

The Milky Way: Structure and Motion



- Large-scale architecture of our galaxy and how it moves



- Structure and motion link rotation curves and stellar orbits



- For science educators, students, and communicators

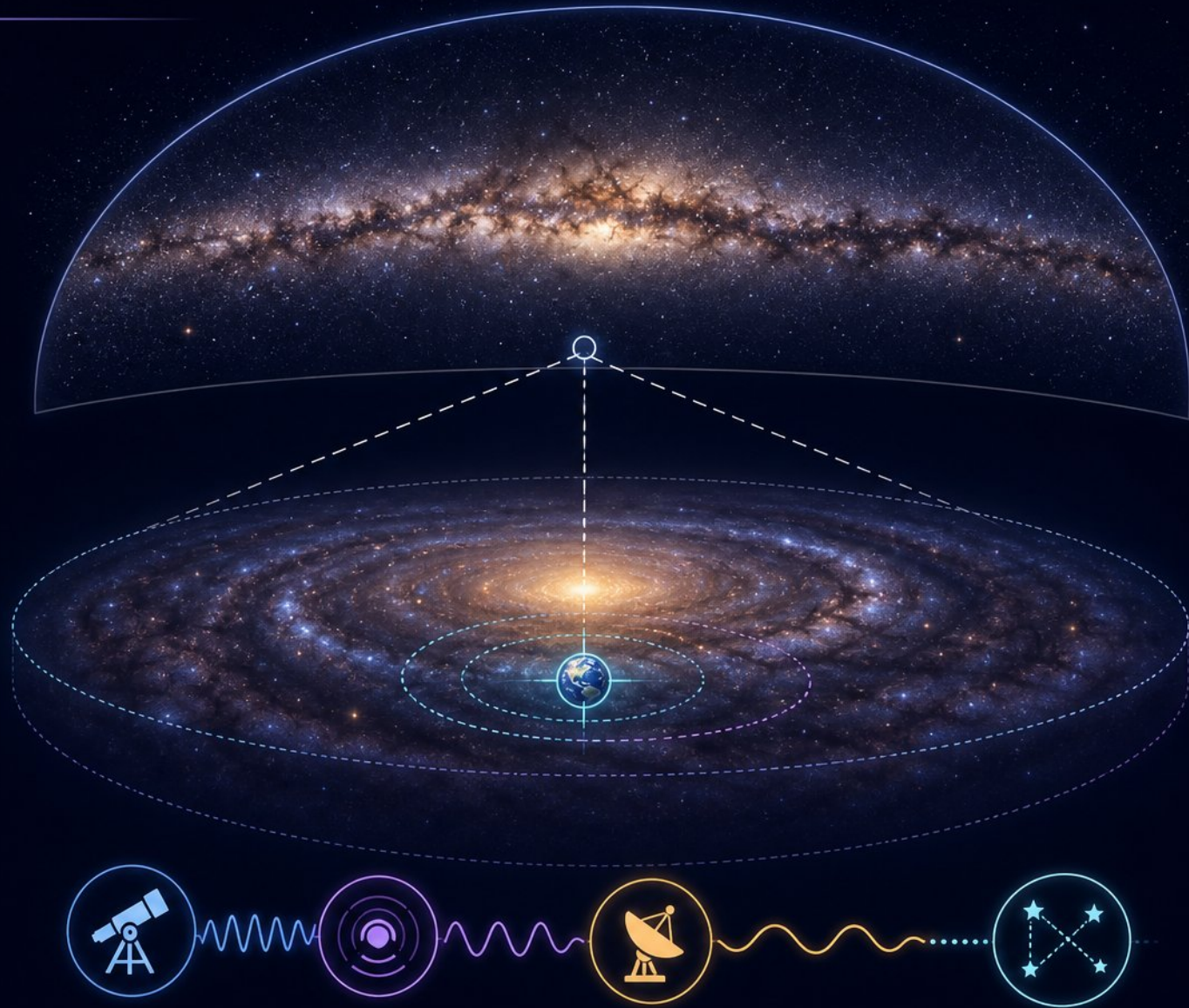


- Goals: describe components, explain Galactic rotation, use analogies



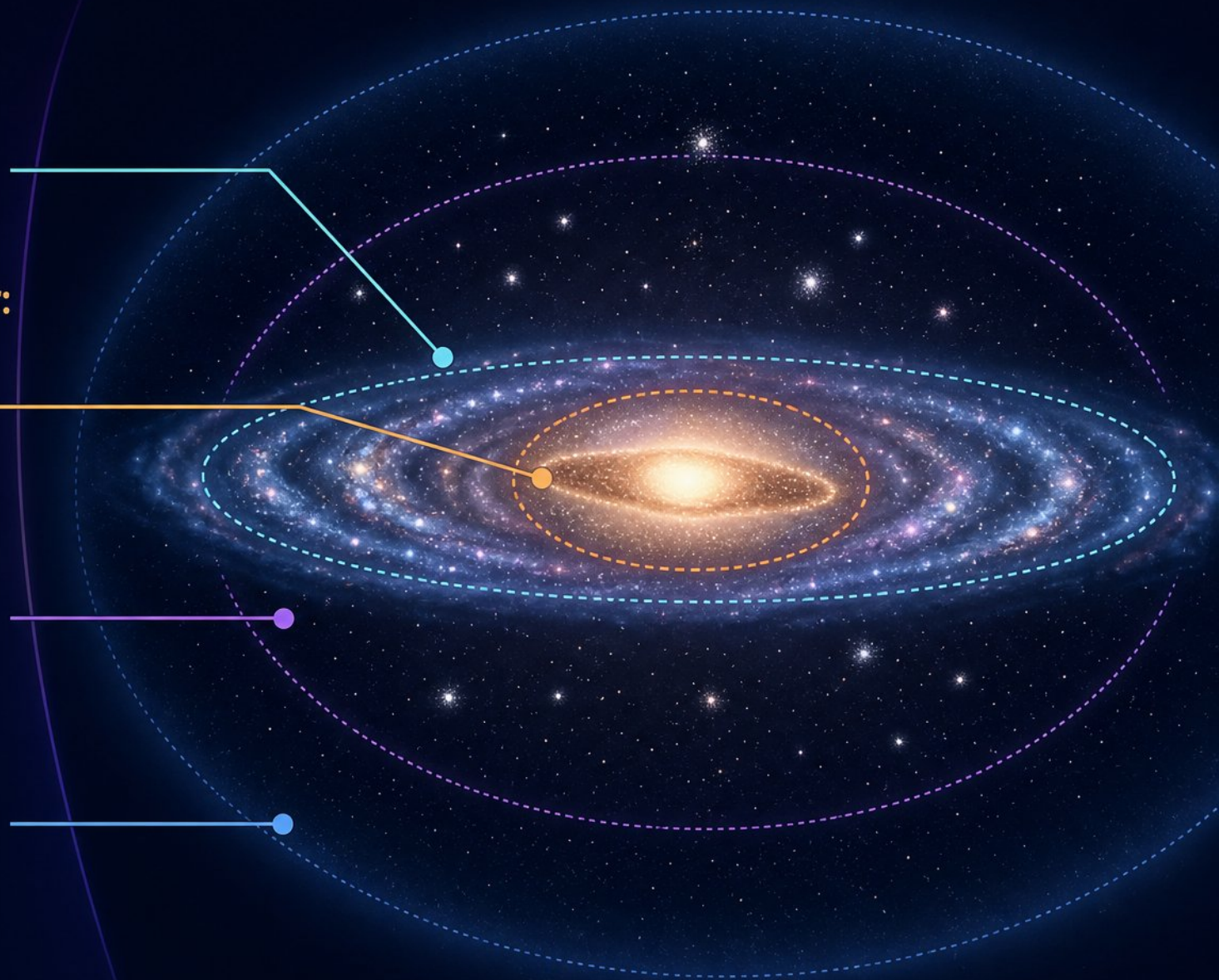
Seeing Our Galaxy from Inside

- We sit inside the disk, so the galaxy appears as a sky band
- Nearby optical views are limited to a few thousand light-years
- Dust absorbs and scatters light, hiding much of the galactic plane
- Radio and infrared observations penetrate dust and reveal structure
- Gaia parallaxes and multiwavelength surveys enable 3D mapping



The Main Structural Components

- **Galactic disk:**
young stars, gas, dust,
and open clusters
- **Central bulge and bar:**
older stars and
elongated central
concentration
- **Stellar halo:**
old, metal-poor stars
and globular clusters
- **Dark matter halo:**
unseen mass inferred
from rotation speeds



Spiral Arms and Star Formation

- Milky Way is a barred spiral galaxy
- Arms are density waves, not fixed star clusters
- Gas enters arms, compresses, and triggers star formation
- Molecular clouds concentrate in arm interiors
- Young, luminous stars and H II regions trace arm edges



