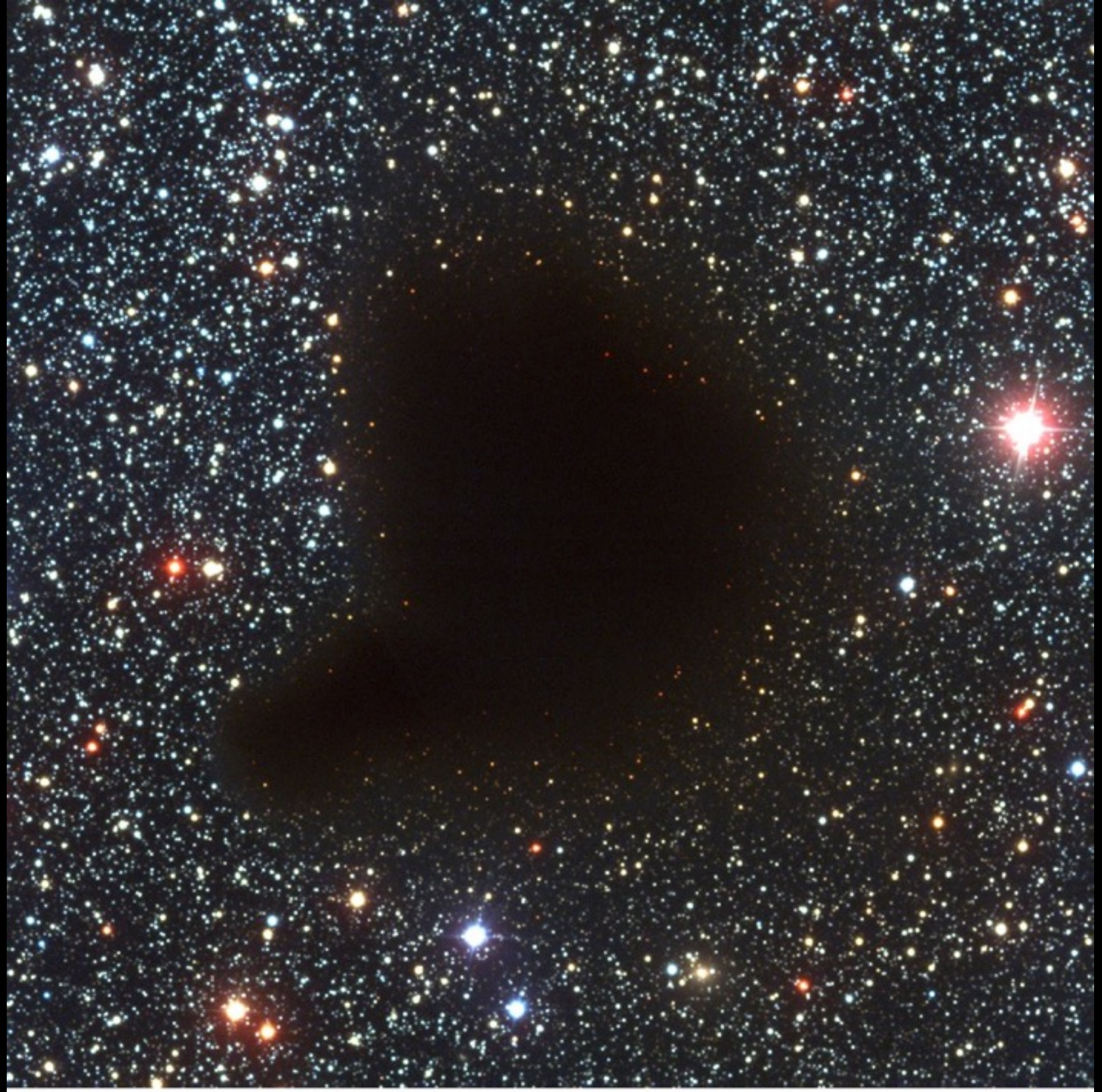
The Interstellar Medium

What is between the stars?



