WOMEN OF ASTRONOMY

AND A TIMELINE OF EVENTS…

Time line of Astronomy

- 2350 B.C. – EnHeduanna (ornament of heaven) –
  - Chief Astronomer Priestess of the Moon Goddess of the City in Babylonia.
  - Movement of the Stars were used to create Calendars

- **2000 B.C.** - According to legend, two Chinese astronomers are executed for not predicting an eclipse.

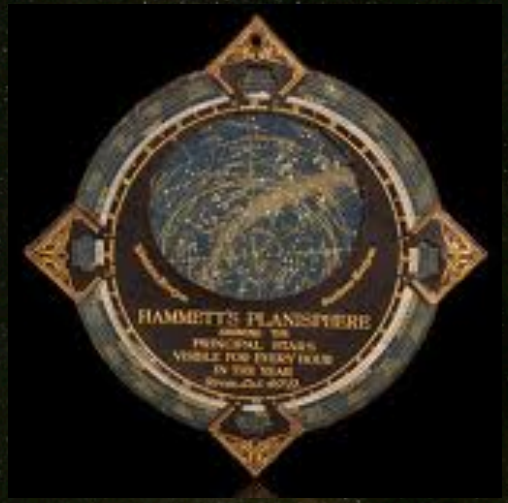
- **129 B.C.** - Hipparchos completes the first catalog of the stars, and invented stellar magnitude (still in use today!)

- **150 A.D. -** Claudius Ptolemy publishes his theory of the Earth-centered universe.

- 350 A.D – Hypatia of Alexandria
  – First woman Astronomer

- Hypatia of Alexandria Born approximately in 350 A.D.
- Accomplished mathematician, inventor, & philosopher of Plato and Aristotle
- Designed astronomical instruments, such as the astrolabe and the planesphere.

An early astrolabe was invented in 150 BC and is often attributed to Hipparchus



The first star chart to have the name "planisphere" was made in 1624 by Jacob Bartsch. Son of Johannes Kepler, who solved planetary motion.

Time line of Astronomy

- **970** - al-Sufi, a Persian Astronomer prepares catalog of over 1,000 stars.
- **1420** Ulugh-Beg, prince of Turkestan, builds a great observatory and prepares tables of planet and stars

- **1543** While on his deathbed, Copernicus publishes his theory that planets orbit around the sun.
- **1609** Galileo discovers craters on Earth's moon, the moons of Jupiter, the turning of the sun, and the presence of innumerable stars in the Milky Way with a telescope that he built.
- **1666** Isaac Newton begins his work on the theory of universal gravitation.
- **1671** Newton demonstrates his invention, the reflecting telescope.
- **1705** Edmond Halley predicts that a great comet will return in 1758.
- **1758** On Christmas, farmer/amateur astronomer Johann Palitzch discovers the return of Halley's Comet.
- **1781** William Herschel discovers Uranus… (with his Sister…)

Caroline Herschel - Comet Hunter

I was born in Hanover, in Germany, in 1750. Until I was 22 I was my mother's unpaid servant.

"My father told me that as I had neither beauty nor riches, no man would be likely to make me an offer until I was old, when some one might like, on account of my worth, to marry me."

In 1772 I moved to Bath to join my musician brother William. He planned to train me as a singer (I was first soloist by 1777), but he was distracted by his growing interest in Astronomy...

My musical career ended in 1781 when William discovered a new planet - Uranus. He was made King's Astronomer the year after and we moved to Berkshire.

"(I) found I was to be trained for an assistant Astronomer...I was to sweep for Comets, and I...began Aug 22nd 1782 to write down...all remarkable appearances that I saw in my Sweeps."

I learned fast and by 1783 I'd already discovered new nebulae with my own telescope, but my main job was to assist William with his observations. This could be dangerous:

"...having to run in the dark on ground covered foot deep with melting snow I fell on one of these hooks which entered my right leg...my brother (called) make haste, I could only answer by a pitiful cry I am hooked"

I found my first comet in 1786, the first ever found by a lady. By 1797 I'd added 6 more.

In 1787 I was granted a salary of £50 per year by George III, making me the **first ever professional female astronomer**.

William died in 1828 and I returned to Hanover. This stopped my astronomical observing but I continued to work with the observations I already had.

The Royal Astronomical Society awarded me their gold medal in 1828 in recognition of my catalogues. I became an Honorary Member of the society in 1835, one of only 2 women.