How the Milky Way Rotates



- Differential rotation: inner parts orbit faster than outer parts



- The Sun orbits at about 230 km/s



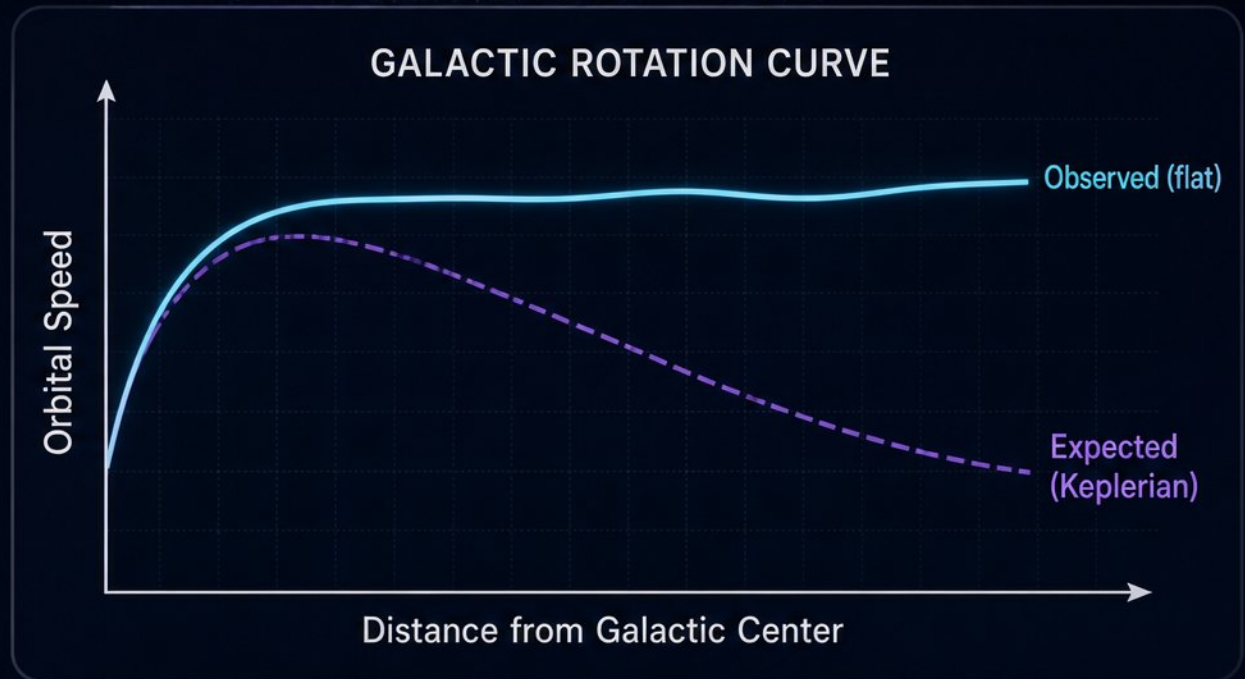
- One Galactic year takes roughly 230 million years