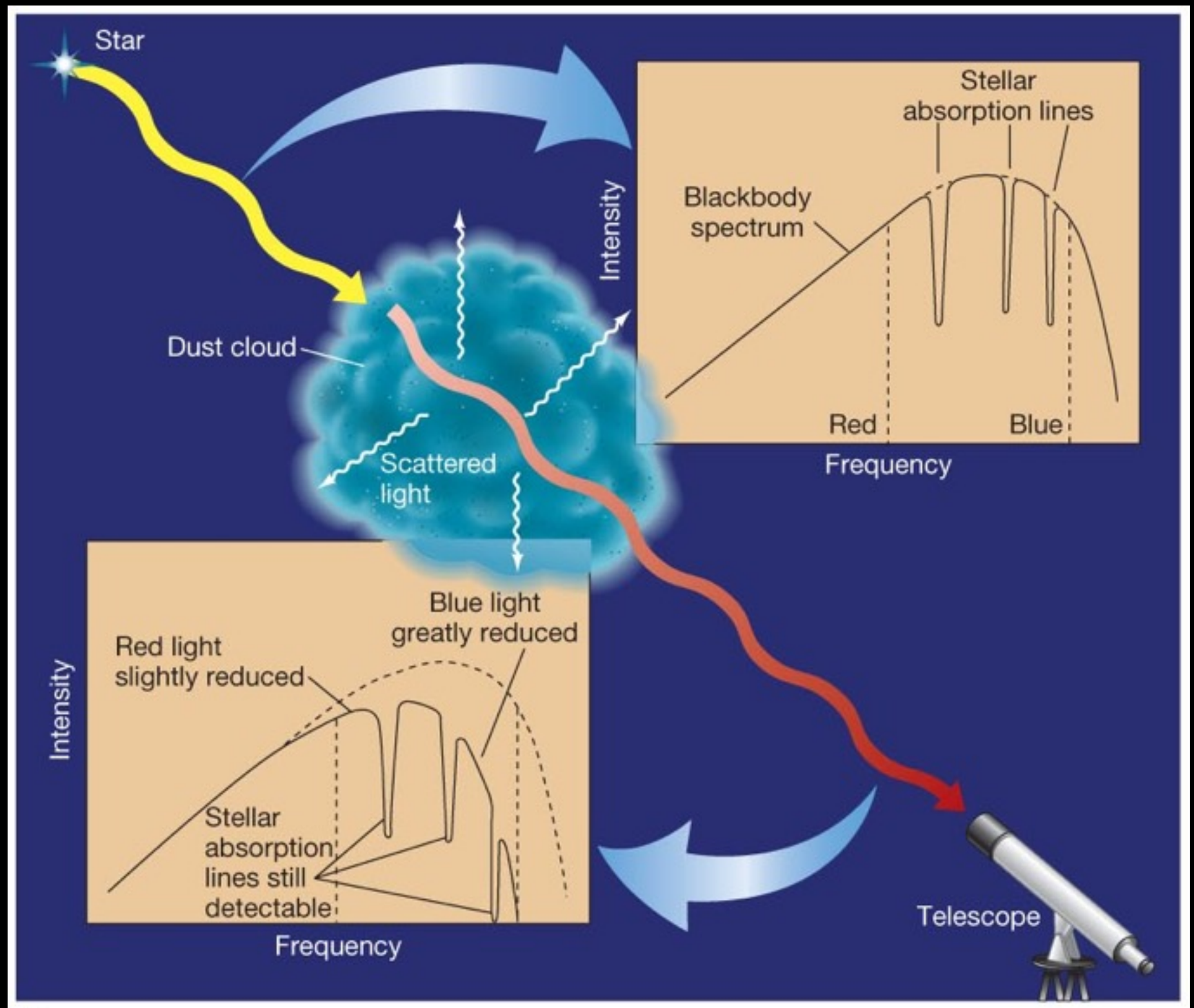
The "Black Cloud" B68
(VLT ANTU + FORS1)

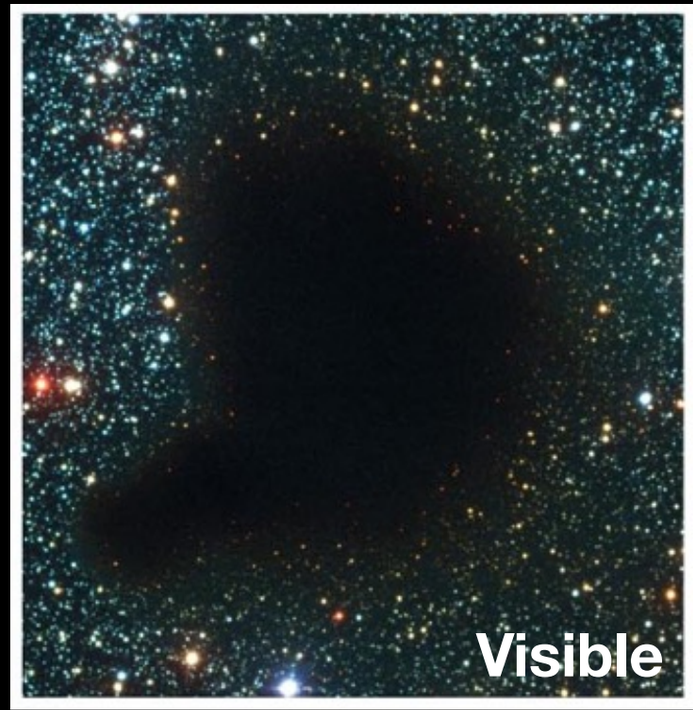
ESO PR Photo 20a/99 (30 April 1999)

