

Spiral Galaxies: Gas Content

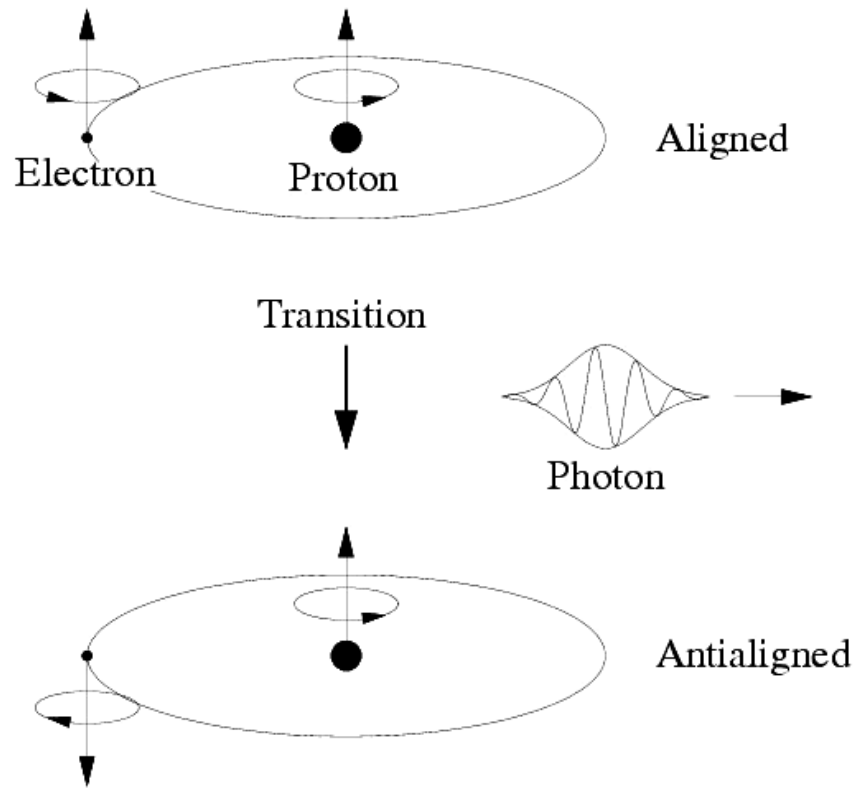
This image is a collage of 25 spiral galaxies, each labeled with its name. The galaxies are arranged in a grid-like pattern, with some larger and more prominent than others. The color scale bar at the top indicates the intensity of the gas content, ranging from dark blue (low intensity) to bright yellow (high intensity). The galaxies shown include:

- NGC 5457 (M51)
- NGC 3351 (M95)
- NGC 3621
- NGC 7331
- NGC 2841
- NGC 3077
- DDO 154
- IC 2574
- NGC 7793
- NGC 2903
- NGC 6948
- NGC 4736 (M94)
- NGC 5194 (M51)
- NGC 4214
- NGC 3198
- NGC 4826 (M64)
- NGC 2366
- NGC 628 (M74)
- NGC 3184
- NGC 4449
- NGC 3521
- NGC 5236 (M83)
- NGC 3031 (M81)
- M81 DWB
- NGC 2976
- NGC 3627 (M66)
- HO II
- DDO 53
- HO I
- M81 DWA
- NGC 1569

Spiral Galaxies: Gas Content

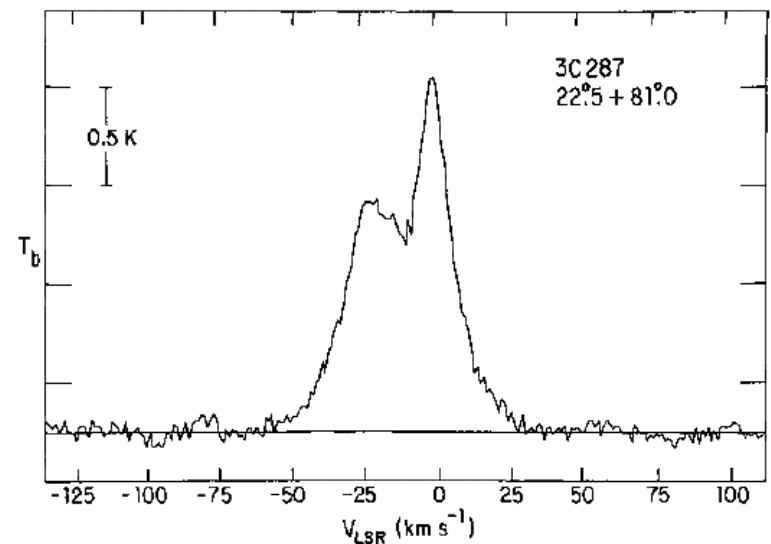
- Gas in spirals
 - Cool atomic HI gas
 - Molecular hydrogen H_2 , CO, many other molecules
 - Need gas to form stars! Star formation associated with dense ISM
 - Can observe ionized hydrogen via optical emission-lines ($H\alpha$)
 - Observe HI via radio emission – 21 cm line due to hyperfine structure – a hydrogen atom that collides with another particle can undergo a spin-flip transition
- Spirals show HI disks (amount of HI depends on Hubble type)
- HI gas is optically thin, 21 cm line suffers little absorption, so we can measure gas mass directly from line intensity
- HI is much more extended than optical light
- Can use radial motion of 21 cm line to measure rotation in spiral galaxies

