

**(Astro)Physics 343 Lecture # 8:
Green Bank trip; gas dynamics**

This week's schedule

Monday – Wednesday: observations for lab # 4

Monday + Thursday: regular office hours

(before) Friday: email your preferences re Green Bank trip

for Monday: start thinking about topics for last lecture!

Trip to Green Bank: 4/22-24

Friday, 4/22:

drive NJ → GB

Saturday, 4/23:

**tours, observing
session(s)**

Sunday, 4/24:

drive GB → NJ



estimated driving time = 7-8 hrs

Observing at Green Bank: 40 ft telescope

Compared to SRT:

**$D = 12\text{m}$, so area
larger by factor 28.**

**Located in radio quiet
zone, so less RFI.**

Transit telescope: doesn't track.

Data acquisition less automated.



Observing at Green Bank: instructor

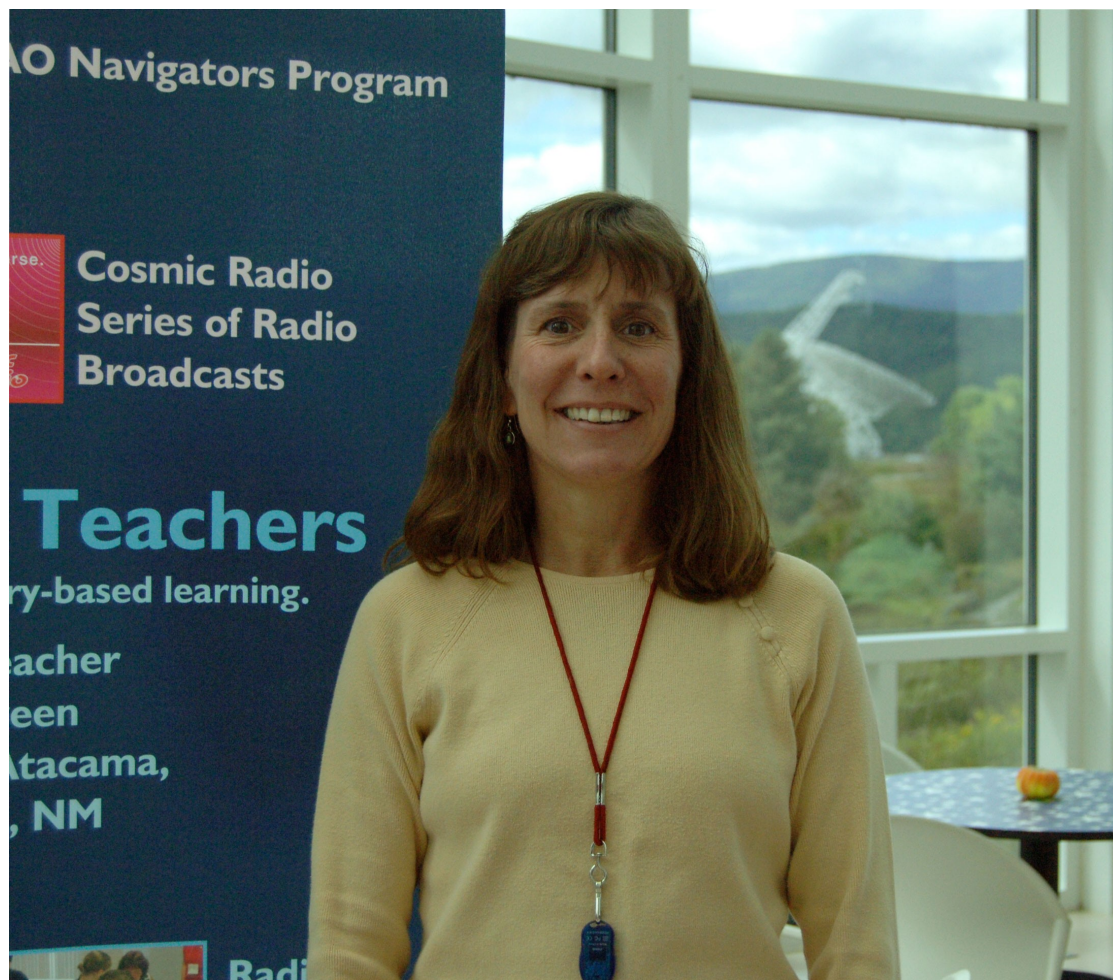
Sue Ann Heatherly

**Education Officer,
National Radio**

