Physics 343 Lecture # 6:
Lab # 3; Bayes theorem; Fourier transforms

This week and next week

Lab sections will meet at regular times this week.

Lab 3 data will be taken Thursday through Saturday (weather permitting...) and emailed to you.

Next week's lecture: guest instructor Professor Pryor.

Next week's “on call” office hours: all covered by Jesse.

Lab # 3: 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've only been interested in continuum emission from the Sun.

For line observations, we care about individual channels!

mode 1 = 500 kHz bandwidth ← all data so far

mode 2 = 250 kHz bandwidth

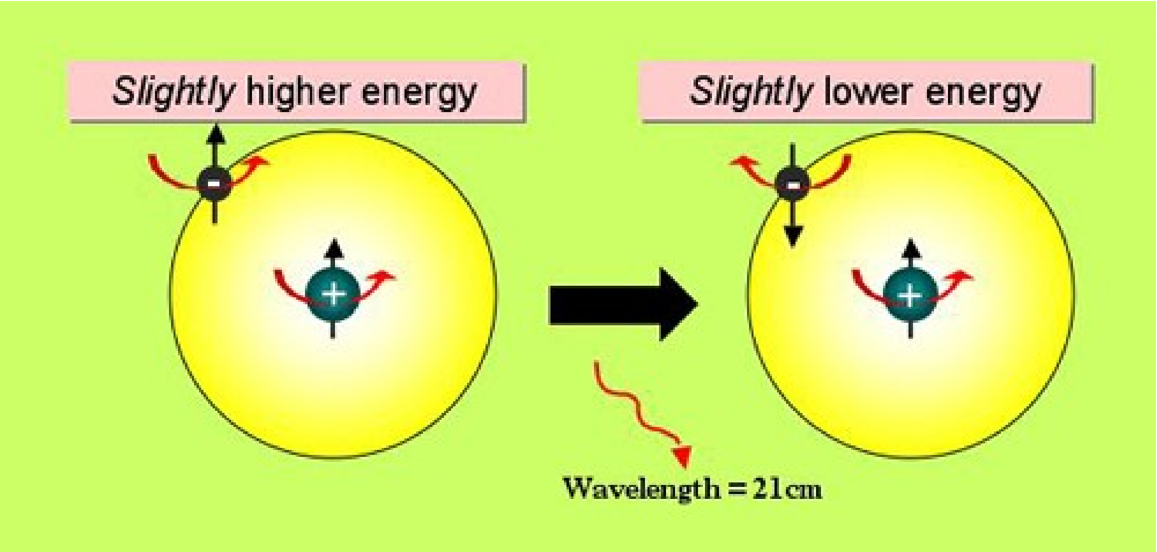
mode 3 = 125 kHz bandwidth

mode 4 = 3 x 500 kHz bandwidth (with overlaps: 1218.75 kHz bandwidth with 156 channels)

The key "spin flip" transition: 21cm H line

In a H atom, when the electron and the proton switch from having parallel spins to having antiparallel spins, a photon is emitted at

λ = 21cm ↔ ν = 1420.4 MHz.



Doesn't trace ionized or molecular gas – just neutral atomic gas!

Courtesy of Swinburne University.

Velocities in astronomy

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

Exact relation = Doppler shift:

$\nu_0/\nu = \lambda/\lambda_0 = 1 + z = \gamma\,(1 + v/c)$ **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 also make different approximations...