- Rotation speeds stay high far from the center

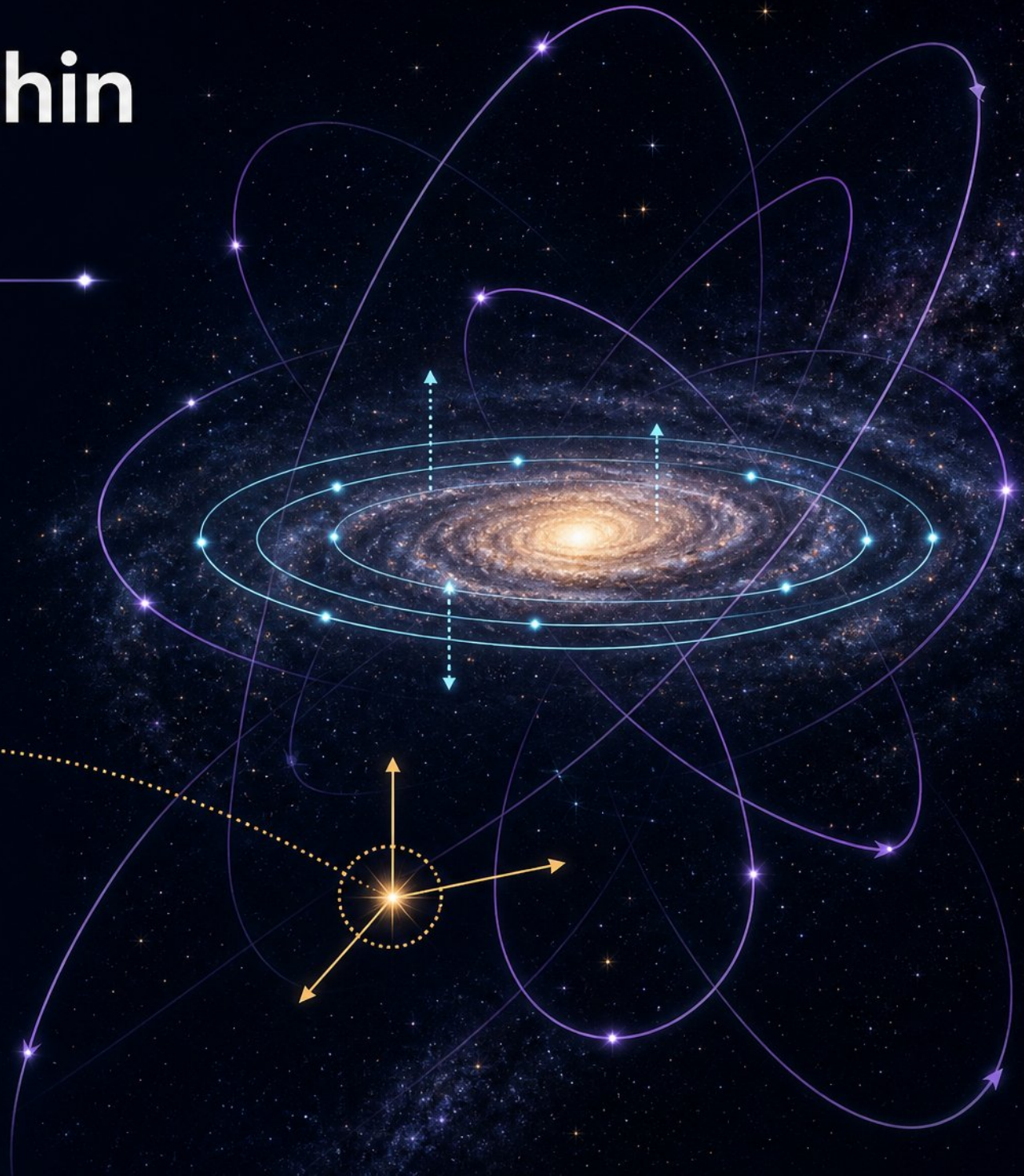


- The flat rotation curve implies unseen dark matter



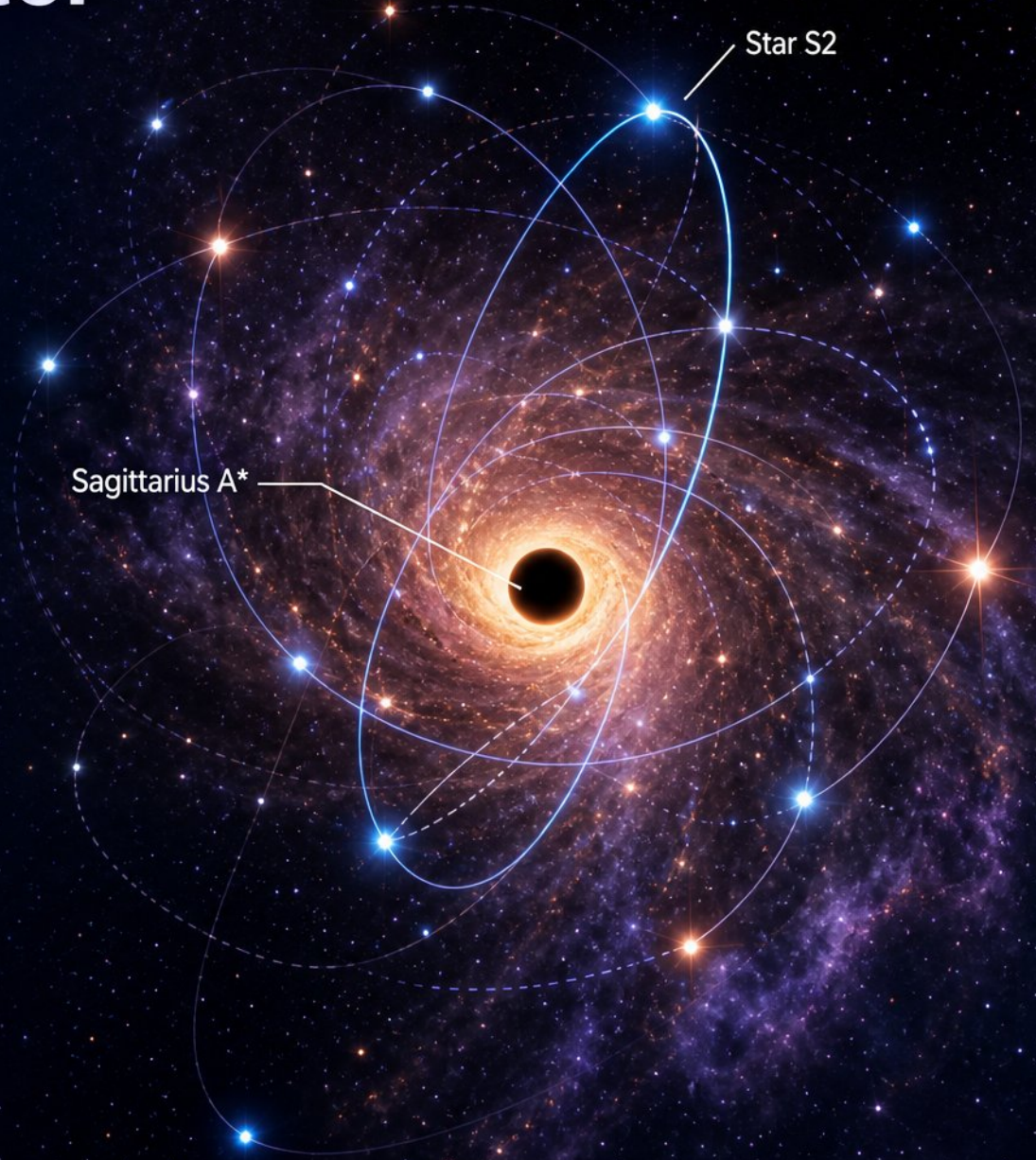
Motion Within the Galaxy

- **Disk stars:** near-circular orbits with gentle vertical bobbing
- **Halo stars:** elongated, tilted orbits with high velocity dispersion
- **Local standard of rest:** reference frame for measuring the Sun's motion
- **Stellar velocities** trace the Galaxy's hidden mass distribution