Astronomy Observatory

**PI of a \$892,000 grant
from the National
Science Foundation**

**to involve teachers and
students in the discovery of new pulsars.**

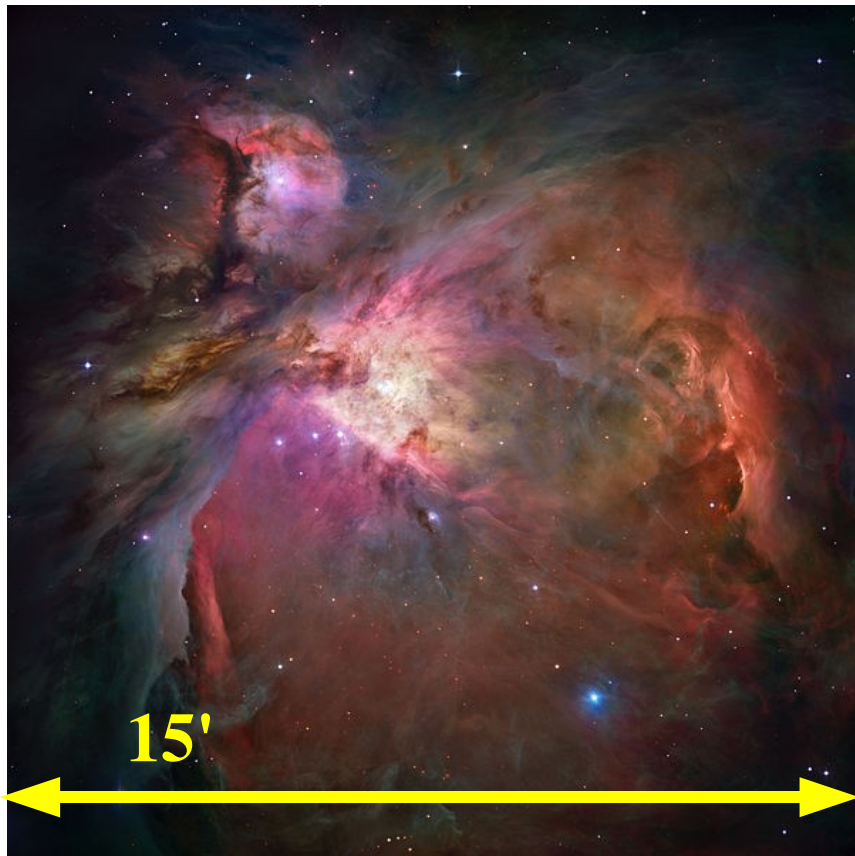


Observing at Green Bank: target(s)

~4pm EDT: Orion Nebula (500 pc)

optional:

~5am EDT: Galactic Center (8 kpc)



Hubble Space Telescope (optical)

Spitzer Space Telescope (infrared)

Staying at Green Bank: instructors



two “chaperone” rooms

Staying at Green Bank: students



**bunks in the two bunkrooms have hard plastic mattresses:
bring pillows + sheets or sleeping bags...**

Staying at Green Bank: students



...and bring towels.

Staying at Green Bank: common area



For doing homework, lab analysis, etc. (internet access tricky: no wireless on the Green Bank site, and no cell phone service...).

