The Herschels and their Astronomy

> Mary Kay Hemenway 24 March 2005

outline

- William Herschel
- Herschel telescopes
- Caroline Herschel
- Considerations of the Milky Way
- William Herschel's discoveries
- John Herschel

Wm. Herschel (1738-1822)



Miniature portrait from 1764

- Born Friedrich Wilhelm Herschel in Hanover, Germany
- A bandboy with the Hanoverian Guards, later served in the military; his father helped him to leave Germany for England in 1757
- Musician in Bath
- He read Smith's *Harmonies*, and followed by reading Smith's *Optics* it changed his life.

Discovery of Uranus 1781

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- William Herschel used a seven-foot Newtonian telescope
- "in the quartile near zeta Tauri the lowest of the two is a curious either Nebulous Star or perhaps a Comet"
- He called it "Georgium Sidus" after his new patron, George III.
- Pension of 200 pounds a year and knighted, the "King's Astronomer" -now astronomy full time.

Sir William Herschel



- Those who had received a classical education in astronomy agreed that their job was to study the sun, moon, planets, comets, individual stars.
- Herschel acted like a naturalist, collecting specimens in great numbers, counting and classifying them, and later trying to organize some into life cycles.
- Before his discovery of Uranus, Fellows of the Royal Society had contempt for his ignorance of basic procedures and conventions.

Isaac Newton's reflecting telescope 1671



William Herschel's 20-foot, 1783



18.4-inch speculum metal mirror

Account of some Observations tending to investigate the Construction of the Heavens

Philosophical Transactions of the Royal Society of London (1784) vol. 74, pp. 437-451

In a former paper I mentioned, that a more powerful instrument was preparing for continuing my reviews of the heavens. The telescope I have lately completed, though far inferior in size to the one I had undertaken to construct when that paper was written, is of the Newtonian form, the object speculum being of 20 feet focal length, and its aperture 18 7/16 inches. The apparatus on which it is mounted is contrived so as at present to confine the instrument to a meridional situation, and by its motions to give the rightascension and declination of a celestial object in a coarse way; which, however, is sufficiently accurate to point out the place of the object, so that it may be found again....

Other telescopes

The national observatory of Spain was founded by the king in 1790 with transit instruments and clocks; two Wm Herschel reflectors were ordered in 1796. This is the assembly watercolor that Herschel sent with the 25-foot (2-ft mirror) in 1802. The telescope was destroyed by Napoleonic troops in 1808.



Herschel, by 1795, built 200 7-ft, 150 10-ft, and 80 20-ft mirrors. His largest was the 40-ft (49.5 inch mirror).

William Herschel's 20-foot



Looking inside the tube as reconstructed by William and his son John in 1820. On applying the telescope to a part of the via lactea, I found that it completely resolved the whole whitish appearance into small stars, which my former telescopes had not light enough to effect. The portion of this extensive tract, which it has hitherto been convenient for me to observe, is that immediately about the hand and club of Orion. The glorious multitude of stars of all possible sizes that presented themselves here to my view was truly astonishing; but, as the dazzling brightness of glittering stars may easily mislead us so far as to estimate their number greater than it really is, I endeavoured to ascertain this point by counting many fields, and computing, from a mean of them, what a certain given portion of the milky way might contain.

How to observe

The telescope's eyepiece was mounted at the top of the tube, so Herschel observed from a platform that could be raised or lowered as needed. Caroline sat inside the house nearby at an open window, recording her brother's observations as he called them down to her. Of his nights at the telescope, Herschel wrote, "*Here an observer may sit for many hours, with constant entertainment, continually expecting new objects to present themselves, which he never could have perceived in common telescopes.*" The work wasn't always so pleasant. Herschel observed whenever possible, sometimes even in bitter cold. One night, while using an earlier telescope, the temperature dropped to -12 °C (11 °F). His ink froze in its bottle and his best mirror "crack'd into two piece."

Quote from National Air and Space Museum.

Caroline Lucretia Herschel (1750-1848)

Cinderella of her family

8th of 10 children
Not taught arithmetic or French, or needlework, or music

•Served as her mother's housemaid until rescued by her brother (1771) who was to give her music lessons.

•She wanted to sing, but became his assistant.