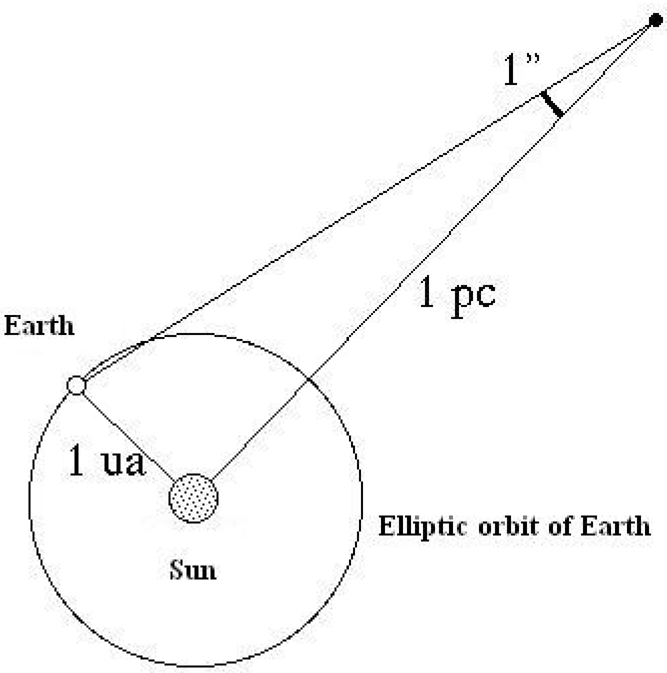
radio: $\nu \simeq \nu_0\,(1 - v_{rad}/c)$

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

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:
3.089×10^{18} cm
~ 3.3 light years



Distances inside galaxies ~ kpc.
Distance between galaxies ~ Mpc.

Stellar components of spiral galaxies

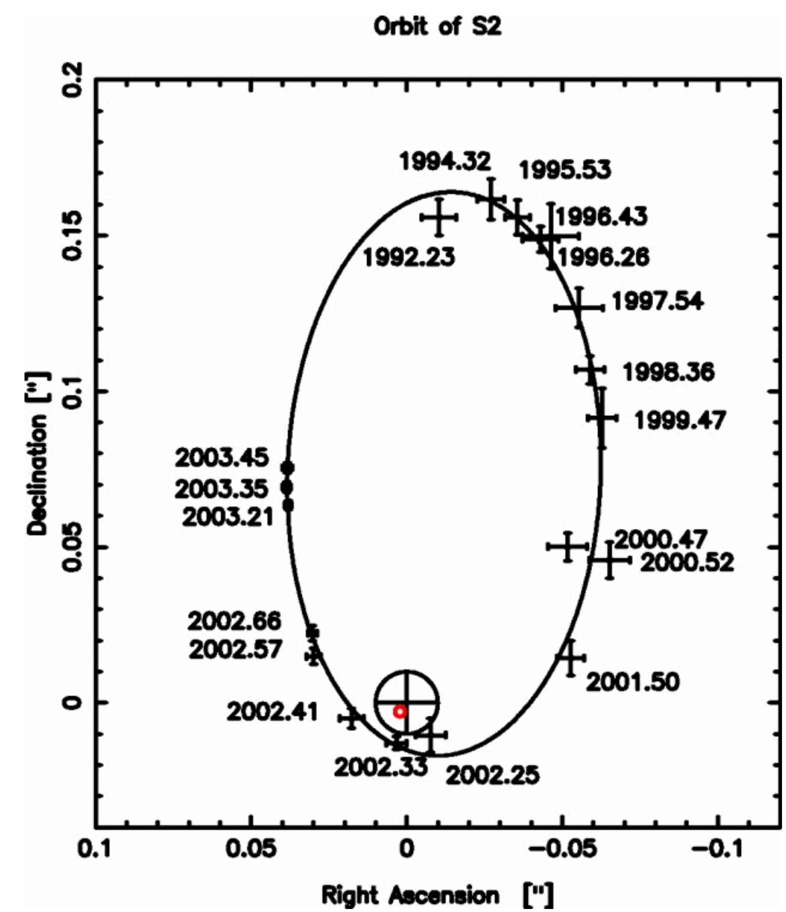
Spiral galaxies have two principal components: disk and bulge.

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 8 kpc from the Galactic Center, where a supermassive black hole lies.

