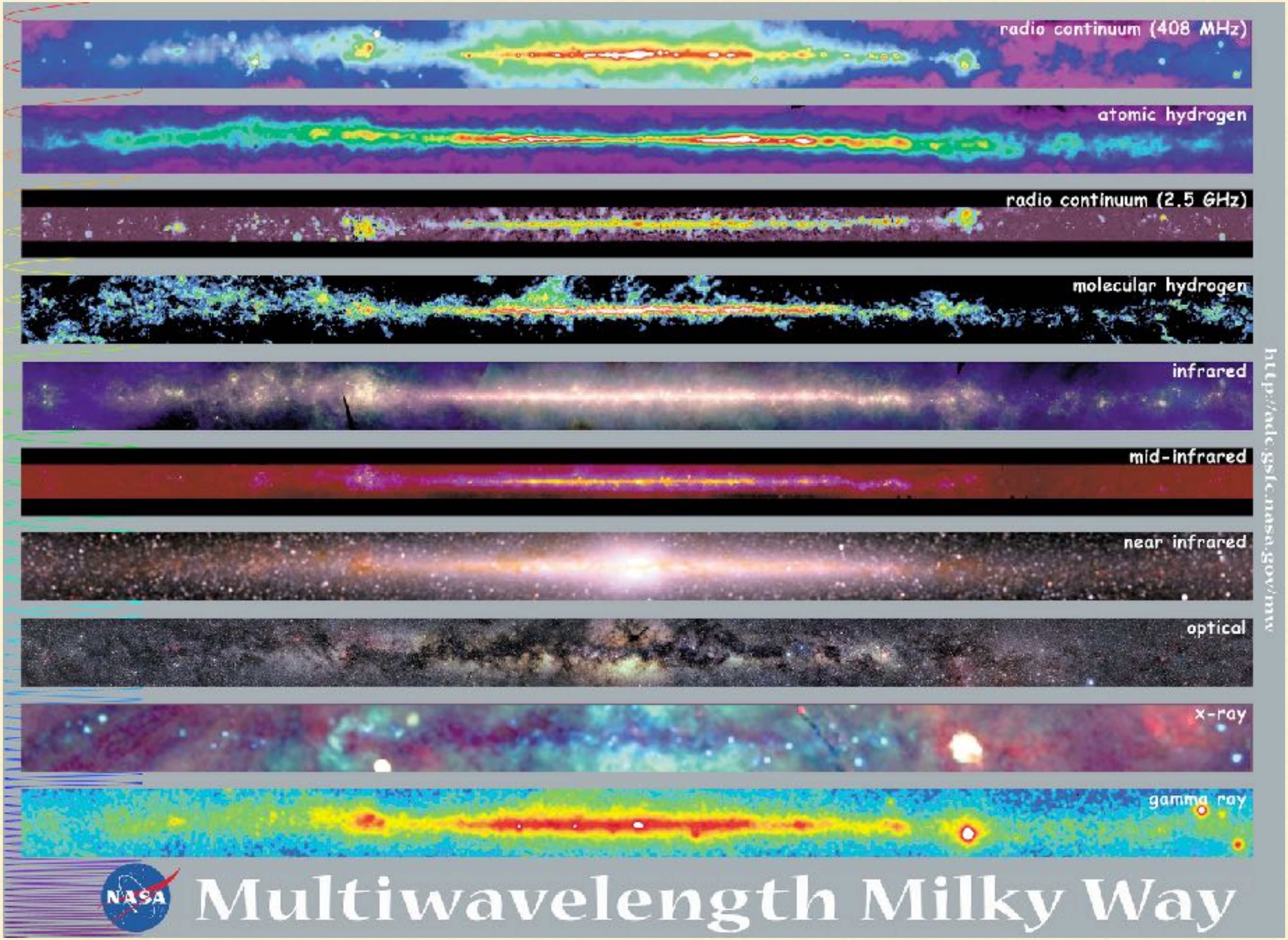
10.10

- using May 22 2005 image of Hale-Bopp.
- a) single waveband (info from website shows that it was observed on Kodak PMZ 1000 film using an optical telescope
- b) The image shows all emission that occurs within the band, including both continuum and line. Continuum emission should be dominated by reflected sunlight from dust particles (emission from dust would be in the infrared which is not being imaged). Thus, the Solar black body spectrum should be seen, but modified by the comet's (potentially frequency dependent) albedo. The caption also indicates that recombination emission from CO is dominant in the ion tail, indicating that electronic transitions are occurring in this molecule. (lines from many molecules are normally present in comets, including C_2, H_2O, NH_2, etc)
  c) The processes mentioned in (b) are all thermal.
  d) Information on the density and temperature could be determined from the ratios of various spectral lines (e.g. section 9.4). Information on the dust grains might be obtainable by studying their reflective/scattering properties as a function of wavelength (e.g. Sect. 5.5).