Caroline Lucretia Herschel (1750-1848)

Initially as William's assistant, she noted measurements, ground telescope mirrors, and carried out calculations on astronomical data, on top of running the household.

In 1782 William gave her a small telescope and she began 'comet hunting'. In her sweeps of the sky she discovered eight comets. She also updated Flamsteed's star catalog.



Caroline's letter

Summer 1774: ...my time was so taken up with copying Music and practising, besides attendance on my Brother when polishing, that by way of keeping his alife I was even obliged to feed him by putting the Vitals by bits into his mouth; -- this was once the case when at the finishing of a 7 feet mirror he had not left his hands from it for 16 hours altogether. And in general he was never unemployed at meals, but always at the same time contriving or making drawings of whatever came into his mind. And generally I was obliged to read to him when at some work which required no thinking; and sometimes lending a hand, I became in time as useful a member of the workshop as a boy might be to his master in the first year of his apprenticeship.

Caroline Herschel

In 1782 William gave her a small telescope and she began 'comet hunting'. In her sweeps of the sky she discovered eight comets.



catalog work

- As her brother observed, she wrote down the observations.
- She used John Flamsteed British Catalogue's 3000 stars (organized by constellation) and indexed it (from the sweeps), finding errors and adding stars.
- When William married in 1788, she received a pension from the king to be her brother's assistant (first paid woman astronomer)
- After William's death, she moved to Hanover and finished the catalogs for John's use

Caroline Herschel

Not eligible for Royal Society Membership, they gave her a gold medal in 1828 for completing Wm's observing logs.





Aunt Caroline at 83

She runs about the town with me, and skips up her two flights of stairs. In the morning until eleven or twelve she is dull and weary, but as the day advances she gains life, and is quite "fresh and funny" at two o'clock P.M., and sings old rhymes, nay even dances! to the great delight of all who see her.

Brightness of stars

- Greeks used 1st magnitude for the brightest stars and 6th for the faintest stars; 5 magnitudes is a factor of 100 in brightness. Herschel helped define the magnitude scale as powers of 2.512
- Does the apparent brightness of a star indicate its distance or intrinsic brightness? Those who thought it indicated distance wanted to use stars of different magnitude that were near each other on the sky to find parallax - thinking the brighter one would move with respect to the stationary distant star.
- William Herschel wrote *Cataloges of the Comparative Brightnesses* of the Stars. Each major star in a given constellation was compared to neighboring stars.

Stars that change position

- Aberration of starlight
- Proper motion
- Parallax

Early theories of the Milky Way



Chinese The seventh Princess of Heaven fell in love with a poor herdsman and ran away to marry him. When her mother sent soldiers to bring her home, the herdsman chased them away. Seeing her daughter's husband running, the mother dropped a silver pin to make a silver stream to separate the lovers forever. Eventually, her father allowed her to have an annual reunion with her husband black birds escorted her across the stream. The Milky Way is that silver stream. The young lovers are the stars Vega and Altair on either side of it.



Early theories of the Milky Way

• Navajo When the world was created, the people gathered around Black God to place stars in the sky. Coyote was frustrated by how long it was taking. He threw the bag of stars over his head, forming the Milky Way.

- Egyptian The goddess Isis spread large quantities of wheat across the sky. We see this bounty as the Milky Way.
- Polynesian a long, blue, cloud-eating shark.
- Eskimo a band of snow
- Arabs a river

• **Greek** The Milky Way is along the circular path where the Sun once moved across the sky. It looks different than the rest of the sky because the Sun scorched it.

African Bushmen The Milky Way is made of the ashes of campfires



More early theories

- Aristotle Milky Way below the orbit of the moon (i.e., subject to change); a dry exhalation from marshy regions of Earth.
- Copernicus main interest in the sun with distant star sphere
- Thomas Digges infinite universe, but ignores Milky Way
- **Kepler** Milky Way was the substance from which novae of 1604 and 1572 emerged.
- **Tycho** Milky Way and comets made of the same substance.

How the telescope changes theories

- Galileo "Starry Messenger" said Milky Way is full of stars (12 lines in a book of 60 pages)
- Thomas Wright (1711-1786) An Original Theory Or New Hypothesis of the Universe is a philosophical book
 - Our Milky Way is merely one among many in the universe
 - It appears as a bright band in the sky because it is a flattened layer of stars, at least in our neighborhood.
 - Each Milky Way is concentric to its own supernatural center.