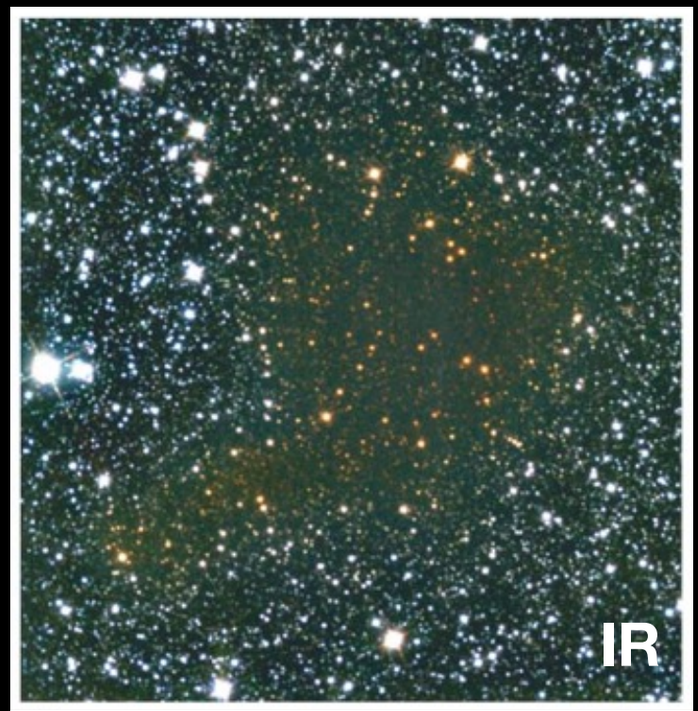
Stars and dust in Corona Australis

Cool clouds emit little visible light, block light from stars

Cool clouds contain dust: scatters light of wavelengths shorter than the size of a typical dust grain, reddening the light that goes through it







