

# Our Home Galaxy: The Milky Way

Physical Sciences

Broward College

Prepared for AST 1002

Horizons in Astronomy

# Objectives

- Herschel's Map of the Milky Way
- Shapley/Curtis Debate
- Star Clusters
- Halo of the Milky Way
- Spiral Arms of the Milky Way
- Central black hole of Milky Way

# Caroline Herschel

- 1750 – 1848
- Born in Hannover, Germany
- She studied mathematics, music, and astronomy
- Worked with her brother, William



Figure 1. Caroline Herschel (Wiki)

# William/Caroline in England

- Moved to England when she was 22 years old
- Worked on telescope building and mathematical tables
- Observed comets, nebulae
- Helped William discover the planet Uranus
- Mapped out the Stars of the Milky Way
- Their model of the Milky Way led to debate on the size and state of our galaxy.

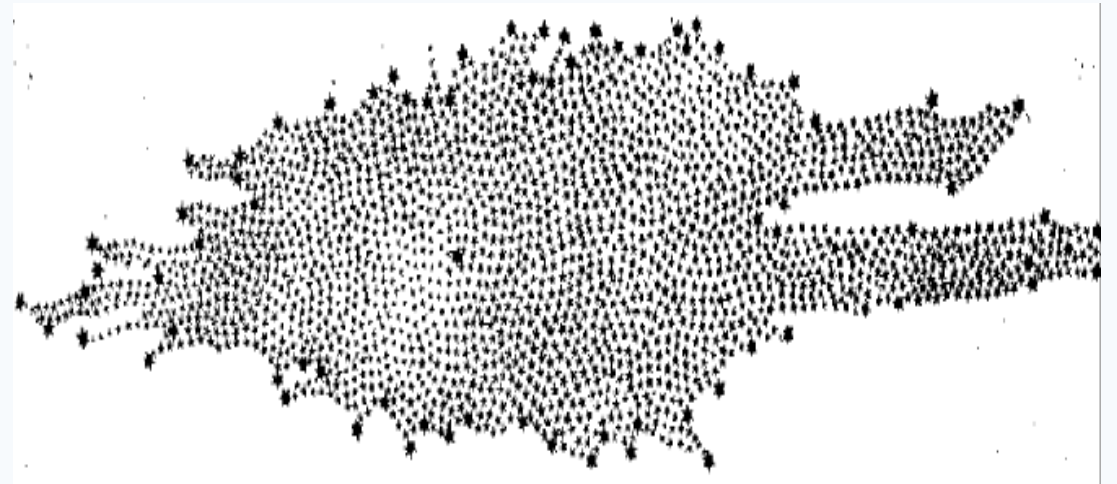


Figure 2. Herschel's Mode of the Milky Way (Wiki)

# What is a Scientific Debate?

- A debate on a hypothesis/theory and the experimental testing on these hypothesis/theories.
- Uses the data collected for multiple experiments to provide evidence for the different claims claimed by each side.
- Outcome is usually an altered paradigm (world view) of the hypothesis/theory debated.

# Differing from other Debates

- Scientific data/observations are the main form of evidence as opposed to quotes/polls
- Outside spin/propaganda is usually not included but does inform the proceedings.
- Usually no winner, both sides have opinions and ideas that do inform further hypothesis/theories.

# Curtis-Shapley Debate

- Many observations of nebulae and variable stars were conducted through 1900's to 1910s.
- Astronomers were unsure of how these objects fit into the set of nebulae called the Milky Way.
- At the American Academy of the Sciences Harlow Shapley debated Heber D. Curtis in 1920.

# *Harlow Shapley*

- 1885 – 1972
- Born in Nashville, Missouri
- School dropout at fifth grade, but returned to graduate high school.
- Studied astronomy in lieu of journalism at the University of Missouri



Figure 3. Harlow Shapley (Wiki)



# Shapley's Work at Princeton

- Studied the luminosity-period relationship for Cepheid variables developed by Henrietta Leavitt.
- Showed that Cepheid variables were not spectroscopic binaries, rather a form of pulsating stars.
- Believed that clusters were much brighter than the Sun from studies, therefore much further than previously thought; thousands of light years rather than hundreds of light years.

# What led Shapley to Debate?

- Shapley initially wanted to be a journalist, so he felt publicizing his results was important to informing the public.
- He thought educating science in public schools was important due to his struggles in education.
- He wanted to present his ideas in forum that would advance them into the public.

