WOMEN OF THE STARS

with

Dr. Bill Thierfelder

Session 1 From Ancient Times to Caroline Herschel

General Introduction

EnHeduanna (circa 2350 BCE) is the earliest known poet whose name has been recorded. She was the High Priestess of the goddess Inanna and the moon god Nanna. She lived in the Sumerian city-state of Ur. She was appointed by her father, King Sargon, to be Chief Astronomer Priestess of the Moon Goddess. We don't know her birth name, but the priestesses she supervised called her EnHeduanna, meaning "Ornament of Heaven." In 2015, the International Astronomical Union named a crater on Mercury after EnHeduanna. STELLAR AND LUNAR OBSERVATIONS

Aglaonike of Thessaly was a Greek astronomer of the 2nd or 1st century BCE. She is mentioned in the writings of Plutarch as a female astronomer and as the daughter of Hegetor (or Hegemon) of Thessaly. She was regarded as a sorceress for her ability to make the Moon disappear from the sky, which has been taken to mean she could predict the time and general area where a lunar eclipse would occur. A Greek proverb makes reference to Aglaonike's alleged boasting: "Yes, as the moon obeys Aglaonike". A number of female astrologers, apparently regarded as sorcerers, were associated with Aglaonike. They were known as the "witches of Thessaly" and were active from the 3rd to 1st centuries BC. In Plato's Gorgias, Socrates speaks of "the Thessalian enchantresses, who, as they say, bring down the moon from heaven at the risk of their own perdition." Plutarch wrote that she was "thoroughly acquainted with the periods of the full moon when it is subject to eclipse, and, knowing beforehand the time when the moon was due to be overtaken by the earth's shadow, imposed upon the women, and made them all believe that she was drawing down the moon." One of the craters on Venus is named after Aglaonike. LUNAR ECLIPSES

Hypatia (born c. 350–370; died 415 AD) was a Hellenistic Neoplatonist philosopher, astronomer, and mathematician, who lived in Alexandria, Egypt, then part of the Eastern Roman Empire. She was the head of the Neoplatonic school at Alexandria, where she taught philosophy and astronomy. She is the first female mathematician whose life is reasonably well recorded. STELLAR MOVEMENTS

Queen Seondeok of Korea (c. 595~610 – 647) reigned as Queen Regnant of Silla, one of the Three Kingdoms of Korea, from 632 to 647. She was Silla's twenty-seventh ruler, and its first reigning queen. She was the second female sovereign in recorded East Asian history and encouraged a renaissance in thought, literature, and the arts in Silla. She built the "Star-Gazing

Tower," or Cheomseongdae, considered the first dedicated observatory in the Far East. The tower still stands in the old Silla capital of Gyeongju, South Korea. FIRST ASTRONOMICAL OBSERATORY IN EAST

Caroline Lucretia Herschel (16 March 1750 – 9 January 1848) was a German astronomer, whose most significant contributions to astronomy were the discoveries of several comets, including the periodic comet 35P/Herschel–Rigollet, which bears her name. She was the younger sister of astronomer William Herschel, with whom she worked throughout her career. She was the first woman to be awarded a Gold Medal of the Royal Astronomical Society (1828), and to be named an Honorary Member of the Royal Astronomical Society (1835, with Mary Somerville). She was also named an honorary member of the Royal Irish Academy (1838). The King of Prussia presented her with a Gold Medal for Science on the occasion of her 96th birthday (1846). COMETS. PLANET URANUS.

Session 2 The Women of Vassar and Harvard

Maria (pronounced Ma-RYE-Ah) Mitchell (August 1, 1818 – June 28, 1889) was a 19th-century astronomer and feminist who is best known for discovering a comet in 1847. Her discovery made her instantly famous and resulted in her being elected to the American Academy of Arts and Sciences — the only woman to have the honor until 1943, according to Harvard University Library Open Collections Program. Mitchell became a professor of astronomy at Vassar College in 1865, and was also named director of the Vassar College Observatory. She not only made strides for female astronomers when few women were working, but asked for — and received — the same salary as a male professor, according to Vassar College. Using a telescope, she discovered "Miss Mitchell's Comet" (modern designation is C/1847 T1) on October 1, 1847, at 10:30 pm. Some years previously, King Frederick VI of Denmark had established gold medal prizes to each discoverer of a "telescopic comet" (too faint to be seen with the naked eye). The prize was to be awarded to the "first discoverer" of each such comet (note that comets are often independently discovered by more than one person). Maria Mitchell won one of these prizes, and this gave her worldwide fame, since the only previous women to discover a comet were the astronomers Caroline Herschel and Maria Margarethe Kirch. A temporary question of priority existed because Francesco de Vico had independently discovered the same comet two days later, but had reported it to European authorities first; however, this was resolved in Mitchell's favor. The prize was awarded in 1848 by the new king Christian VIII. TELESCOPIC COMETS