A Basic Tool: Spin-Flip (21 cm) Line of H I

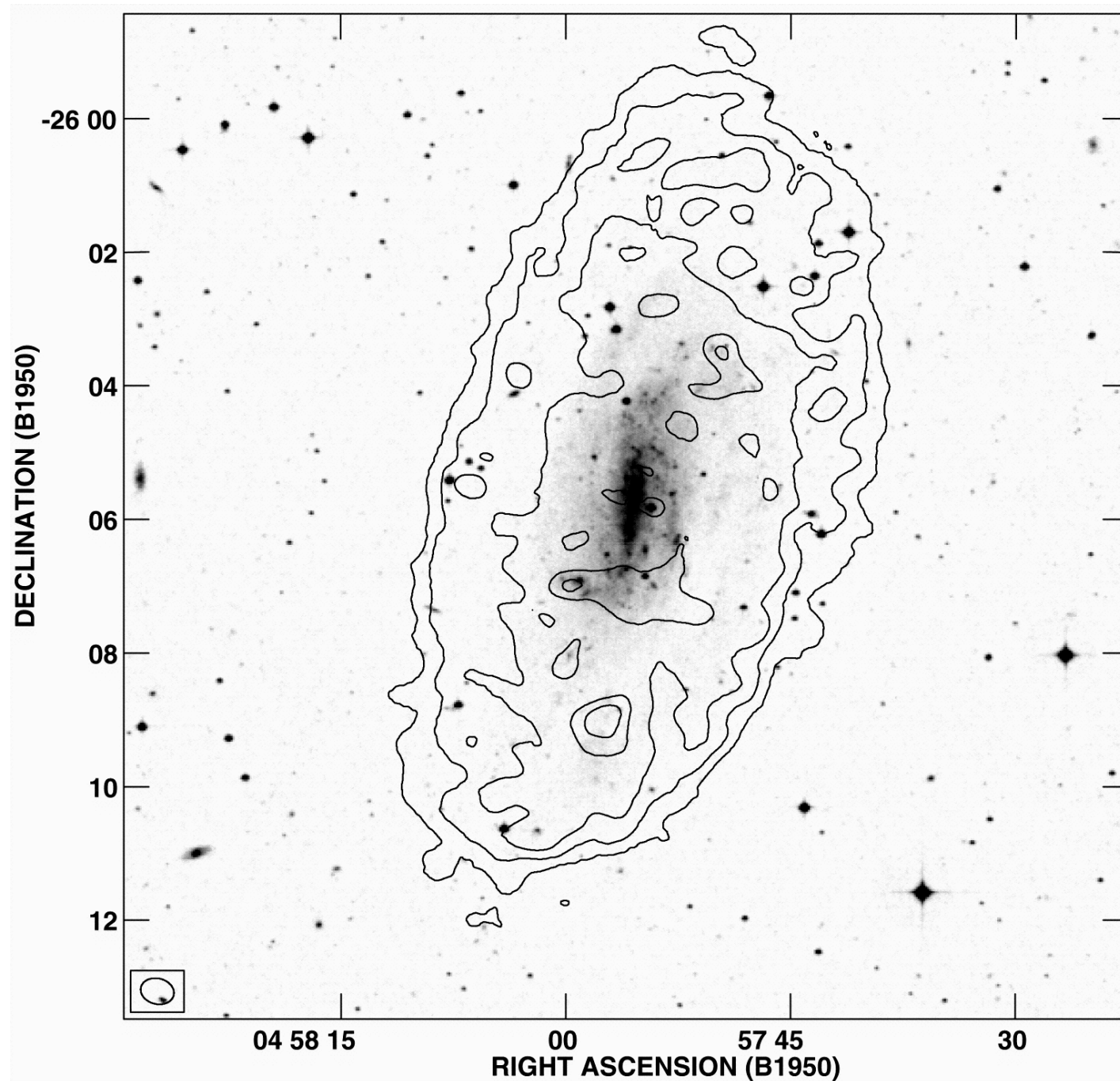


In emission generally originates from warm ($T \sim 100 - 6000$ K) ISM, which accounts for $\sim 30 - 65\%$ of the total ISM volume in