

= Henrietta Swan Leavitt =

Henrietta Swan Leavitt (July 4 , 1868 ? December 12 , 1921) was an American astronomer who discovered the relation between the luminosity and the period of Cepheid variable stars . A graduate of Radcliffe College , Leavitt started working at the Harvard College Observatory as a " computer " in 1893 , examining photographic plates in order to measure and catalog the brightness of stars . Though she received little recognition in her lifetime , it was her discovery that first allowed astronomers to measure the distance between the Earth and faraway galaxies . She explained her discovery : " A straight line can readily be drawn among each of the two series of points corresponding to maxima and minima , thus showing that there is a simple relation between the brightness of the variables and their periods . " After Leavitt 's death , Edwin Hubble used the luminosity ? period relation for Cepheids together with spectral shifts first measured by fellow astronomer Vesto Slipher at Lowell Observatory to determine that the universe is expanding (see Hubble 's law) .

= = Early years and education = =

Henrietta Swan Leavitt , the daughter of Congregational church minister George Roswell Leavitt and his wife Henrietta Swan (Kendrick) , was born in Lancaster , Massachusetts , a descendant of Deacon John Leavitt , an English Puritan tailor , who settled in the Massachusetts Bay Colony in the early seventeenth century . (The family name was spelled Levett in early Massachusetts records .) She attended Oberlin College , and graduated from Radcliffe College , then called the Society for the Collegiate Instruction for Women , with a bachelor 's degree in 1892 . She studied a broad curriculum including classical Greek , fine arts , philosophy , analytic geometry and calculus . It wasn't until her fourth year of college that Leavitt took a course in astronomy , in which she earned an A ? . She then traveled in America and in Europe during which time she lost her hearing .

= = Career = =

In 1893 , Leavitt began working at the Harvard College Observatory as one of the women human " computers " hired by Edward Charles Pickering to measure and catalog the brightness of stars as they appeared in the observatory 's photographic plate collection . (In the early 1900s , women were not allowed to operate telescopes) . Because Leavitt had independent means , Pickering initially did not have to pay her . Later , she received \$ 0 @. @ 30 an hour for her work . She was reportedly ? hard @-@ working , serious @-@ minded ? , little given to frivolous pursuits and selflessly devoted to her family , her church , and her career . ?

Pickering assigned Leavitt to study " variable stars , " whose luminosity varies over time . According to science writer Jeremy Bernstein , " variable stars had been of interest for years , but when she was studying those plates , I doubt Pickering thought she would make a significant discovery ? one that would eventually change astronomy . " Leavitt noted thousands of variable stars in images of the Magellanic Clouds . In 1908 she published her results in the Annals of the Astronomical Observatory of Harvard College , noting that a few of the variables showed a pattern : brighter ones appeared to have longer periods . After further study , she confirmed in 1912 that the Cepheid variables with greater intrinsic luminosity did have longer periods , and that the relationship was quite close and predictable .

Leavitt used the simplifying assumption that all of the Cepheids within each Magellanic Cloud were at approximately the same distances from Earth , so that their intrinsic brightness could be deduced from their apparent brightness (as measured from the photographic plates) and from the distance to each of the clouds . " Since the variables are probably at nearly the same distance from the Earth , their periods are apparently associated with their actual emission of light , as determined by their mass , density , and surface brightness . "

Her discovery , which she produced from studying some 1 @, @ 777 variable stars recorded on Harvard 's photographic plates , is known as the " period ? luminosity relationship " or " Leavitt 's law

" : The logarithm of the period is linearly , (i.e. , directly) related to the logarithm of the star 's average intrinsic optical luminosity (which is the amount of power radiated by the star in the visible spectrum) . In Leavitt 's words , " A straight line can be readily drawn among each of the two series of points corresponding to maxima and minima , thus showing that there is a simple relation between the brightness of the Cepheid variables and their periods . "

Leavitt also developed and continued to refine the Harvard Standard for photographic measurements , a logarithmic scale that orders stars by brightness over 17 magnitudes . She initially analyzed 299 plates from 13 telescopes to construct her scale , which was accepted by the International Committee of Photographic Magnitudes in 1913 .

= = Influence = =

The period ? luminosity relationship for Cepheids made them the first " standard candle " in astronomy , allowing scientists to compute the distances to galaxies too remote for stellar parallax observations to be useful . One year after Leavitt reported her results , Ejnar Hertzsprung determined the distance of several Cepheids in the Milky Way , and with this calibration the distance to any Cepheid could be accurately determined .