Williamina Fleming (May 15, 1857 – May 21, 1911) was a Scottish-American astronomer. During her career, she helped develop a common designation system for stars and cataloged thousands of stars and other astronomical phenomena. Among several career achievements that advanced astronomy Fleming is noted for her discovery of the Horsehead Nebula in 1888. STAR CATALOGUING

Annie Jump Cannon (December 11, 1863 – April 13, 1941) was an American astronomer whose cataloging work was instrumental in the development of contemporary stellar classification. With Edward C. Pickering, she is credited with the creation of the Harvard Classification Scheme, which was the first serious attempt to organize and classify stars based on their temperatures and spectral types. She was nearly deaf throughout her career. She was a suffragist and a member of the National Women's Party. STAR CLASSIFICATION

Antonia Maury (March 21, 1866 – January 8, 1952) was an American astronomer who observed stellar spectra and published an important catalogue of classifications in 1897. As part of this work, she noticed periodic doubling of some lines in the spectrum of Ursae Majoris which led to the publication of the first spectroscopic observation of a binary star system. CHEMICAL COMPOSITION OF STARS (SPECTRAL ANALYSIS)

Henrietta Swan Leavitt (July 4, 1868 – December 12, 1921) was an American astronomer who did extensive work on variable stars. A variable star is a star whose brightness (its magnitude) as seen from Earth fluctuates. This variation may be caused by a change in emitted light or by something partly blocking the light, so variable stars are classified as either:

> *Intrinsic variables*, whose luminosity actually changes; for example, because the star periodically swells and shrinks. *<or>*
> *Extrinsic variables*, whose apparent changes in brightness are due to changes in the amount of their light that can reach Earth; for example, because the star has an orbiting companion that sometimes eclipses it.

She discovered that some of these stars have a consistent brightness no matter where they are located, making these variables a good measuring stick for astronomical distances. (Brighter objects are closer than dimmer objects if one can determine its mass and actual magnitude.) Her work helped American astronomer Edwin Hubble measure galaxy distances in the 1920s, which led to his realization that the universe is expanding.
STAR LUMINOSITY (DETERMINING COSMIC DISTANCES)

Session 3 From Stars to Saturn's Rings

Cecilia Helena Payne-Gaposchkin (May 10, 1900 – December 7, 1979) was a British–American astronomer and astrophysicist who, in 1925, proposed in her Ph.D. thesis an explanation for the composition of stars in terms of the relative abundances of hydrogen and helium. Payne's career marked a turning point at Harvard College Observatory. Under the direction of Harlow Shapley and Dr E. J. Sheridan (whom Payne-Gaposchkin described as a mentor), the observatory had already offered more opportunities in astronomy to women than did other institutions, and notable achievements had been made earlier in the century by Williamina Fleming, Antonia Maury, Annie Jump Cannon, and Henrietta Swan Leavitt. However, with Payne-Gaposchkin's Ph.D., women entered the 'mainstream'. In 1956, she became the first

female professor at Harvard and first female head of the Department of Astronomy. STRUCTURE AND COMPOSITION OF STARS

Nancy Roman (May 16, 1925--December 25, 2018) is an American astronomer who was one of the first female executives at NASA. She is known to many as the "Mother of Hubble" for her role in planning the Hubble Space Telescope. Throughout her career, Roman has also been an active public speaker and educator, and an advocate for women in the sciences. HUBBLE TELESCOPE

Vera Rubin (July 23, 1928 – December 25, 2016) was an American astronomer who pioneered work on galaxy rotation rates. She uncovered the discrepancy between the predicted angular motion of galaxies and the observed motion, by studying galactic rotation curves. This phenomenon became known as the galaxy rotation problem, and was evidence of the existence of dark matter. Although initially met with skepticism, Rubin's results were confirmed over subsequent decades. Her legacy was described by The New York Times as "ushering in a Copernican-scale change" in cosmological theory. Beginning her academic career as the sole undergraduate in astronomy at Vassar College, Rubin went on to graduate studies at Cornell University and Georgetown University, where she observed deviations from Hubble flow in galaxies and provided evidence for the existence of galactic superclusters. Rubin spent her life advocating for women in science and was known for her mentorship of aspiring women astronomers. DARK MATTER