the Galactic disk. In absorption, it probes a cooler ISM (can be also self-absorbed).

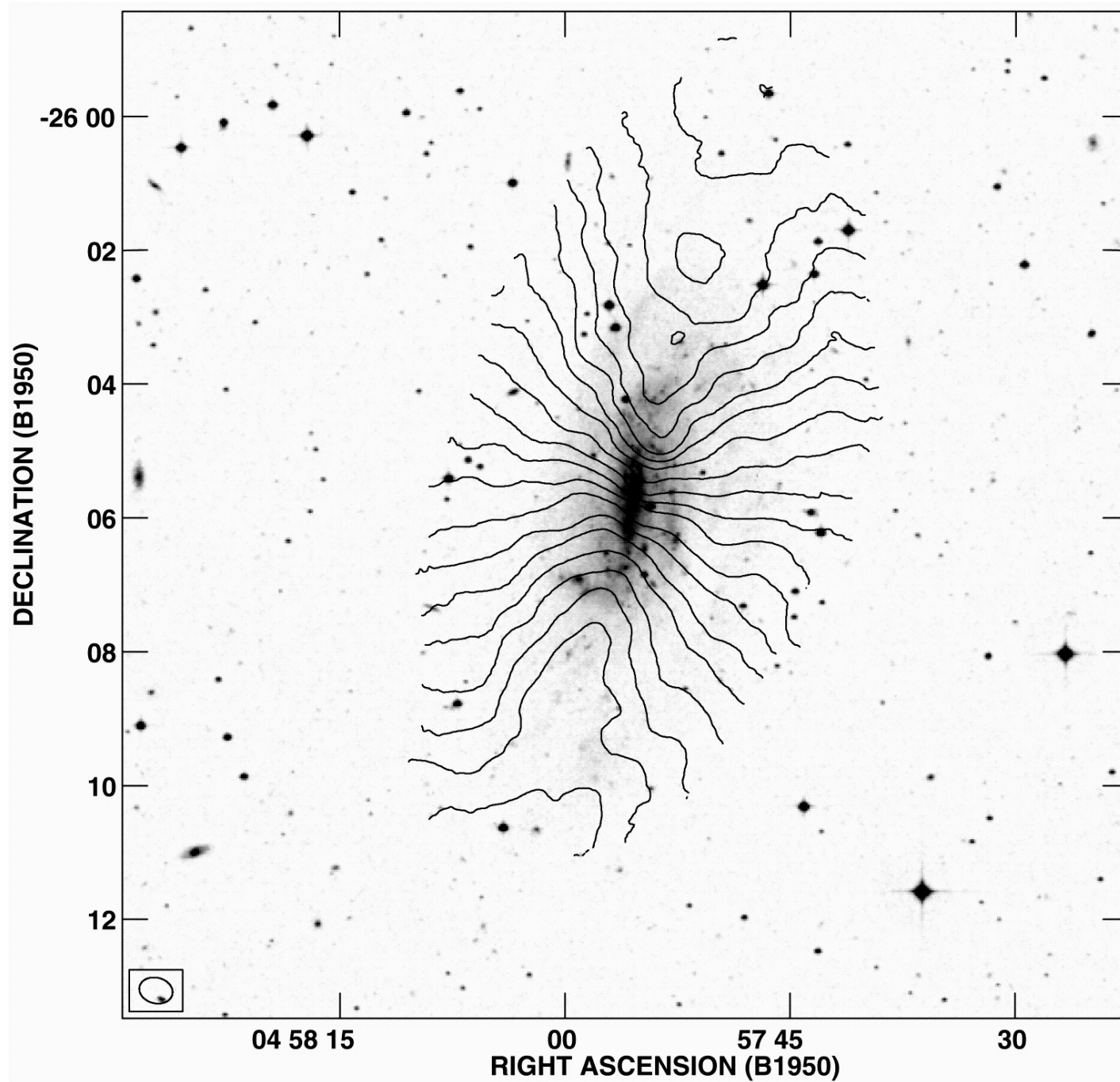
Typical line profile \rightarrow



A major advantage: it is not affected by the dust absorption!

