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Diameter of the Milky Way

 Once distance to center from Sun found, this is added to distance to outer edge from Sun to arrive at the Milky Way's diameter – a value of about 40 kpc or more





- The mass of the Milky Way is determined by using Kepler's modified third law
- Using the Sun's distance to the center and its period of revolution, the mass interior to the Sun's orbit is at least $10^{11}\,M_{\odot}$







• Because the galactic center is not observable in the visible, astronomers must rely on radio, infrared, X-ray, and gamma-ray observations

The Galactic Center

- At a distance of 3 kpc, an arc of cold hydrogen sweeps outward at a speed exceeding 100 km/sec
- A giant swarm of stars, packed in at millions of stars per cubic light-year, are arranged in an elongated structure about 1000 light-years across
- Some energetic event, perhaps a supernova explosion,
- violently disturbed the center in the not-to-distant past
- Deep within the core lies an incredibly small (10 AU diameter) radio source known as Sgr A*
- A $10^6\,M_{\odot}$ black hole may occupy the very center of the galaxy, although other explanations have been given

A Black Hole?



Formation of the Milky Way

- Forming galaxies is still a major unsolved problem. The McCase-MI Computer for Permanent for Interdiction or departy.
- Currently it is thought that galaxies form like stars, but only on a larger scale
 - Begin with a million-light-year cloud with 100 billion solar masses of material
 - The cloud gravitationally collapses and breaks up into stars
- Evidence for this galaxy formation process can be found in the Pop I and Pop II stars





Formation of the Milky Way



cloud; supernovas add heavy elemen to gas that begins settling into disk.

- The massive Pop II stars exploded early on, seeding the galactic cloud with heavy elements
- By the time the cloud collapsed into a disc it was rich enough in heavy elements to generate the Pop I stars we see there today





Formation of the Milky Way



- However, the collapse model fails to explain two important properties of stars
 - Pop II stars appear to have formed over a longer time scale than the collapse model allows
 - Some stars should have virtually no heavy elements, but no such stars have ever been observed

Formation of the Milky Way



• Today, astronomers also believe the collapse model fails to include the effects of galactic mergers on galactic and stellar evolution – merging appears to be the rule, not the exception

Population III Stars

- Despite uncertainties, the basic idea of the initial stars being made of pure hydrogen and helium is still true so where are they
- These *population III stars* may not be observable for three reasons
- Only short-lived massive population III stars can form – consequently none are left today
- Population III stars exist, but are masquerading as Pop II since their atmospheres have been contaminated by gas ejected when a more massive star exploded
- Pop II stars may be rare and hard to find

The Future of the Milky Way

- Eventually all gas finds its way into stars, which in turn will lock up material in stellar remnants
- Hundreds of billions of years from now the Milky Way will fade, slowly spinning in space, a dark disk of stellar cinders

