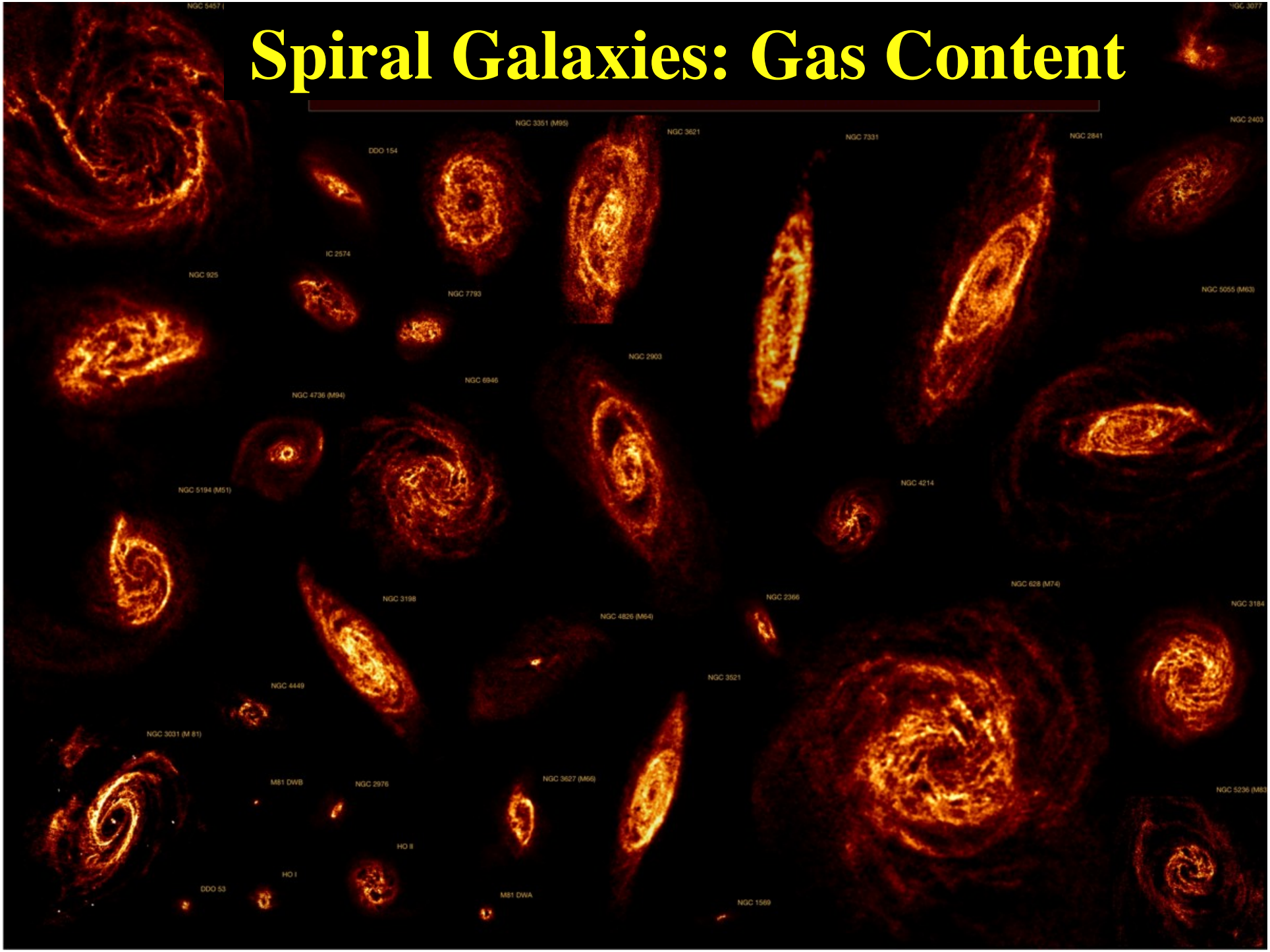
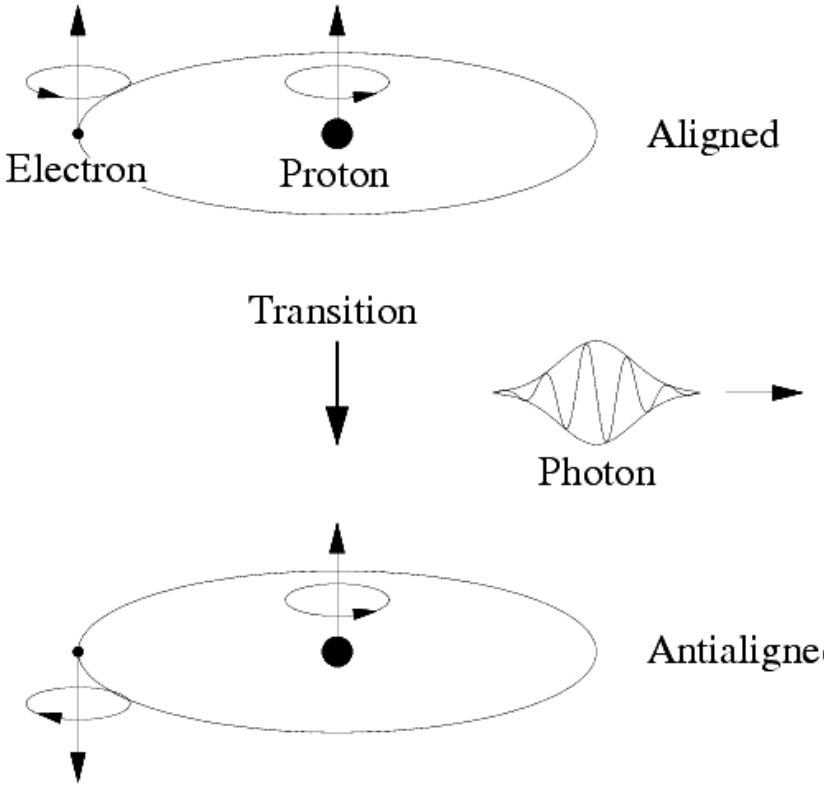
Spiral Galaxies: Gas Content