I died in 1848, aged 97. My obituary said that *"...her memory...will live on its own merits, even though...the time should come when the astronomical celebrity of a woman will not...be sufficient to excite the slightest remark"*

The Herschel Space Telescope, launched in 2009, carries on the Herschel name. It has just begun its study of the Universe

Picture credits: Science Museum Martin Francois Tielemans, R. Jay GaBany, ESA

c Credits to http://weareallinthegutter.wordpress.com (looking at the stars)

Time line of Astronomy

- **1791** Benjamin Banneker, the first African-American scientist, begins star observations needed for the geographical survey to establish the future capital city of the United States, Washington, D.C.

- **1833** Abraham Lincoln and thousands of others see an enormous meteor shower over North America on November 12th and 13th (Leonids, Tempel – Tuttle comet).

- **1842** Christian Doppler discovers the principle by which sound or light shifts in frequency and wavelength due to the motion of its source with respect to the observer.

- **1846** Johann Galle is the first person to spot Neptune.

- 1847 – Maria Mitchell, first American female Astronomer

Maria Mitchell – First American Astronomer
1818 - 1889

- Father taught her astronomy using his telescope at home
- 1847 – Discovered "Miss Mitchell's Comet" using this scope
- Won King Frederick VI of Denmarks gold medal prize for "telescope comets"
- 1848 – First woman member of the American Academy of Arts and Sciences
- 1848 – became professor of astronomy at Vassar College
- 1865 – first person appointed to the faculty (male or female!)

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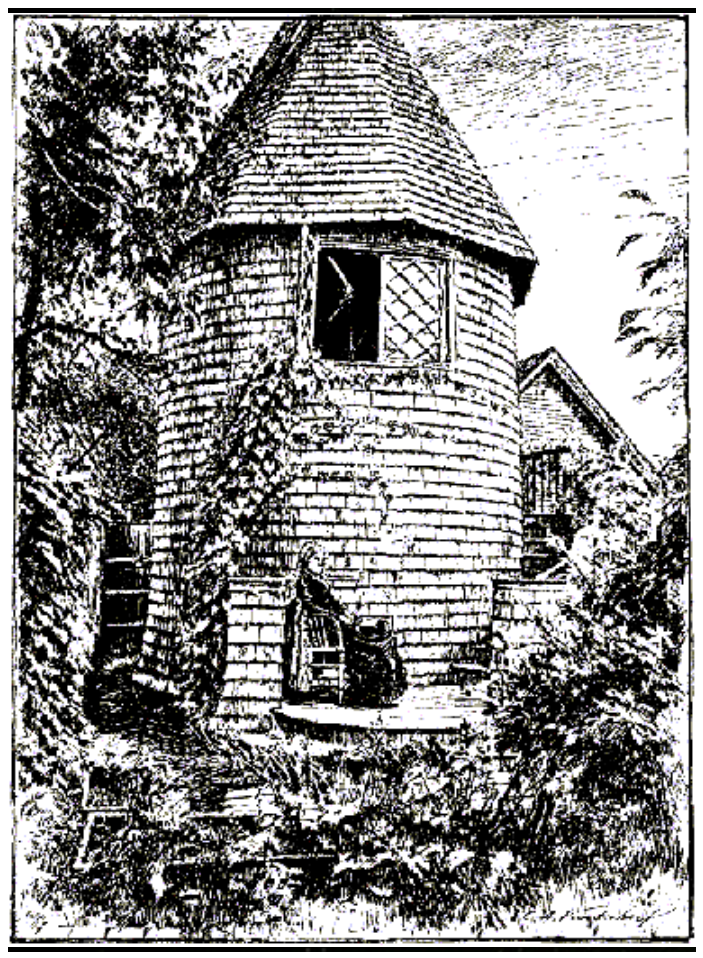