Eisenhauer et al. (2003)

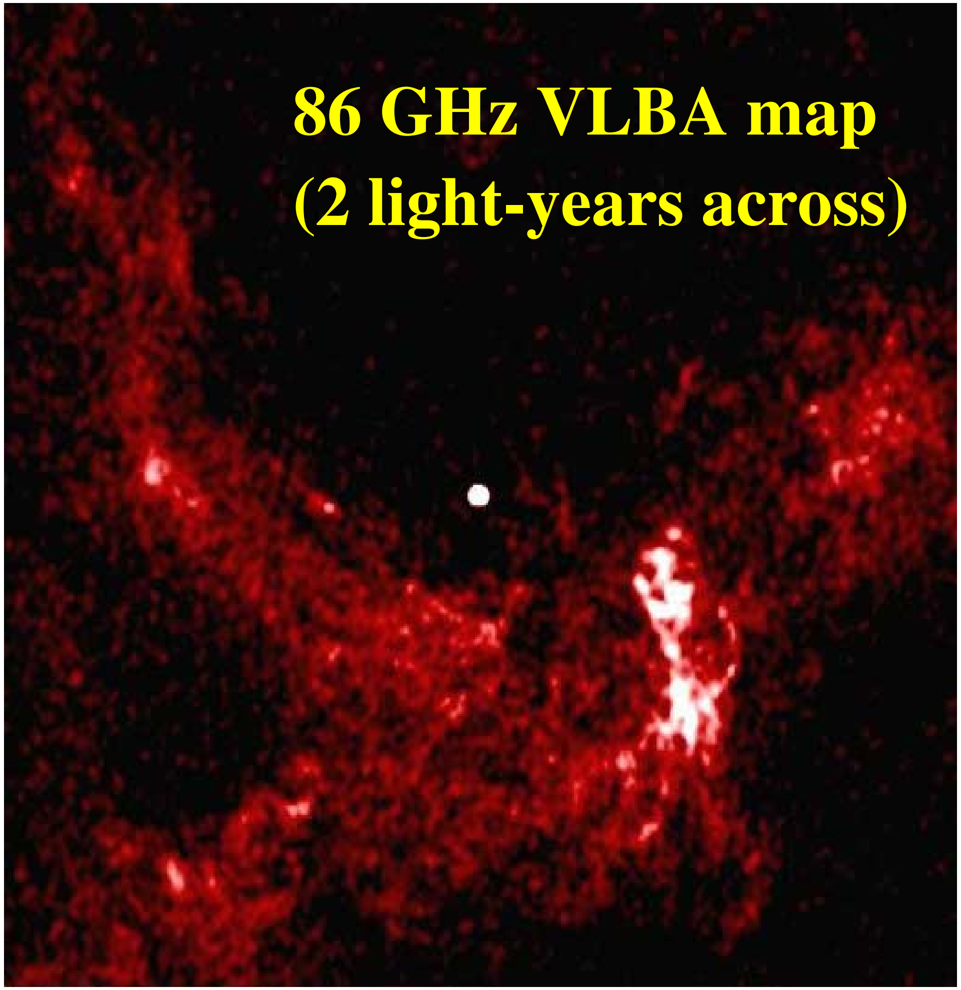


Central black hole is a radio source!

Motions of stars imply a large central mass – but from low proper motion of Sgr A* ("Sagittarius A–star"), we know that *it* must be massive.

Observations with the Very Long Baseline Array reveal a proper motion only due to the Sun's motion around the Galaxy.

Shen et al. (2005)



Galactic coordinates

The Sun is located in the disk.