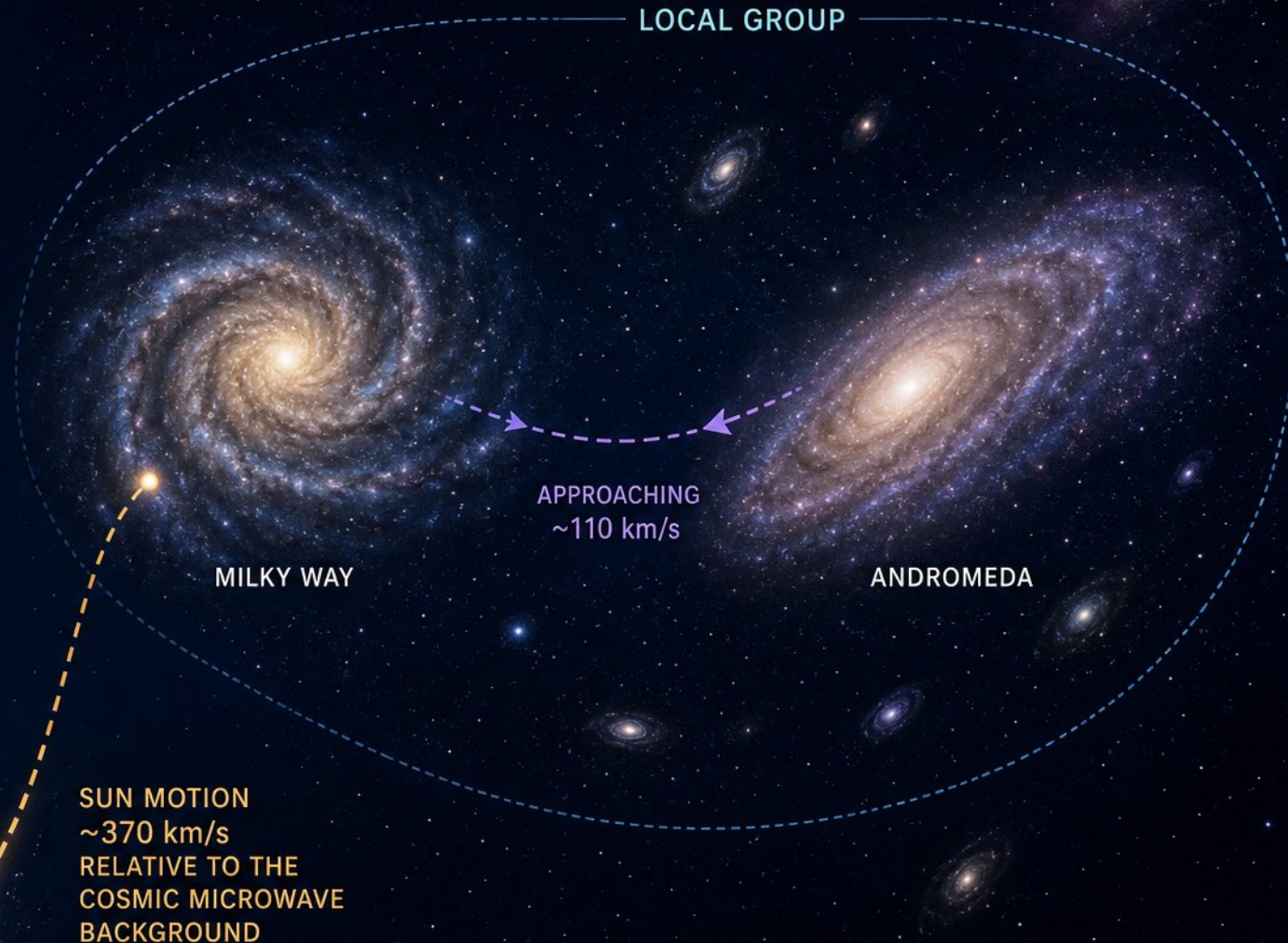
The Galactic Center

- Dense central region marked by Sagittarius A* and a nuclear star cluster
- High orbital speeds of nearby stars imply a supermassive black hole
- Star orbits, especially S2's, measure a mass of 4.3 million Suns
- Center includes a dense star field, gas, and energetic flares



The Milky Way in Motion Through Space

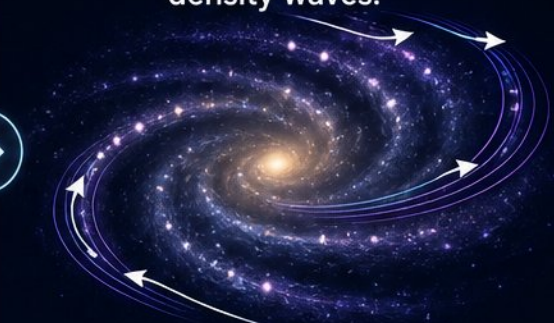
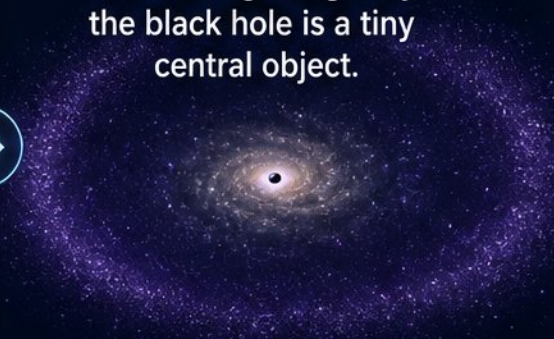
- Sun moves ~ 370 km/s relative to the cosmic microwave background
- Local Group: Milky Way, Andromeda, and dozens of dwarf galaxies
- Andromeda approaches at ~ 110 km/s; major merger likely in ~ 5 Gyr
- Interactions reshape structure—galaxies are evolving, not static