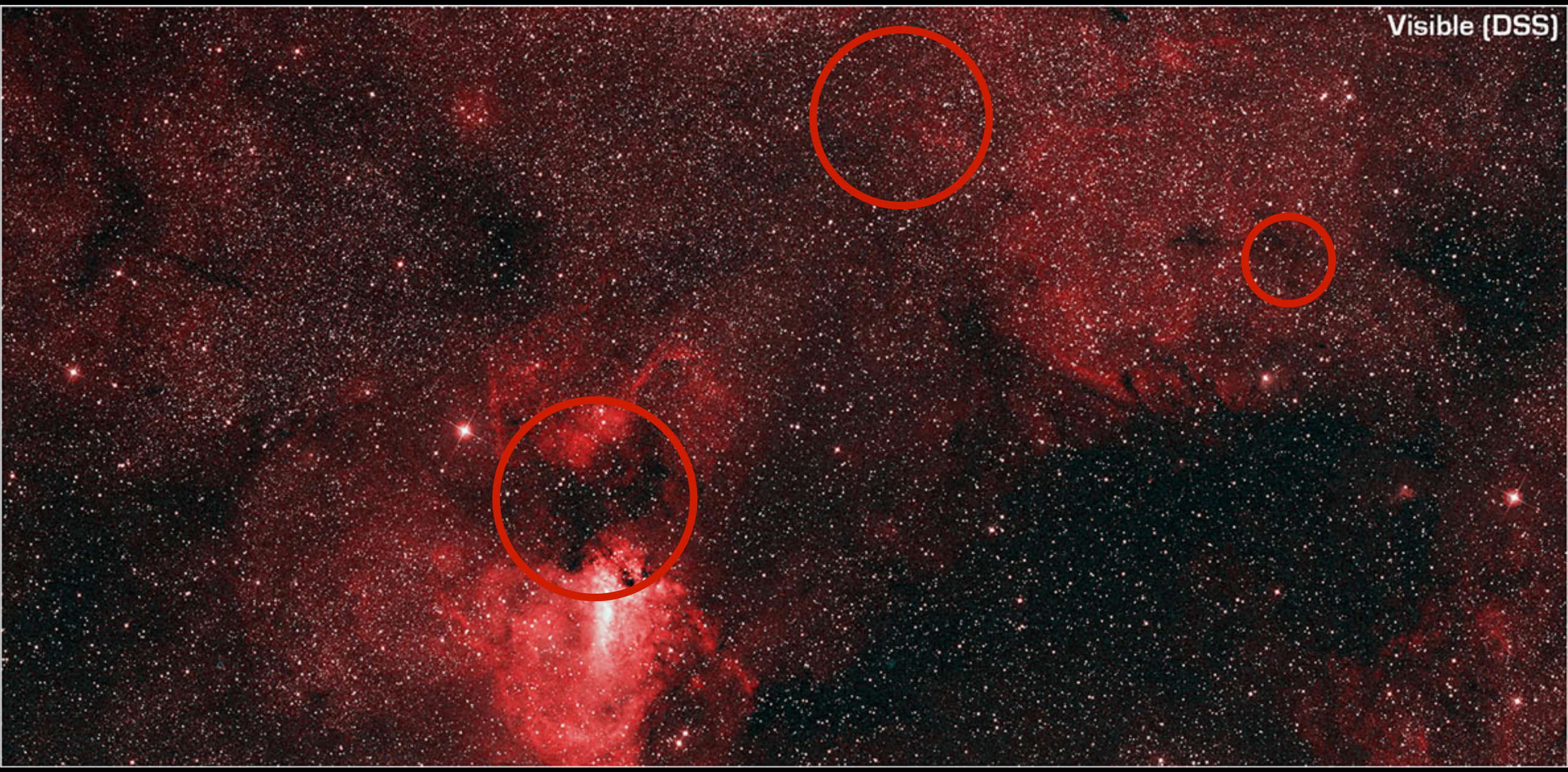
Cold clouds are **dusty**

Dust grains are a few hundred nm in size, about the wavelength of visible light

Light is scattered by things about the same size as its wavelength. Blue light is shorter in wavelength than red light: blue light is scattered more by dust than red light