Spiral Galaxies: Gas Content

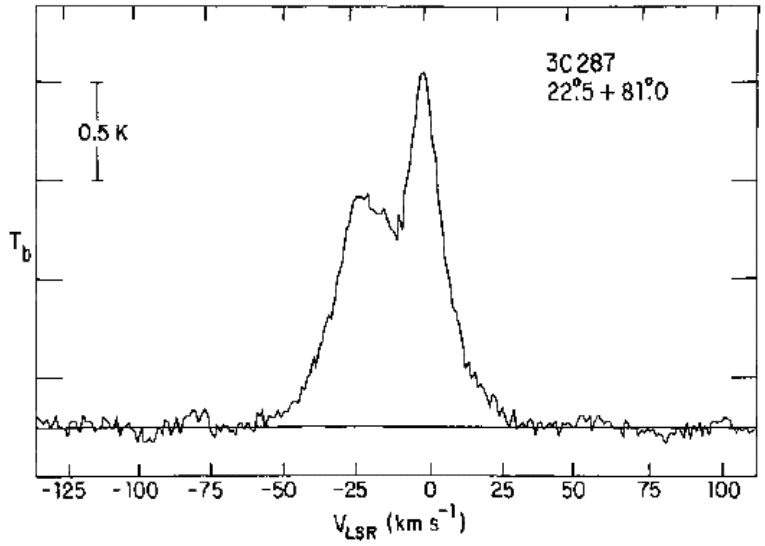
- Gas in spirals
  - Cool atomic HI gas
  - Molecular hydrogen H_2, CO, many other molecules
  - Need gas to form stars! Star formation associated with dense ISM
  - Can observe ionized hydrogen via optical emission-lines (Hα)
  - Observe HI via radio emission – 21 cm line due to hyperfine structure – 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