# Heber D. Curtis

- 1872 – 1942
- Born in Muskegon, Michigan
- Studied Latin at University of Michigan; then received his PhD at the University of Virginia

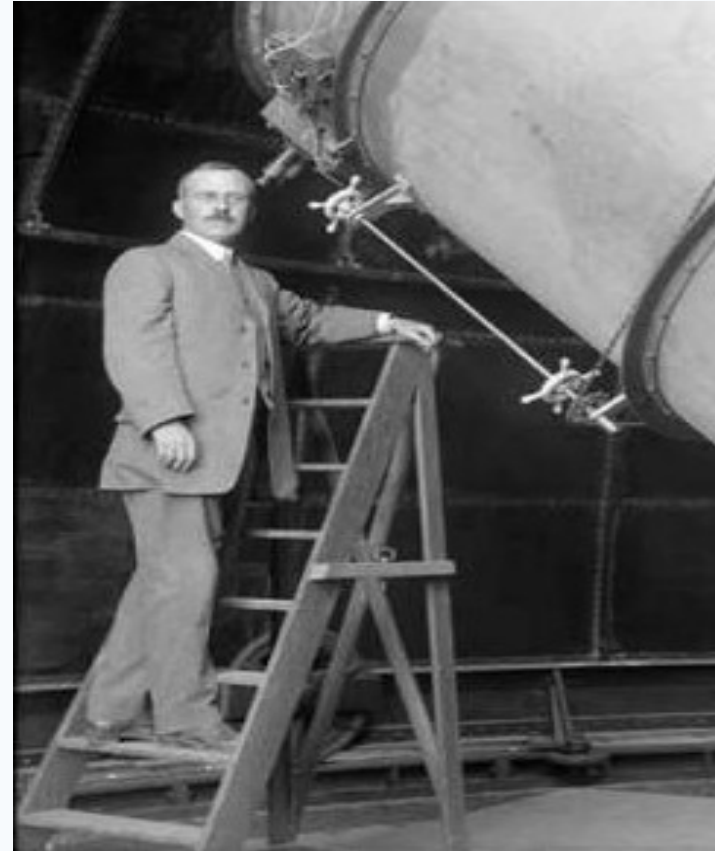


Figure 4. Heber D. Curtis (Wiki)

# Work at Lick/Allegheny

- Started to study the distances in nebulae using spectra and Cepheid Variables at Lick.
- Studied various nebulae, including spiral nebulae.
- Offered the position of Observatory Director of the Allegheny and continued study of nebulae and asteroids.
- Built a compact plate comparator to compare photo-plates more quickly and accurately.

# What led Curtis to Debate?

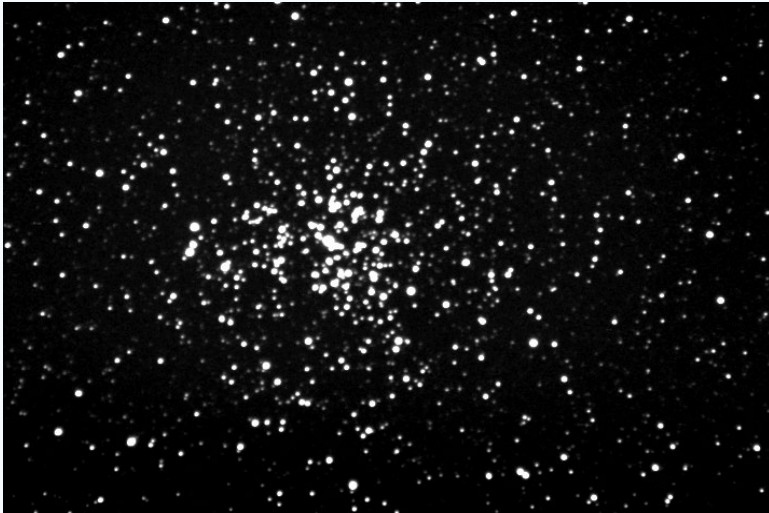
- He was steadfastly attached to his opinion on Spiral Nebulae and wanted to communicate his hypotheses to a wider audience.
- He had recently taken the observatory director position and wanted to represent the observatory in a public forum.

