Physics 343 Lecture # 2:
Lab #1 & the HI 21cm line

Lab and office hour schedules

Section	Time	Students
A	Mon 1:40	C. Deegan, I. Krstevska, J. McKeegan
B	Mon 5:00	V. Agostinelli, A. Divakarla, C. Dou
C	Mon 6:40	S. Ogg, W. Qawasmi, M. Ramekar
D	Tue 3:20	J. Deshpande, A. Thuppul, L. Valentin
E	Wed 12:00	S. Cheedella, S. Pathan, C. Ray
F	Wed 3:20	J. Bradli, T. Emami, A. Ioakimidis
G	Thu 12:00	P. Chi, Y. Cohen, R. Galinkin, R. Gruytch

Meet this week outside Serin 403b!

Office hours (every week): Mon 3:30–4:30pm (Baker) and Thu 5:00–6:00pm (Wu), or by appointment

“On call” hours (analysis week): regular lab times

Computing protocol for labs

We will be using the astrolab.physics.rutgers.edu server for most of our labs – including lab # 1 this week. If you took 344 last semester, nothing has changed. If you did not take 344:

Username = [redacted]

Logon password = [redacted] **(reset w/ "passwd")**

VNC password = [redacted] **(reset w/ "vncpasswd")**

VNC session number = [redacted]

Lab # 1: HI in early-type galaxies

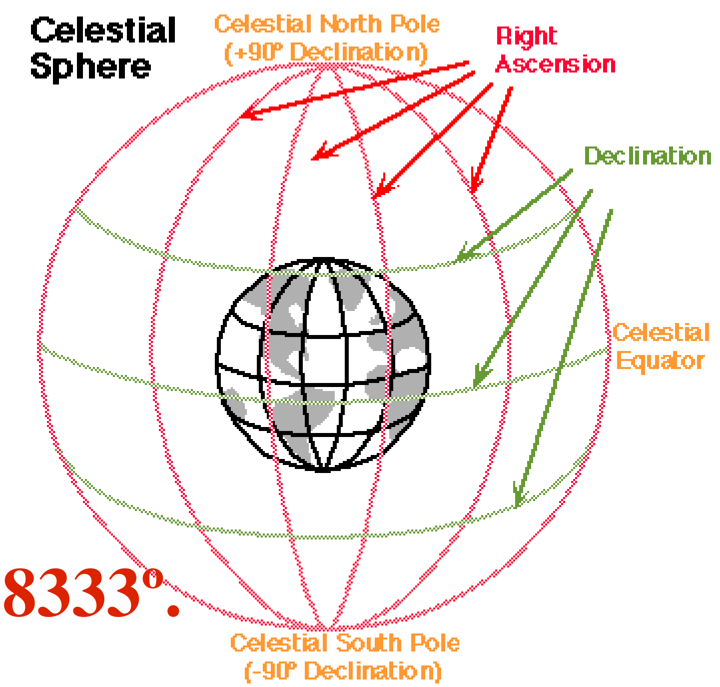
You will be analyzing archival data from the 100m diameter Effelsberg Ratio Telescope near Bonn, Germany, which for 29 years was the largest steerable telescope in the world (only beaten now by the GBT!).

You will be using the CLASS software within the GILDAS package (all created within a French/German/Spanish consortium).

Goal = detect (or place upper limit on) HI content of three early-type (elliptical/lenticular) galaxies based on 21cm observations. Targets are small relative to telescope's resolution, so these are single-pixel observations.

Celestial coordinates: units of R.A.

Right ascension ("R.A.", α) & declination ("Dec.", δ) = celestial latitude and longitude that describe a source's position.



Example # 1:

A source has R.A. 14:11:45.2.

What is this in units of degrees?

Answer:

$$15 \times (14 + 11/60 + 45.2/3600) = 212.938333^{\circ}.$$

(Note that R.A. 23:59:59 corresponds to 359.995833°.)

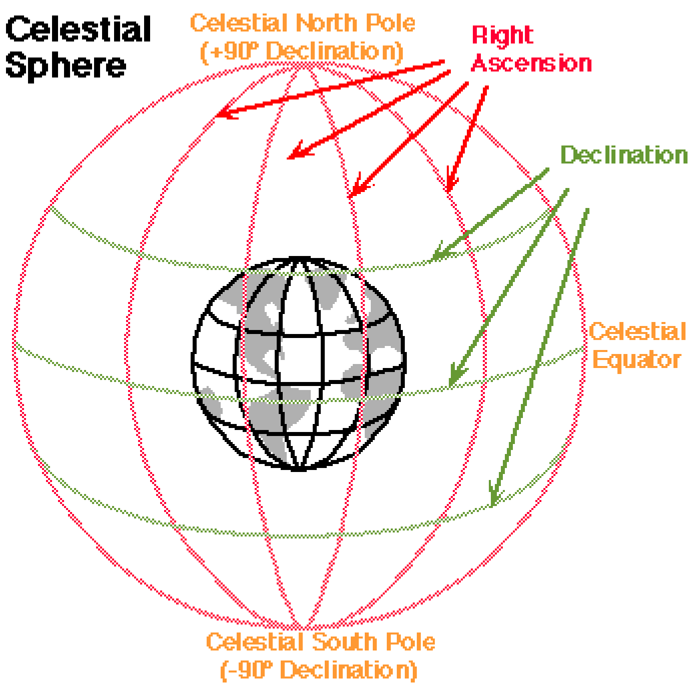
Celestial coordinates: source separations

Example # 2:

Source A lies at 02:33:24.5 +15:32:29.

Source B lies at 02:33:32.9 +15:24:06.

How far apart are they on the sky?