Maria Mitchell's Observatory

1847 telescope @ National Museum of American History, Smithsonian Institute

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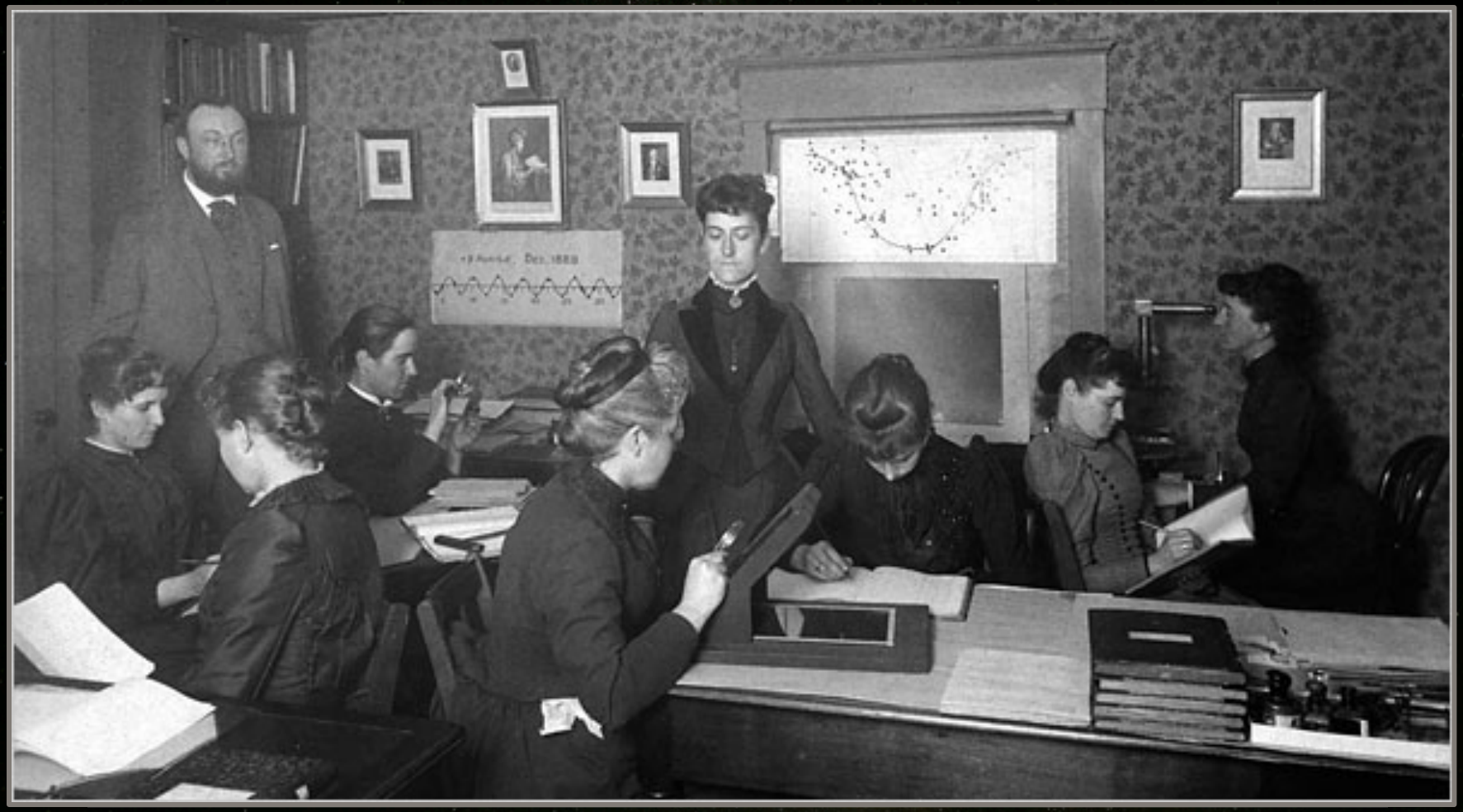
Time line of Astronomy

- **1882 – Edward Charles Pickering developed a method to photograph spectra of multiple stars simultaneously by using a large prism.**
- **1890s – The Harvard University Computers**
- **1893 – Henrietta Swan Leavitt discovers period-luminosity relation of Cepheid variable stars**
- **1896 – Annie Jump Cannon began work to classify star spectral classes**

The Harvard "Computers"



- Director Edward Pickering at Harvard
- Women Examined glass photographic plates of sky images
- Tasks included Discovering starts that changed brightness
- Pay was $0.25 per hour

Williamina Paton Stevens Fleming – 1857 - 1911

- Was a maid in the home of Professor Pickering
- 1881 Fleming was hired to do clerical work at the observatory
- 1888 – Discovered the Horsehead nebula
- Noted stars could be organized by hydrogen amounts was observed in their spectra
- She Cataloged over 10,000 stars
- 1906 – first American woman in the Royal Astronomical Society

Henrietta Swan Leavitt – 1868-1921

- Graduate of Radcliffe
- 1893 – worked at Harvard as a "computer" to count images on photo plates
- Led her to discover "period-luminosity" of Cepheid variable stars.
- *Pivotal work* which was critical to Edwin Hubble's discovery of "the universe goes beyond the Milky Way" and Redshift increases with distance
- Henrietta received very little credit during her lifetime.

