Milky Way

- Orbits of stars in the Milky Way
- Rotation curves
- Finding the mass from the orbit
- Center of the Milky Way
- Stars orbiting the black hole
- X-ray flares from the black hole
How do we know that the Milky Way has a spiral structure?

A) By observing the gravitational influence of the arms on nearby galaxies
B) By plotting the distances and directions of objects known to be in spiral arms
C) By observing the changing conditions as the Sun enters and leaves a spiral arm
D) By viewing the Milky Way from a point well above its plane
Which of the following objects are not found primarily in the spiral arms of the Galaxy?

A) white dwarf stars  
B) HII regions  
C) supernovas  
D) O and B stars
What keeps the planets in orbit around the Sun?

• The force of gravity from the Sun

• To orbit, a planet at a particular distance from the Sun must have a particular orbital speed.
Orbits of stars in the Milky Way

• The orbit of a star is determined by the total mass lying inside the orbit
• By measuring the speed of the star’s orbit and its distance from the center, we can figure out the total mass lying inside the orbit of the star
Rotation curves

A  Wheel-like rotation

B  Planet-like rotation

Rotation curve for wheel-like rotation

Rotation curve for planet-like rotation
Rotation curve of the Milky Way
Rotation curve of Milky Way

Sun’s velocity **is** about 220 km/sec

Sun’s velocity **should** be only 160 km/sec

Difference is contributed by the dark matter halo.

Visible matter only
Dark Matter

• Dark – it doesn’t produce light (any kind)
• Does have mass, produces gravity
• Nature is unknown
• Might be normal matter in a form that doesn’t emit much light – very small and dim star, little black holes
• More likely it is elementary particles other than normal matter
What properties of the sun could be used to measure the total mass enclosed within the sun's orbit?

A) mass and orbital speed
B) mass and distance from the center
C) mass and age
D) orbital speed and distance from the center
If the orbital velocities of stars in the Milky Way were found to be half of what they are now measured to be

A) Our estimate of the mass of the Milky Way would decrease
B) Our estimate of the diameter of the Milky Way would decrease
C) Our estimate of the mass of the Milky Way would increase
D) Our estimate of the diameter of the Milky Way would increase
Radio image, central 3 ly

Center is the red ellipse at the center
Called Sgr A*
Infrared image, central 3 ly

Sgr A* does not appear.

There are about 1,000,000 stars in the area covered by this image.

Stars are only 1000 AU apart.
Stellar Orbits in the Galactic Center
Mass of Sgr A* can be measured using stellar orbits

- Fastest moving star moves at 2% of the speed of light, 5000 km/s
- Mass is about 3 million solar masses
- Emits radio and X-rays
- Almost certainly a black hole
X-ray image, central 3 ly

Sgr A* is the bright object in the center of the image.

Makes flares in X-rays.

Movie.
Review Questions

• What properties of a star’s orbit around the Galaxy enable one to measure the mass inside its orbit?
• What is the shape of the rotation curve of the Milky Way and why is it unexpected?
• What lies at the center of the Milky Way?