

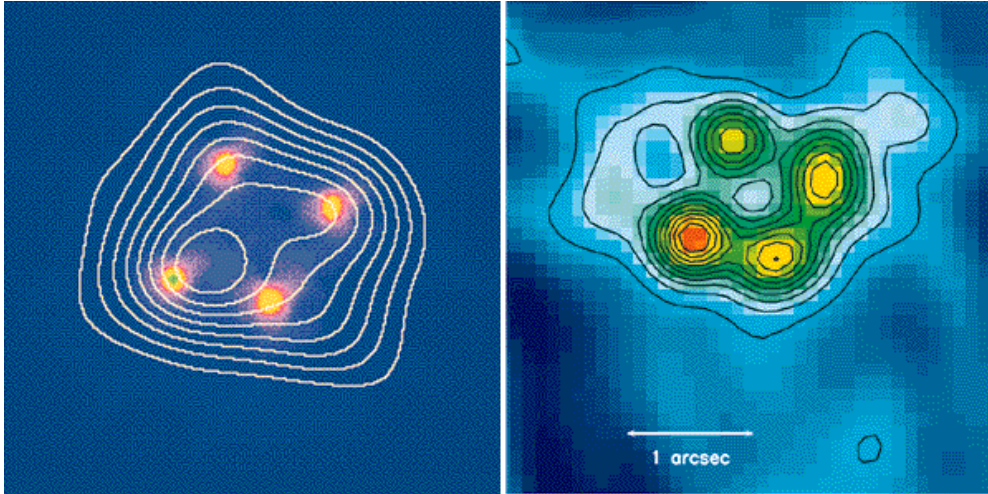
**(Astro)Physics 343 Lecture # 6:  
Lab # 3 + Radio Antennas**

# Problem: ambiguous data from the GBT

**A new instrument (the *Z*spectrometer) observes new sources  
(dusty high-redshift galaxies) and doesn't detect anything...**

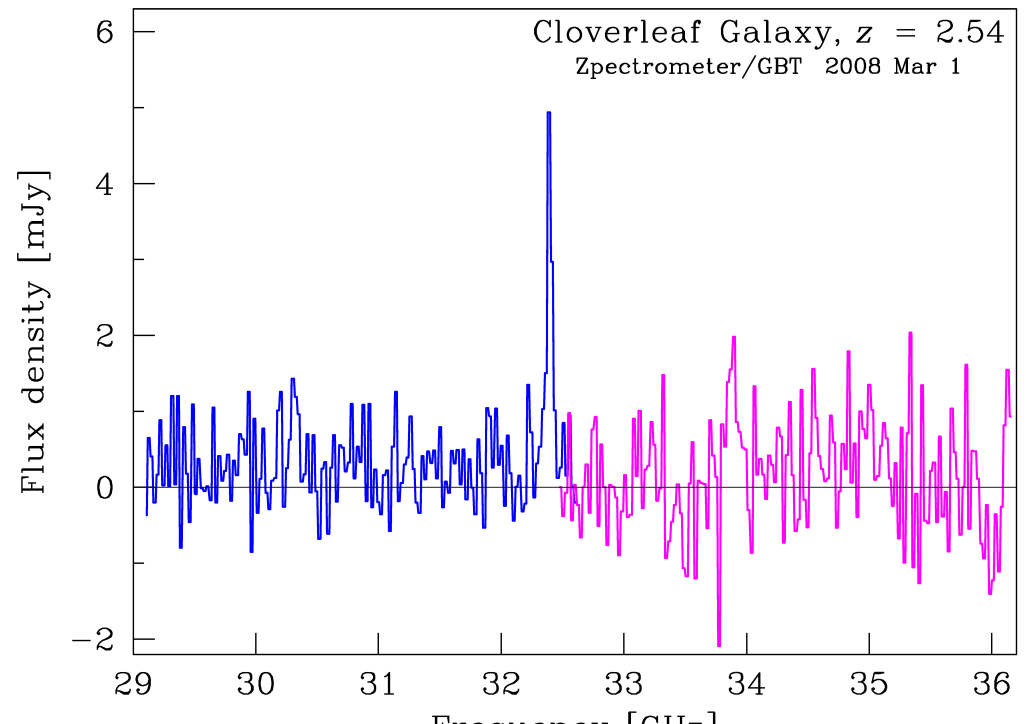
**Weak CO lines or a malfunctioning instrument?**