Pickering's staff at Building C - Harvard May 13, 1913

Back row (L to R):

Margaret Harwood (far left), Mollie O'Reilly, Edward C. Pickering, Edith Gill, Annie Jump Cannon, Evelyn Leland (behind Cannon), Florence Cushman, Marion Whyte (behind Cushman), Grace Brooks

Front row:

Arville Walker, unknown (possibly Johanna Mackie), Alta Carpenter, Mabel Gill, Ida Woods

Annie J Cannon 1868 - 1941

- Cannon's mother had an interest in star gazing…
- 1896 – became one of the "computers" at harvard
- Worked on the Draper Catalog to map and define all stars to mag 9

- Developed a method to classify stars
- O, B, A, F, G, K, M
- Complete catalog consisted of 230,000 stars
- The SUN is a class G star (G2V to be exact)

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The Harvard Spectral Classification of Stars

Class	Surface temperature[8] (kelvin)	Conventional color	Apparent color[9][10][11]	Mass[8] (solar masses)	Radius[8] (solar radii)	Luminosity[8] (bolometric)	Hydrogen lines	Fraction of all main-sequence stars[12]
O	≥ 33,000 K	blue	blue	≥ 16 $M_\odot$	≥ 6.6 $R_\odot$	≥ 30,000 $L_\odot$	Weak	~0.00003%
B	10,000–33,000 K	white to blue white	blue white	2.1–16 $M_\odot$	1.8–6.6 $R_\odot$	25–30,000 $L_\odot$	Medium	0.13%
A	7,500–10,000 K	white	white to blue white	1.4–2.1 $M_\odot$	1.4–1.8 $R_\odot$	5–25 $L_\odot$	Strong	0.6%
F	6,000–7,500 K	yellowish white	white	1.04–1.4 $M_\odot$	1.15–1.4 $R_\odot$	1.5–5 $L_\odot$	Medium	3%
G	5,200–6,000 K	yellow	yellowish white	0.8–1.04 $M_\odot$	0.96–1.15 $R_\odot$	0.6–1.5 $L_\odot$	Weak	7.6%
K	3,700–5,200 K	orange	yellow orange	0.45–0.8 $M_\odot$	0.7–0.96 $R_\odot$	0.08–0.6 $L_\odot$	Very weak	12.1%
M	2,000–3,700 K	red	orange red	≤ 0.45 $M_\odot$	≤ 0.7 $R_\odot$	≤ 0.08 $L_\odot$	Very weak	76.45%
L	1,300–2,000 K	purple-red	red	Unknown	Unknown	Unknown	Extremely weak	≥ 100.00%
T	700-1,300 K	brown	purple-red	Unknown	Unknown	Unknown	Extremely weak	≥ 100.00%
Y	≤ 700 K	dark brown	brown	Unknown	Unknown	Unknown	Extremely weak	≥ 100.00%

Time line of Astronomy

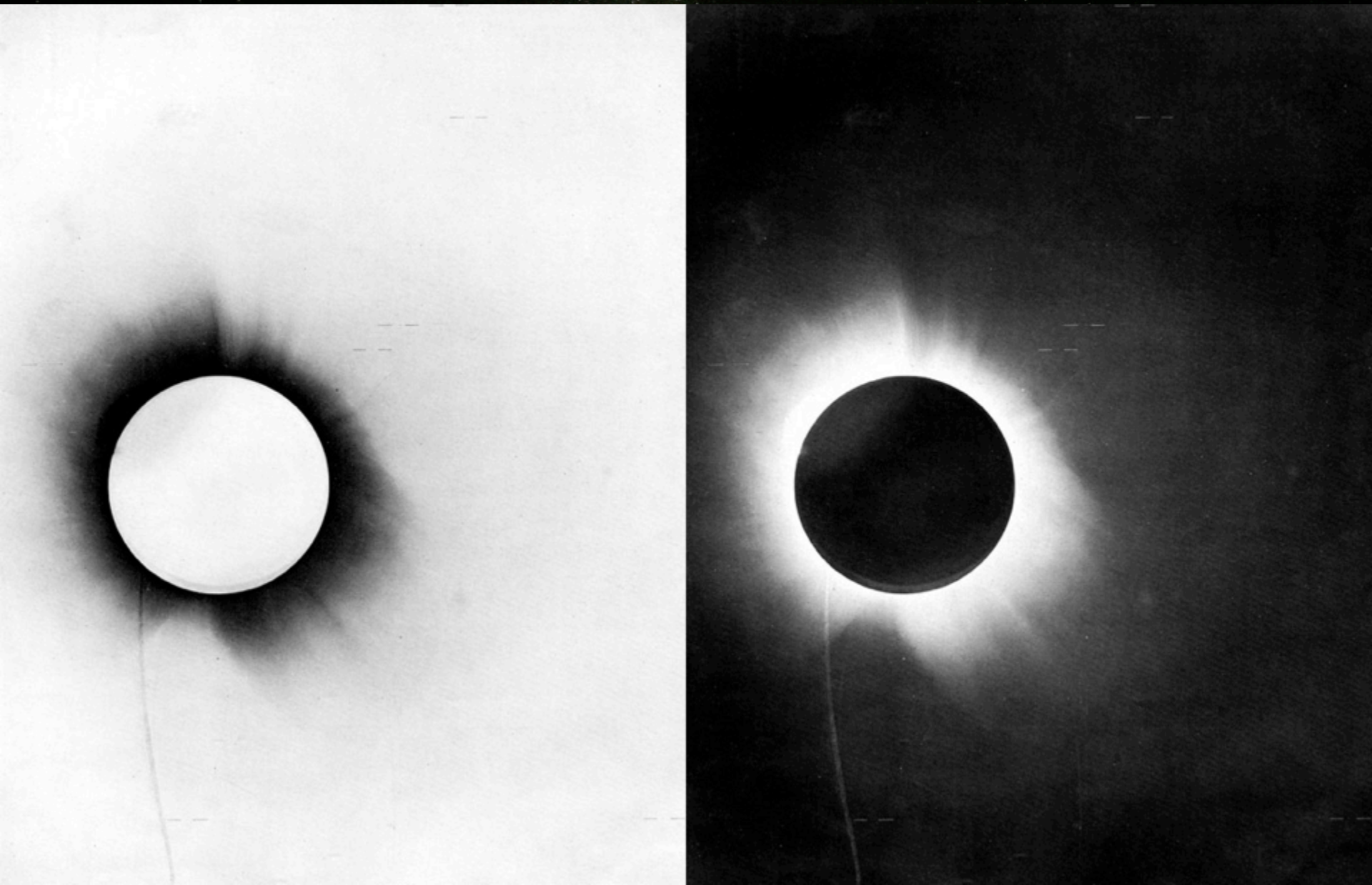
- **1916** Albert Einstein proposes the General Theory of Relativity, which explains the nature of gravity and the bending of light as it passes the sun, predicts the existence of black holes, and details the twisting of time and space in the vicinity of a massive, spinning object.