b **= Galactic latitude**

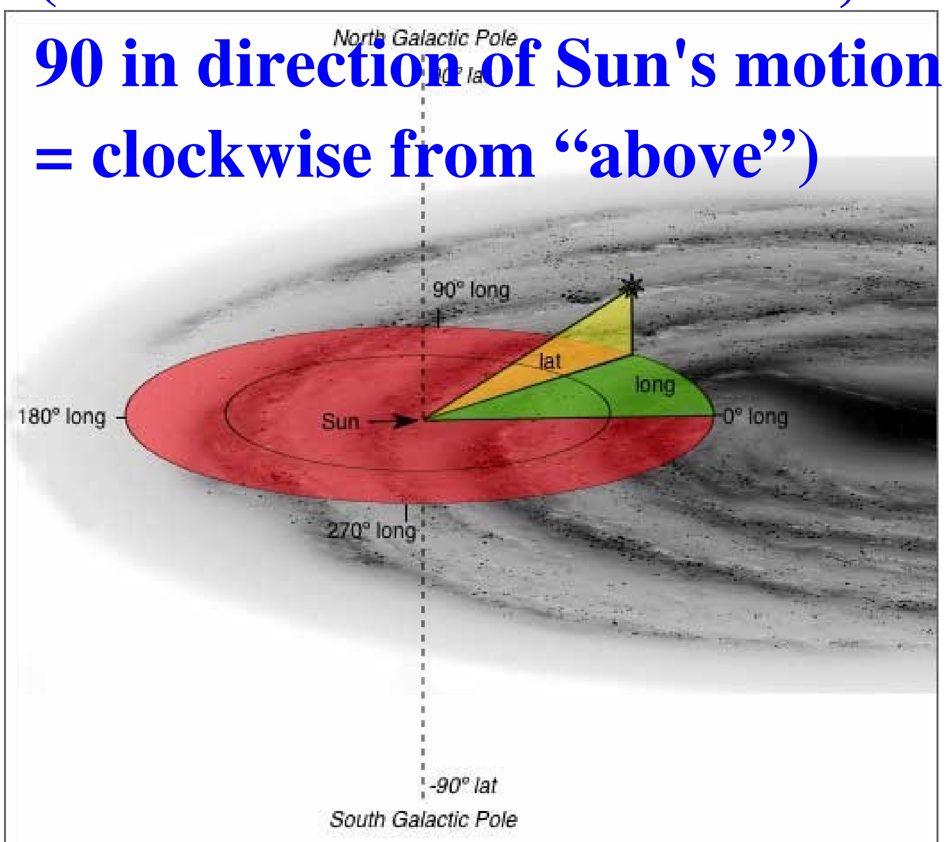
(above/below plane)