Dusty regions look redder

Visible wavelength image of star formation in the M17 nebula

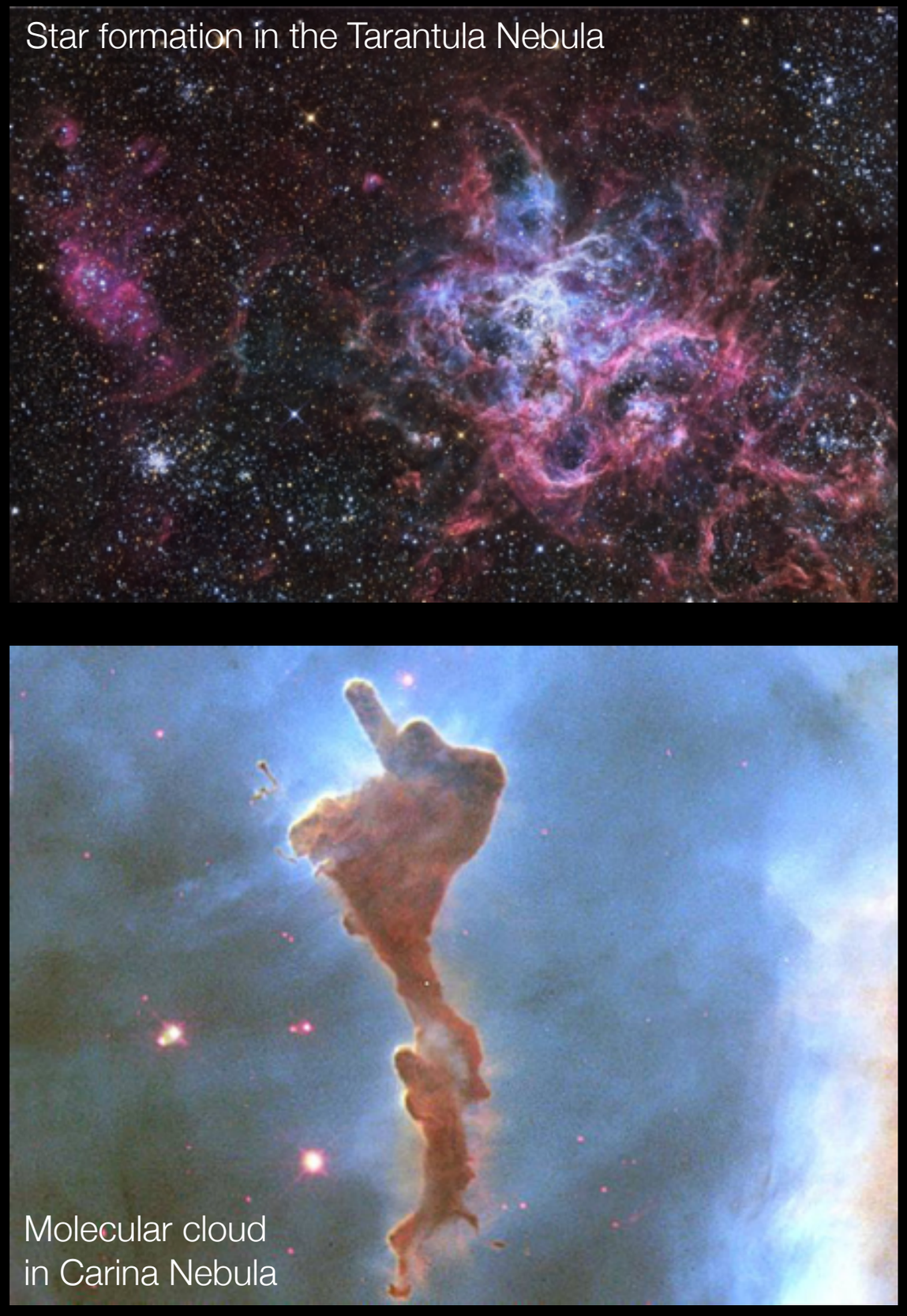


Infrared wavelength image of star formation in the M17 nebula

Dusty regions are bright in infrared but dark in visible light

Phases of the ISM


Cygnus Wall star forming region


Star formation in the Tarantula Nebula

Supernova remnant N49

Molecular cloud
in Carina Nebula