- **1923** Edwin Hubble proves that other galaxies lie beyond the Milky Way.

- 1925 Cecilia Payne-Gaposchkin – First person to receive a PhD in astronomy from Radcliffe (part of Harvard)

    - Suggested that the sun was made mostly of hydrogen, which was very controversial at the time.

Cecillia Payne-Gaposchkin 1900 - 1979



Cecillia Payne-Gaposchkin 1900 - 1979

"The reward of the young scientist is the emotional thrill of being the first person in the history of the world to see something or to understand something. Nothing can compare with that experience…"

"The reward of the old scientist is the sense of having seen a vague sketch grow into a masterly landscape."

—Cecilia Payne-Gaposchkin

(accepting the Henry Norris Russell Prize from the American Astronomical Society)

Time line of Astronomy

- **1926** The first launch of a liquid-fuel rocket, developed by Robert Goddard.
- 1929 – Edwin Hubble proposed the Big Bang Theory
- **1930** Clyde Tombaugh discovers Pluto.
- **1931** Karl Jansky discovers radio waves from space.
- **1939** Hans Bethe explains the energy source of the sun and other stars.
- **1940** Grote Reber reports the first radio telescope survey of the sky.

Beatrice M.H. Tinsley (1941 – 1981)

- Made fundamental contributions to our understanding of how galaxies change and evolve with time
- 1978 – First female Astronomer at Yale.

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Helen Sawyer Hogg (1905 – 1993)

- At 5 years old she witnessed Haley's Comet

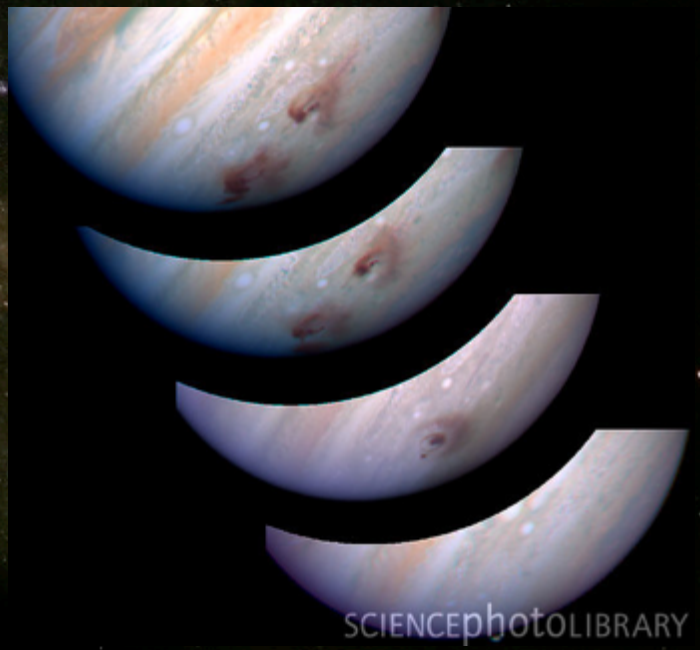
- She worked with her husband, Frank Hogg as his assistant in the Dominion Astrophysical Observatory
- Create many star catalogs of variable stars in star clusters, Still referenced today!
- LOVED to share the stars… Know to even come out on cloudy nights incase one of her clusters peeked through

Eleanor Margaret Burbidge (1919 -

- Much of her work based on Optical Spectroscopy
- Sought a Carnegie Fellowship at Mount Wilson (but only available to men)
- 1976 – First Woman President of American Astronomy society
- Found that ALL elements except the lightest are produced in stars.