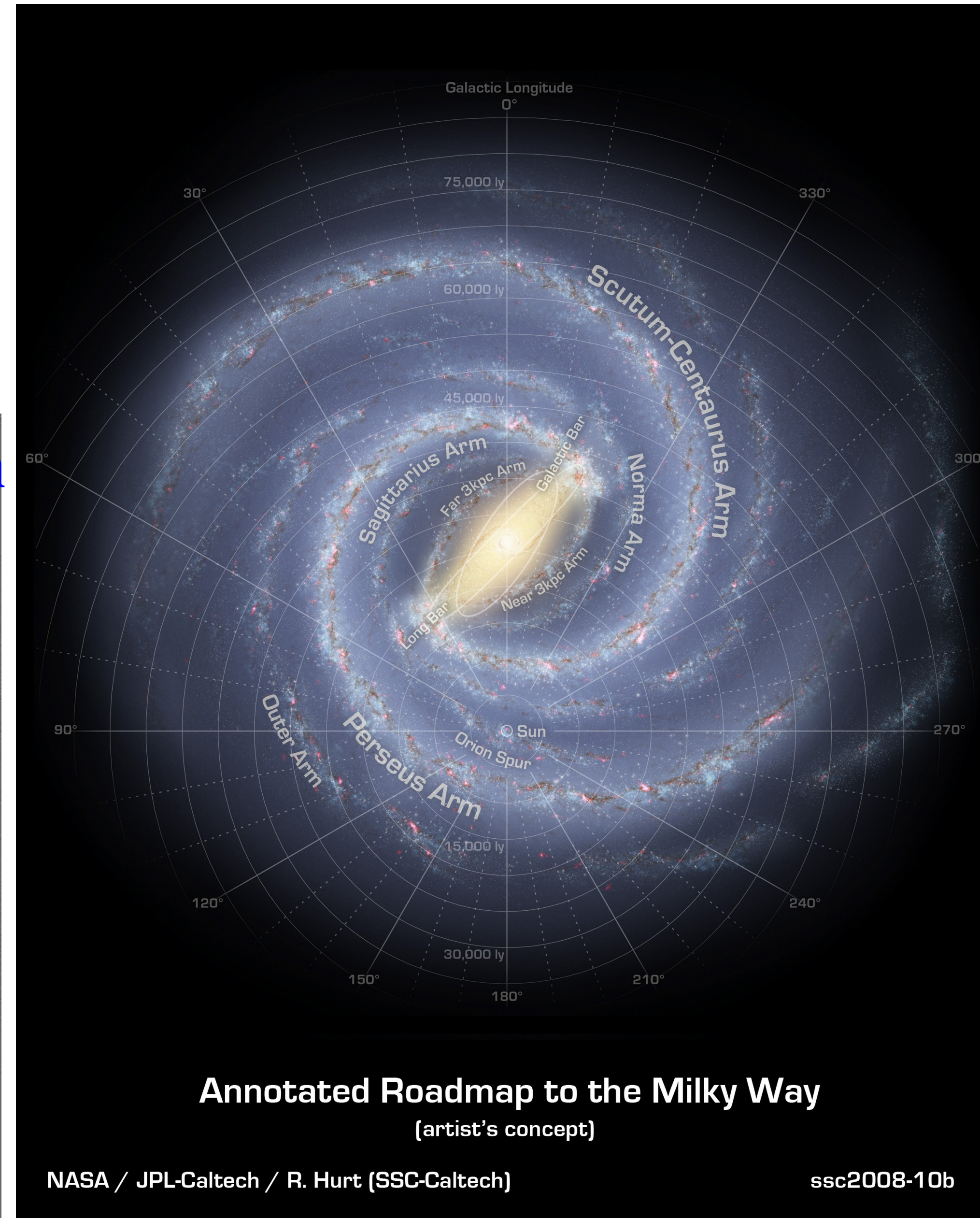
l **= Galactic longitude**

(0 towards Galactic Center;

90 in direction of Sun's motion

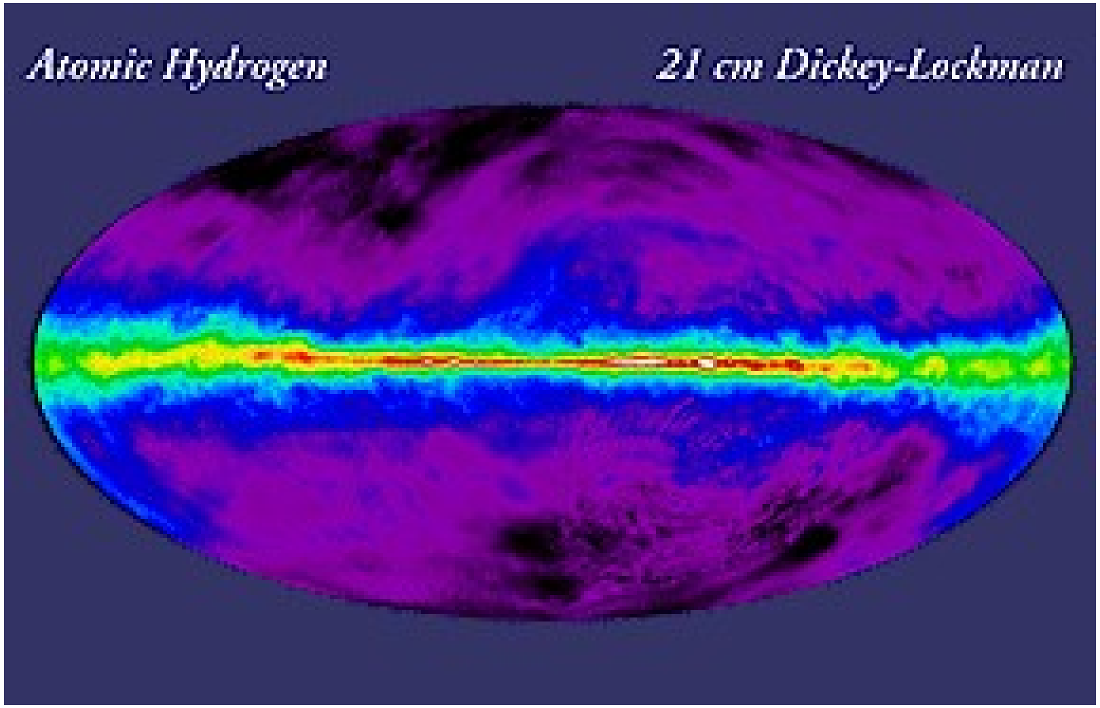
= clockwise from "above")





HI in the Milky Way

Nearly all the HI (neutral H) in the Galaxy is located in the disk.
Observed velocities governed by (a) rotation (b) random motions.



(plotted in Galactic coordinates)

Quiz