Answer:

$\Delta\delta$ **is easy:** $(24 \times 60 + 6) - (32 \times 60 + 29) = -503'' = -8.383'$

$\Delta\alpha$ **is harder:** $15 \times (32.9 - 24.5) \times \cos(15.4715) = 121'' = 2.024'$

For small angles, separation $\simeq [(\Delta\delta)^2 + (\Delta\alpha)^2]^{1/2} = 8.6'$

Celestial coordinates: directions

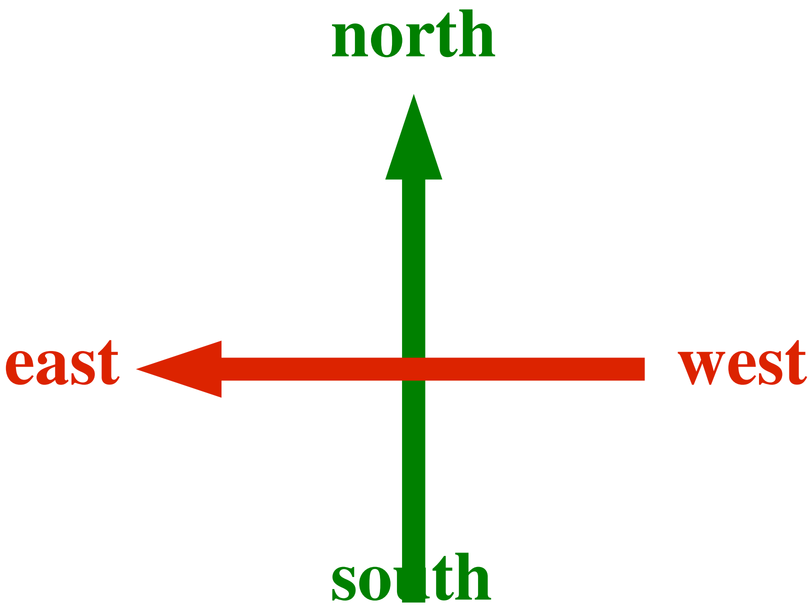
Consider again: source A lies at 02:33:24.5 +15:32:29,

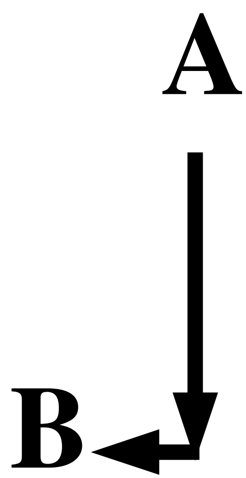
source B lies at 02:33:32.9 +15:24:06.

How do they *look* on the sky?

$\Delta\delta = -8.383'$

$\Delta\alpha = 2.024'$





Celestial coordinates: precession

When can a source's right ascension and declination change?

(1) It's a solar system object (Sun, moon, planet, asteroid, etc.).

(2) It's a nearby star with a high "proper motion" (e.g., α Cen).

(3) We wait long enough that the earth's rotation axis wobbles a little (i.e., it precesses).

To deal with (3), every right ascension and declination must be specified with an epoch ("B1950" and "J2000" are common).

Celestial timekeeping

Astronomers use two principal time conventions:

(1) UT = Universal Time

This is a solar time that corresponds (apart from daylight savings) to the local time in Greenwich, England.

At a given moment, UT is the same everywhere.

(2) LST = Local Sidereal Time

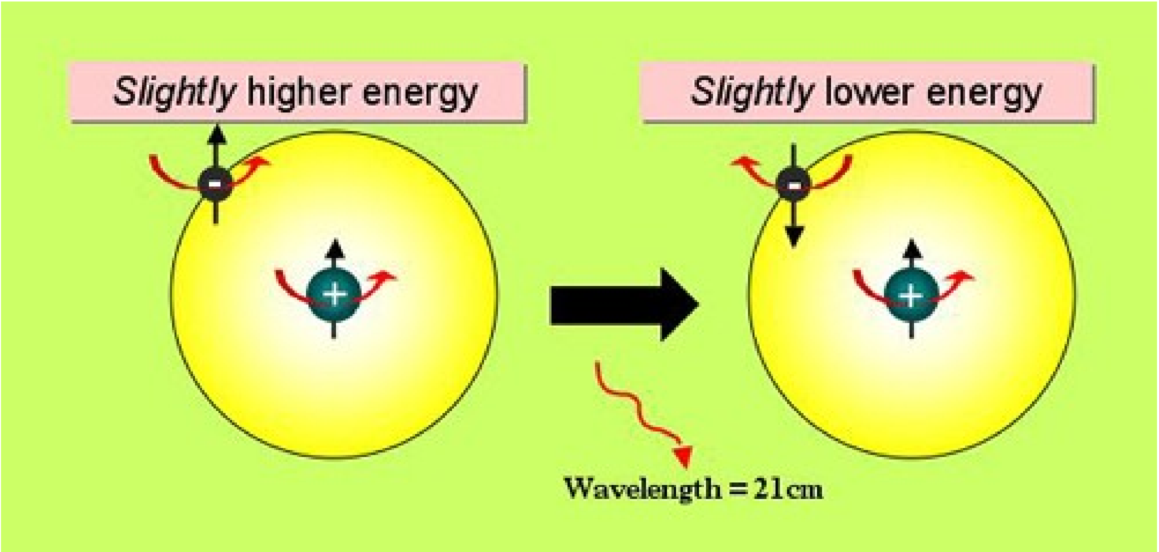
This is the R.A. that is directly overhead right now.

At a given moment, LST is different at different longitudes.

