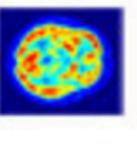


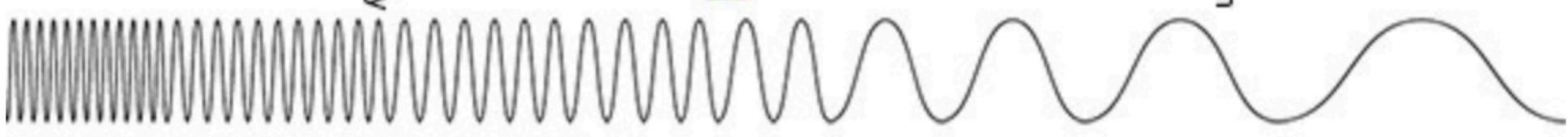
Mapping the Galaxy, Missing Matter

The Principal Evidence for Dark Matter

Physics 090

2020-05-13

Gamma-ray	X-ray	Ultraviolet	Visible	Infrared	Microwave	Radio
						
Terrestrial gamma-ray flashes	PET scan	Airport security scanner	UV light from the Sun	Night vision goggles	Microwave oven	Aircraft communication
AM radio	Amateur radio			TV Remote Control		



Electromagnetic Spectrum

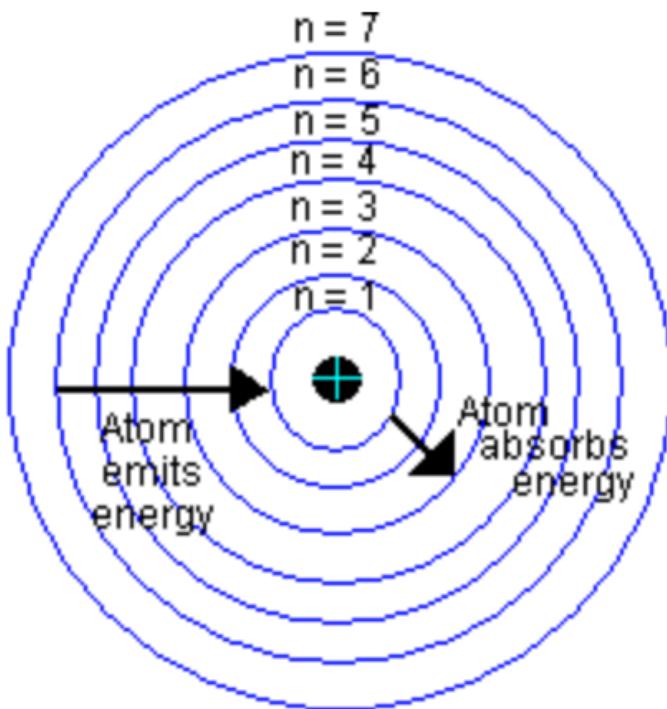
Where is 3K, 0.001mm radiation peaked?

Where is 3000K, 1mm radiation peaked?

What is the wavelength of red? 700nm or 0.0007mm or 0.7μm

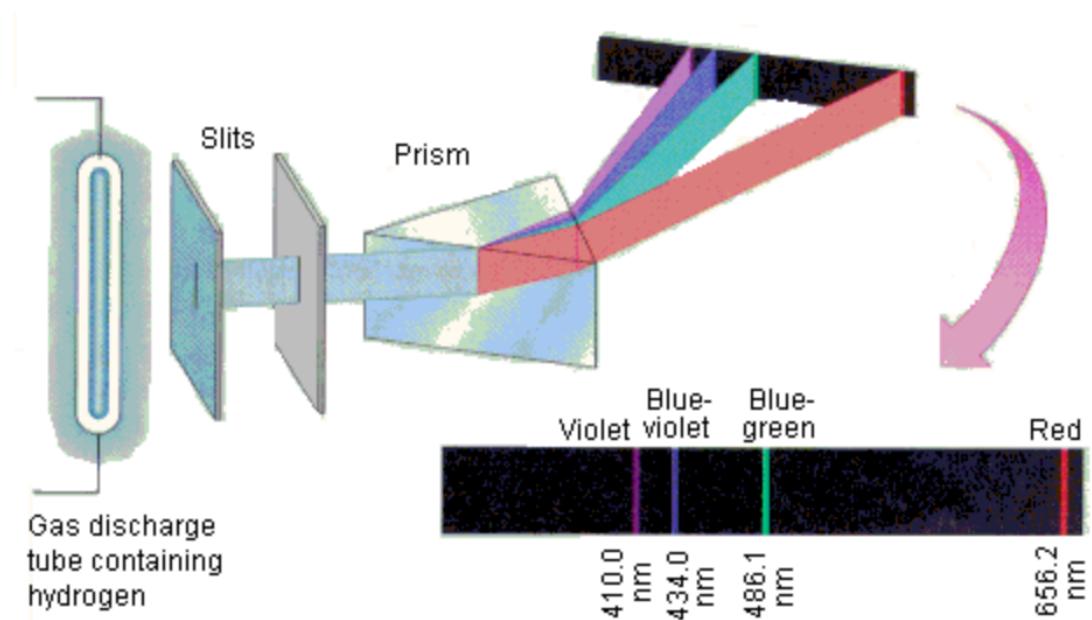
What is 21cm radiation?