# Solution: observe an “old” source



**Blain (1998): optical (left) and submillimeter (right) images of the “Cloverleaf” quasar**

**Data from yesterday:  
CO(1-0) detected at  
expected frequency  
for source redshift.**



# Lab # 2: spectral line observations!

**So far all of our observations with the SRT have been with receiver mode 1, and we've simply averaged over (most) channels since we're interested in continuum emission from the Sun.**

**For HI observations, we care about individual channels!**

**mode 1 = 500 kHz bandwidth**

**mode 2 = 250 kHz bandwidth**

**mode 3 = 125 kHz bandwidth**

**mode 4 = 3 x 500 kHz bandwidth (with overlaps)**

# Velocities in astronomy

**Observed** frequency and wavelength are related to **rest** (emitted) frequency and wavelength by a velocity (or redshift).

**Exact relation = Doppler shift:**

$$\nu_0/\nu = \lambda/\lambda_0 = 1 + z = \gamma (1 + v/c) \text{ for } \gamma = (1 - v^2/c^2)^{-1/2}$$

and for relative velocities,  $\Delta\nu/\nu = \Delta\lambda/\lambda = \Delta z/(1 + z) = \Delta v/c$ .

**However, astronomers make approximations...**

$$\text{radio: } \nu \simeq \nu_0 (1 - v_{\text{rad}}/c)$$

$$\text{optical: } \lambda \simeq \lambda_0 (1 + v_{\text{opt}}/c)$$

# Distances in astronomy

Nearest stars can have distances measured by **parallax**:

the apparent shift in position relative to the background pattern of more distant stars caused by the earth's motion around the Sun.

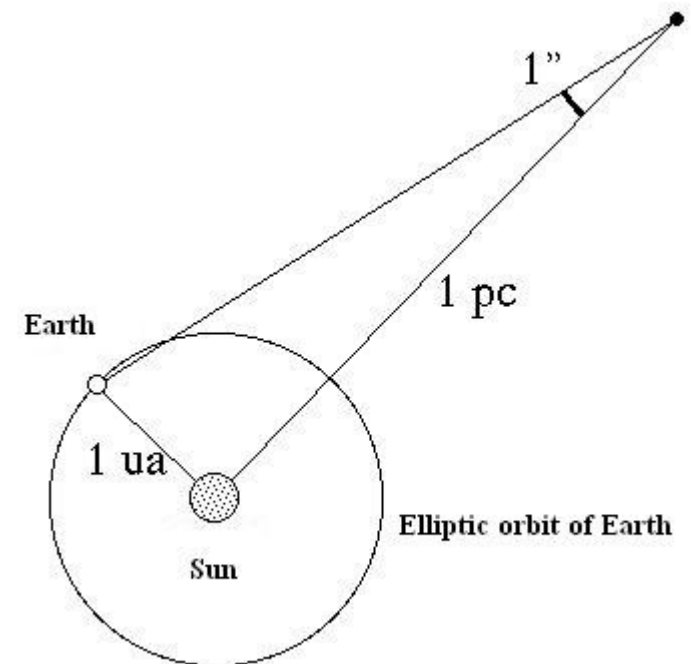
1 parsec = 1 pc:

$3.089 \times 10^{18}$  cm

~ 3.3 light years

Distances inside galaxies ~ kpc.

Distance between galaxies ~ Mpc.



# Stellar components of spiral galaxies

Spiral galaxies have two principal components: **disk** and **bulge**.