Gas cool enough that its hydrogen is in the form of atoms is called **HI**

HI (“H one”) is astronomer-speak for neutral hydrogen

Neutral hydrogen gas cannot be seen in visible light. This is a radio image of HI gas in a small nearby galaxy called the Large Magellanic Cloud.

Radio emission from gas

Clouds of cool gas give off radiation at radio wavelengths. Two methods:

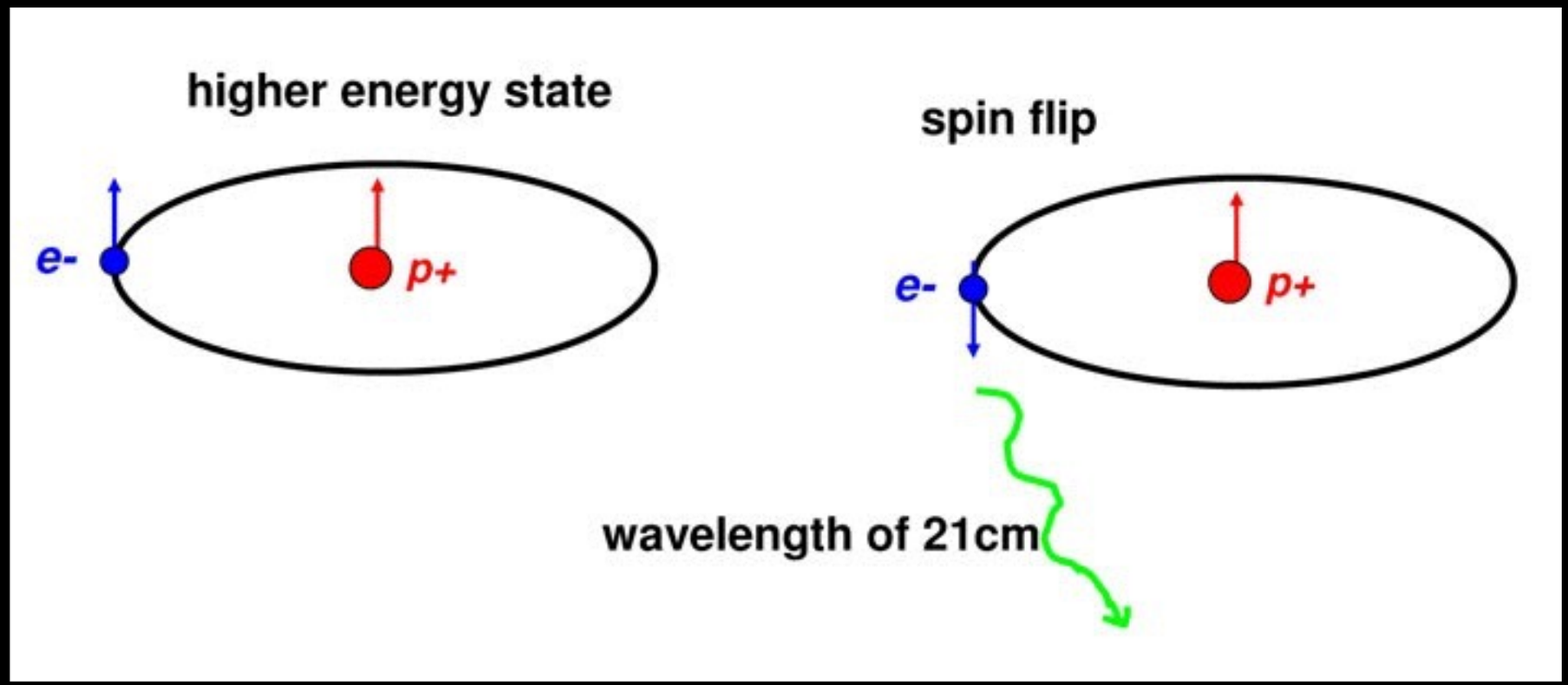
Molecular radio lines: works best for the densest clouds