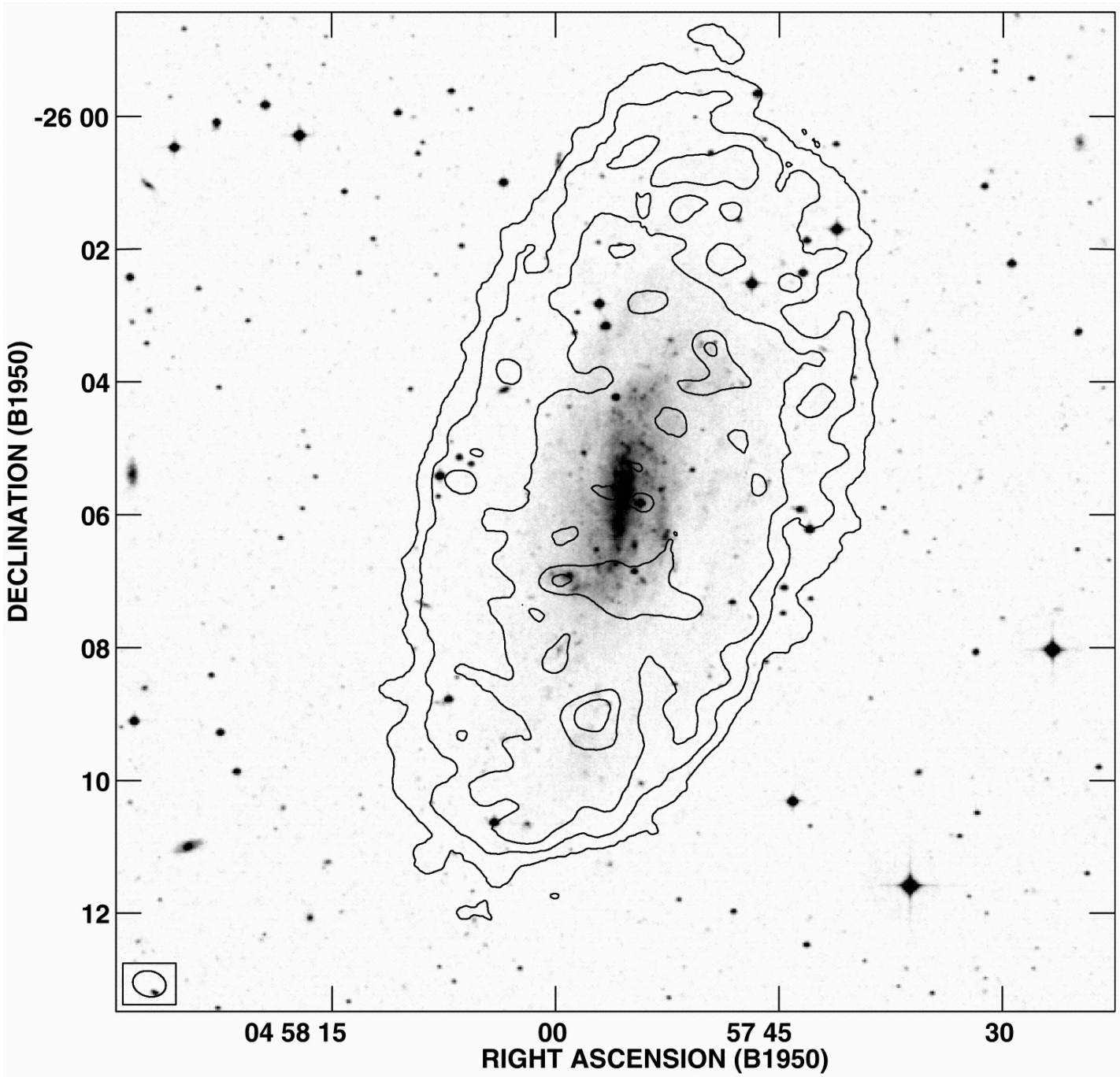


In emission generally originates from warm (T ~ 100 - 6000 K) ISM, which accounts for ~ 30 - 65% of the total ISM volume in the Galactic disk. In absorption, it probes a cooler ISM (can be also self-absorbed).