# Conclusions from the Curtis-Shapley Debates

Shapley	Curtis
<ul style="list-style-type: none"><li>• Sun not at the center of the Milky Way</li><li>• Milky Way 20, 000 pc across</li><li>• Spiral Nebulae were part of the Milky Way</li><li>• Milky Way was the only galaxy</li></ul>	<ul style="list-style-type: none"><li>• Sun was the center of the Milky Way</li><li>• Milky Way was smaller than 20,00 pc across</li><li>• Spiral Nebulae were their own galaxies</li><li>• Milky Way was one of many galaxies</li></ul>
<p>Presently, we observe the Milky Way as one of many galaxies; we also observe the Sun to be between two spiral arms at 14, 000 pc from the center of the Milky Way. In conclusion, both men had some correct ideas about the size and shape of our galaxy.</p>	

# Star Clusters

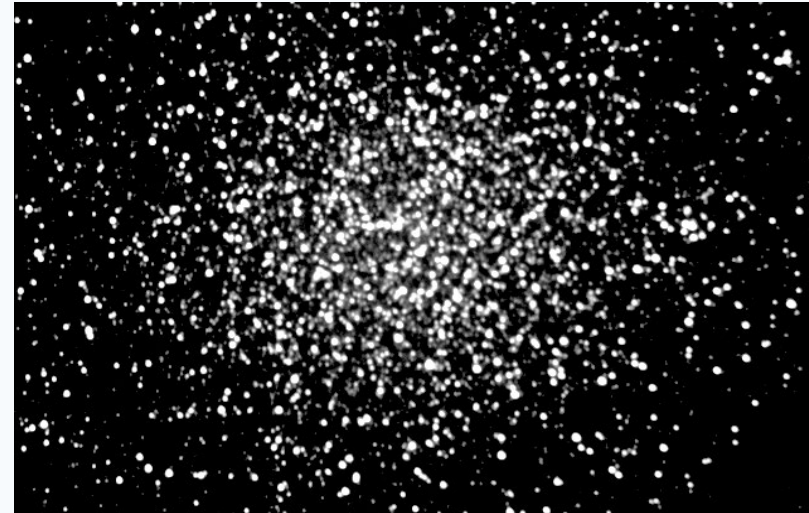
## Open Clusters M 37



- Consists of 1000 stars
- In the plane of the Milky Way Galaxy
- Formed together in the same nebula

Figure 5. Open Cluster M 37 (Van Werven, 2015)