From APOD:

- **Explanation:** In 1997, Comet Hale-Bopp's *intrinsic* brightness exceeded any comet since 1811. Since it peaked on the other side of the Earth's orbit, however, the comet *appeared* only brighter than any comet in two decades. Visible above are the two tails shed by Comet Hale-Bopp. The blue ion tail is composed of ionized gas molecules, of which carbon monoxide particularly glows blue when reacquiring electrons. This tail is created by the particles from the fast solar wind interacting with gas from the comet's head. The blue ion tail points directly away from the Sun. The light colored dust tail is created by bits of grit that have come off the comet's nucleus and are being pushed away by the pressure of light from the Sun. This tail points *nearly* away from the Sun. The above photograph was taken in March 1997.

10.11


radio continuum (408 MHz)
atomic hydrogen
radio continuum (2.5 GHz)
molecular hydrogen
infrared
mid-infrared
near infrared
optical
x-ray
gamma ray
http://adc.gsfc.nasa.gov/mw
NASA
Multiwavelength Milky Way

Radio (0.4 GHz): This is low frequency radio emission where synchrotron radiation dominates the spectrum (see Fig. 10.2). **Supernova remnants and other high energy sources like pulsars** emit synchrotron radiation. Cosmic ray electrons that have leaked from such acceleration sites into the ISM also result in synchrotron emission since the ISM contains a magnetic field.

Atomic hydrogen: This is emission in the λ 21 cm line of HI (a bound-bound emission line). **Cool HI clouds interspersed through the Milky Way** emit in this spectral line (e.g. Fig. 6.10b).

Radio (2.7 GHz): This is high frequency radio emission at which thermal Bremsstrahlung radiation is now becoming important in comparison to synchrotron radiation (Fig. 10.2). Note that some synchrotron-dominant emission has been subtracted from this image. HII regions and the WIM (Sect. 8.2.2) are contributing sources.

Molecular Hydrogen: This is bound-bound line emission from the CO molecule in the J = 1 – 0 transition (Sect. 9.5.1). It is due to the cold molecular clouds that are distributed throughout the ISM of the Galaxy.

Infrared: This image is a composite that includes λ 12, λ 60 and λ 100 μm emission. The emission is due the collective Planck curves from dust.

Mid-infrared: This waveband goes from λ 6.8 to λ 10.8 μm. Most of the diffuse MIR emission is due to PAHs (Sect. 3.5.2), i.e. spectra line emission, with a contribution from the warm dust Planck continua. Using Wien's Displacement Law (Eq. 4.8), at λ_{max} = 9 μm, the characteristic temperature is T_{dust} = 322 K. This is quite warm for dust but is too cool to represent stars. The emission from point-like sources is due to dust that has been heated from embedded sources such as stars and planetary nebulae or originates in the cool dusty envelopes of evolved stars.

Near-infrared: This is another composite which includes the λ 1.25, λ 2.2, and λ 3.5 μm bands. By Wien's Displacement Law (Eq. 4.8), the corresponding temperature range is 829 K ≤ T ≤ 2320 K. This range now begins to pick up the Planck continua from cool stars, mostly red giants since they are brightest (Fig. 1.14). A small contribution from very hot dust around embedded objects may be present, but the cooler dust, which is more prevalent, is starting to produce absorption in this band.

Optical: This is a photographic image. Most of the emission is due to the collective Planck curves from stars. Dust obscures, reddens, and dims this starlight (Sect. 3.5). Individual reddish objects may be HII regions whose red Hα line dominates in the optical (e.g. Fig. 3.13) and individual bluish objects may be reflection nebulae (e.g. Fig. 5.3).

X-ray: This is a composite which includes the 0.25 , 0.75, and 1.5 keV bands, all of which are soft X-ray bands in which thermal Bremsstrahlung emission from hot gas dominates (e.g. Fig. 8.5). Some point sources are also observed, however, suggesting that the hard, non-thermal X-ray synchrotron spectra of point sources, such as pulsars, may also be present.

γ-ray: At energies greater than 300 MeV, the emission is dominated by Inverse Compton emission and neutral Pion decay, with the latter dominating (see Fig. 10.1). The Pion decay results from collisions of cosmic ray particles with ISM gas (see Sect. 10.1.2). The cosmic rays are produced in high energy sources such as supernova remnants and pulsars.

Note how you now understood the background of these terms, whereas when I showed it last time, they would have been unknown! :) :) :)