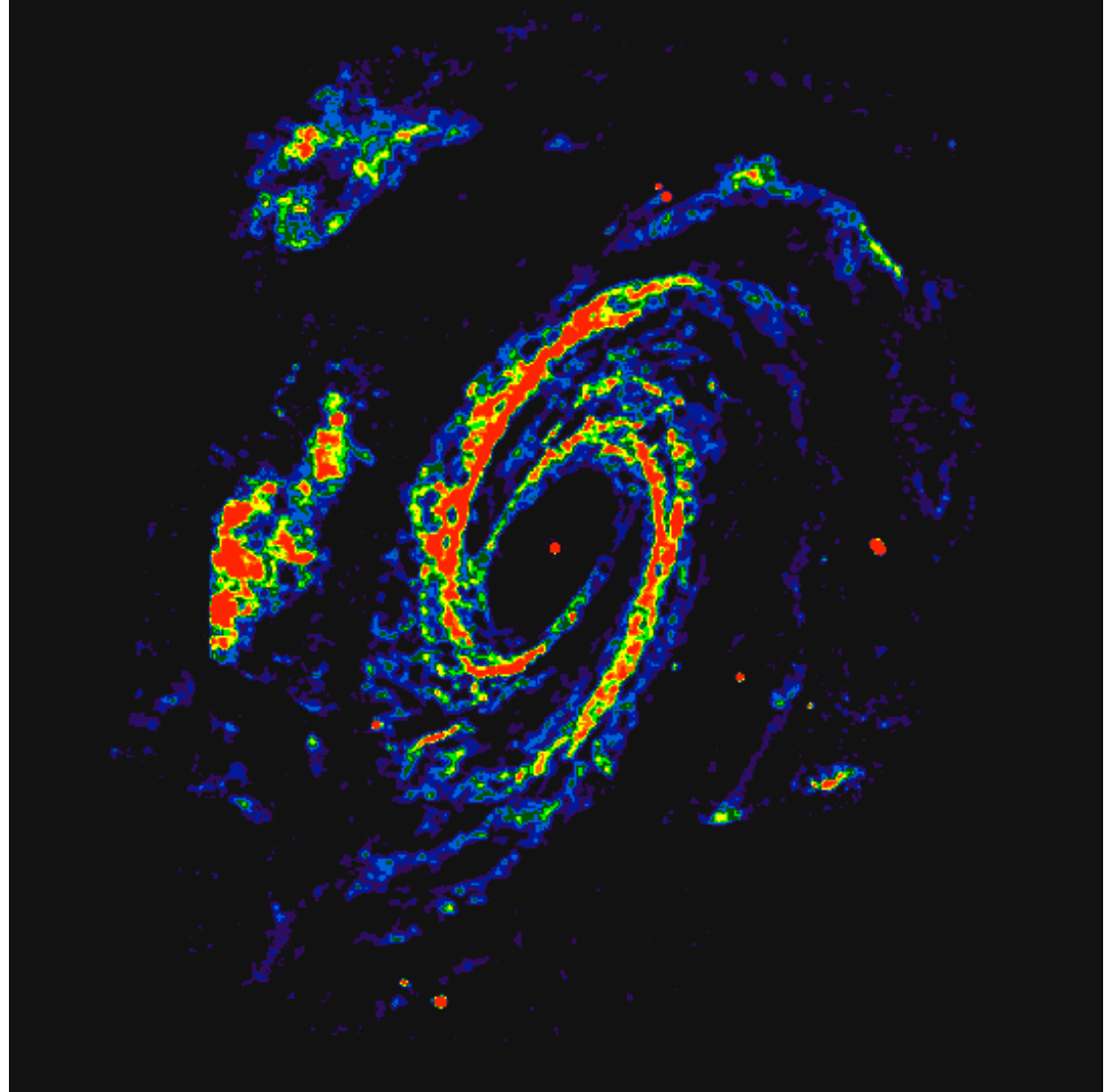


NGC 1744
Optical and
HI contours

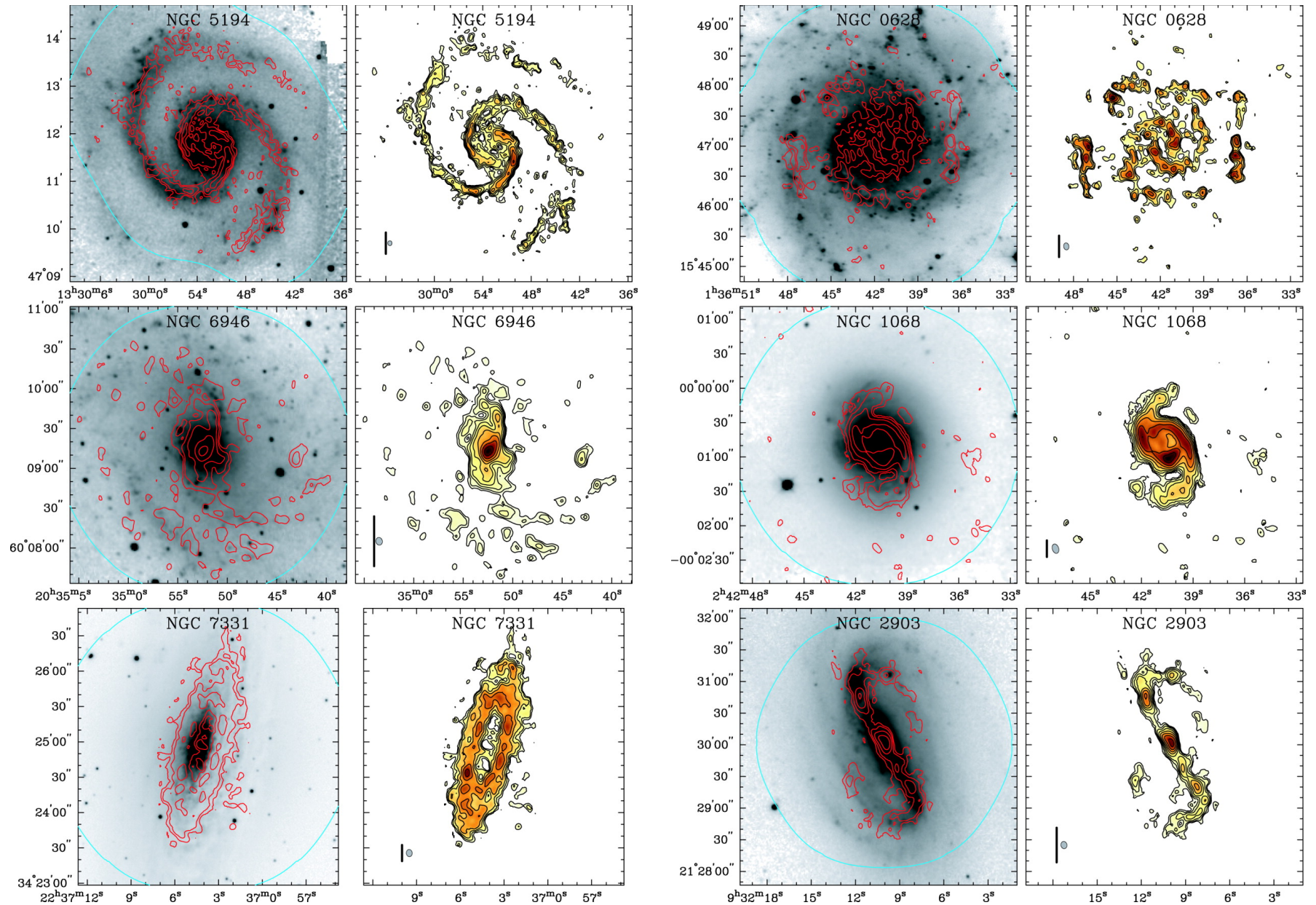


NGC 1744
Optical
contours
and H I
radial
velocities

M81: Optical and H I



Optical and CO

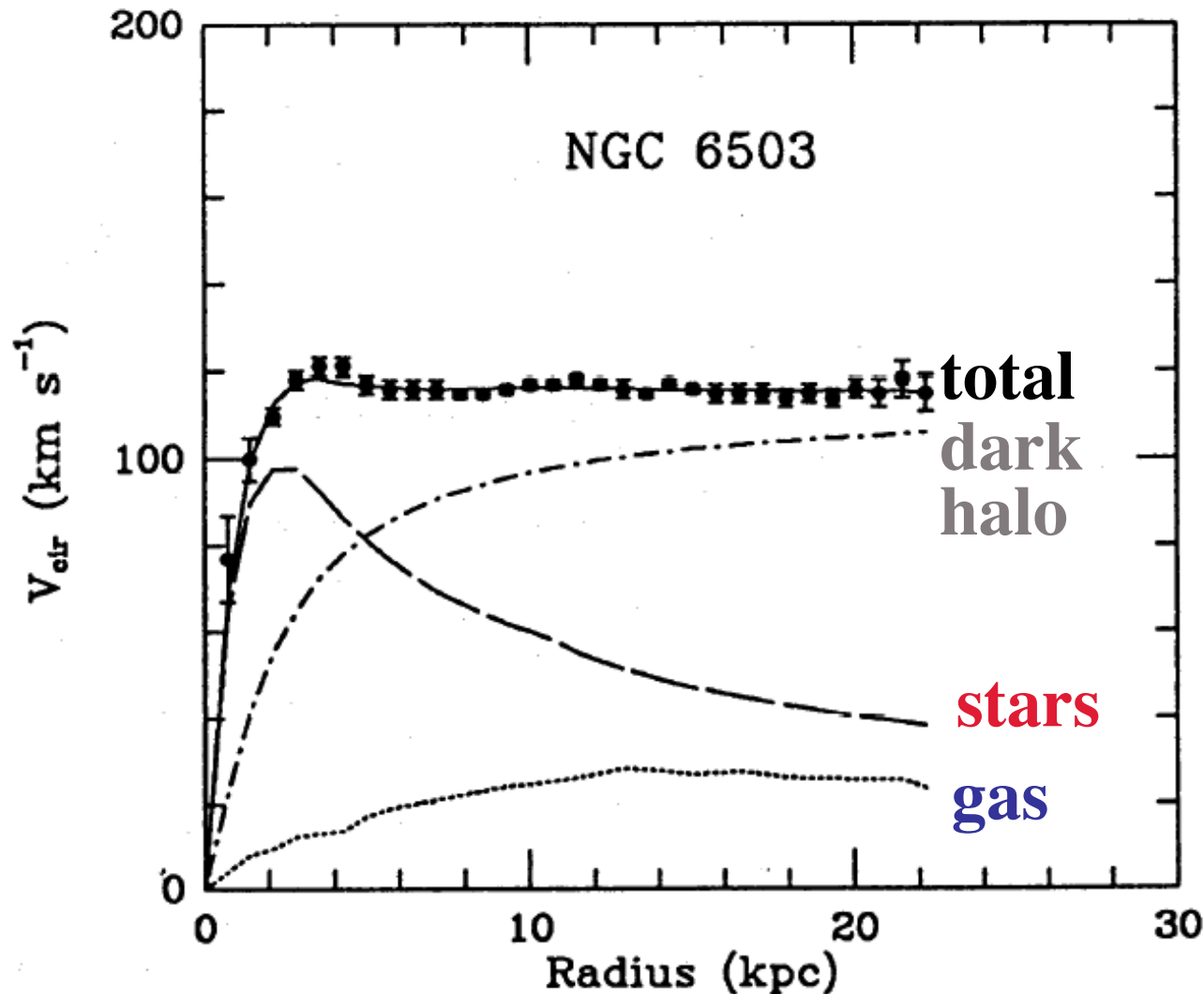


Multi-Phase ISM

The ISM has a complex structure with 3 major components:

1. **Cold** ($T \sim 30 - 100$ K), dense ($n_{\text{H I}} > 10 \text{ cm}^{-3}$) atomic (H I) and molecular (H_2 , CO, ...) gas and dust clouds
 - ★ Only $\sim 1 - 5$ % of the total volume, but most of the mass
 - ★ Confined to the thin disk
 - ★ Low ionization fraction ($x_{\text{H II}} < 10^{-3}$)
 - ★ Stars are born in cold, dense clouds
2. **Warm** ($T \sim 10^3 - 10^4$ K) neutral & ionized gas, $n \sim 1 \text{ cm}^{-3}$
 - ★ Energized mainly by UV starlight
 - ★ Most of the total ISM volume in the disk
3. **Hot** ($T \sim 10^5 - 10^6$ K), low density ($n \sim 10^{-3} \text{ cm}^{-3}$) gas
 - ★ Galactic corona
 - ★ Almost fully ionized, energized mainly by SN shocks

Disk Galaxy Rotation Curves: Mass Component Contributions



Dark Matter
dominates at
large radii

It cannot be
concentrated
in the disk, as
it would make
the velocity
dispersion of
stars too high

Next:

Spiral Galaxies: Density Waves