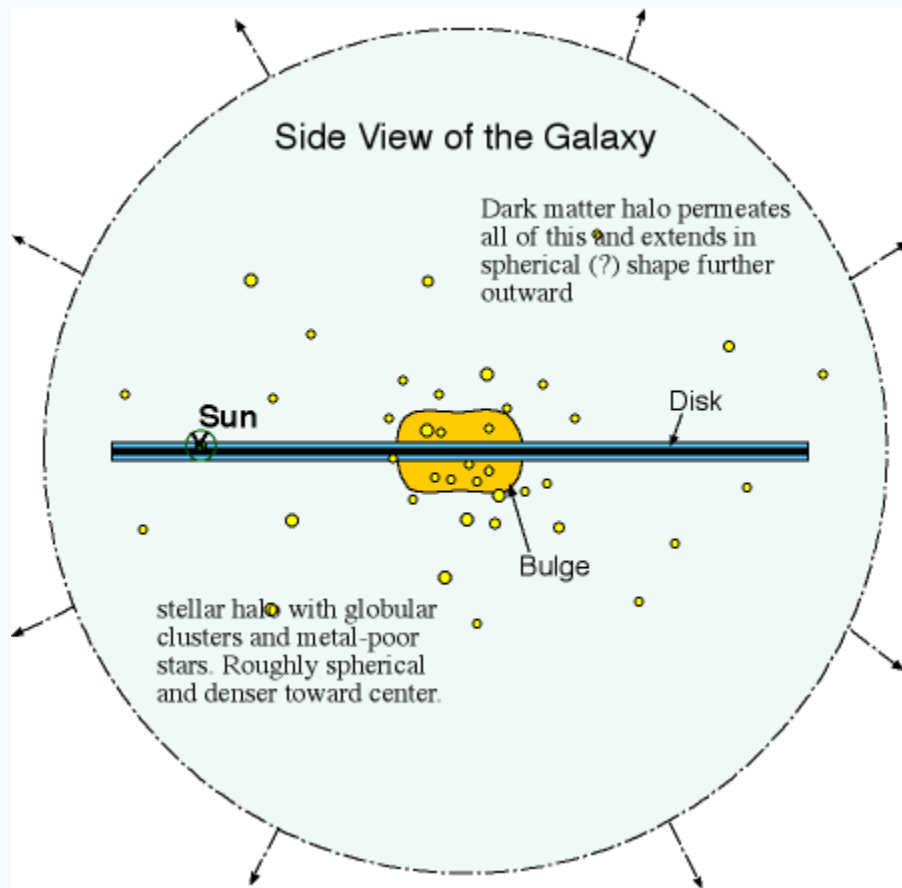
## Globular Clusters Omega Cen



- Consists of 1,000,000 stars
- Clusters orbit galaxies.
- Formed along side the Milky Way Galaxy

Figure 6. Globular Cluster Omega Cen (Van Werven, 2015)

# Halo of the Milky Way Galaxy



- The halo region of the galaxy contains many different objects.
  - Globular Clusters
  - Dark Matter

Figure 7. The Halo of the Milky Way (Strobel, 2013)



# Tracers of Spiral Arms

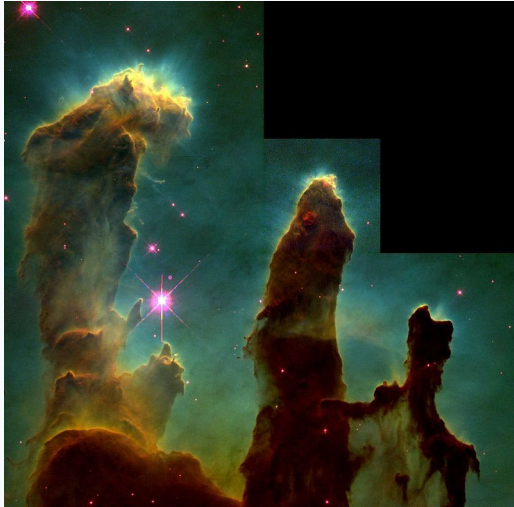


Figure 8. Eagle Nebula (Wiki)

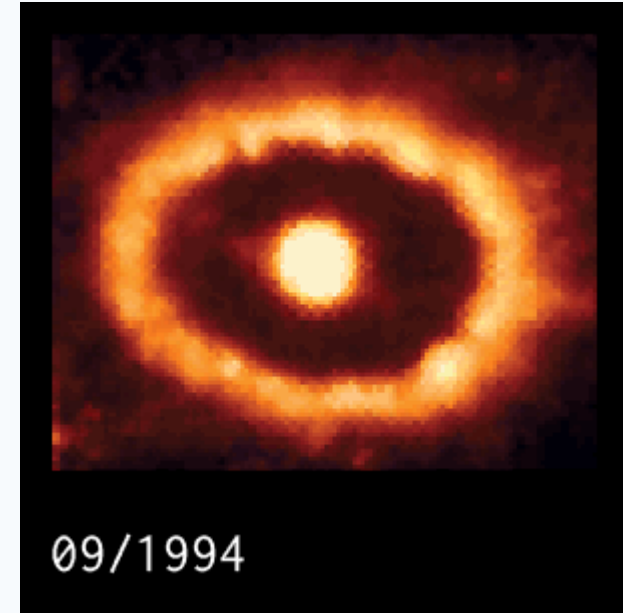
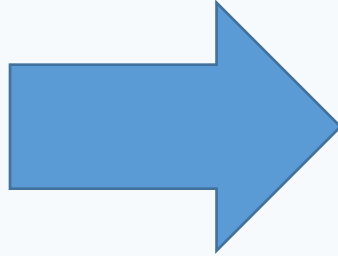


Figure 9. Supernova 1987a (Wiki)

As the spiral density waves rotate, they excite areas to form stars. We observe these areas in the radio as H II regions. H II generate large, supermassive stars that experience Type II supernovas. By measuring their rotational velocities and distances of both H II regions; we map out the arms and their motion.