Cepheids were soon detected in other galaxies , such as Andromeda (notably by Edwin Hubble in 1923 ? 24) , and they became an important part of the evidence that " spiral nebulae " are actually independent galaxies located far outside of our own Milky Way . Thus , Leavitt 's discovery would forever change our picture of the universe , as it prompted Harlow Shapley to move our Sun from the center of the galaxy in the " Great Debate " and Edwin Hubble to move our galaxy from the center of the universe .

The accomplishments of the American astronomer Edwin Hubble , who established that the universe is expanding , were also made possible by Leavitt 's groundbreaking research . " If Henrietta Leavitt had provided the key to determine the size of the cosmos , then it was Edwin Powell Hubble who inserted it in the lock and provided the observations that allowed it to be turned , " wrote David H. and Matthew D.H. Clark in their book *Measuring the Cosmos* . To his credit , Hubble himself often said that Leavitt deserved the Nobel Prize for her work . Gösta Mittag @-@ Leffler of the Swedish Academy of Sciences tried to nominate her for that prize in 1924 , only to learn that she had died of cancer three years earlier (The Nobel Prize is not awarded posthumously) . Though she was paid only \$ 10 @.@ 50 per week , her discovery of a way to accurately measure distances on an inter @-@ galactic scale paved the way for modern astronomy ? s understanding of the structure and scale of the universe .

= = Illness and death = =

Leavitt worked sporadically during her time at Harvard , often sidelined by health problems and family obligations . An illness contracted after her graduation from Radcliffe College rendered her increasingly deaf . In 1921 , when Harlow Shapley took over as director of the observatory , Leavitt was made head of stellar photometry . By the end of that year she had succumbed to cancer , and was buried in the Leavitt family plot at Cambridge Cemetery in Cambridge , Massachusetts .

" Sitting at the top of a gentle hill , " writes George Johnson in his biography of Leavitt , " the spot is marked by a tall hexagonal monument , on top of which (cradled on a draped marble pedestal) sits a globe . Her uncle Erasmus Darwin Leavitt and his family are also buried there , along with other Leavitts " A plaque memorializing Henrietta and her two siblings Mira and Roswell is mounted on one side of the monument . Nearby are the graves of Henry and William James . There is no epitaph at the gravesite memorializing Henrietta Leavitt 's achievements in astronomy .

Leavitt was a member of Phi Beta Kappa , the American Association of University Women , the American Astronomical and Astrophysical Society , the American Association for the Advancement of Science , and an honorary member of the American Association of Variable Star Observers . Her early death was seen as a tragedy by her colleagues for reasons that went beyond her scientific achievements . In an obituary her colleague , Solon I. Bailey , noted that " she had the happy faculty

of appreciating all that was worthy and lovable in others , and was possessed of a nature so full of sunshine that , to her , all of life became beautiful and full of meaning . "

= = Awards and honors = =

The asteroid 5383 Leavitt and the crater Leavitt on the Moon are named after her to honor deaf men and women who have worked as astronomers .

Unaware of her death four years prior , the Swedish mathematician Gösta Mittag @-@ Leffler considered nominating her for the 1926 Nobel Prize in Physics , and wrote to Shapley requesting more information on her work on Cepheid variables , offering to send her his monograph on Sofia Kovalevskaya . Shapley replied , let Mittag @-@ Leffler know that Leavitt had died , and suggested that the true credit belonged to his (Shapley 's) interpretation of her findings . She was never nominated , because the Nobel Prize is not awarded posthumously .

= = Books and plays = =

Lauren Gunderson wrote a play , Silent Sky , which followed Leavitt 's journey from her acceptance at Harvard to her death .

George Johnson wrote a biography , Miss Leavitt 's Stars , which showcases the triumphs of women 's progress in science through the story of Henrietta Swan Leavitt .

Robert Burleigh wrote the biography Look Up ! : Henrietta Leavitt , Pioneering Woman Astronomer for a younger audience . It is ideal for 4 @-@ 8 year olds. [http : / / books.simonandschuster.com / Look @-@ Up ! / Robert @-@ Burleigh / 9781416958192](http://books.simonandschuster.com/Look-Up!/Robert-Burleigh/9781416958192)

= = Additional resources = =