Quiz

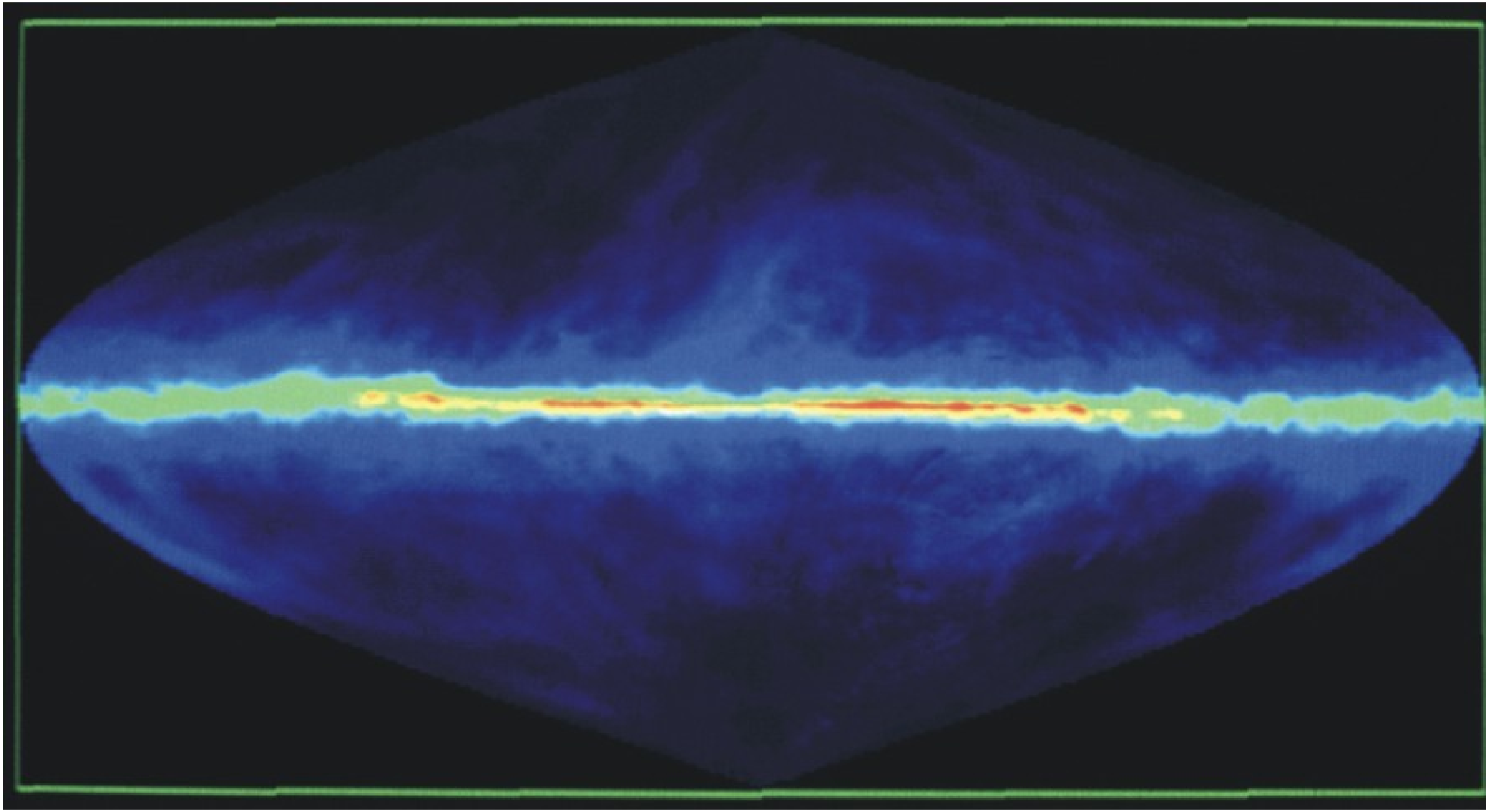
The key "spin flip" transition: 21cm H line

In a H atom, when the electron and the proton switch from having parallel spins to having antiparallel spins, a 21cm photon is emitted.



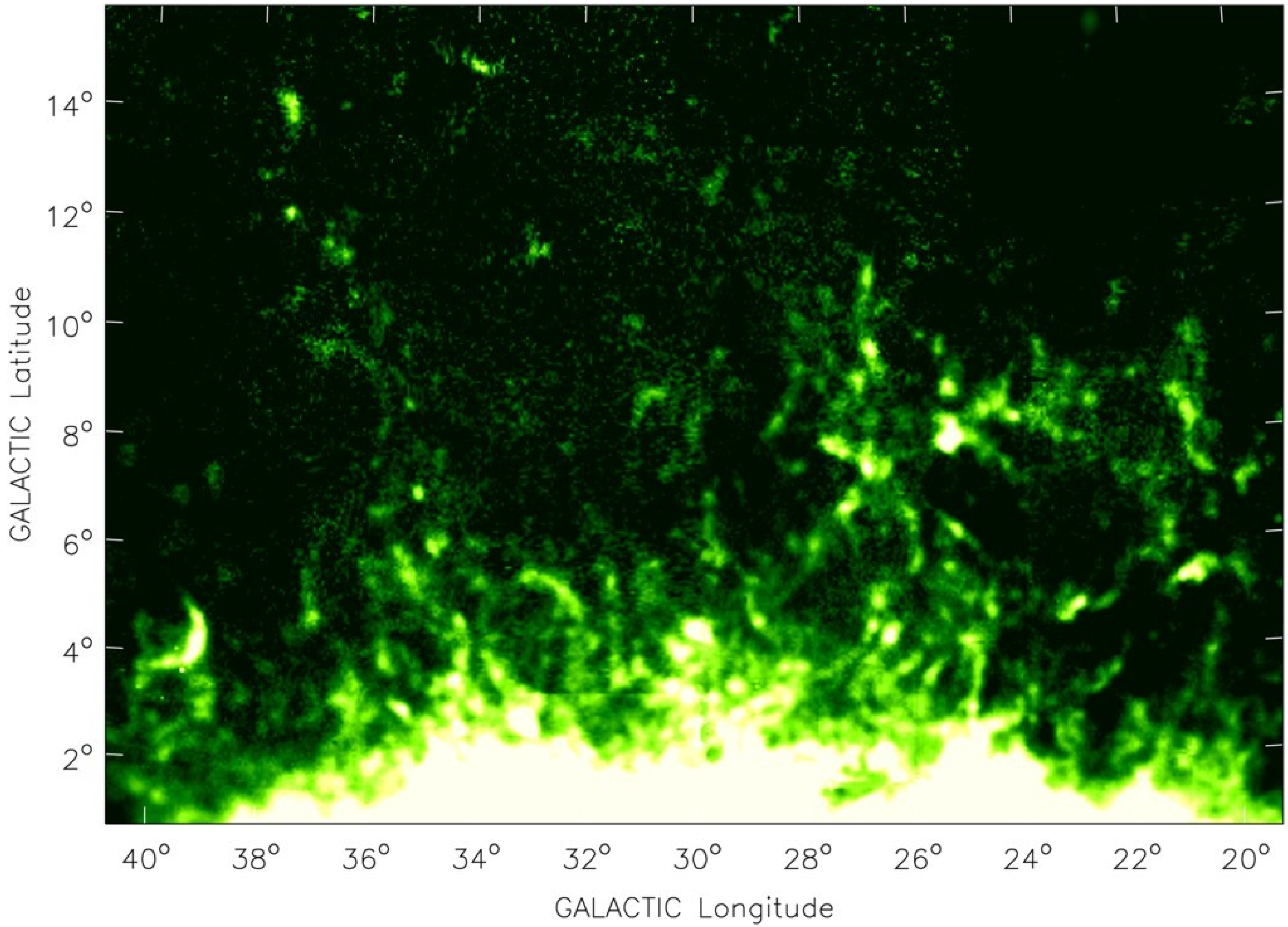
Doesn't trace ionized or molecular gas – just neutral atomic gas!