Common Misconceptions

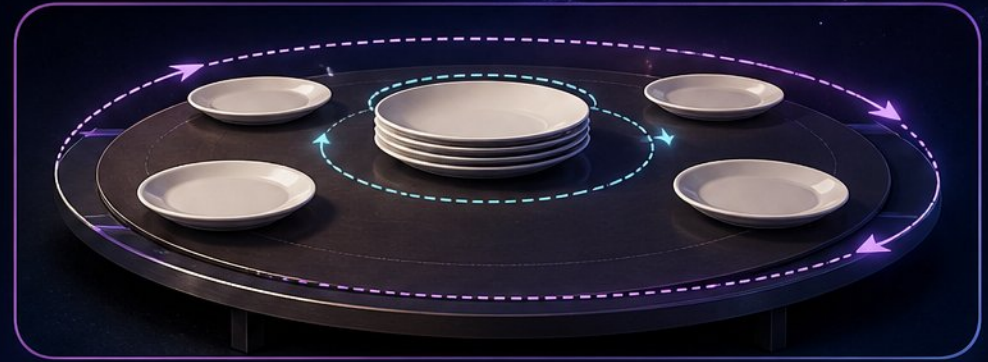
- - Spiral arms are passing density waves, not fixed star groups
- - The Sun orbits the center; galaxies are not static
- - Dark matter is not the same as the central black hole
- - Address mentally: link misconception to observed motion and mass evidence



COMMON MISCONCEPTION	CORRECT UNDERSTANDING
Spiral arms are fixed star groups. 	Spiral arms are passing density waves. 
The Sun is at the center; galaxies are static. 	The Sun orbits the center; galaxies are not static. 
Dark matter is the same as the central black hole. 	Dark matter is an invisible halo surrounding the galaxy; the black hole is a tiny central object. 

Everyday Analogies That Work

- Lazy Susan: plates move together, but inner plates travel slower
- Traffic compression: cars bunch up, like gas in spiral arms
- Orbital clocks: one Galactic year equals about 230 million years
- Match analogies to audience level to avoid new misconceptions



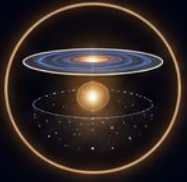
Classroom Activities and Demos



- Plot rotation curves from real or simulated radio data



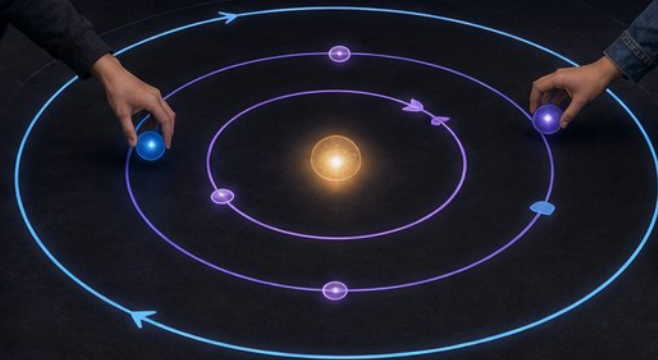
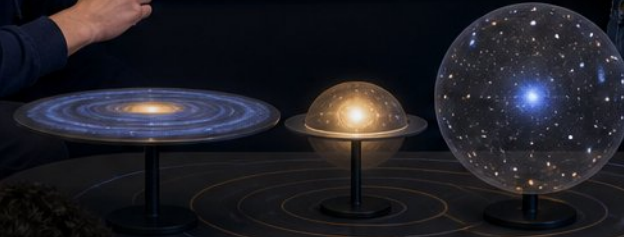
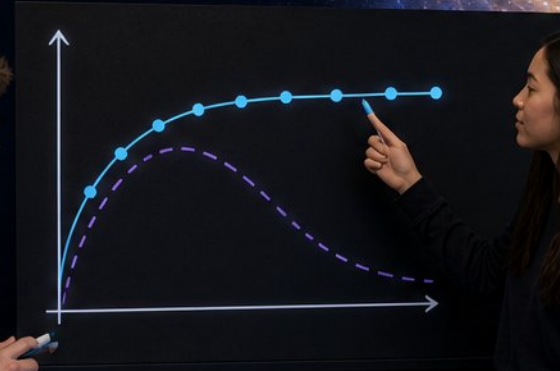
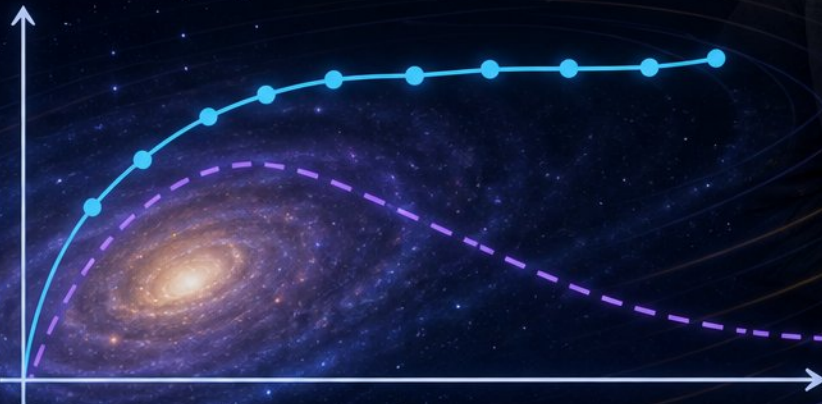
- Kinesthetic demos for solid-body vs. differential rotation