Carolyn Shoemaker (born June 24, 1929) is an American astronomer who once held the record for most comets discovered by an individual. She has found more than 800 asteroids and 32 comets. Additional fame comes from her co-discovery, with husband Gene and David Levy, of Comet Shoemaker-Levy 9 in 1993. The comet was ripped apart by gravitational forces on a near collision with Jupiter in 1992. A string of 21 icy fragments continued in orbit until impacting the planet in 1994, as the world observed from telescopes and the Voyager 2 spacecraft views. Carolyn was co-recipient, with her husband Gene, of the Rittenhouse Medal in 1988 and the Scientists of the Year Award in 1995. She received an honorary doctorate of science from Northern Arizona University of Flagstaff in 1990 and the NASA Exceptional Scientific Achievement Medal in 1996. It's hard to believe these amazing achievements were accomplished by a woman who took up astronomy in 1980, at the age of 51. “QUEEN OF THE COMETS”

Dame Jocelyn Bell-Burnell (born 15 July 1943) is an astrophysicist from Northern Ireland who was credited with "one of the most significant scientific achievements of the 20th Century". As a postgraduate student, she discovered the first radio pulsars in 1967. The discovery was recognized by the award of the Nobel Prize in Physics to her thesis supervisor Antony Hewish and to the astronomer Martin Ryle. Bell was excluded, despite having been the first to observe and precisely analyze the pulsars. PULSARS

6. Margaret Geller (born December 8, 1947) is an American astrophysicist at the Harvard–Smithsonian Center for Astrophysics. Her work has included pioneering maps of the nearby universe, studies of the relationship between galaxies and their environment, and the

development and application of methods for measuring the distribution of matter in the universe. MAPPING THE UNIVERSE

Carolyn Porco (born March 6, 1953) is an American planetary scientist known for her work in the exploration of the outer solar system, beginning with her imaging work on the Voyager missions to Jupiter, Saturn, Uranus and Neptune in the 1980s. She led the imaging science team on the Cassini mission in orbit around Saturn and September 15, 2017 when Cassini was de-orbited to burn up in Saturn's upper atmosphere. She is an expert on planetary rings and the Saturnian moon, Enceladus. She has co-authored more than 110 scientific papers on subjects ranging from the spectroscopy of Uranus and Neptune, the interstellar medium, the photometry of planetary rings, satellite/ring interactions, computer simulations of planetary rings, the thermal balance of Triton's polar caps, heat flow in the interior of Jupiter, and a suite of results on the atmosphere, satellites, and rings of Saturn from the Cassini imaging experiment. Porco has won a number of awards and honors for her contributions to science and the public sphere; for instance, in 2009, New Statesman named her as one of 'The 50 People Who Matter Today.' In 2010 she was awarded the Carl Sagan Medal, presented by the American Astronomical Society for Excellence in the Communication of Science to the Public. And in 2012, she was named one of the 25 most influential people in space by Time magazine. OUTER SOLAR SYSTEM. SATURN.

Session 4 Recent Times

Laura Danly (born July 7, 1958) is an American astronomer and academic. Currently, Danly serves as Curator at Griffith Observatory in Los Angeles. Prior to her current position, she served as chair of the Department of Space Sciences at the Denver Museum of Nature & Science. Previously, Danly held academic posts at the University of Denver (where she served as assistant professor), and at Pomona College (where she served as visiting assistant professor). In these positions, she developed curricula focusing on astronomy, archaeoastronomy, solar physics, astrophotography and astrobiology. Danly spent several years at the Space Telescope Science Institute in Baltimore, Maryland, where she held a variety of positions including project scientist for education, assistant astronomer and Hubble Fellow. As an astronomer, Danly has extensive observational experience, including some 441 hours of ultraviolet observation (much of it via the Hubble Space Telescope). Danly has also completed hundreds of hours of optical and radio observation at such facilities as Kitt Peak National Observatory, McDonald Observatory, Cerro Tololo Inter-American Observatory, and the National Radio Astronomy Observatory. In 1991, Danly founded the Women's Science Forum to encourage young women to pursue careers in science by providing opportunities to meet and ask questions of leading women scientists and engineers and take part in hands-on activities to explore opportunities in various career disciplines. In 1993, Danly co-authored The Baltimore Charter for Women in Astronomy to address the concerns of women as a minority group in the field of astronomy. SCIENCE EDUCATION FOR WOMEN