Courtesy of Swinburne University.



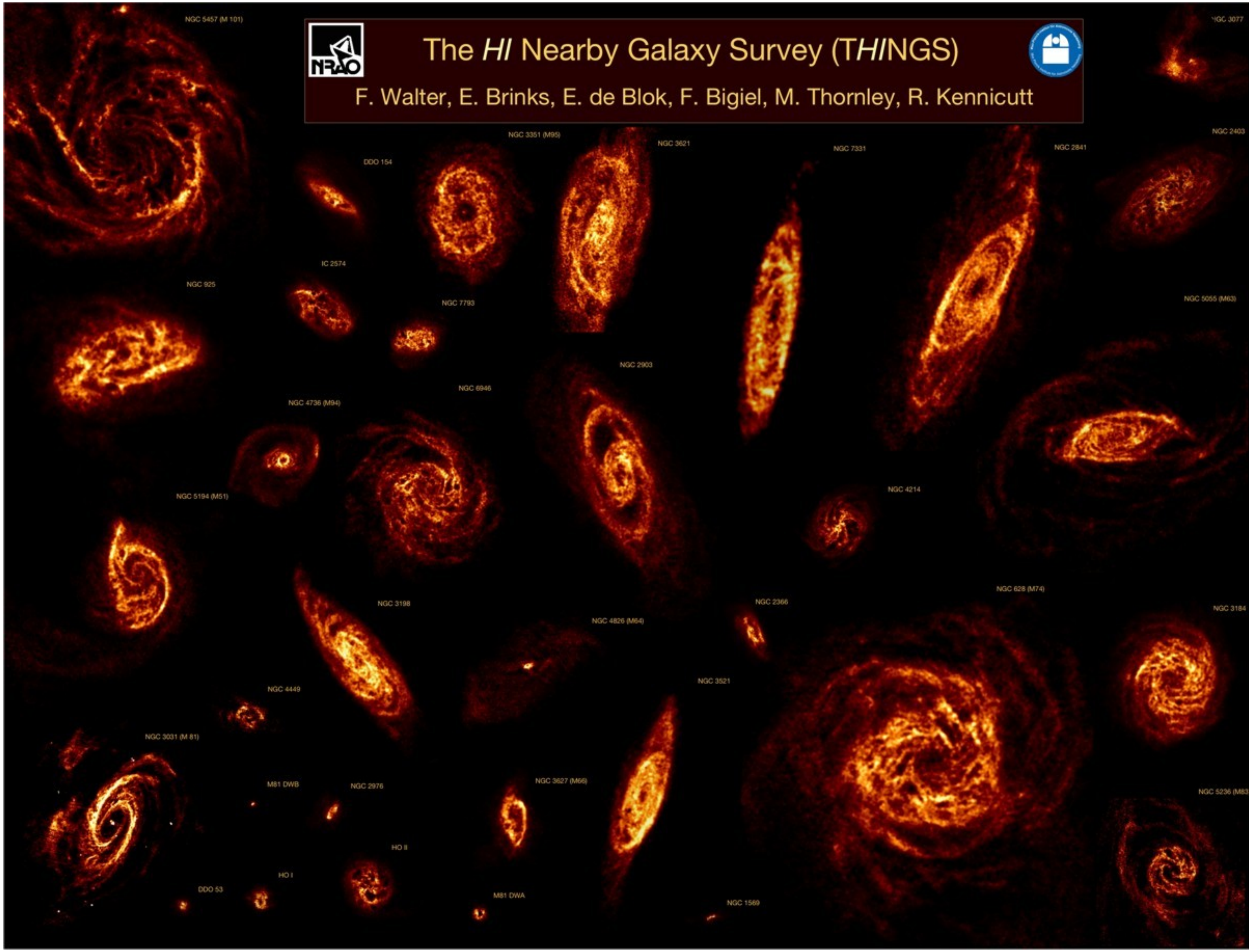
HI in the Milky Way, plotted in (*l*,*b*) coordinates