An Original Theory Or New Hypothesis of the Universe

Stars near enough to be seen by us form a small segment of a vast spherical system whose radius is so great that the boundaries of the segment approximate to parallel planes. At A an observer sees only a handful of nearby stars when looking towards **B** or **C**, but milkiness when looking towards **D** or **E**.



D

Immanuel Kant (1724-1804)

• Kant in (1755) a thin book called *Cosmogony*. mused on the meaning of the Milky Way. Kant recognized that the Milky Way represented the disk-like structure of a vast swarm of stars - all orbiting some common center or centers in a manner very similar to the planets orbiting around the sun. (He didn't realize that Wright left the center empty because the Divine Center was there.)

 Kant went on to speculate on the vastness of the universe.

 He used the term "island universe" to describe the fuzzy patches.

Wm. Herschel's Star gages



In one 3° x 8° region, he counted 44,000 stars. He counted 683 regions. This pioneered the use of statistics in astronomy. "Various methods may be pursued to come to a full knowledge of the sun's place in the sidereal stratum, of which I shall only mention one as the most general and most proper for determining this important point, and which I have already begun to put in practice. I call it Gaging the Heavens, or the Star-Gage.

It consists in repeatedly taking the number of stars in ten fields of view of my reflector very near each other, and by adding their sums, and cutting off one decimal on the right, a mean of the contents of the heavens, in all the parts which are thus gaged, is obtained.... "

Wm. Herschel's assumptions

- all fuzzy little objects are resolvable into clusters of stars
- our sun is part of a similar cluster of stars
- stars in our cluster are roughly the same brightness
- (variations in brightness are due to variations in distance)
- stars in our cluster are distributed uniformly
- (thickness of the cluster in any given part of the sky can be deduced from the numbers of stars)
- we can see to the edge of our cluster

Account of some Observations tending to investigate the Construction of the Heavens Herschel in Philosophical Transactions of the Royal Society of London (1784) vol. 74, pp. 437-451

It is very probable, that the great stratum, called the milky way, is that in which the sun is placed, though perhaps not in the very center of its thickness. We gather this from the appearance of the Galaxy, which seems to encompass the whole heavens, as it certainly must do if the sun is within the same.

For, suppose a number of stars arranged between two parallel planes, indefinitely extended every way, but at a given considerable distance from each other; and, calling this a sidereal stratum, an eye placed somewhere within it will see all the stars in the direction of the planes of the stratum projected into a great circle, which will appear lucid on account of the accumulation of the stars; while the rest of the heavens, at the sides, will only seem to be scattered over with constellations, more or less crowded, according to the distance of the planes or number of stars contained in the thickness of sides of the stratum....



flat "grindstone" of stars with the sun situated roughly at the center

On the Construction of the Heavens William Herschel *Philosophical Transactions of the Royal Society of London* (1785) vol. 75, pp. 213-266

[I]f we would hope to make any progress in an investigation of this delicate nature, we ought to avoid two opposite extremes, of which I can hardly say which is the most dangerous. If we indulge a fanciful imagination and build worlds of our own, we must not wonder at our going wide from the path of truth and nature; but these will vanish like the Cartesian vortices, that soon gave way when better theories were offered.

On the other hand, if we add observation to observation, without attempting to draw no only certain conclusions, but also conjectural views from them, we offend against the very end for which only observations ought to be made. I will endeavour to keep a proper medium; but if I should deviate from that, I could wish not to fall into the latter error....



I shall now proceed to shew that the stupendous sidereal system we inhabit, this extensive stratum and its secondary branch, consisting of many millions of stars, is, in all probability, *a detached Nebula*....

[I]t is ... to be hoped that in some future time this branch of astronomy will become more cultivated, so that we may have gages for every quarter of a degree of the heavens at least, and these often repeated in the most favourable circumstances.... I look upon what is here given partly as only an example to illustrate the spirit of the method.

From this figure however, which I hope is not a very inaccurate one, we may see that our nebula, as we observed before, is of the third form; that is: *A very extensive, branching, compound Congeries of many millions of stars*; which most probably owes its origin to many remarkably large as well as pretty closely scattered small stars, that may have drawn together the rest....