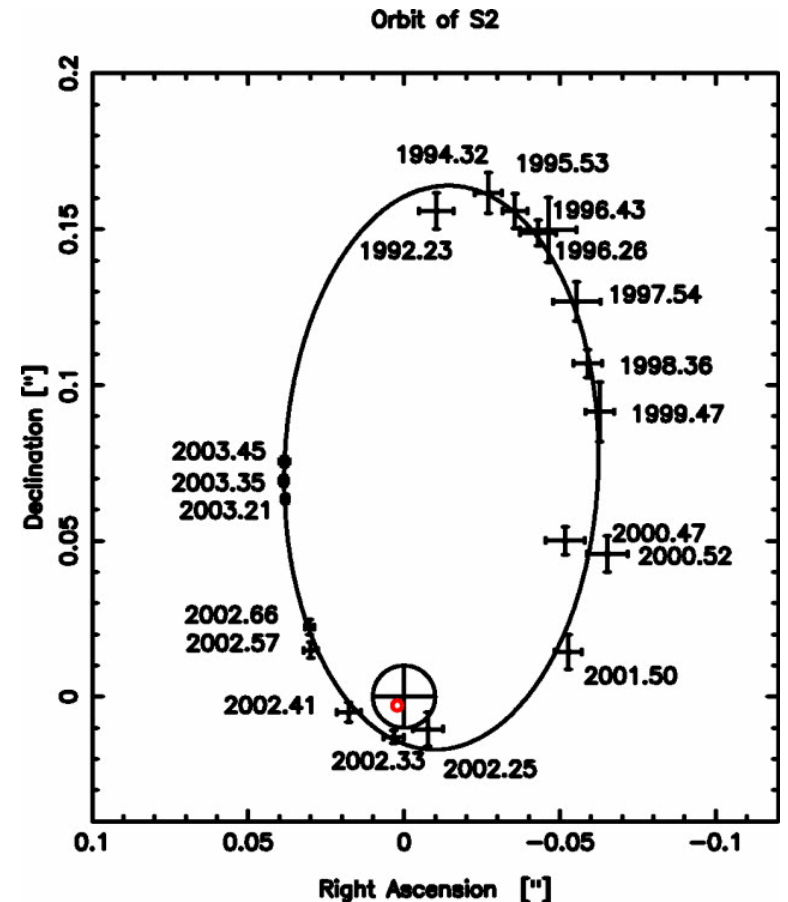


# Where is the Sun within the Galaxy?

Note on terminology: Milky Way = “the Galaxy”; other “galaxies” are not capitalized.

Sun and solar system lie at a distance of 7.94 kpc from the Galactic Center, where a supermassive black hole lies.

Eisenhauer et al. (2003)