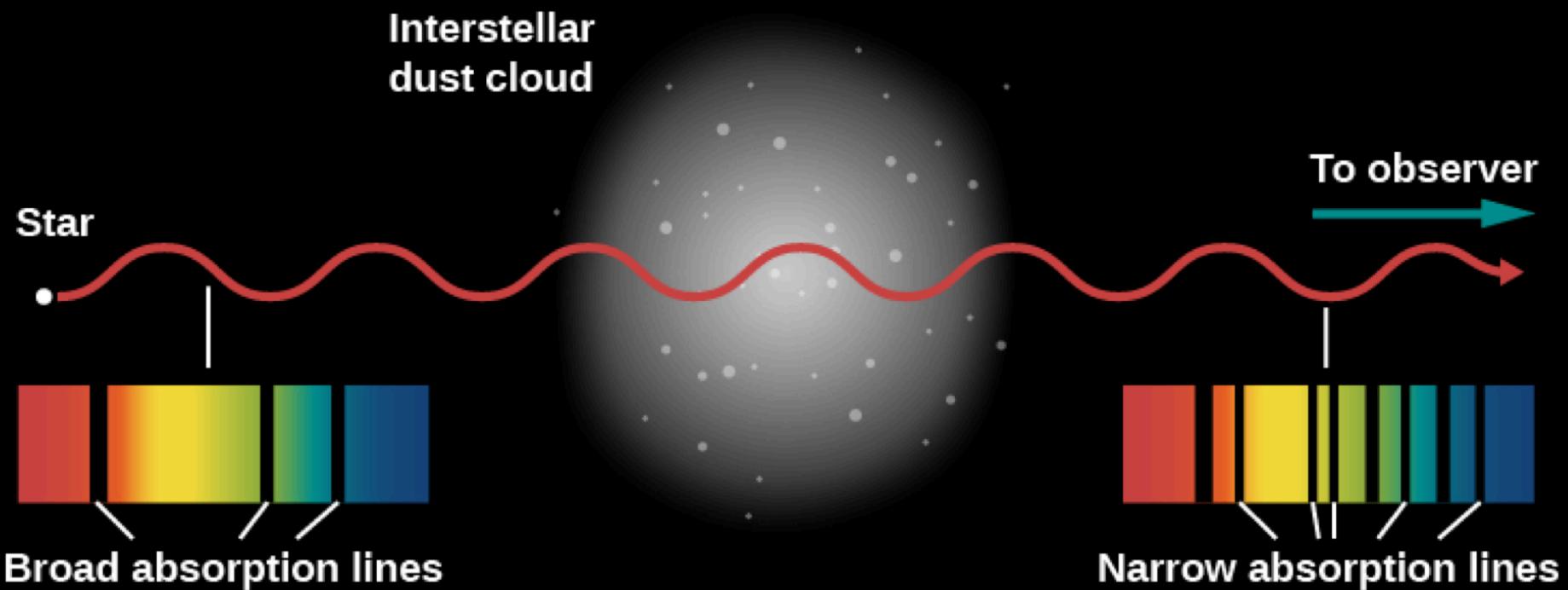




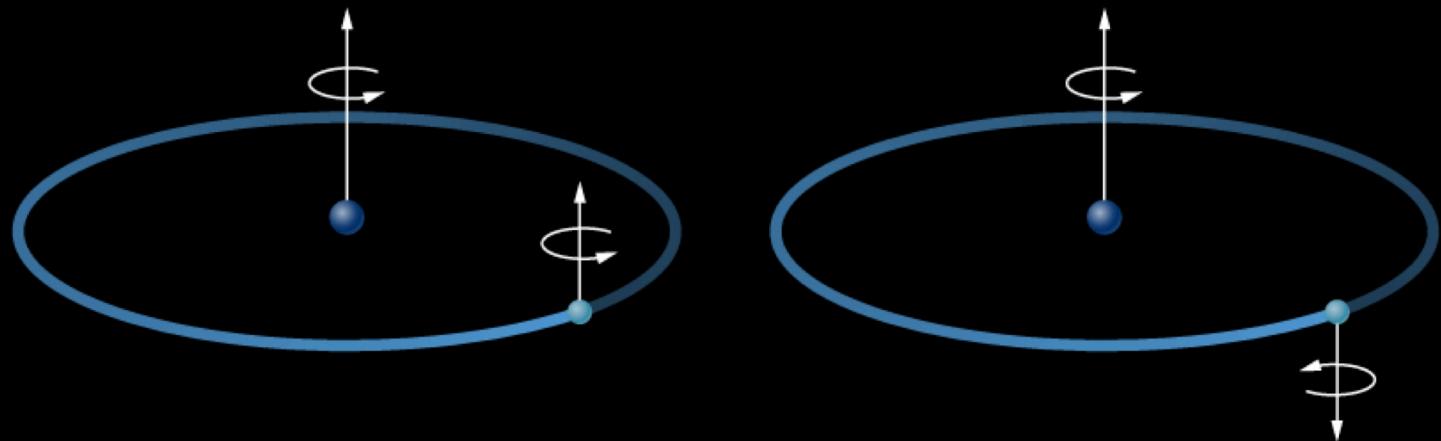
Explanation of Hydrogen Emission and Absorption Lines