Jedidah C. Isler is an American astrophysicist, educator, and an active advocate for diversity in STEM. She became the first African-American woman to complete her PhD in astrophysics at Yale in 2014. She is currently an assistant professor of Astrophysics at Dartmouth College. Her research explores the physics of blazars (hyperactive supermassive black holes) and examines the jet streams emanating from them. In November 2020, Isler was named a member of Joe Biden's presidential transition Agency Review Team to support transition efforts related to the National Aeronautics and Space Administration. SUPERMASSIVE BLACK HOLES

Beth Brown (July 15, 1969 – October 5, 2008) was a NASA astrophysicist. She studied astrophysics at Howard University, graduating summa cum laude in 1991. She earned her M.S. in astronomy from the University of Michigan and a Ph.D. from there in 1998. She was the first African-American woman to earn a Ph.D. from the University of Michigan's Department of Astronomy. Her research there concerned X-ray observations of elliptical galaxies. She passed at 39 from a pulmonary embolism. THE STRUCTURE OF GALAXIES

Michelle Thaller (born November 28, 1969) is an American astronomer and research scientist. Thaller is the assistant director for Science Communication at NASA's Goddard Space Flight Center. From 1998 to 2009 she was a staff scientist at the Infrared Processing and Analysis Center, and later Manager of the Education and Public Outreach program for the Spitzer Space Telescope, at the California Institute of Technology. She is a frequent on camera contributor to programming on The History Channel and Science Channel. ASTRONOMY FOR THE MASSES/TELEVISION EDUCATOR

Jill Tarter (born January 16, 1944) is an American astronomer best known for her work on the search for extraterrestrial intelligence (SETI). Tarter is the former director of the Center for SETI Research, holding the Bernard M. Oliver Chair for SETI at the SETI Institute. She currently lectures world-wide. EXTRATERRESTRIAL LIFE

Katherine Johnson. Though not an astronomer in the traditional sense, Katherine Johnson was a trail-blazer in the field of space exploration. Johnson (August 26, 1918 – February 24, 2020) was an American mathematician whose calculations of orbital mechanics as a NASA employee were critical to the success of the first and subsequent U.S. crewed spaceflights. During her 35-year career at NASA and its predecessor, she earned a reputation for mastering complex manual calculations and helped pioneer the use of computers to perform the tasks. The space agency noted her "historical role as one of the first African-American women to work as a NASA scientist". Johnson's work included calculating trajectories, launch windows, and emergency return paths for Project Mercury spaceflights, including those for astronauts Alan Shepard, the first American in space, and John Glenn, the first American in orbit, and rendezvous paths for the Apollo Lunar Module and command module on flights to the Moon. Her calculations were also essential to the beginning of the Space Shuttle program, and she worked on plans for a mission to Mars. In 2015, President Barack Obama awarded Johnson the Presidential Medal of Freedom. In 2016, she was presented the Silver Snoopy Award by NASA astronaut Leland D. Melvin and a NASA Group Achievement Award. She was portrayed by Taraji

P. Henson as a lead character in the 2016 film Hidden Figures. In 2019, at the age of 101, Johnson was awarded the Congressional Gold Medal. TRAJECTORIES

Eleanor Margaret Burbidge, (12 August 1919 – 5 April 2020), was a British-American observational astronomer and astrophysicist. In the 1950s, she was one of the founders of stellar nucleosynthesis and was first author of the influential B2FH paper. During the 1960s and 70s she worked on galaxy rotation curves and quasars, discovering the most distant astronomical object then known. In the 1980s and 90s she helped develop and utilize the Faint Object Spectrograph on the Hubble Space Telescope. Burbidge was well known for her work opposing discrimination against women in astronomy. Burbidge held several leadership and administrative posts, including Director of the Royal Greenwich Observatory (1973–75), President of the American Astronomical Society (1976–78), and President of the American Association for the Advancement of Science (1983). Burbidge worked at the University of London Observatory, Yerkes Observatory of the University of Chicago, the Cavendish Laboratory of the University of Cambridge, the California Institute of Technology, and the University of California San Diego (UCSD). From 1979 to 1988 she was the first director of the Center for Astronomy and Space Sciences at UCSD, where she worked from 1962 until her retirement. She passed at 101 years of age in 2020 just a few weeks after Katherine Johnson.
GALAXIES FAR, FAR AWAY