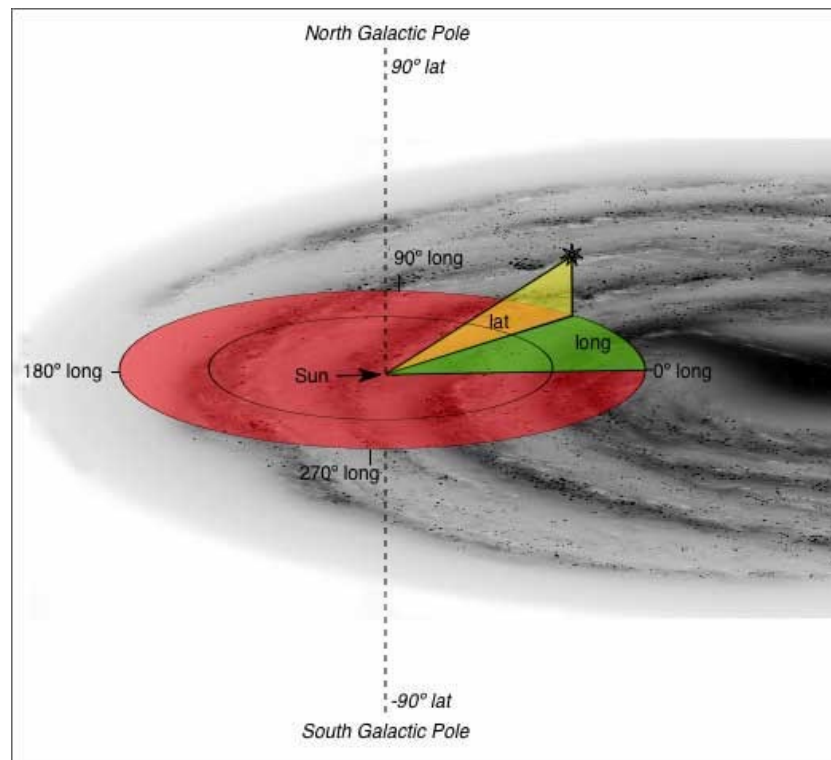


# Galactic coordinates

**The Sun is also located within the disk.**

**$b$  = Galactic latitude (above/below plane)**

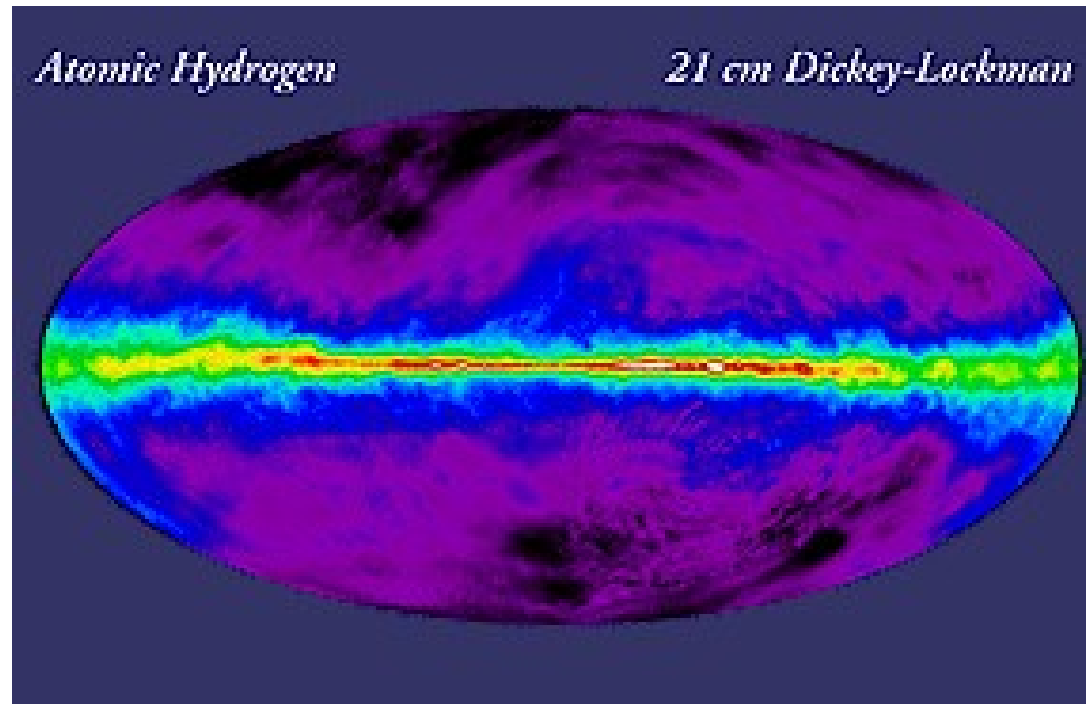
**$l$  = Galactic longitude (0 towards Galactic Center)**



# HI in the Milky Way

**Nearly all the HI in the Galaxy is located in the disk.**

**Observed velocities governed by (a) rotation (b) random motions.**



**(plotted in Galactic coordinates)**

# Quiz