Result



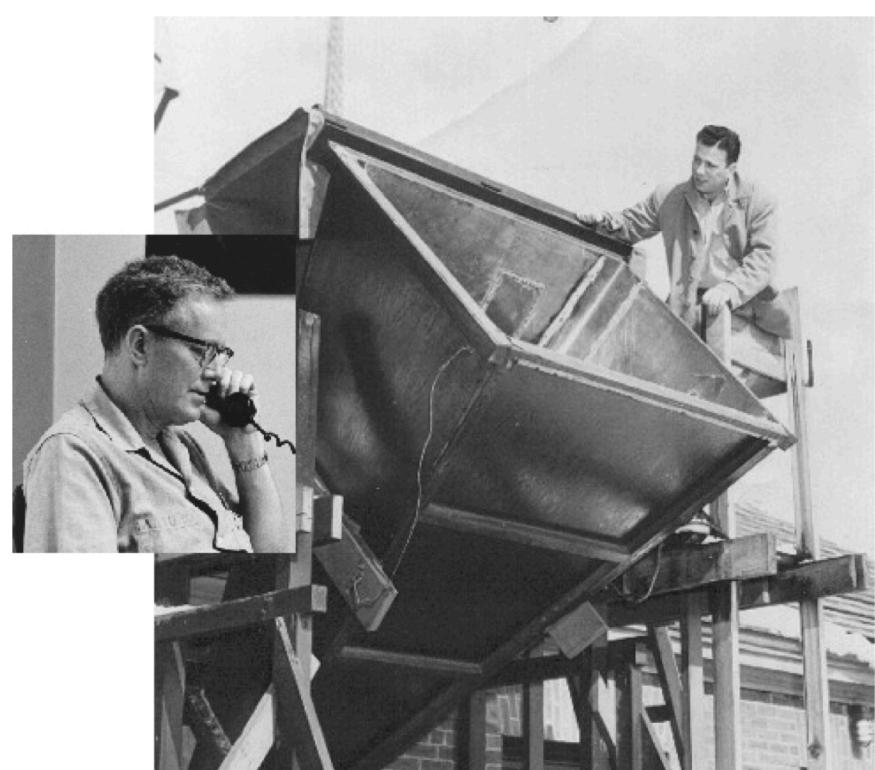


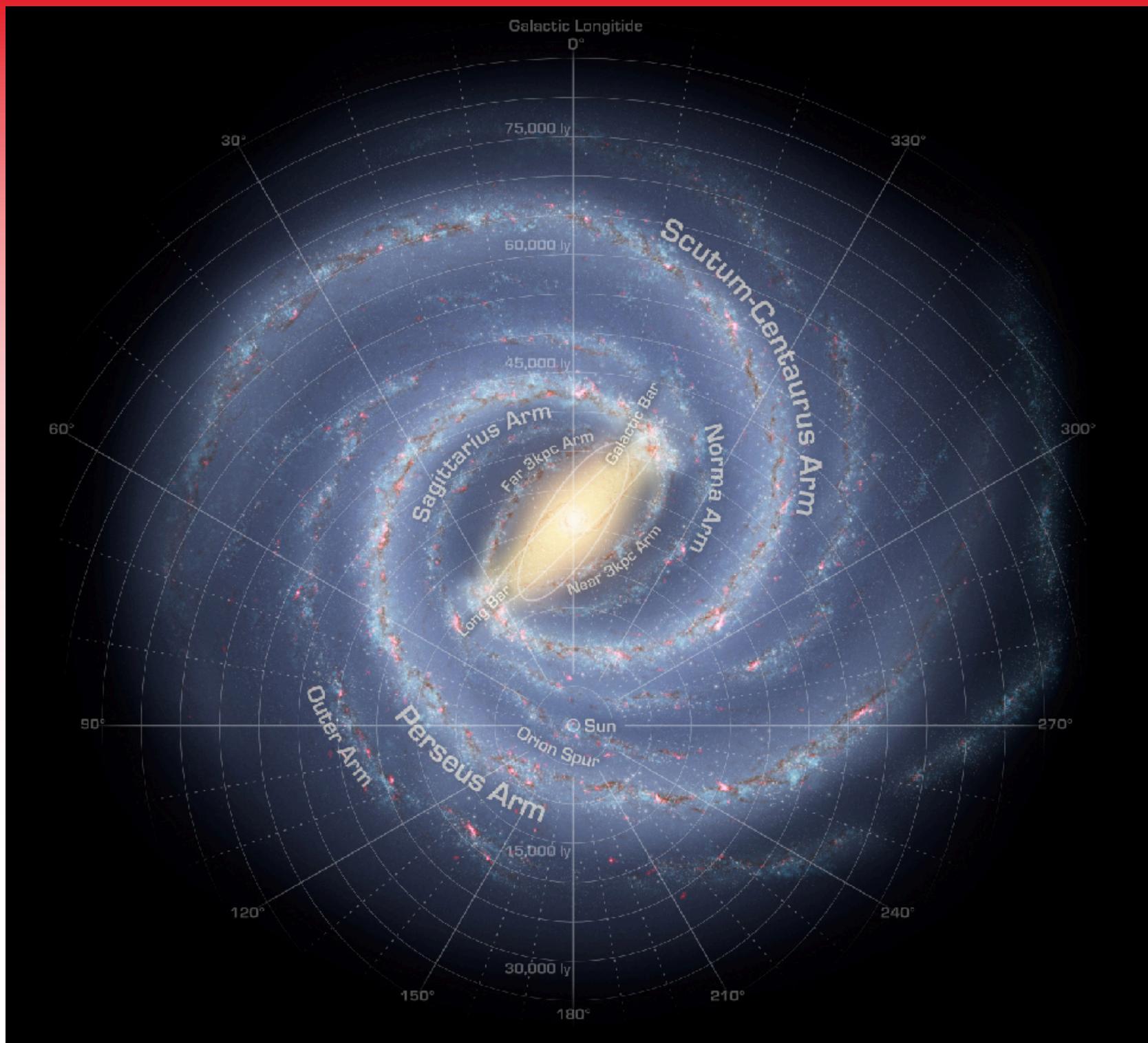
Absorbtion Lines vs Emission Lines

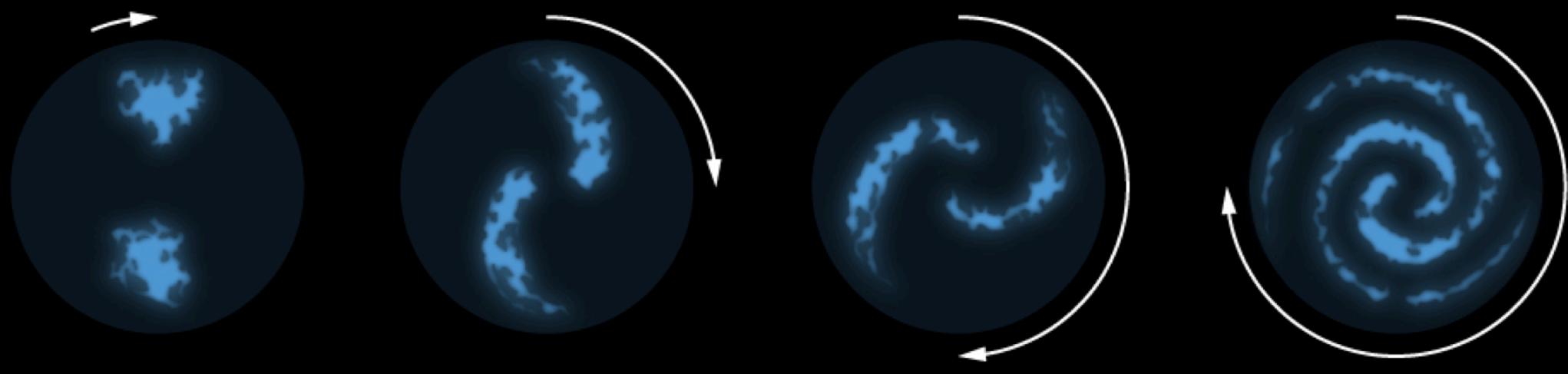


Explanation of the 21cm Line