What I need from you via email by Friday

- (1) Do you plan to come on the trip?**
- (2) Do you need me to write a letter to a boss or teacher so that you will be able to participate?**
- (3) How early can you leave campus on Friday, and how late can you return on Sunday?**
- (4) Can you drive your own car (if necessary)?**
- (5) Do you have any special dietary constraints?**

Gas dynamics: the Keplerian case

If an ensemble of gas clouds is distributed in a disk orbiting a single massive object with $M \gg m$, then for each cloud we can write

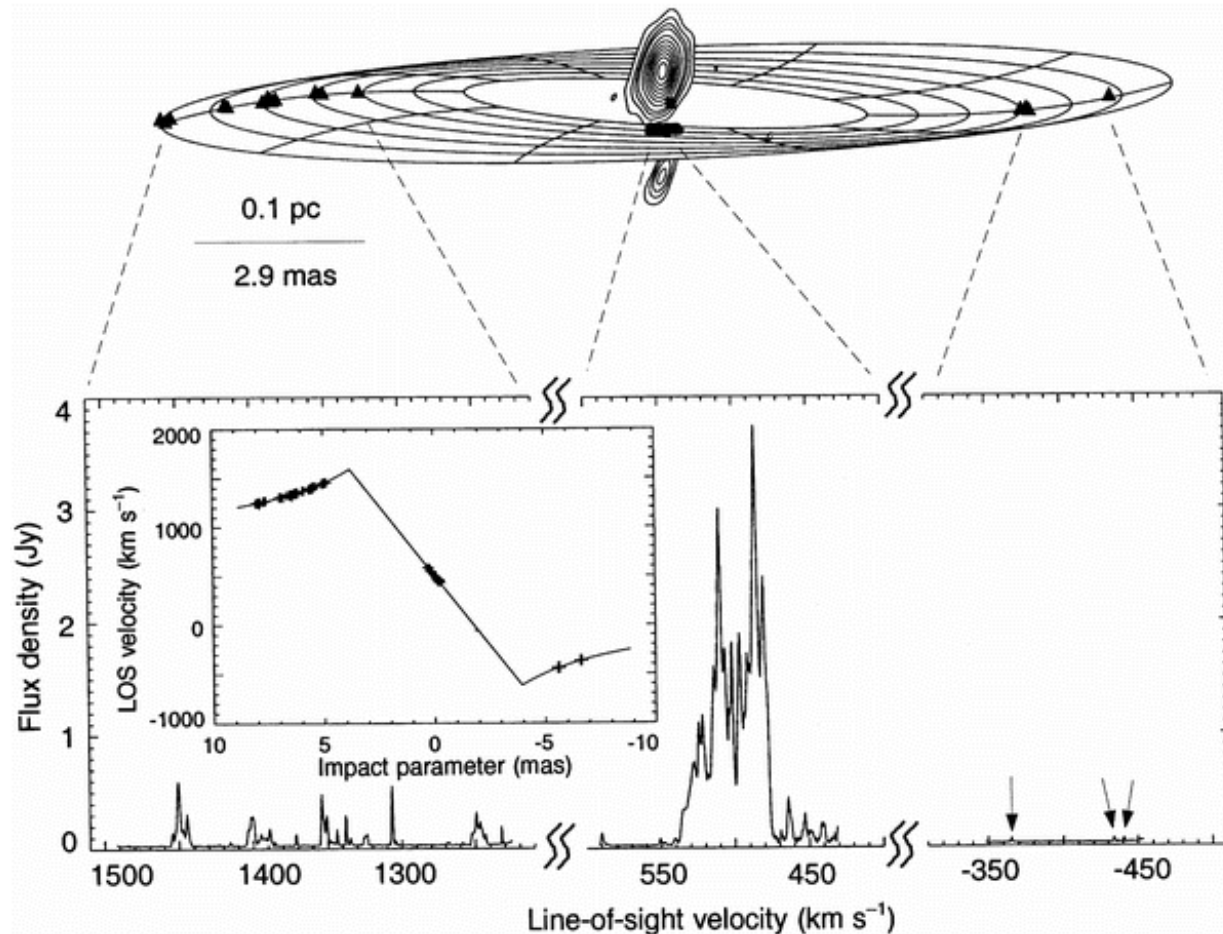
$$F = mv^2/R = GMm/R^2$$

$$v^2R = GM$$

which is equivalent to Kepler's third law for $v = 2\pi R/T$.