As we are used to call the appearance of the heavens, where it is surrounded with a bright zone, the Milky-Way, it may not be amiss to point out some other very remarkable Nebulæ which cannot well be less, but are probably much larger than our own system; and, being also extended, the inhabitants of the planets that attend the stars which compose them must likewise perceive the same phænomena. For which reason they may also be called milky-ways by way of distinction....

Catalogue of a second Thousand Nebulæ and Clusters of Stars; with a few introductory Remarks on the Construction of the Heavens

Philosophical Transactions of the Royal Society (1789) vol. 79, pp. 212-255

The method I have taken of analyzing the heavens, if I may so express myself, is perhaps the only one by which we can arrive at a knowledge of their construction. In the prosecution of so extensive an undertaking, it may well be supposed that many things must have been suggested, by the great variety in the order, the size, and the compression of the stars, as they presented themselves to my view, which it will not be improper to communicate....

[B]y my analysis it appears, that the heavens consist of regions where suns are gathered into separate systems, ...

Wm. Herschel's later results

- earlier observations had not revealed the edge of our cluster after all
- some fuzzy little objects remained unresolvable.
 Discovery of a planetary nebula in 1790 (nebula plus star) made him change his theory. He thought it was a pre-stellar stage in a star's life.
- Do some objects appear fuzzy because they are made of fluid or gas, or are they clusters?

Wm. Herschel: other research

- In 1786, Herschel published a catalogue of 1,000 nebulae.
 - In 1789, he added another thousand to the list.
 - In 1802, the third and final catalogue of 500 nebulae.
- Eventually, catalogs of 2,500 nebulae and star clusters plus 849 double stars
- Four moons: Titania, Oberon (1787), Mimas, Enceladus (1789)
- He discovered, using proper motion, solar motion towards Hercules.
- He discovered infrared radiation



Philosophical Transactions of the Royal Society 1811



John Frederick William Herschel 1792-1871



Eton - age 8 St John's College Cambridge (1809-1813) with first place in math Fellow of Royal Society, 1813 Studied law

John Herschel

He wrote on 10 October 1816 to Babbage-

I shall go to Cambridge on Monday where I mean to stay just enough time to pay my bills, pack up my books and bid a long - perhaps a last farewell to the University. ... I am going under my father's directions, to take up the series of his observations where he has left them (for he has now pretty well given over regular observing) and continuing his scrutiny of the heavens with powerful telescopes ...

John Herschel's and M 51





Flipped image from PFC, 1997



John Herschel

His 1833 catalog (done with Caroline's help) listed 2306 nebulae, as well as double stars. He had re-observed all the sky accessible to him.

Married Margaret Steward in 1829 - 12 children. Lost election as Royal Society president in 1833, he went to South Africa with 20-ft telescope and continued his father's catalogs. Cape Town 1834-1838.

John Herschel with the 20-inch Feldhausen, South Africa 1833



Herschel's catalog

Finished catalog (*Results of Astronomical Observations Made During the Years 1834, 5, 6, 7,8 at the Cape of New Hope*) in 1847. (Sent to Caroline with note, "You...have in your hands the completion of my father's work." (She was 97.)

- Over 1700 nebulae and clusters
- Over 2700 double stars
- Thousands of star counts, including extensive sequences of comparative brightness

Only astronomer in history to systematically examine entire sky with a major telescope

John's poem (1857)

To thee, fair Science, long and early loved, Hath been of old my open homage paid; Nor false, nor recreant have I ever proved, Nor grudged the gift upon thy alter laid. And if from thy clear path my foot have strayed, Truant awhile, - 'twas but to turn, with warm And cheerful haste; while thou didst not upbraid, Nor change thy guise, nor veil thy beauteous form, But welcomed'st back my heart with every wonted charm.

The "truant" refers to the four years of public service as Master of the Mint - which ended when he had a nervous breakdown. He spent the rest of his life compiling catalogs of celestial objects.

Portrait of Sir John Herschel

- Artist: Julia Margaret Cameron
- Artist's Lifespan: 1815-1879
- **Title:** Portrait of Sir John Herschel
- **Date:** 1867
- Location of Origin: England
- Medium: Photography
- Genre: Portrait
- **Commentary:** Albumen on wet collodion photograph.



References

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