Observation of
the 21cm Line,
Ewen and Purcell







Simple, but Wrong, Explanation of
Formation of Spiral Arms

Review Newton's Version of Kepler's Laws

M = mass of center of Galaxy

m = mass of star orbiting center of Galaxy

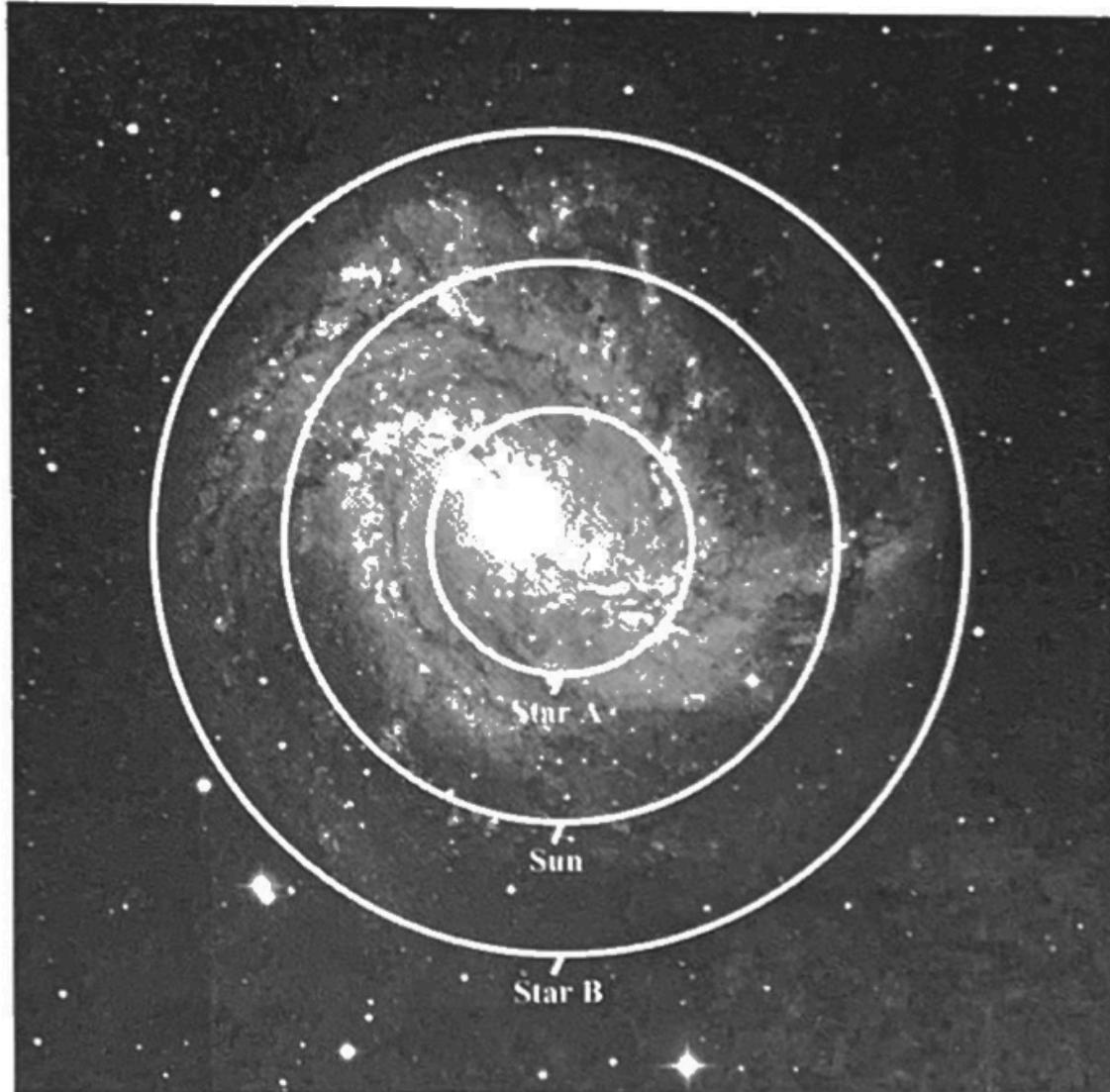
r = distance from center of Galaxy

v = orbital velocity

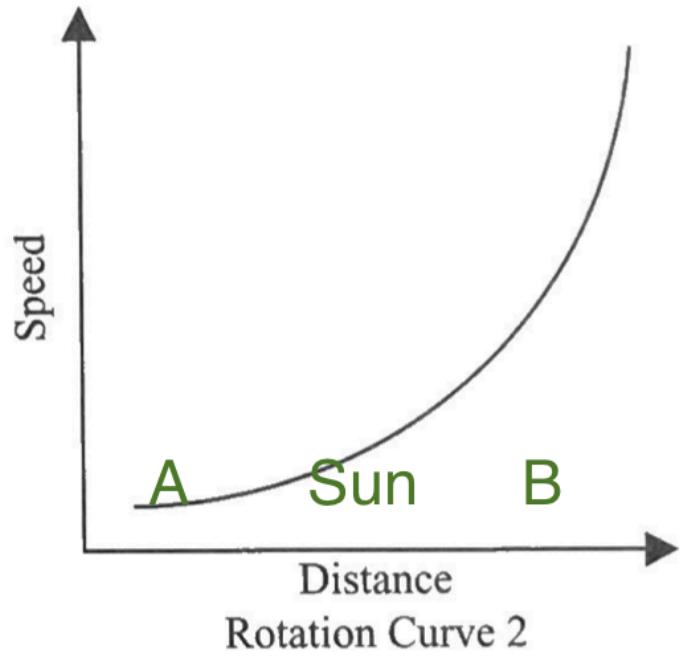