Gas dynamics: a Keplerian example

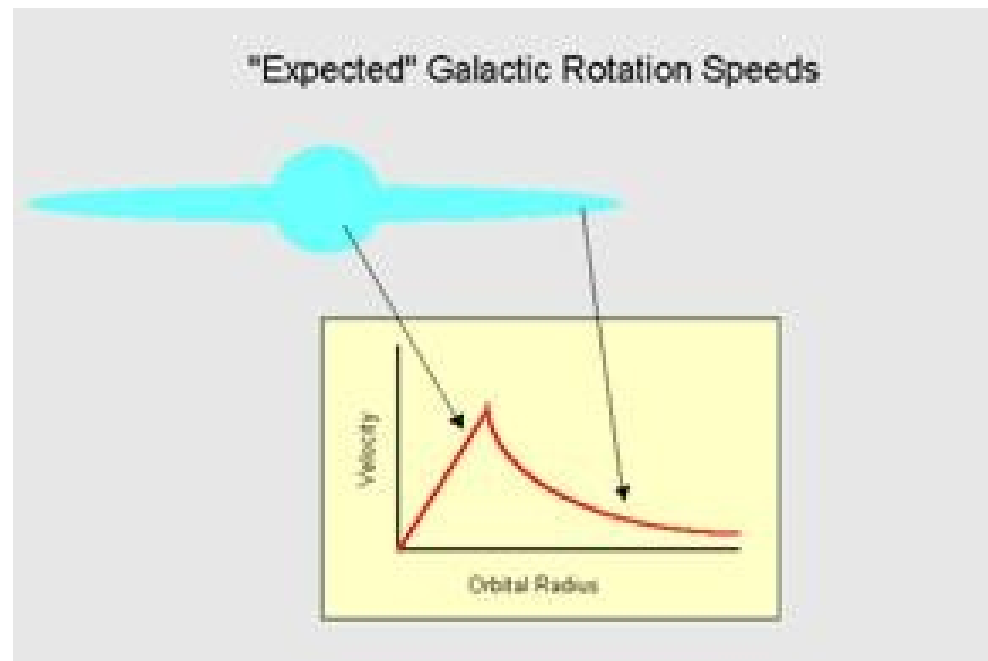
From Herrnstein et al. (1999): water masers tracing orbital motions around the central black hole in NGC4258.



Rotation curves in galaxies: expected

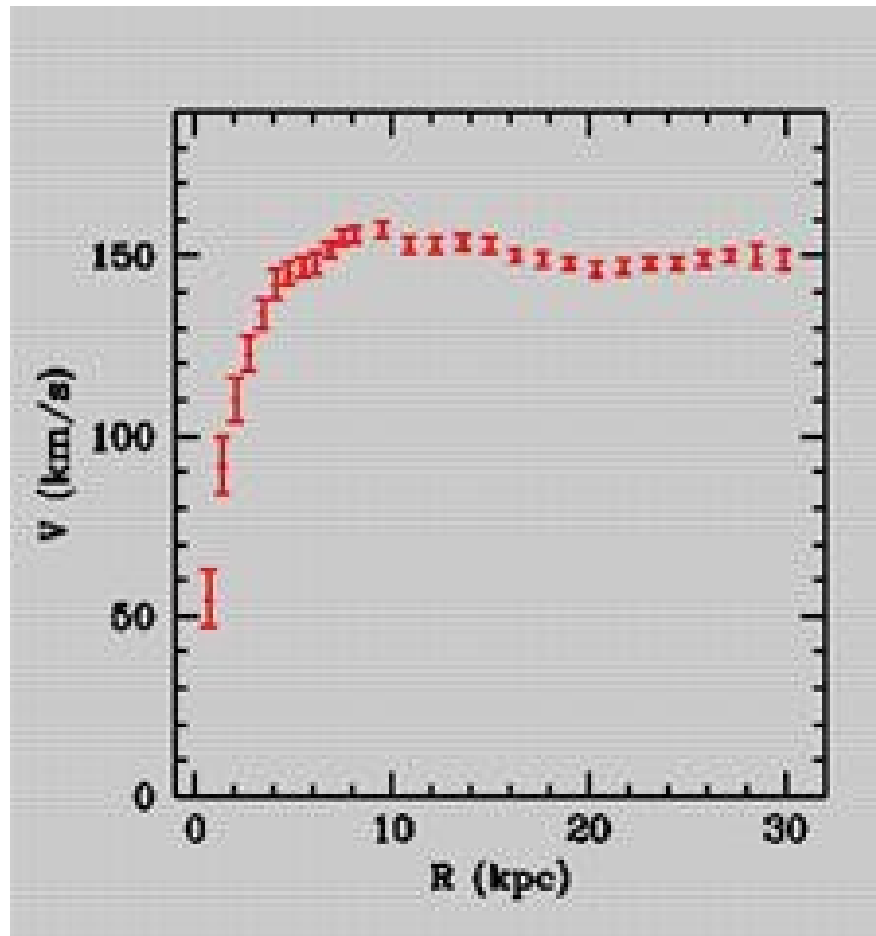
Rotation curves in galaxies are not Keplerian because we must replace M with the “interior mass” $M(<R)$ in the force equation... and $M(<R)$ is not constant as in the case of a central dominant mass.