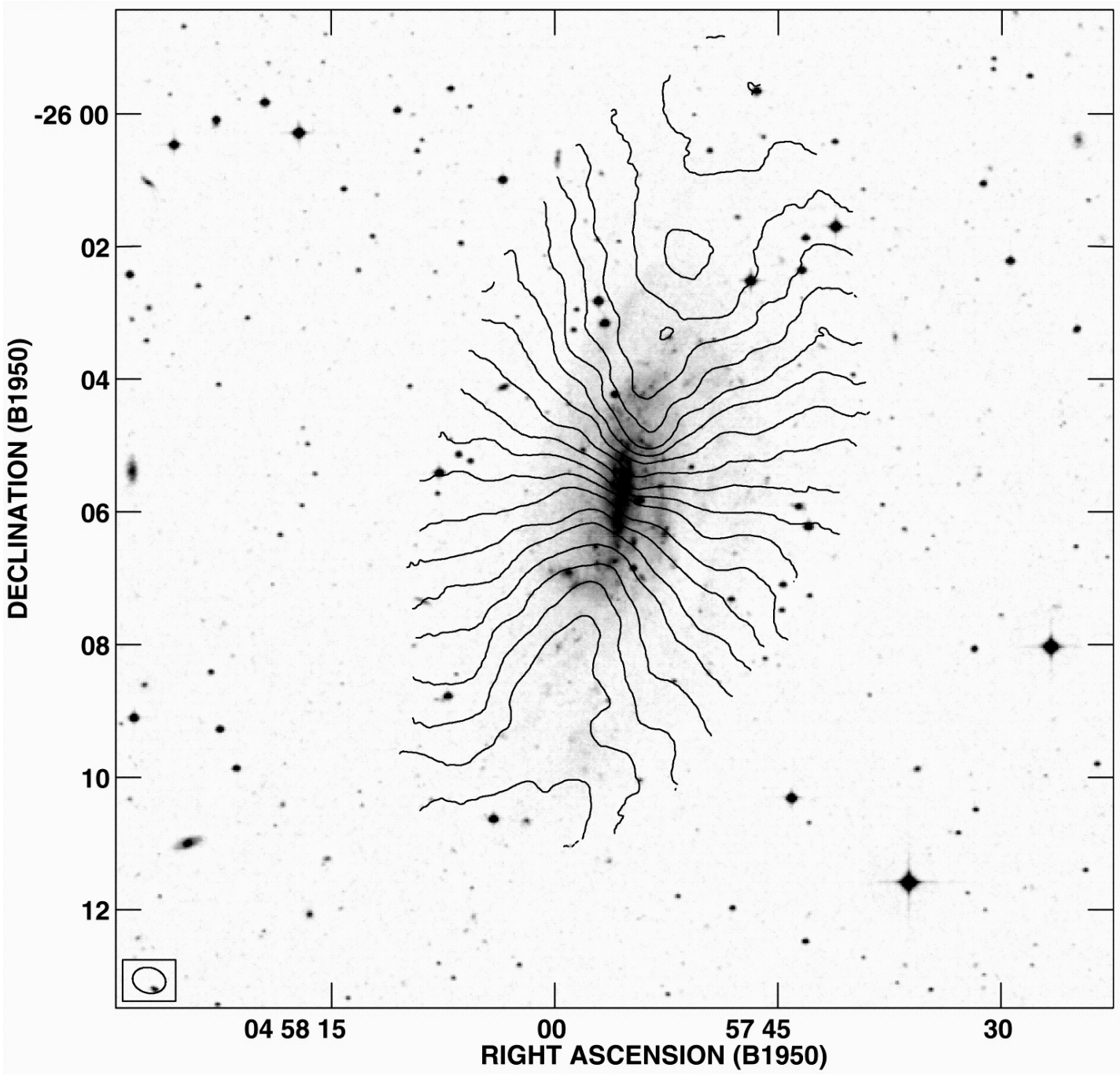
Typical line profile →



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