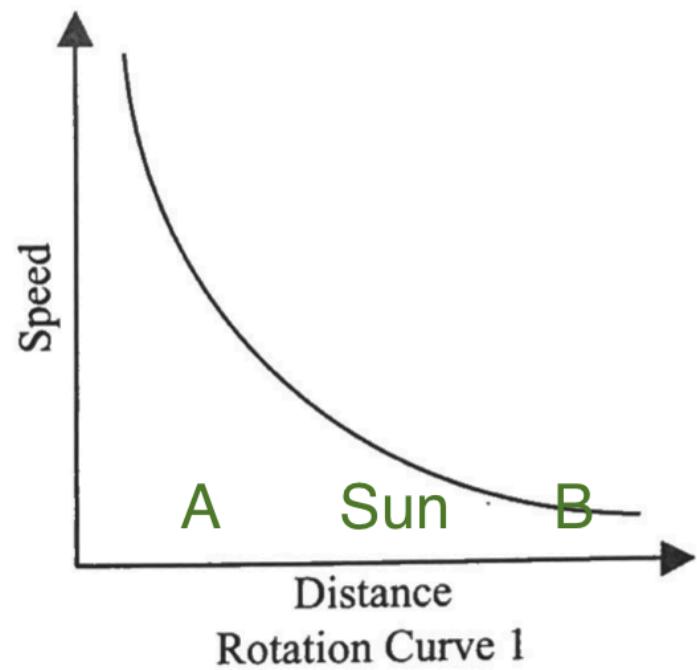
$$G M m / r^{**2} = m v^{**2} / r$$

$$G M / r = v^{**2}$$

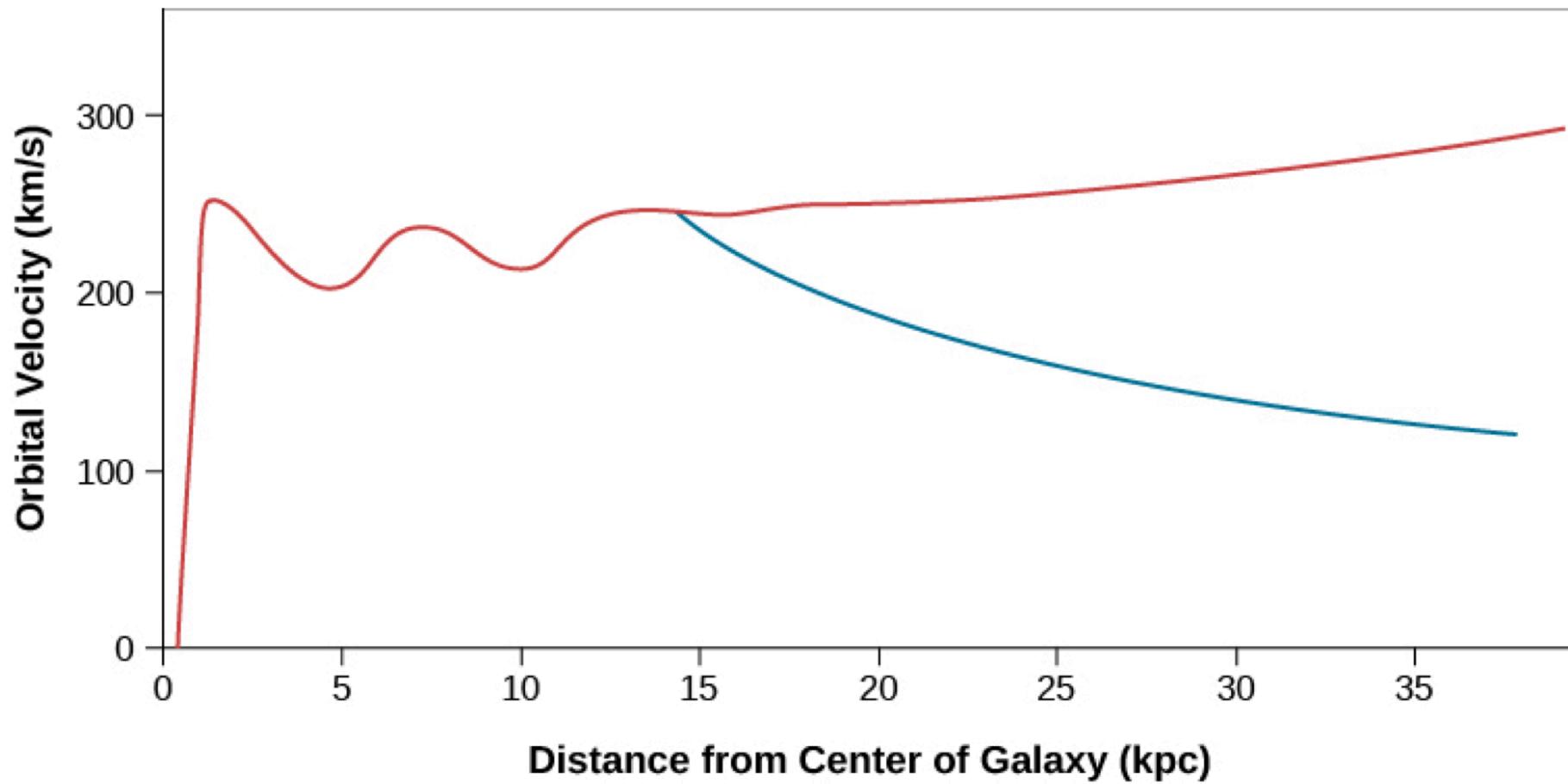
$$v = \text{SQRT}(G M / r) = \text{const} * \text{SQRT}(1/r)$$