J. M. Dickey & F. J. Lockman

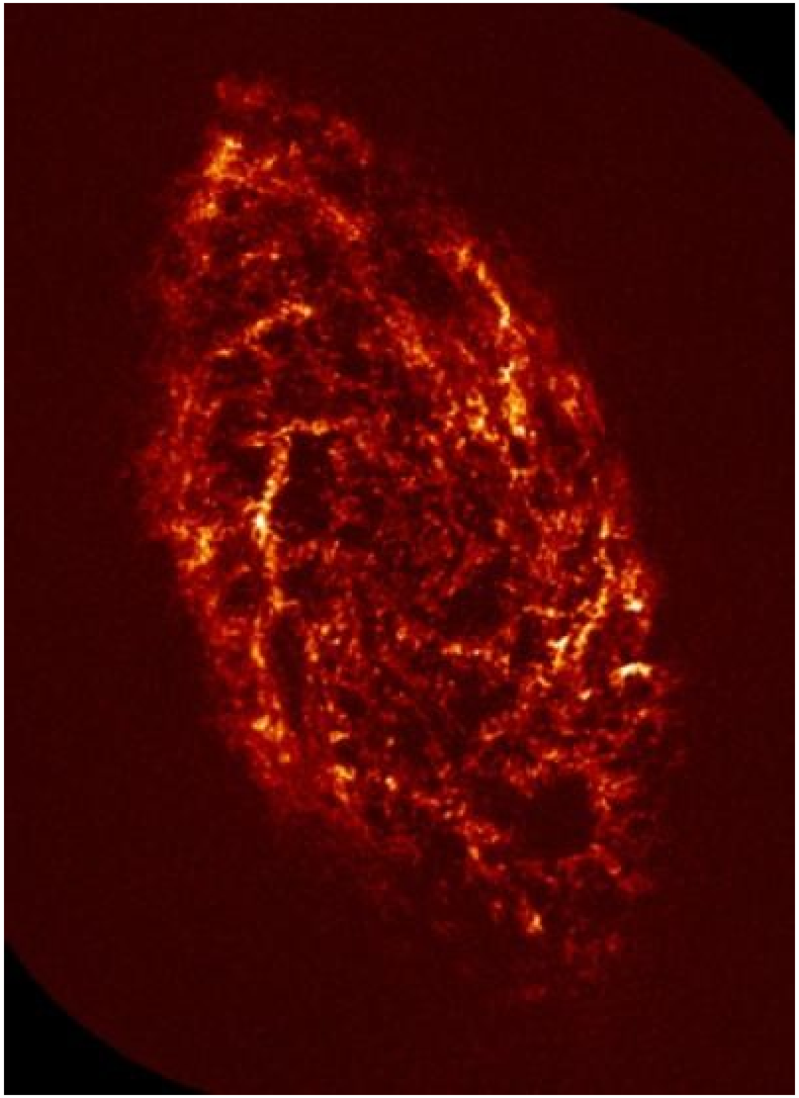


HI in the Milky Way halo (z ~ 2 kpc); field's total M_{HI} ~ 10^6 $M_\odot$

