David Gill: The Third Bruce Medalist

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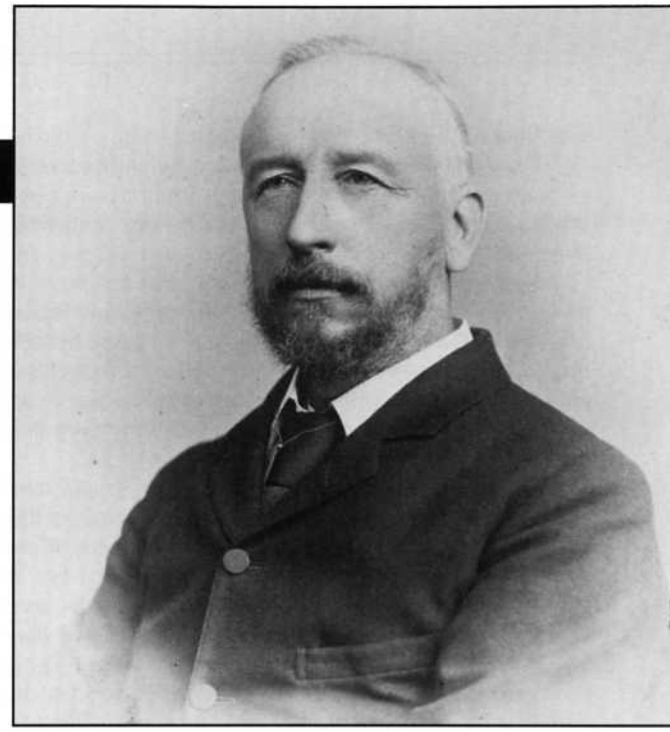

David Gill
12 June 1848 — 24 January 1914
1900 Bruce Medalist

(Photograph 1896, courtesy of the Mary Lea Shane Archives of the Lick Observatory, University of California, Santa Cruz)

As a young man David Gill showed little evidence that he would eventually win six medals for contributions to astronomy. He had but two years of college in Aberdeen, Scotland, where he was greatly influenced by his science teachers, among them James Clerk Maxwell. But by then his father was 71, and Gill was called upon to end his formal education, and as eldest son, prepare to take over the prosperous watch and clock-making business in Aberdeen begun by his grandfather.

During his decade in business Gill was known as an avid marksman and an amateur astronomer. He restored an old transit telescope in order to establish accurate time for Aberdeen, and he bought a 12-inch reflecting telescope and built its mount and clock drive. His excellent photographs of the moon brought him to the attention of the wealthy young Lord Lindsay. In December 1871 the 24-year-old Lindsay persuaded his father to build him a lavish observatory near Aberdeen, and to hire Gill, 28, to create, equip, and direct it. After consulting with his bride, whose reaction was, "How glorious!" Gill accepted, even though it meant a substantial diminution in income.

During four years as a privately-employed astronomer, Gill consulted with most of the prominent astronomers on the Continent, traveled tens of thousands of miles, and became probably the world's most expert user of the heliometer[1]. During this period he began what was to be his great life's work, the measurement of the fundamental distance scale of the solar system. While *relative* distances for the known bodies had been worked out from an understanding of Kepler's and Newton's laws, it was much more difficult to find a *real* distance to calibrate the scale model that had been established. What was required was a "surveyor's triangulation" of some object such as a nearer planet or asteroid, a measurement that had challenged Edmond Halley and other astronomers over the years.

The search for the distance scale of the solar system could be summarized as the measurement of the *astronomical unit* (AU), the distance from the Earth to the Sun. One path to the AU involved measuring the time the planet Venus takes to move across (transit) the face of the Sun as seen from the Earth. In 1874, Gill carried fifty chronometers to the island of Mauritius in the Indian Ocean to make such transit measurements. All of the expeditions failed, because it was too difficult to determine just when the dark planet made its "contacts" with the Sun. Gill, using Lindsay's four-inch heliometer, achieved greater precision by observing the tiny shifts in position of the minor planet Juno between evening and morning.[2]

Upon returning to Britain, Gill, rapidly becoming a well-known astronomer in his own right, amicably parted from Lindsay and mounted his own expedition to Ascension Island in the Atlantic to determine the solar parallax by observations of Mars during its close approach to Earth. This difficult trip, funded by the Royal Society and the Royal Astronomical Society, led to the Gills camping in a tent for six months on the rugged volcanic island, to a book by Mrs. Gill, and to the first two of Gill's medals.[3] But by the time they were awarded in 1882, Gill was a full-fledged professional astronomer.

In 1879, while reducing his observations of Mars, Gill had applied for the position of Radcliffe Observer at Oxford. He didn't get it, but he was appointed to succeed the successful applicant as Her

1. A heliometer was an instrument used for measuring the separation of two celestial objects or the slight motion of an object against the background of "fixed" stars with great precision. It used a lens cut in half; the two parts could be moved relative to one another and the displacement measured using an accurate screw.

2. To be precise, what Gill actually measured was the *solar parallax*, the angle subtended by the Earth's equatorial radius as seen from the Sun. The astronomical unit equals the Earth's radius times 360 degrees divided by the solar parallax.

3. For more on Gill's work on Ascension Island, see the article "Sir David Gill and the Measurement of the Astronomical Unit" by Jacqueline Mitton in the Sep/Oct. 1980 issue of *Mercury*.

Majesty's Astronomer at the Cape of Good Hope. Now his real work began.