- Scale models of disk, bulge, and halo

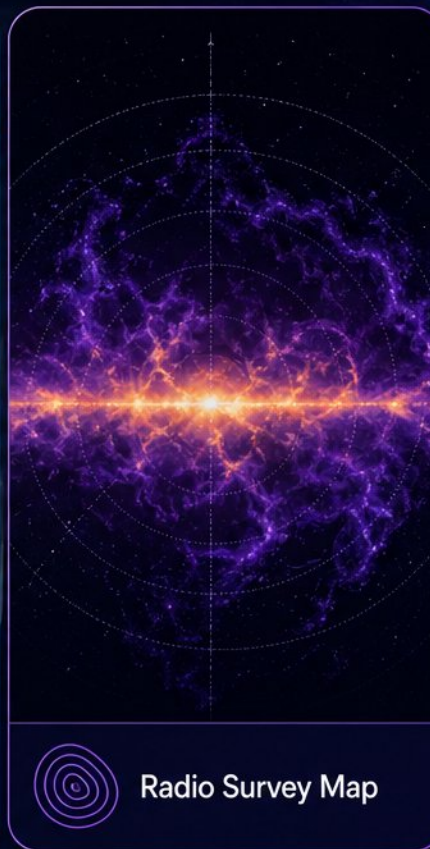


- Doppler-style exercises for measuring stellar motion

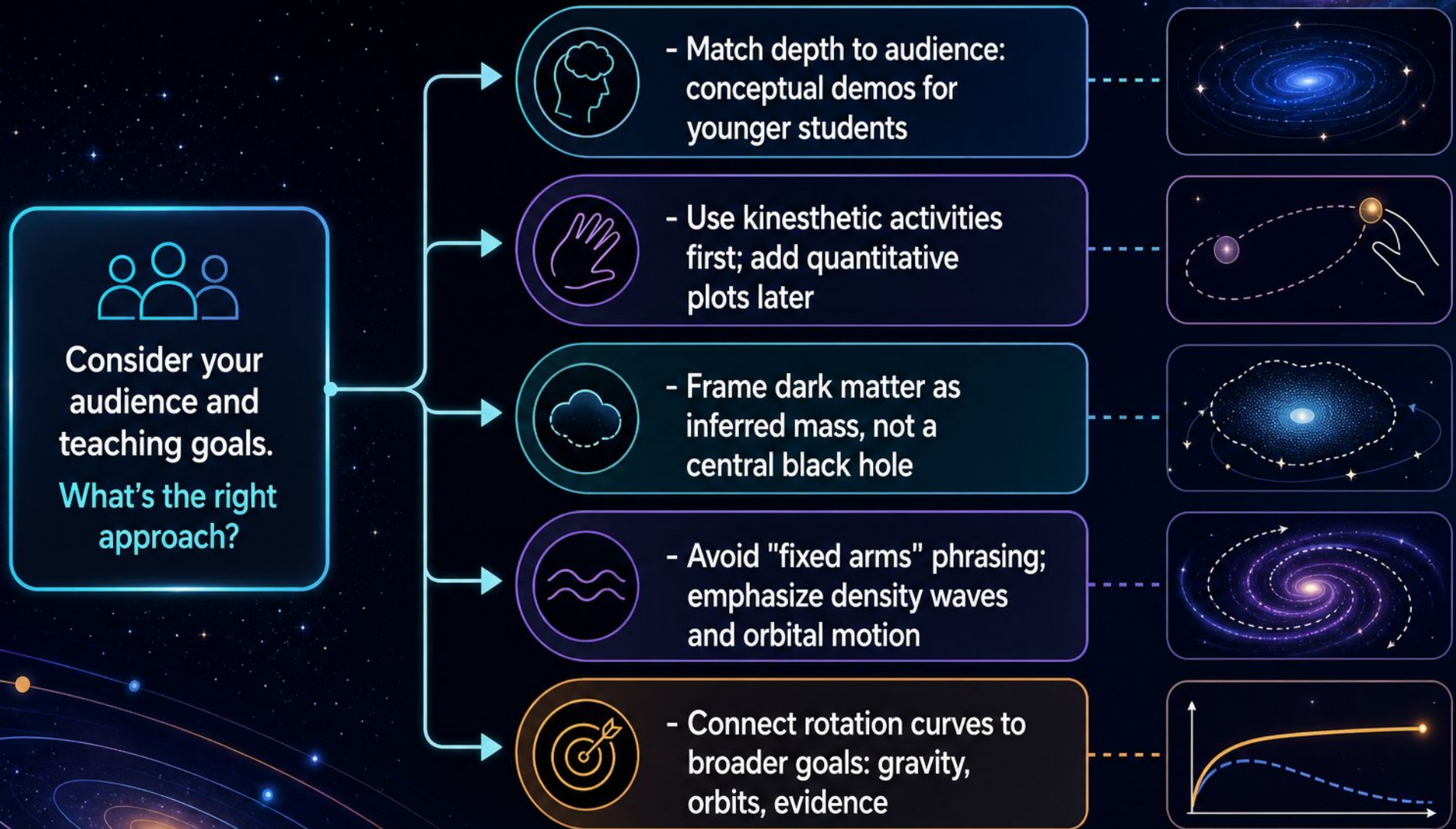


Resources for Current Data and Visualizations

- Gaia data and interactive maps for stellar positions and velocities
- Radio surveys for mapping hydrogen gas and spiral arms
- NASA and ESA visualizations for Milky Way structure
- Accessible datasets and tools for educators and communicators