21 cm radiation from neutral, atomic hydrogen

Radio emission allows us to map gas without looking at emission from stars

Spiral galaxy M81 seen at radio and IR wavelengths

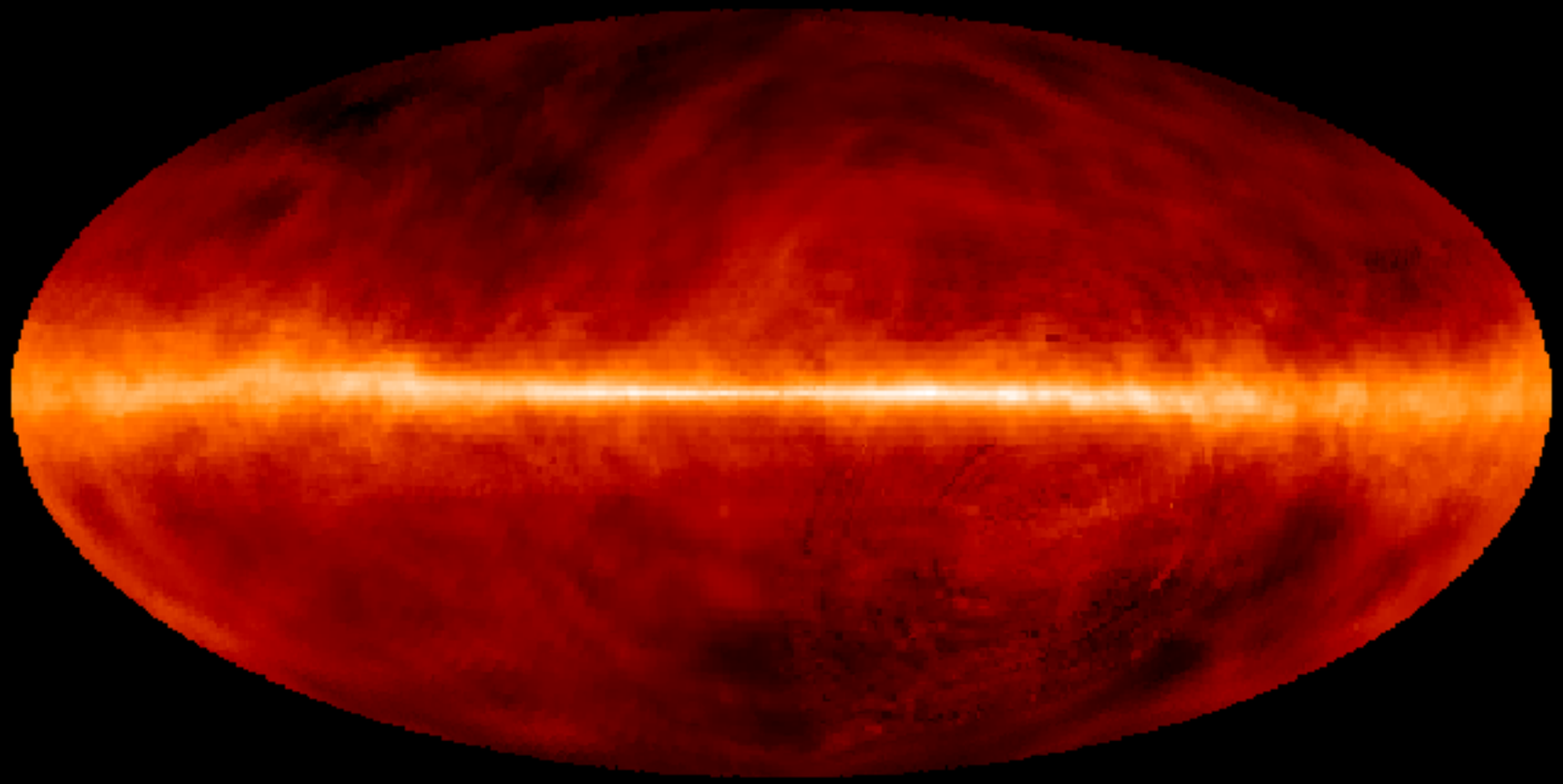
21 cm radio emission



Electron and proton in an atom of neutral hydrogen have **spin**

Spins can be aligned, or they can point in opposite directions

Sometimes the spin of the electron flips: when this happens a photon is emitted with wavelength 21 cm. This can be observed with radio telescopes, and is used to map neutral hydrogen gas.



Neutral hydrogen emission from the disk of the Milky Way

Spiral Galaxies in THINGS — The HI Nearby Galaxy Survey

THINGS

The HI Nearby Galaxy Survey

color coding:
THINGS Atomic Hydrogen
(Very Large Array)
Old stars
(Spitzer Space Telescope)
Star Formation
(GALEX & Spitzer)

scale:
15,000 light years

Image credits:
VLA THINGS: Walter et al. 08
Spitzer SINGS: Kennicutt et al. 03
GALEX NGS: Gil de Paz et al. 07

Molecular gas

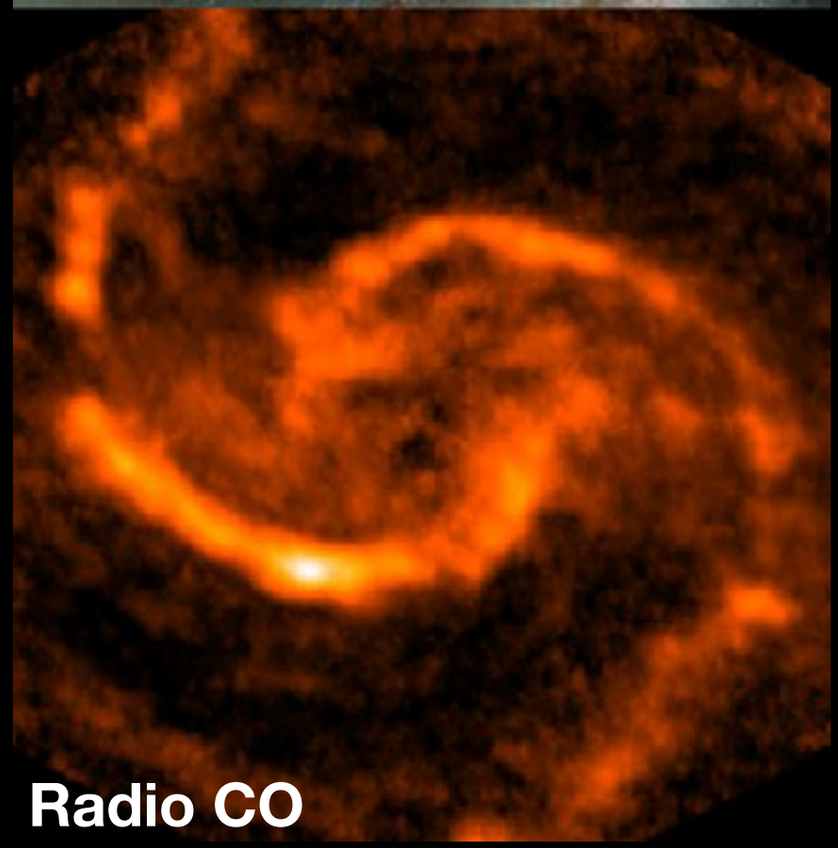
Stars form in regions where the gas is coldest and densest