What we expect, based on the central concentration of luminous matter (stars and gas):



Rotation curves in galaxies: observed

What we observe: **flat rotation curves**, implying the existence of additional non-luminous matter (i.e., **dark matter**).

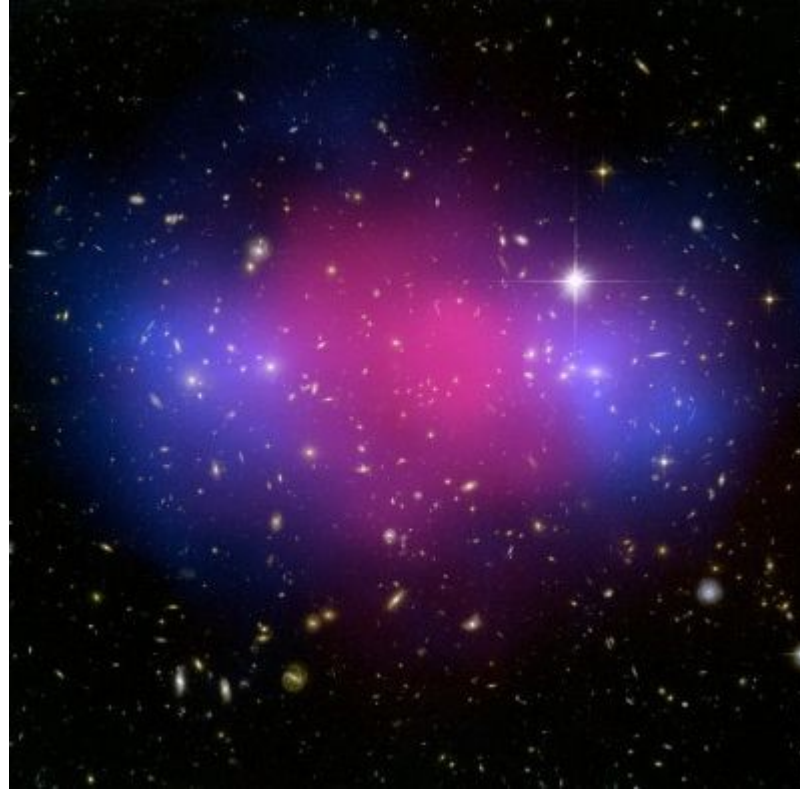


A heretical alternative?

A few bold souls have pointed out that once can just as easily relax the assumption of a universal law of gravitation as the assumption that all matter is luminous.

The idea that gravity might behave differently at low values of acceleration is known as **Modified Newtonian Dynamics (MOND). It works well in the context of spiral galaxy rotation curves, but not so well elsewhere.**

The “Bullet Cluster” vs. MOND



A collision between two clusters of galaxies: pink shows X-rays from hot gas, while blue shows mass based on weak lensing (apparently, mostly dark matter that is not “collisional”).

Inclination and rotation curves

If a galaxy is inclined relative to our line of sight, where

$i = 90$ means edge-on

$i = 0$ means face on

then the observed line of sight velocity is related to the intrinsic rotation velocity by $v_{\text{obs}} = v_{\text{rot}} \sin i$ if we make the assumption of azimuthal symmetry.

Quiz