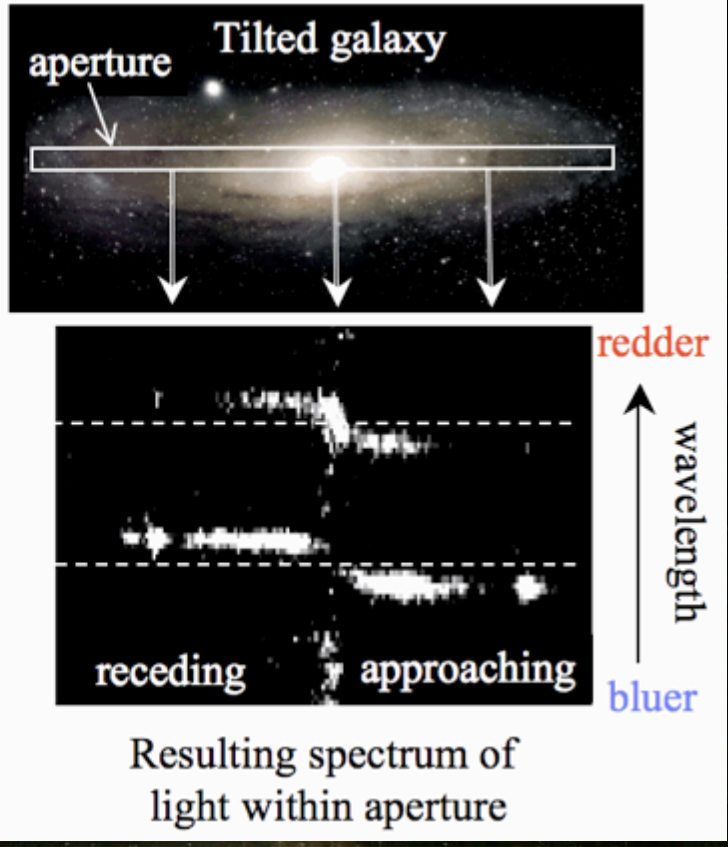
Carolyn Shoemaker (1929 -)

- Astronomer and co-discoverer of Comet Shoemaker-Levy 9
- Holds the record for most comets discovered
- 2002, 32 comets and 800 asteroids



Vera Rubin (1928 --)

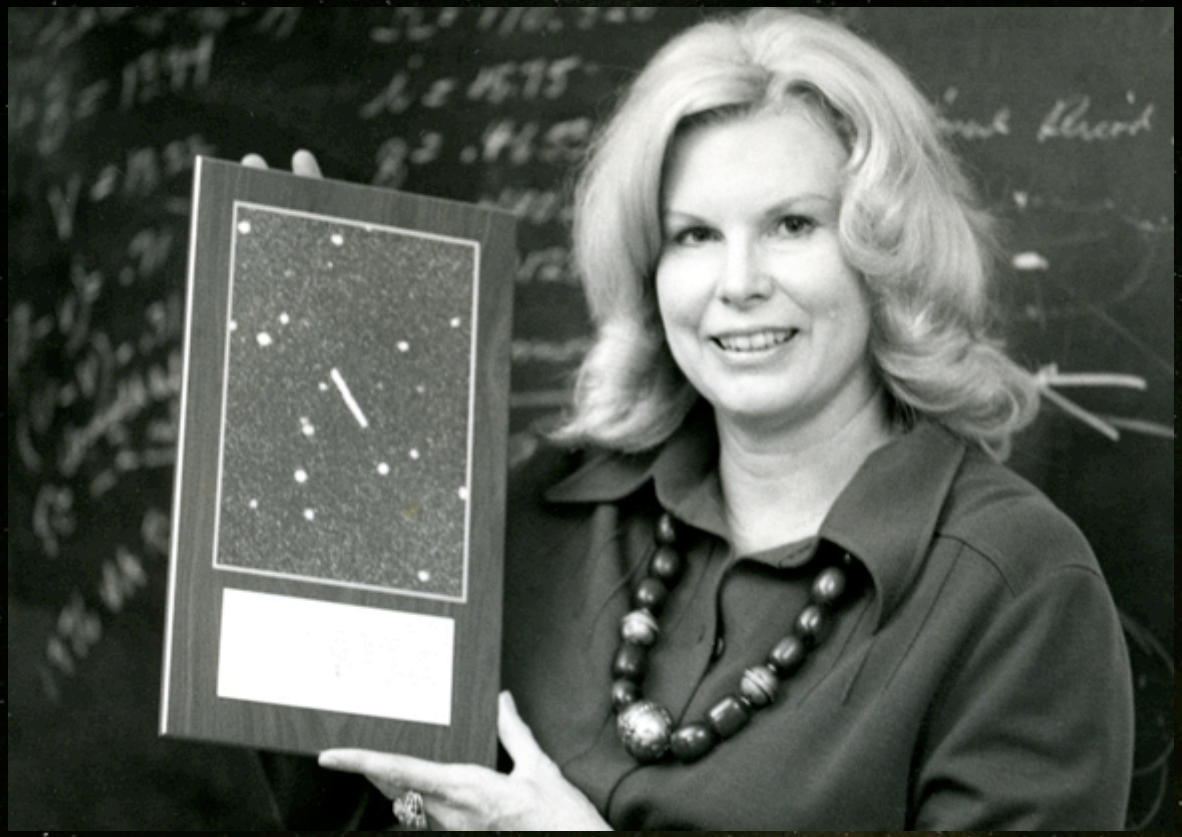
Vera Rubin measuring galaxy rotation curves (~1970)