# Spiral Arms of the Milky Way

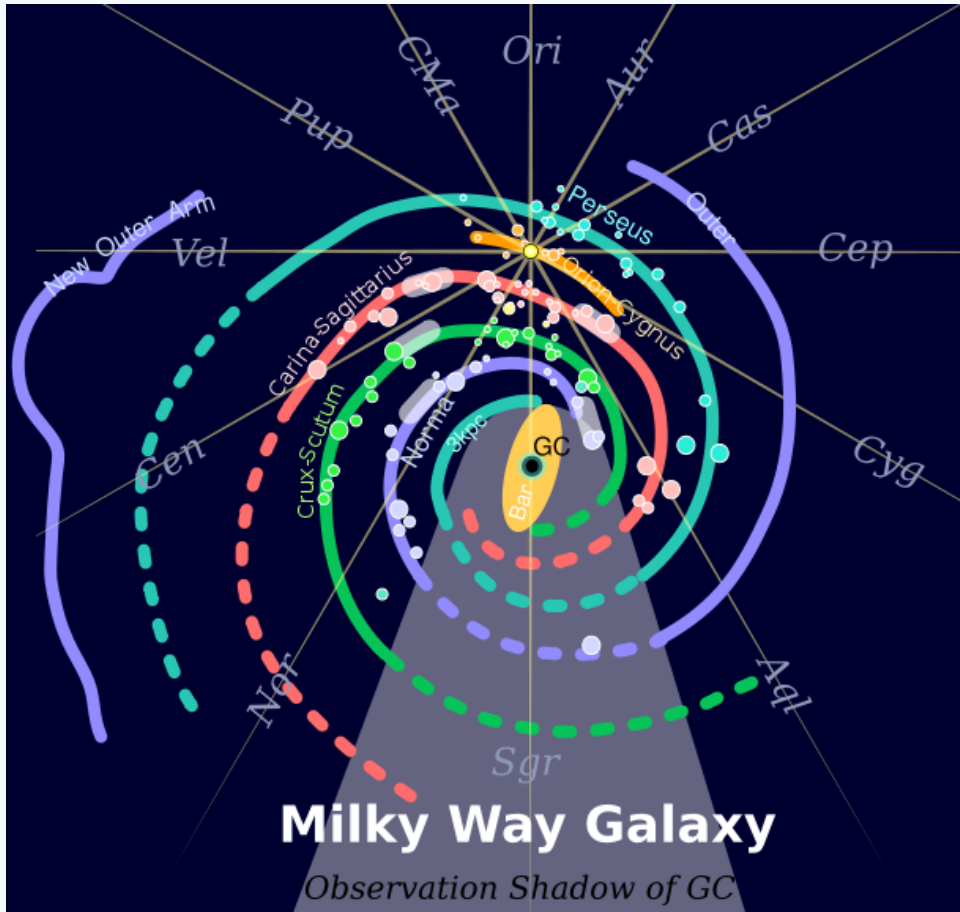


Figure 10. Map of the Spiral Arms in the Milky Way (Wiki)

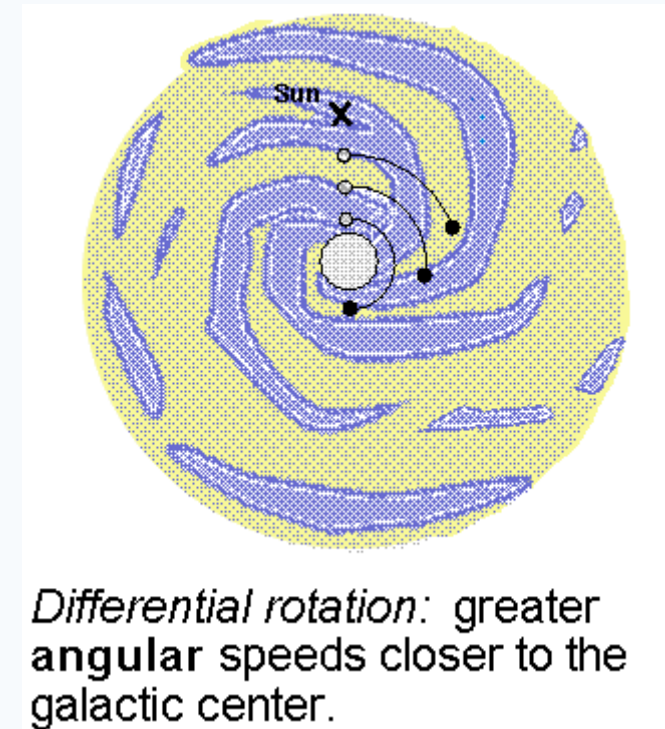


Figure 11. Motion of the Spiral Arms (Strobel, 2013)