In his 27 years at the Cape Observatory, Gill made it by far the most important observatory in the southern hemisphere. His achievements were manifold. He directed geodetic surveys, triangulating distances through most of the southern part of Africa. One goal was to determine directly the length of most of a meridian of longitude, from northern Europe to southern Africa. These measurements determined the latitude and longitude of numerous places, helped determine boundaries of African territories, and aided in the determination of the shape of the Earth.

With Lord Lindsay's 4-inch heliometer, which he personally purchased, and later with a magnificent 7-inch, which he persuaded the British Admiralty to fund and which he designed, Gill measured positions of minor planets with increasing precision to determine the solar parallax. He took incredible pains to eliminate possible sources of error, until his value of 8.80 arc seconds was adopted by Simon Newcomb[4] and by the world. It was used in preparing nautical almanacs until 1968, when it was replaced by 8.794, the result of radar observations of planetary distances.

The first systematic, precise group of stellar parallaxes (which gave the distances to other stars) were measured under Gill's supervision. He was able to obtain distances of 22 southern stars.

As his biographer George Forbes points out, all of these measurements could be related: The geodetic triangulations related the dimensions of the Earth directly to the meterstick which Gill had personally calibrated at the home of the international standard meter in Paris. The astronomical unit was related directly to the size of the Earth by the heliometer observations of minor planets. And the parallax measurements gave the distances of the nearby stars in terms of the astronomical unit. "Thus, without any extraneous help, *he measured the distances of the stars with the Paris standard metre*." [5]

Enormous strides were made in the instrumentation required for such work during Gill's lifetime. Not only was Gill an expert engineer, who could design instruments of great precision, but he was also extremely successful in persuading his superiors in London to come through with the necessary funding. Besides the heliometer, he designed an innovative reversible transit instrument of unprecedented precision, and several other instruments as well. Thanks to a windfall gift by a British amateur astronomer, he put into use a double refracting telescope (24-inch photographic and 22-inch visual) named the Victoria telescope in honor of the Queen's jubilee.

In designing the new transit circle, Gill took account of personal errors varying with the magnitude of the star, errors depending on whether the star crossed the wires from left to right or from right to left, errors caused by temperature changes affecting the levels of the piers on which the instrument rested, even errors caused by local heating from the observer's body. He greatly departed from conventional design to eliminate or reduce these errors. He dug pits down to bedrock and placed marks on the rock which were used to determine possible shifts of the telescope from the north-south line. The results were precise enough to improve the knowledge of the Moon's mass and to measure the minute wanderings of the Earth's axis.

His analysis of probably errors was based on a simple philosophy, which he summarized in a letter he wrote on Jan. 18, 1885 to Jacobus C. Kapteyn :

> "But however perfect an instrument may be (and it is the astronomer's business to see that it is perfect), it is the astronomer's further business to look upon it with complete and utter mistrust."

Perhaps the best known of Gill's achievements has to do with the introduction of photography for mapping the sky and the separation of observation from reduction. The appearance of the Great Comet of 1882 inspired Gill to enlist the aid of a local portrait photographer who mounted his 2 1/2-inch lens on a 6-inch telescope for guiding. The comet photos were excellent, but more important was the background. In Gill's words, "I drew particular attention to the large number of stars shown upon the plate, and insisted upon the importance of the means thus offered to photograph comparatively large areas of the sky and thus rapidly make charts of the entire heavens."

Gill, possibly the most precise visual observer of all time, became a powerful advocate of astrophotography. Similar conclusions were reached by the brothers Paul and Prosper Henry at Paris, and Gill played a significant role in the 1887 Astrographic Congress called by the Paris Observatory director, Admiral E. B. Mouchez, to enlist most of the world's astronomers in a coordinated plan to photograph and catalog the entire sky. (This project, known as the *Carte du Ciel* or *Astrographic Catalogue*, has been blamed by some for keeping most of the world's astronomers doing "busy work" while those who declined to participate, notably the Americans, were making breakthroughs in astrophysics.) [6]

In 1885, shortly after beginning to photograph the sky for a southern atlas Gill was surprised to receive a letter from Kapteyn in the Netherlands:

> ". . . I will make bold to make and explain to you a proposal that I hope you will not deem indelicate....If you will confide to me one or two of the negatives I will try my hand at them, and if the result proves as I expect I would gladly devote some years of my life to this work which would disburden you a little as I hope and by which I would gain the honour of associating my name to one of the grandest undertakings of our time."

The *Cape Photographic Durchmusterung* helped Kapteyn make statistical studies of the distribution of stars and to discover "star-streaming," a precursor to the later discovery of galactic rotation.

Unlike some of his contemporaries, Gill appears to have been well-liked by nearly all of his colleagues. He worked closely with Newcomb, Auwers, and Kapteyn. He provided hospitality and instruction to W. L. Elkin, later director at Yale, to Willem de Sitter, who computed the motions of the Jupiter system at the Cape before achieving fame for cosmological work in the Netherlands, and to historian of astronomy Agnes Clerke. In his retirement years in London, Gill was active in the Royal Astronomical Society and Royal Society, where he was close to younger astronomers such as Arthur Stanley Eddington. He completed his monumental *History and Description of the Cape Observatory* shortly before his death. ■

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4. For more on the work and reputation of Simon Newcomb, see the first of the Bruce Medalist profiles in the Jan/Feb. 1990 issue of *Mercury*.

5. See *David Gill, Man and Astronomer* by George Forbes (1916, John Murray).

6. For more on this controversy, see: J. Lankford, "The Impact of Photography on Astronomy" in *Astrophysics and 20th Century Astronomy to 1950*, O. Gingerich, editor (1984, Cambridge U. Press.)