Resulting spectrum of light within aperture

- Best know for the study of rotational speeds in galaxies
- Led her to the theory of dark matter.
- Won the National Medal of Science in 1993
- 2nd woman to receive the Royal Astronomical Society's Gold Medal (Caroline Hershel was first)

Eleanor Helin – (1932 – 2009)



- Principal investigator of the Near Earth Asteroid Tracking (NEAT) program.
- Discovered over 872 Asteroids, several comets

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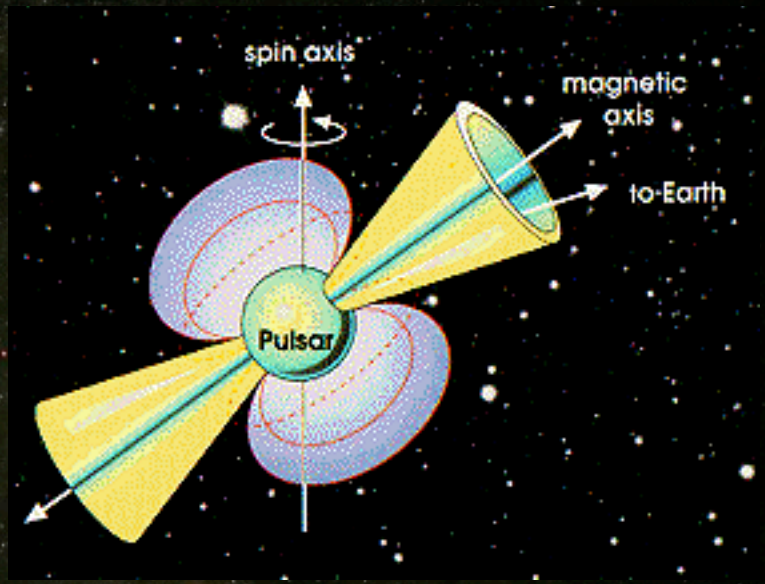
Jocelyn Bell Burnell (1943 -)

- As a post grad, she discovered the first radio pulsars



- She did not share in the 1974 Nobel peace prize with Antony Hewish, despite her being the discover… (Hewish was Bell's Advisor)

Jill Tarter (1944 –)

- American Astronomer and director of the Center for SETI
- 1989 – Lifetime Achievement Award by Women in Aerospace
- 2004 – One of 100 most influential people in the world
- 2005 – Carl Sagan Prize for Science Popularization
- 2009 – Ted Prize

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Wendy Freedman – (1957 -)

- Found her calling to Astronomy in a high school physics class
- Known for the "Hubble Key Project" to measure the Hubble constant or the RATE at which the universe is expanding.
- 2009 – Won the Gruber Cosmolgy Prize (with Robert Kennicutt and Jeremy Mould
- It was this project that determined the age of the universe

Carolyn Porco (1953 –)

- Imaging work started with Voyager missions
- Leads the Cassini mission to the planet Saturn
- Works on New Horizons mission (Pluto, Images will exceed Hubble on May 5th, 2015)