Stars at Three Distances, Orbital Velocity



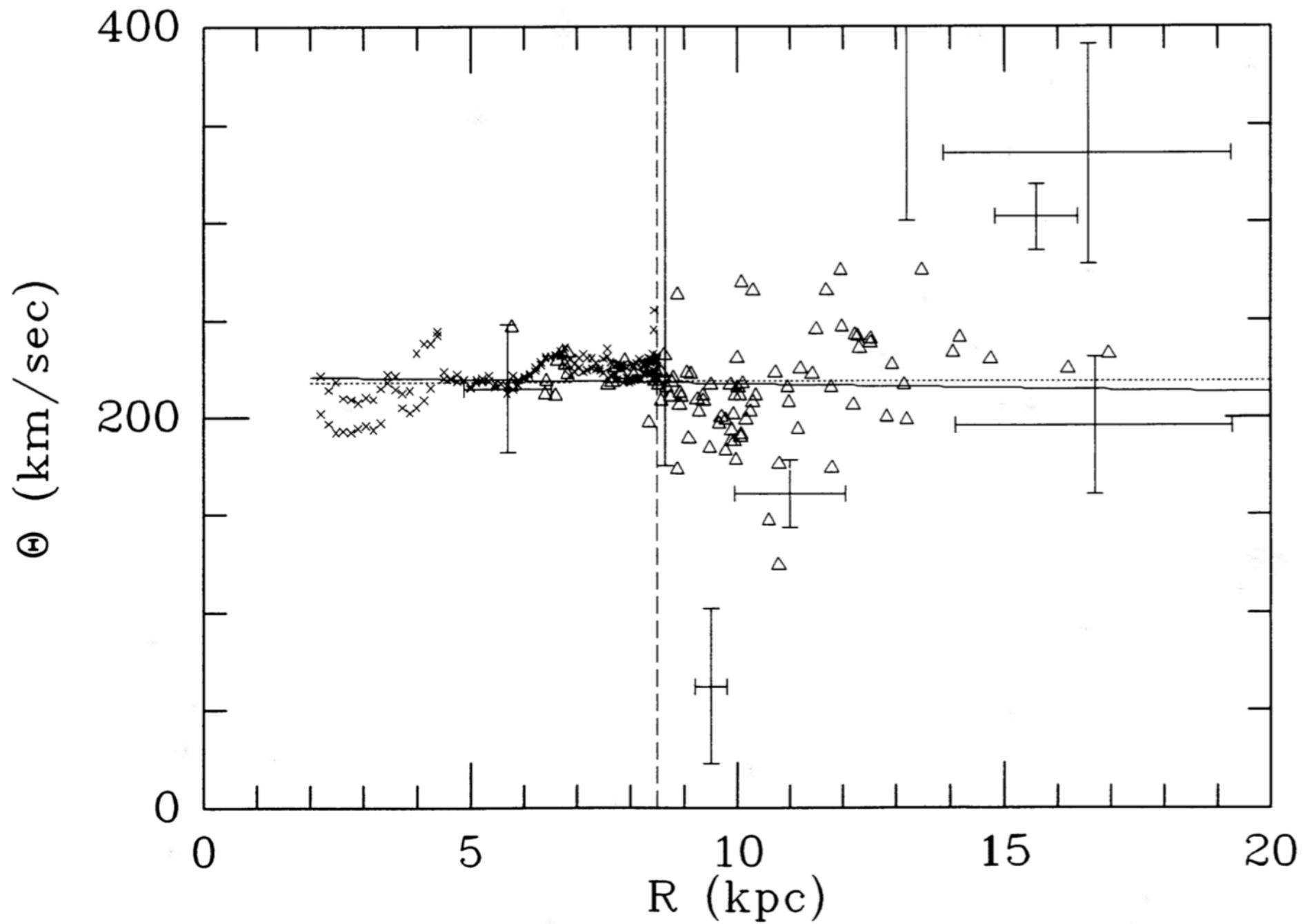
Actual Rotation Curve For Milky Way

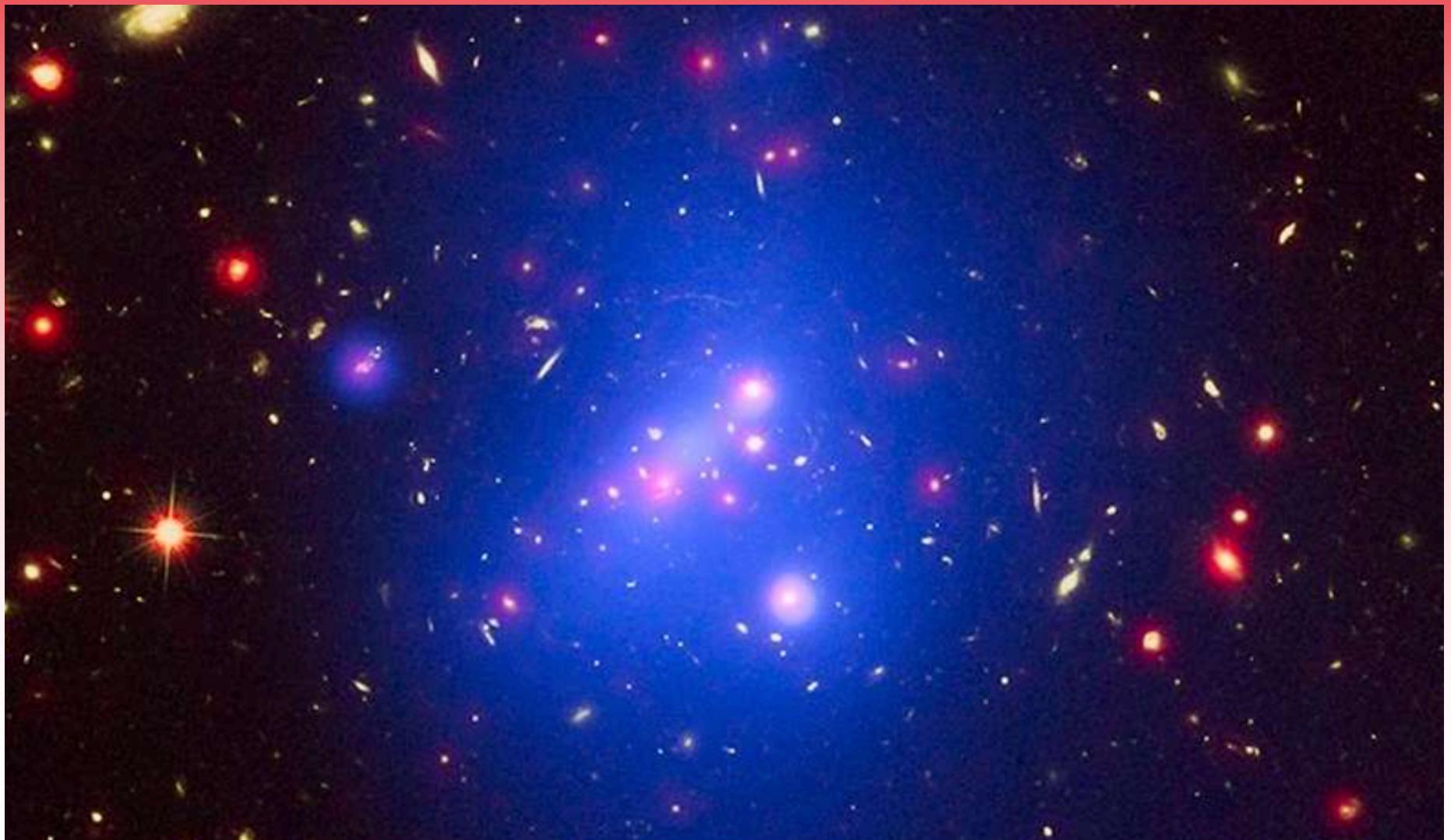


Red, Hydrogen — Blue, Carbon Monoxide

95% of Milky Way is Dark

Fich, et al, 1989, Milky Way Rotation Curve





Friday, Dark Matter and Dark Energy