# Stellar Motion of the Center of the Milky Way Galaxy



# Book/Course Image References

- Strobel, N. (2014) *Astronomy Notes* Retrieved from: <http://www.astronomynotes.com>
- Van Werven, A. (2015) Retrieved from: <http://www.ilovestars.com>

# Wiki Commons/Wikipedia Image References

- Heber D. Curtis: "H. D. Curtis Lick Observatory" by Source (WP:NFC#4). Licensed under Fair use via Wikipedia - [https://en.wikipedia.org/wiki/File:H. D. Curtis Lick Observatory.jpg#/media/File:H. D. Curtis Lick Observatory.jpg](https://en.wikipedia.org/wiki/File:H._D._Curtis_Lick_Observatory.jpg#/media/File:H._D._Curtis_Lick_Observatory.jpg)
- Eagle Nebula HII Region: "Eagle nebula pillars" by Credit: NASA, Jeff Hester, and Paul Scowen (Arizona State University) - <http://hubblesite.org/newscenter/newsdesk/archive/releases/2003/34/image/a>. Licensed under Public Domain via Wikimedia Commons - [https://commons.wikimedia.org/wiki/File:Eagle\\_nebula\\_pillars.jpg#/media/File:Eagle\\_nebula\\_pillars.jpg](https://commons.wikimedia.org/wiki/File:Eagle_nebula_pillars.jpg#/media/File:Eagle_nebula_pillars.jpg)
- Herschel Model of Milky Way: "Herschel-Galaxy" by Caroline Herschel. Licensed under Public Domain via Wikimedia Commons - <https://commons.wikimedia.org/wiki/File:Herschel-Galaxy.png#/media/File:Herschel-Galaxy.png>
- Caroline Herschel: "Caroline Herschel 2" by Unknown - <http://www.hawksmoorsbazaar.net/?p=130>. Licensed under Public Domain via Wikimedia Commons - [https://commons.wikimedia.org/wiki/File:Caroline\\_Herschel\\_2.jpg#/media/File:Caroline\\_Herschel\\_2.jpg](https://commons.wikimedia.org/wiki/File:Caroline_Herschel_2.jpg#/media/File:Caroline_Herschel_2.jpg)
- Milky Way Map: "Milky Way Arms" by User:Rursus - A redevelopment of Image:Milky Way Arms-Hypothetical.png: details about method below. User:YUL89YYZ, User:Ctachme, Kevin Krisciunas, Bill Yenne: "The Pictorial Atlas of the Universe", page 145 (ISBN 1-85422-025-X) and  $\mu$ OR.. Licensed under CC BY-SA 3.0 via Wikimedia Commons - [https://commons.wikimedia.org/wiki/File:Milky\\_Way\\_Arms.svg#/media/File:Milky\\_Way\\_Arms.svg](https://commons.wikimedia.org/wiki/File:Milky_Way_Arms.svg#/media/File:Milky_Way_Arms.svg)
- Harlow Shapley: "HarlowShapely-crop" by Unknown - [http://siarchives.si.edu/collections/siris\\_arc\\_306337?back=%2Fcollections%2Fsearch%3Fquery%3Dshapley%26page%3D1%26perpage%3D10%26sort%3Drelevancy%26view%3Dlist](http://siarchives.si.edu/collections/siris_arc_306337?back=%2Fcollections%2Fsearch%3Fquery%3Dshapley%26page%3D1%26perpage%3D10%26sort%3Drelevancy%26view%3Dlist). Licensed under Public Domain via Wikimedia Commons - <https://commons.wikimedia.org/wiki/File:HarlowShapely-crop.jpeg#/media/File:HarlowShapely-crop.jpeg>
- Supernova 1987a: "SN1987a debris evolution animation time scaled" by Housewarmer at commons.wikimedia. Licensed under CC BY-SA 3.0 via Wikimedia Commons - [https://commons.wikimedia.org/wiki/File:SN1987a\\_debris\\_evolution\\_animation\\_time\\_scaled.gif#/media/File:SN1987a\\_debris\\_evolution\\_animation\\_time\\_scaled.gif](https://commons.wikimedia.org/wiki/File:SN1987a_debris_evolution_animation_time_scaled.gif#/media/File:SN1987a_debris_evolution_animation_time_scaled.gif)