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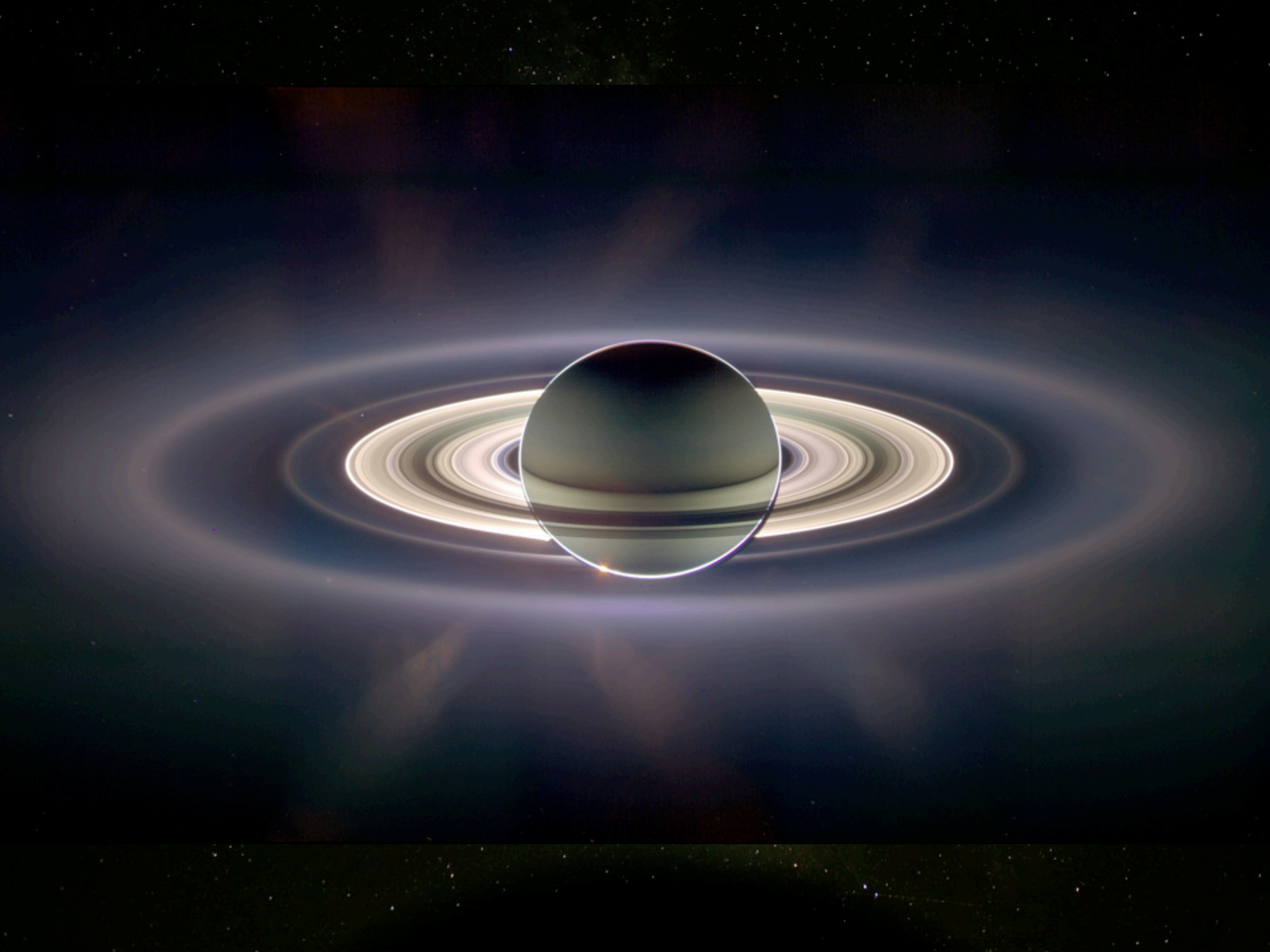

Women who have been in space

- 1963 First woman in space : Valentina Tereshkova, Russia
- 1983 -- Sally Ride, First American woman
- A total of 59 women have been in space
- Total flights by women 132… (total flights by men 1068)

Clara Ma – (1997 -)

"Curiosity is an everlasting flame that burns in everyone's mind. It makes me get out of bed in the morning and wonder what surprises life will throw at me that day. Curiosity is such a powerful force. Without it, we wouldn't be who we are today. When I was younger, I wondered, 'Why is the sky blue?', 'Why do the stars twinkle?', 'Why am I me?"

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Andrea Jones – NASA –

- **Nasa Lunar Reconnaissance Obiter EPO Team**
- **Aura Mission**
- **High Resolution Imaging Science Experience Team**
- **Exploring Mars with NASA's Mars Science Laboratory Curiosity Rover!**