Y. Pidopryhora, F. J. Lockman, & J. Shields

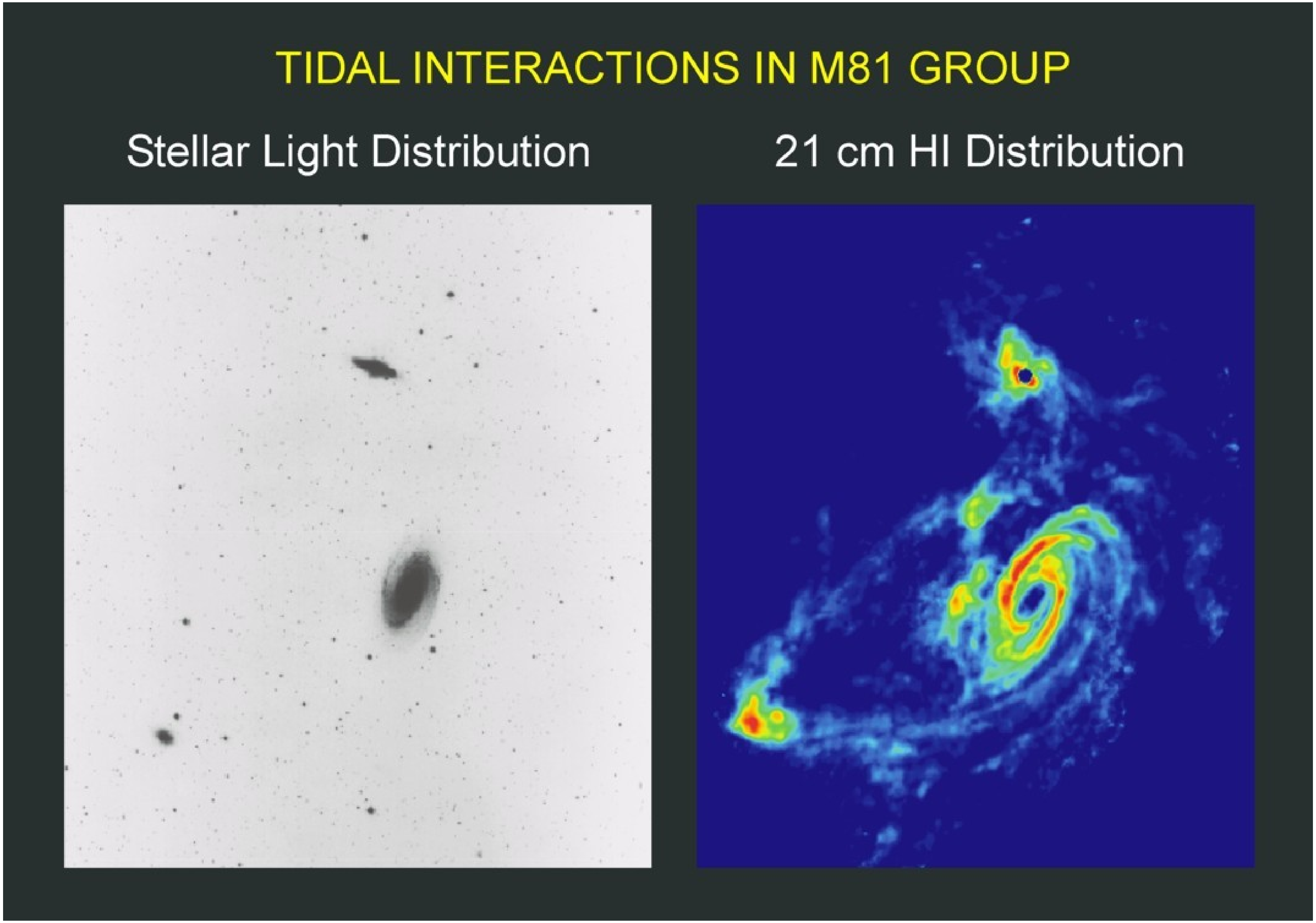


HI in nearby, normal galaxies



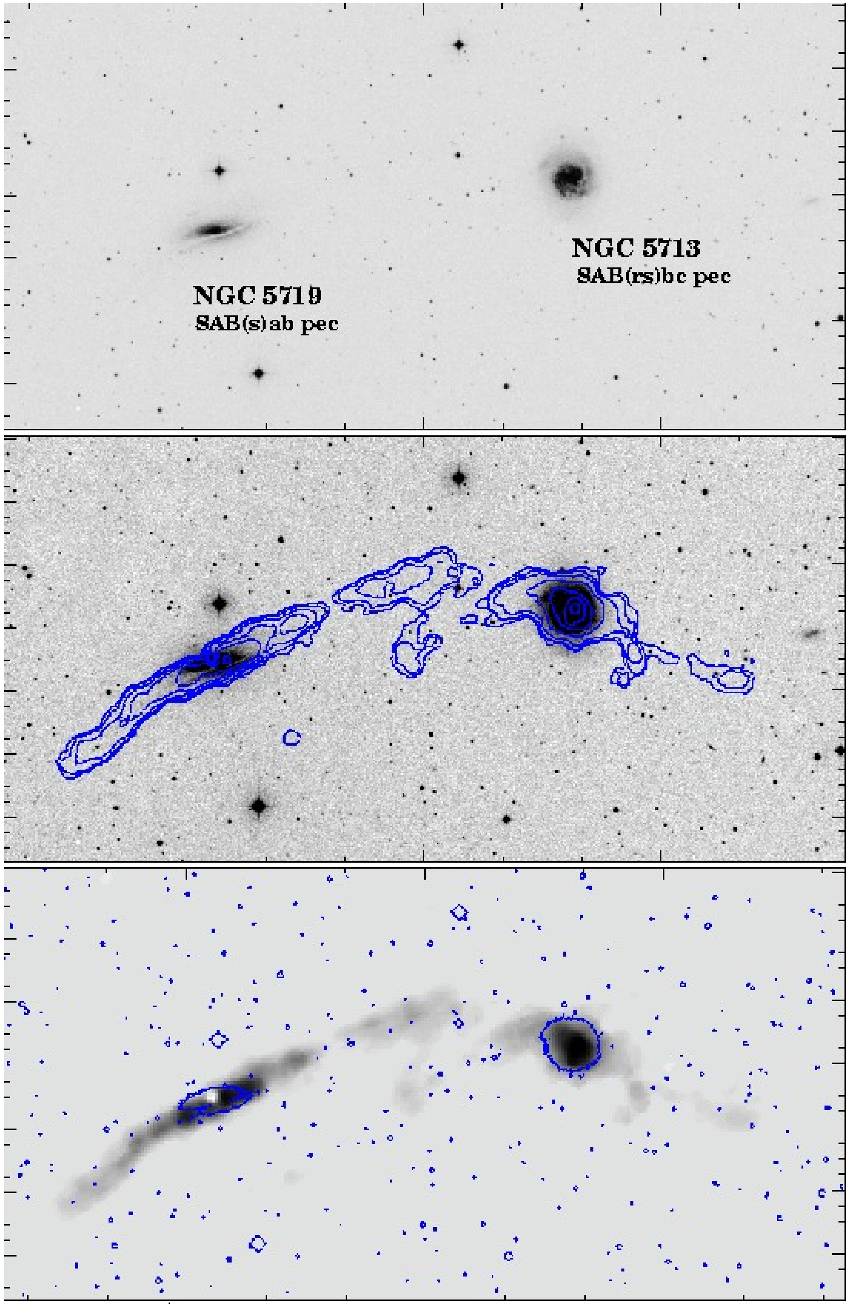
HI in M33 (very nearby spiral)