Teaching Strategies for Different Audiences



Summary and Key Takeaways



- **Structure:** disk, bulge, bar, halo, spiral arms, central black hole



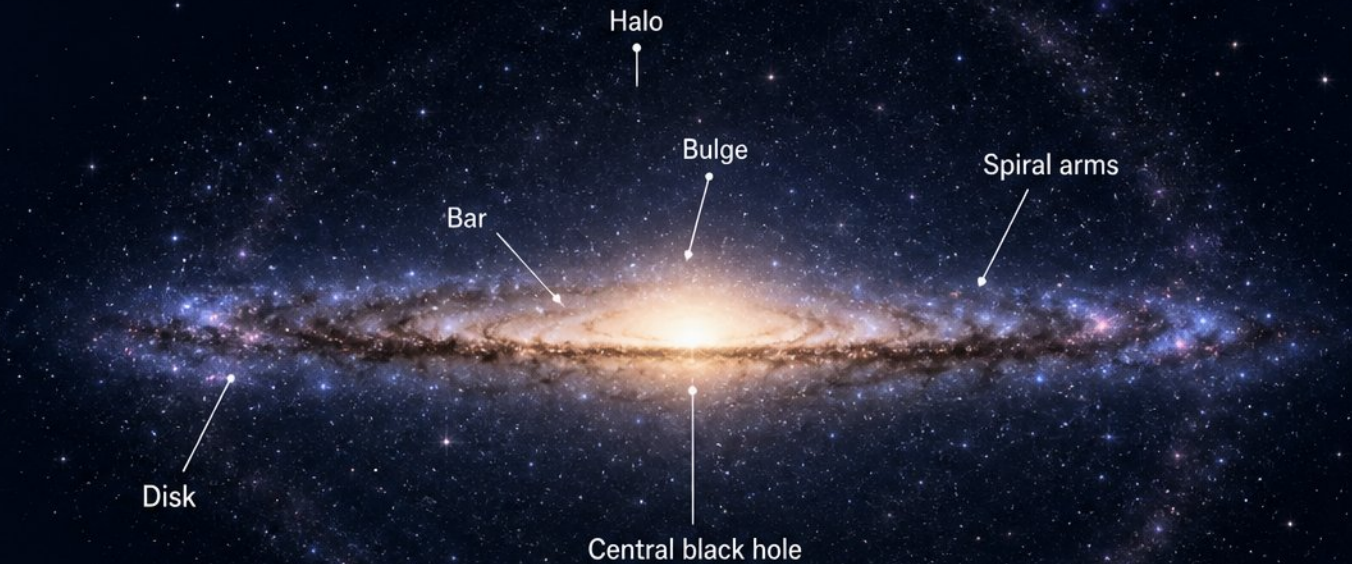
- **Motion:** differential rotation, flat rotation curve, diverse stellar orbits



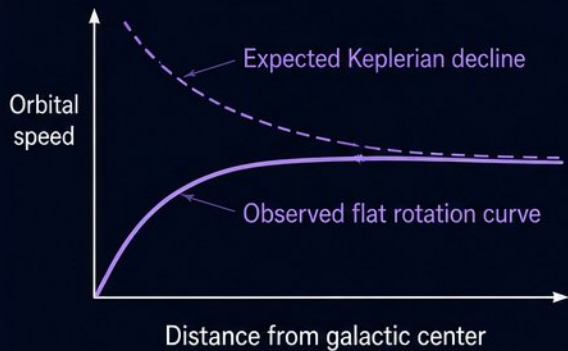
- **Dark matter:** the hidden link between structure and observed motion



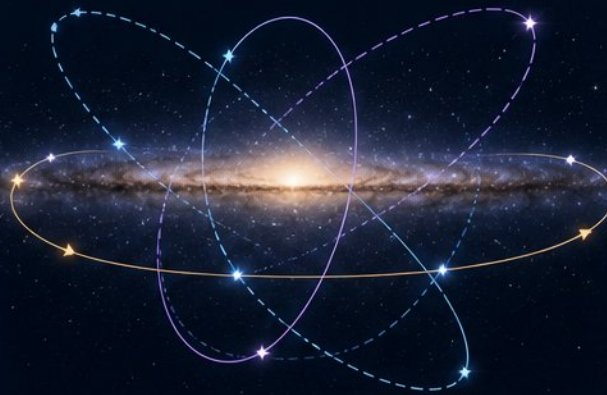
- Use analogies, data, and diagrams for different audiences



Differential Rotation and Flat Rotation Curve



Diverse Stellar Orbits



Connecting with Different Audiences



Analogies



Data



Diagrams



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