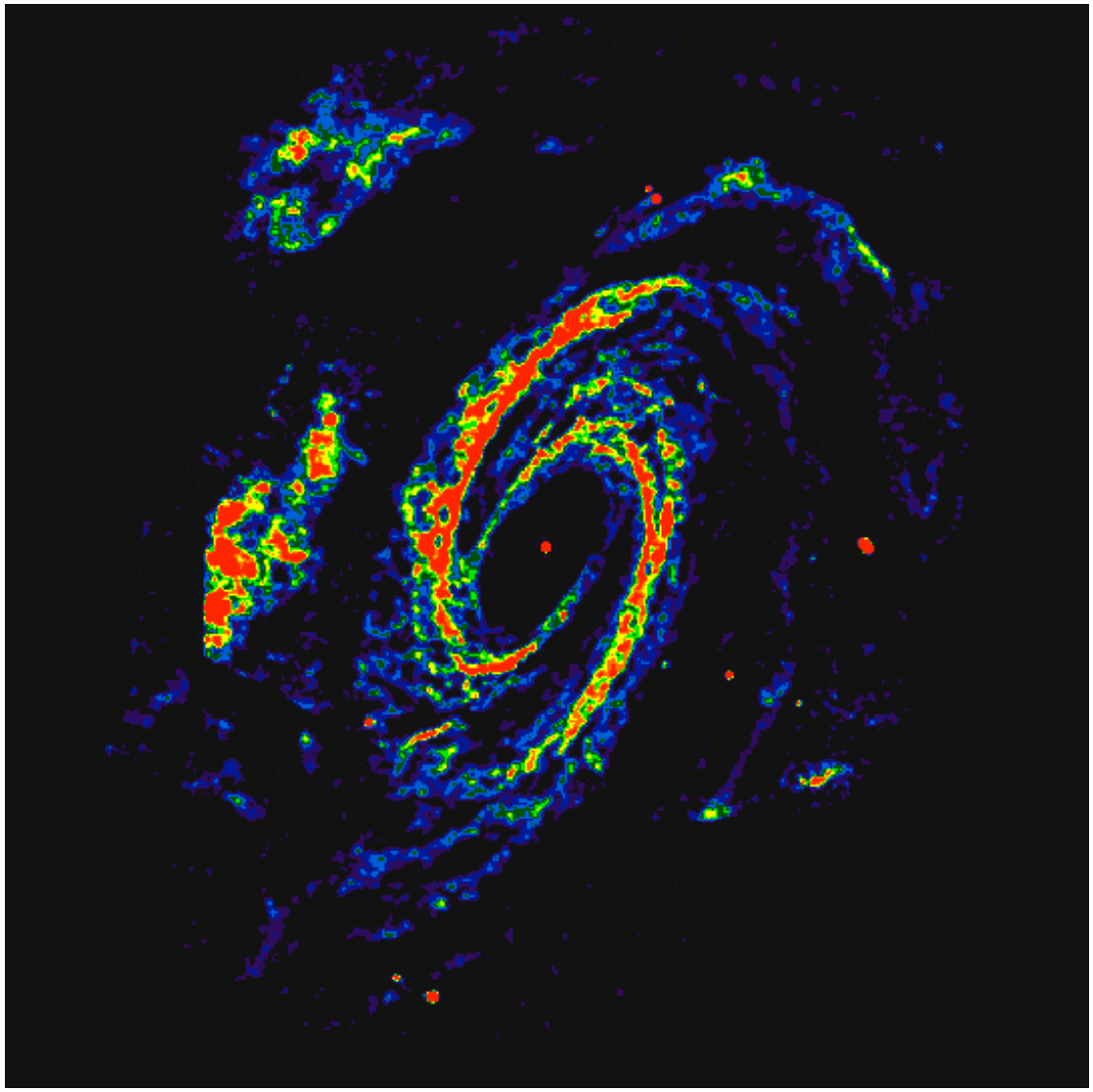


NGC 1744
Optical and HI contours

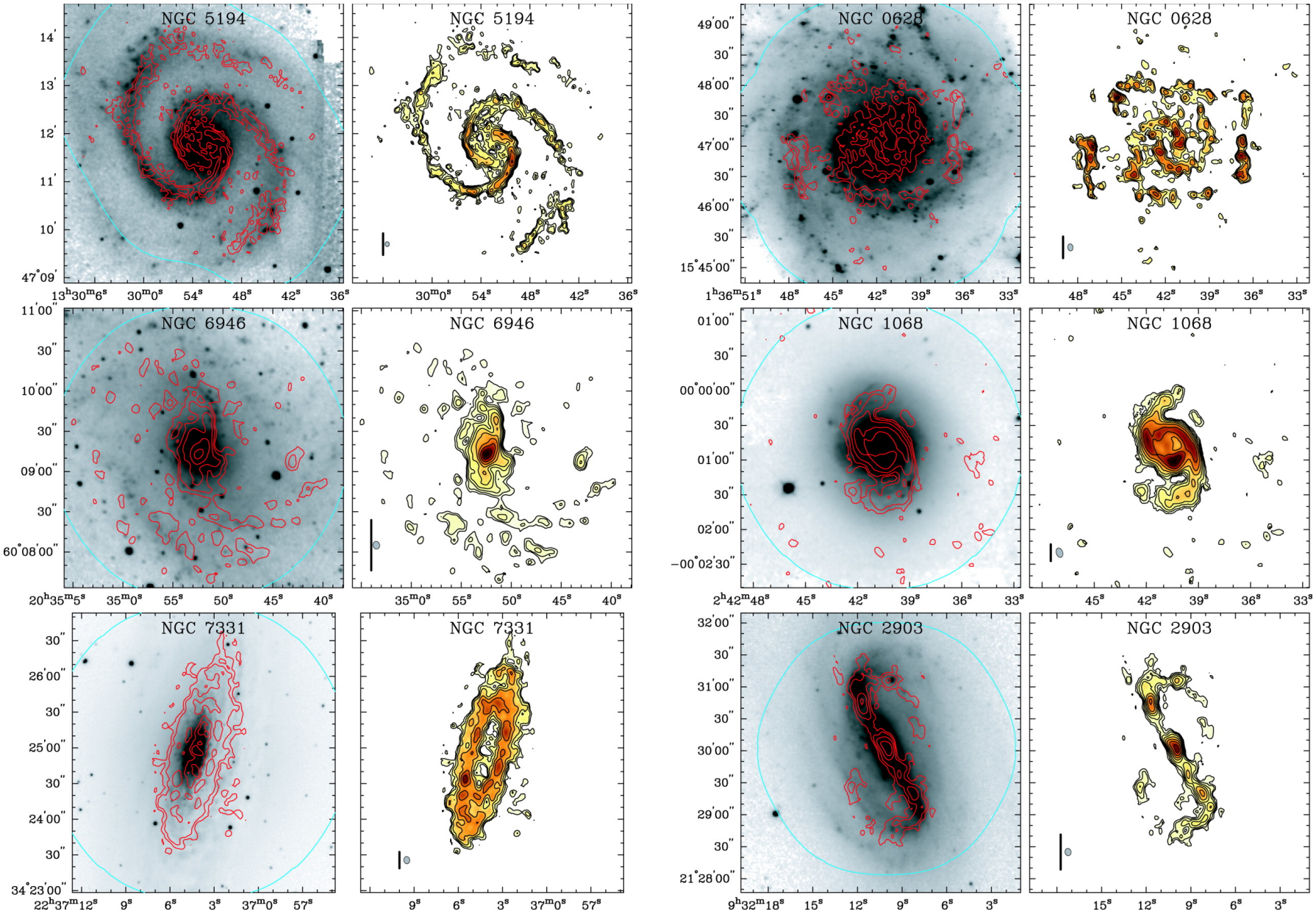