Under these conditions, hydrogen forms **molecules**

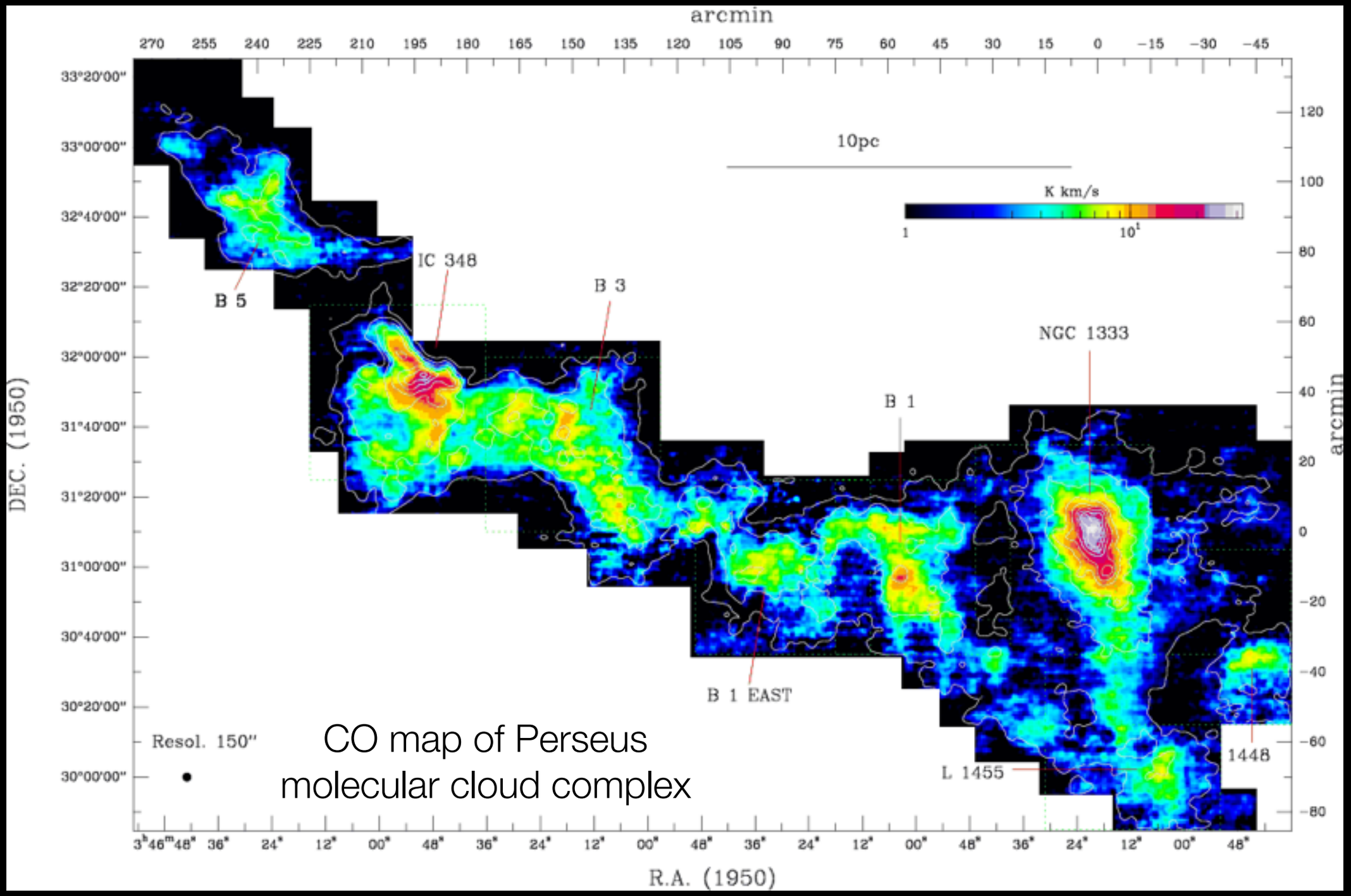
Molecular hydrogen gas (two hydrogen atoms bonded together to form a molecule) is hard to see

Usually accompanied by more complex molecules like carbon monoxide (CO)

These more complex molecules have emission lines we can see with radio telescopes



Sun et al 2006



Mapping gas in CO (molecules) and HI (atomic hydrogen) shows that molecular clouds contain an enormous amount of gas, > 1 million times the mass of the Sun. They are also in enormous collections known as molecular cloud complexes

The Eagle nebula

Pillars are molecular clouds, stellar nurseries that partly hide their newborn protostars

Carina Nebula Details

HST•ACS/WFC

When massive stars form, they can heat the hydrogen gas enough for it to be ionized

These regions of hot gas are called **HII regions**

HII (“H two”) is astronomer-speak for ionized hydrogen

Hot clouds of ionized gas are bright and can be seen in visible light

The Rosette Nebula: Newly formed O and B stars heat the center of cloud, pressure of their starlight blows gas away from the center

Spitzer Space Telescope (IR): Star formation in the Orion nebula

Radiation and wind from massive stars blows away gas and dust