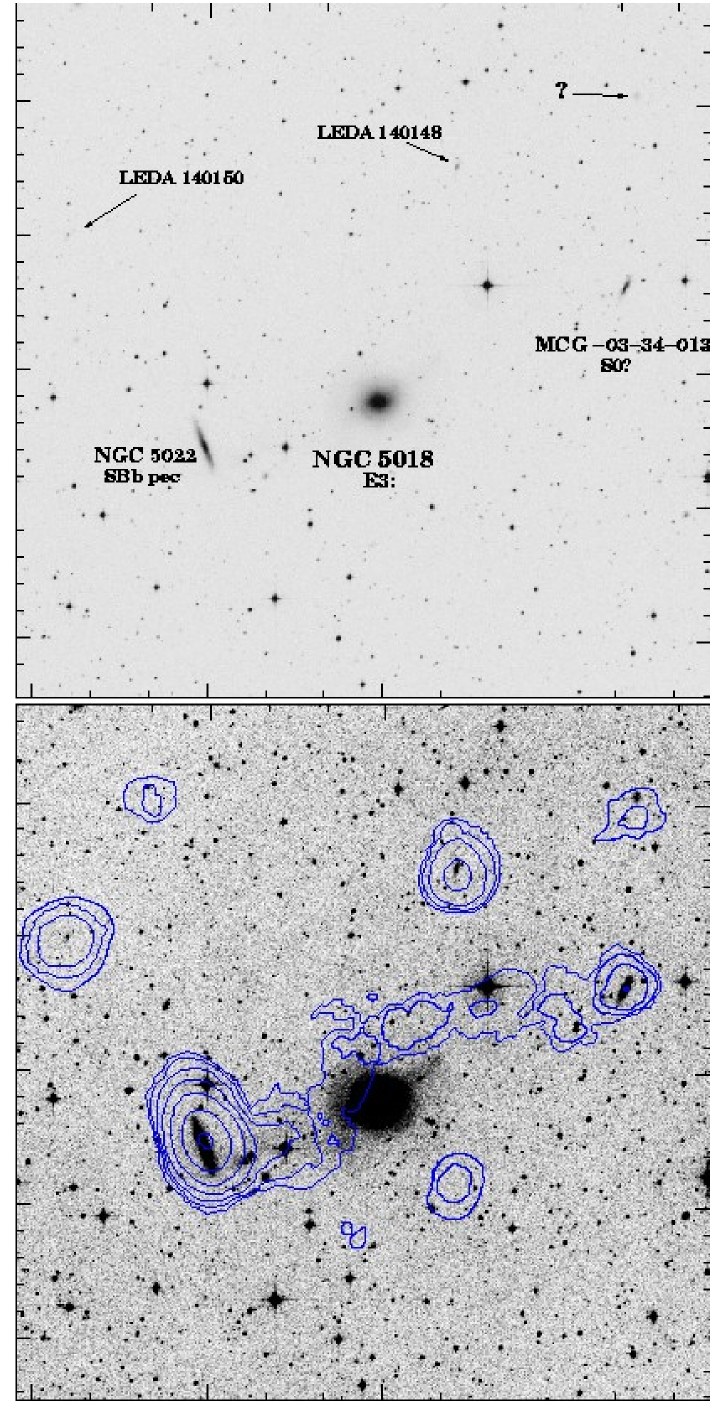
D. Thilker, R. Braun, & R. Walterbos



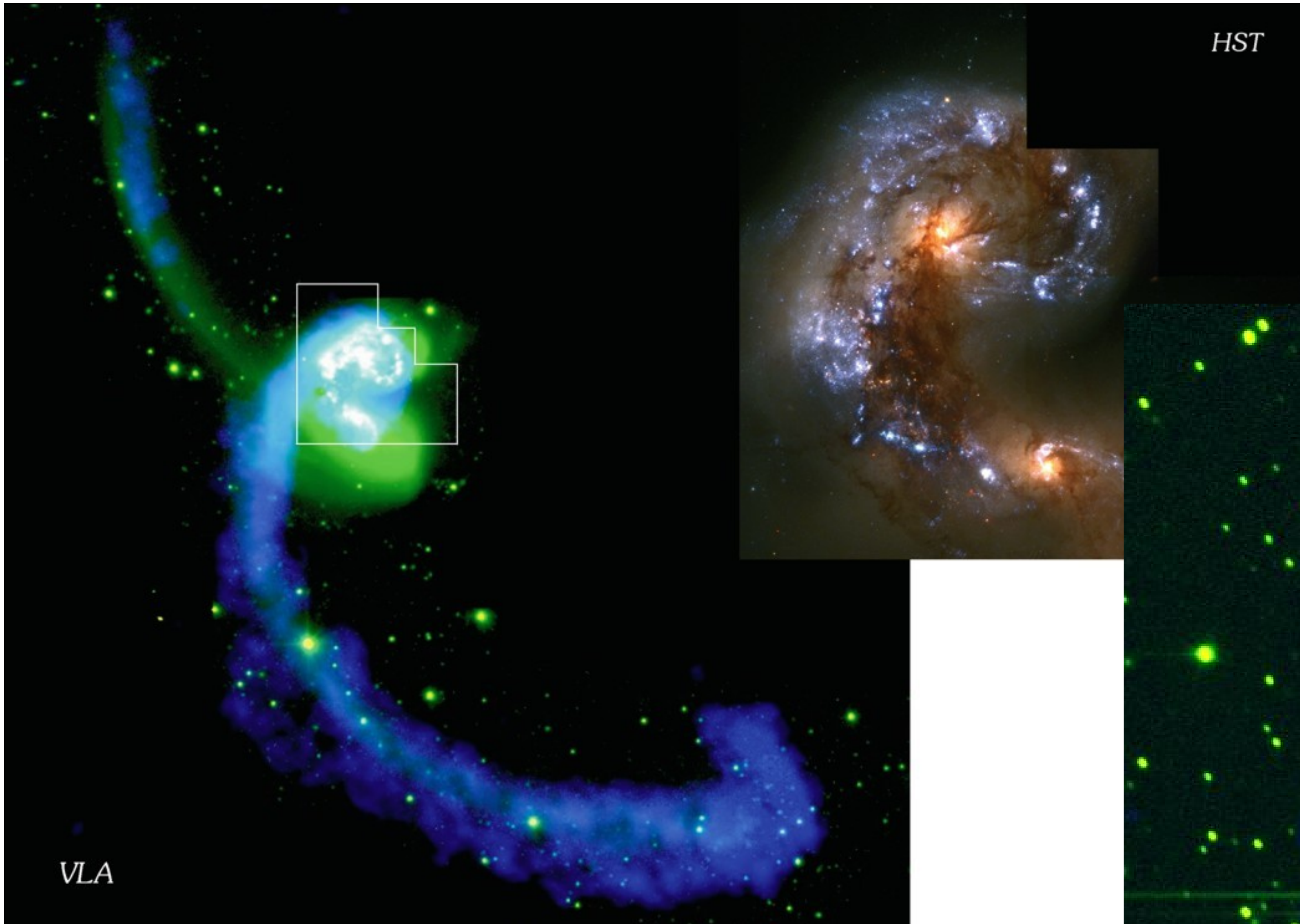
HI in common envelope for the M81 galaxy group