NGC 1744 Optical contours and H I radial velocities

M81: Optical and H I



Optical and CO

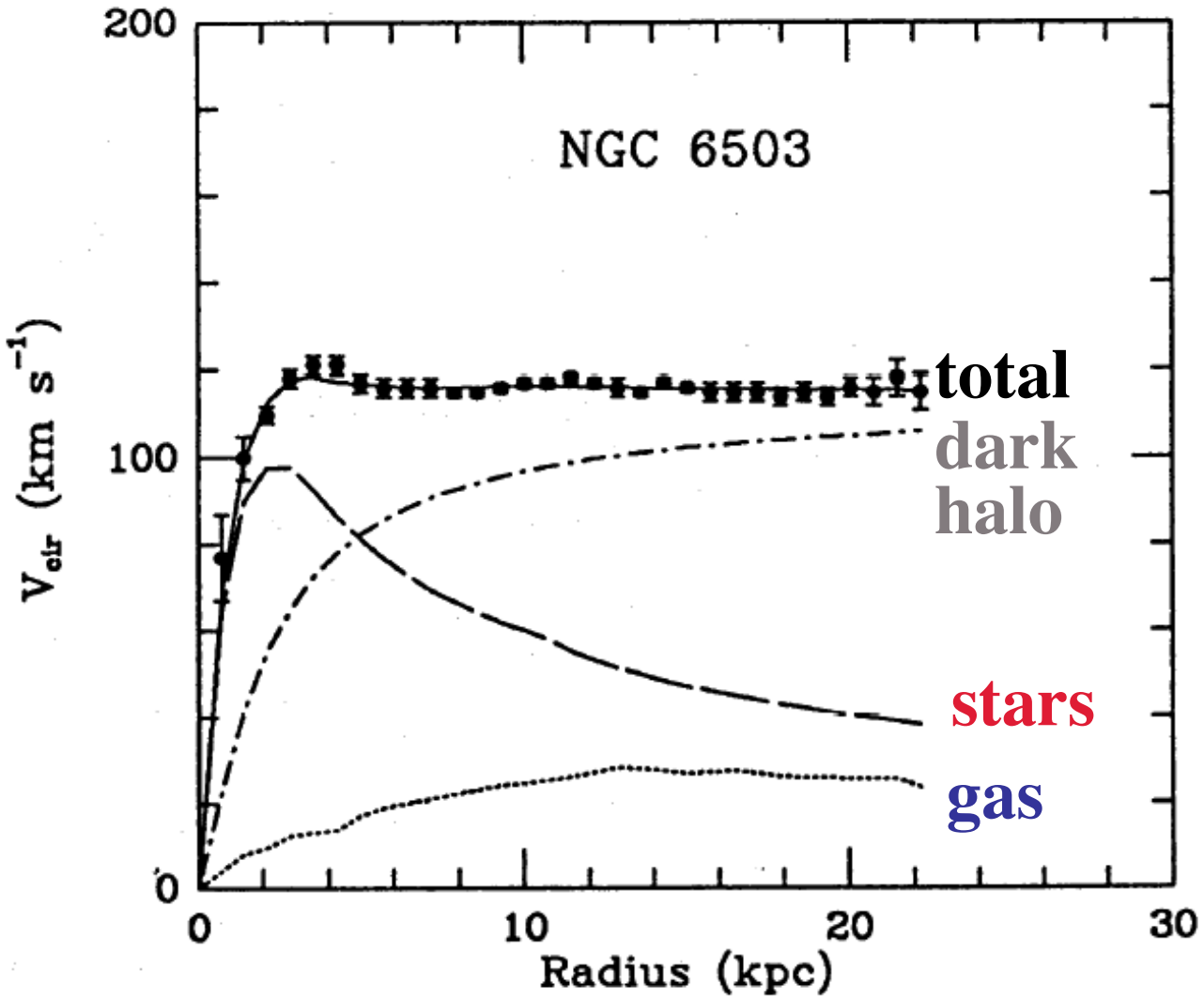


Multi-Phase ISM

The ISM has a complex structure with 3 major components:

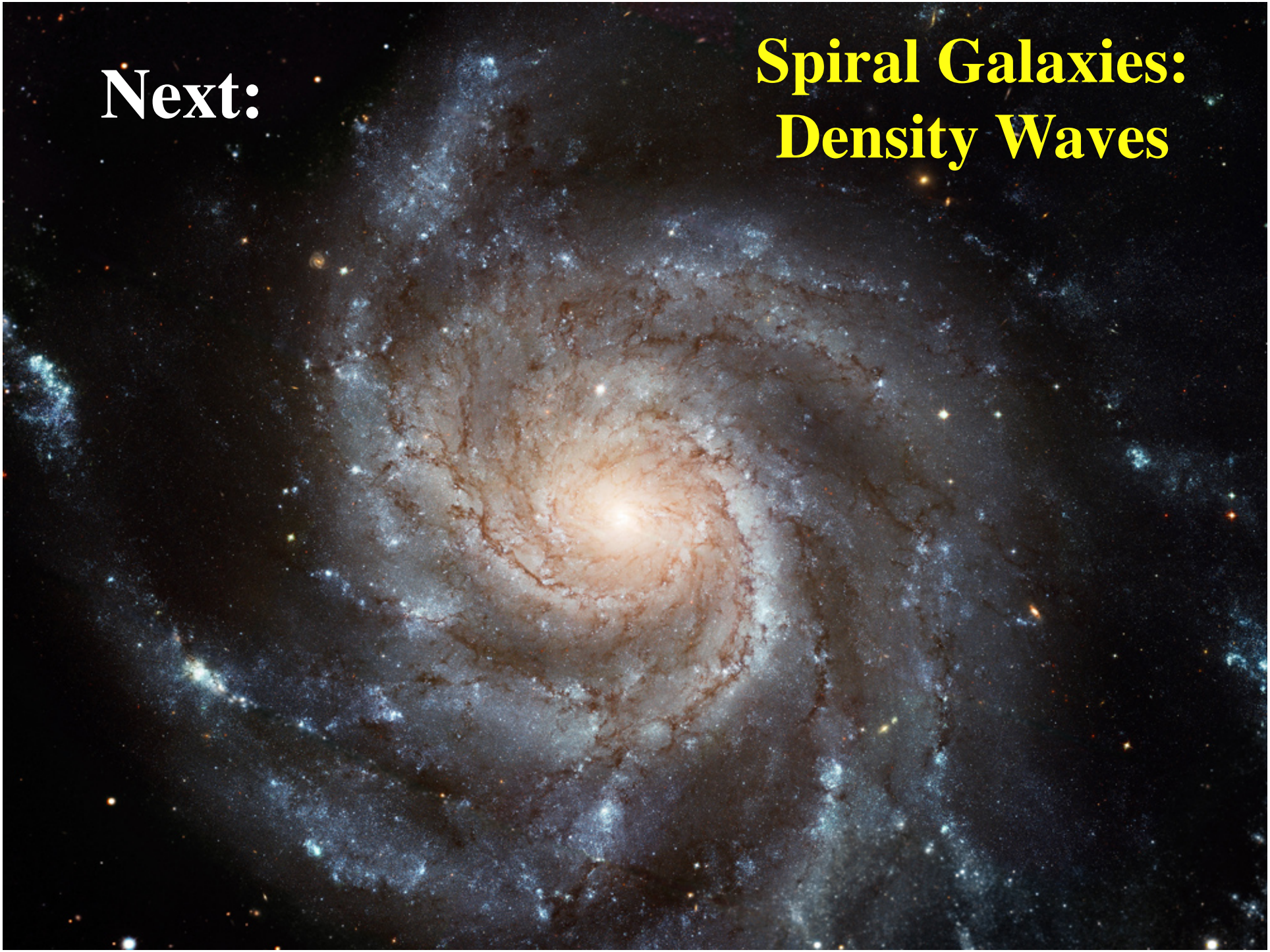
1. **Cold** (T ~ 30 - 100 K), dense ($n_{H\,I} > 10$ cm^{-3}) atomic (H I) and molecular (H_2, CO, …) gas and dust clouds
   - ☆ Only ~ 1 - 5 % of the total volume, but most of the mass
   - ☆ Confined to the thin disk
   - ☆ Low ionization fraction ($x_{H\,II} < 10^{-3}$)
   - ☆ Stars are born in cold,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