M. S. Yun, P. T. P. Ho, & K. Y. Lo

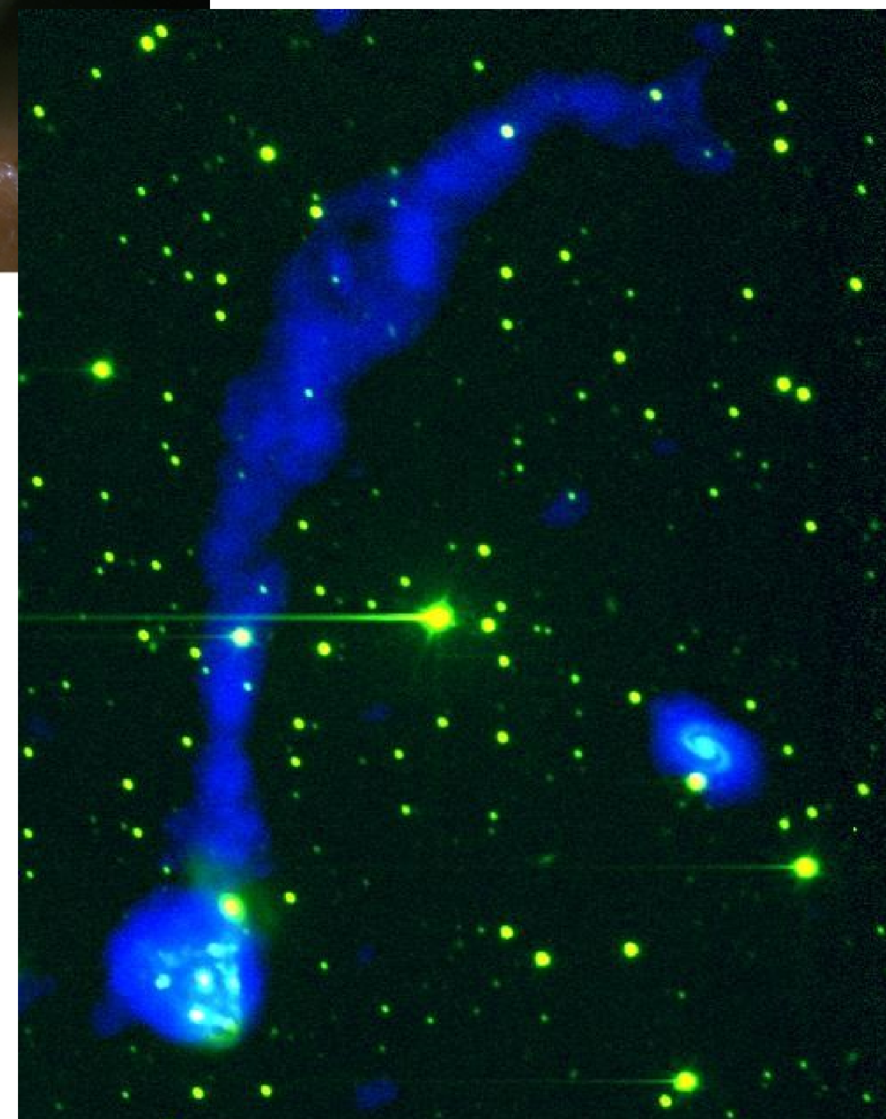




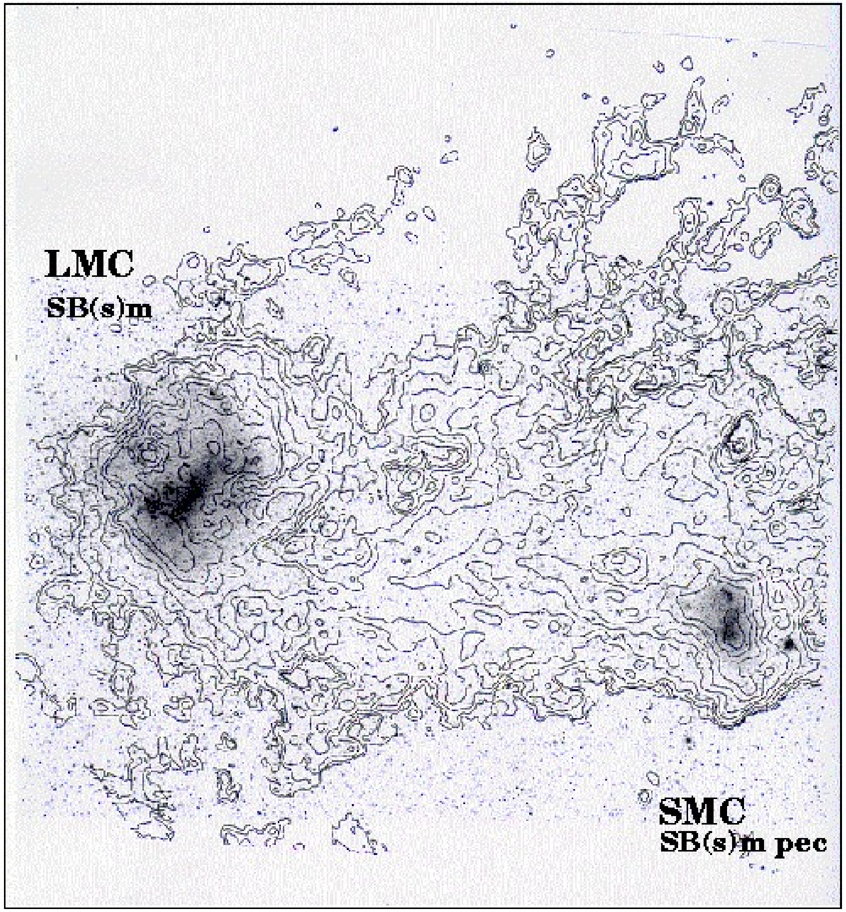
HI in current or past interacting systems

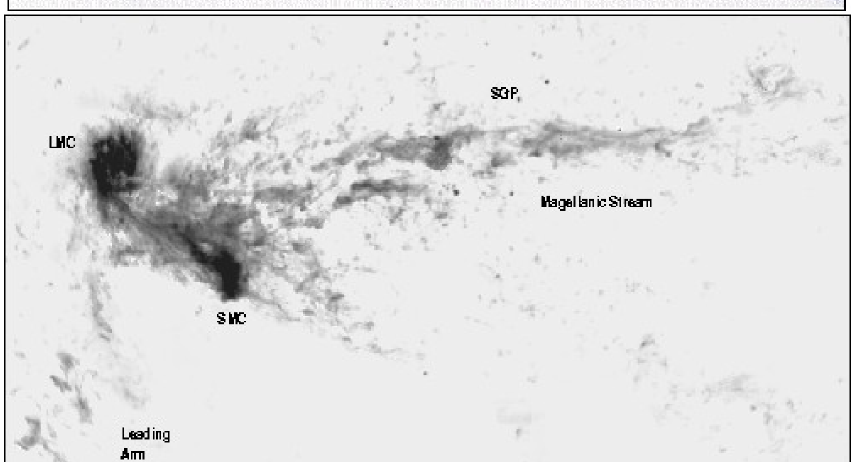


J. E. Hibbard et al.



gas+stellar tails imply tidal (gravity)
gas-only tails imply ram-pressure stripping





Magellanic Stream is being ripped out of Large & Small Magellanic Clouds by hot gas in halo of Milky Way.