Erwin Finlay Freundlich

German astronomer and mathematician **Erwin Finlay Freundlich** (May 29, 1885 – July 24, 1964) made observations of the motion of Mercury that differed from Newtonian predictions and helped convince the scientific community of the validity of Einstein's relativity theory. Freundlich was born in Biebrich, Germany, the son of a German businessman and his British wife. He was educated in Wiesbaden and upon completing his school studies in 1903 went to work in the dockyards at Stettin. He entered the Technische Hochschule of Charlottenburg with the intention of making a career in naval architecture. A heart condition interrupted his schooling and after his recovery he entered the University of Göttingen to study mathematics, physics, and astronomy. He earned a doctorate in mathematics in 1910 with a thesis on analytic function theory supervised by Felix Klein. Following Klein's suggestion Freundlich applied for and received a post as an assistant at the Royal Observatory in Berlin.

Due to Freundlich's reputation for very accurate astronomical measurements, Einstein sought him to confirm his general theory of relativity. Freundlich worked with Einstein, making measurements of Mercury's orbit, seeking and finding evidence that the orbit of Mercury did not fit that predicted by Newton's theory of gravitation. Despite warnings from the Director of the Berlin Observatory about supporting the idea that Newton's long cherished theory could be wrong, Freundlich published his results. To validate Einstein's theory, Freundlich needed to measure the deflection in a light ray passing close to the sun. This required an expedition to somewhere within the path of totality of an eclipse to occur in 1914. Freundlich convinced a member of the Krupp family of industrialists to finance the trip. Unfortunately, while in the Crimea for the eclipse, WWI broke out and Freundlich was briefly interned

as a suspected spy before being allowed to return to Berlin without having made his measurements.

In 1916, following Einstein's publication of the general theory of relativity, Freundlich published *Grundlagen der Einsteinschen Gravitationstheorie*, in which he discussed the ways that the general theory of relativity could be tested by astronomical observations. Arthur Stanley Eddington's observations of star positions during the solar eclipse of 1919, which demonstrated the bending of light by gravity, provided some of the best evidence in support of Einstein's amended theory of relativity. In 1918, Freundlich resigned from the Observatory to work full-time with Einstein. Freundlich was appointed an observer at the newly created observatory of the Einstein Institute in Potsdam and later was named chief observer and professor of astrophysics. The Solar Observatory Einsteinturm (Einstein Tower) is the outer wrap of a telescope to observe the Sun. Standing 16 meters high the observatory was designed by the famous architect Erich Mendelsohn, and was constructed during the years 1921–24. Due to the incredible inflation in Germany during the construction, the original plan for reinforced concrete was abandoned, and the tower was built in brick covered in plaster. The financing was dependent on private donation. The Tower was severely damaged during a bomb attack on Potsdam in 1945, and it was quite a time after the war before it was repaired and could be used again. Originally the telescope was built to prove that the lines in the spectrum of the Sun should be shifted due to its large gravitation.

Einstein had the highly original ideas and it was his Freundlich's job to check them. When Freundlich confessed he was not always able to understand Einstein's mathematical formulations, the latter sought to simplify them, reasoning if a student of Felix Klein had trouble understanding his equations, who else would be able to make sense of them? Freundlich made three more expeditions to observe an eclipse and make measurements. The first two, in 1922 and 1923, were unsuccessful when the weather didn't cooperate. Finally in 1929, in Sumatra, he observed a solar eclipse, enabling him to make the

desired measurements, but his tests of the general theory were inconclusive. At the time Freundlich made his observations, the gravitational redshift could not be proven, because the outer layers of the Sun are in turbulent motion producing a variety of line shifts as well. His tests showed that the deflection of light was more than predicted by Einstein's theory. Unable to accept the recessional velocity interpretation as the source of the galaxy redshifts, Freundlich published his speculations on these data and spent the rest of his life defending his controversial position.

Einstein, who like most scientists of the time believed the universe was a static body, introduced an anti-gravity constant, known as the cosmological constant into his equations dealing with the universe. He would later confess this was "the biggest blunder" of his life. Two hundred years earlier, Isaac Newton puzzled over how the universe could be static, because his law of gravity required that masses attract each other. Then why didn't all objects in a static universe fall together into a massive "central lump?" Newton wondered but did not pursue the question of whether there might be a large-scale outward motion of the universe to counter the inner force. In 1929 Edwin Hubble reported that distant galaxies had red shifts proportionate to their distances. The visible color spectrum ranges from the low-frequency red, orange, and yellow, to the higher frequency green, blue, indigo, and violet. Using the Doppler effect, astronomers measure the speed at which stellar objects are traveling, rotating, or revolving. As one section of a stellar object turns toward the Earth, the other side rotates away from the Earth. Therefore the frequency of light emitted from the side moving toward the Earth gets higher, resulting in a blue shift. The light from the side spinning away for the Earth produces a lower frequency, called a red shift. The red shift causes lines in the spectra of galaxies to be shifted toward the red end of the spectrum. More distant galaxies have greater red shifts than nearer galaxies. A strong gravitational field can also produce a red shift in light; this is termed gravitational red shift. Because red shifts can be caused by motion of an object away from the observer, Hubble concluded that galaxies are receding from the Milky Way. This became the cornerstone of the theories of an expanding

universe.

When Hitler came to power in 1933, Freundlich realized that his family would have trouble under Nazi rule, because his wife Käte Hirschberg, who he married in 1913, was Jewish. Reluctantly he resigned his position at Potsdam and moved to Turkey, where he helped create a modern observatory at Istanbul. He returned to Europe in 1937 accepting a position at the Charles University of Prague. By 1939, Nazi policies in conquered Czechoslovakia forced him to escape to Holland, which soon also proved not unsafe. He accepted an offer from the University of St. Andrews in Scotland to create a department of astronomy and organize the construction of an observatory. Freundlich became the Napier Professor of Astronomy in St. Andrews in 1951, and retired from the post in 1959. Freundlich left Scotland for Wiesbaden where he was appointed honorary professor at the University of Mainz. He died at the age of 79.

Quotation of the Day: " … Freundlich was very close to me. He was a fatherly friend of whom I have many fond memories … during the war Freundlich and I taught navigation at the Initial Training Wing of the RAF which was stationed in St. Andrews. We also published a joint paper in the Monthly Notices of the Royal Astronomical Society in 1944…. he was a tall impressive man, and when we walked side by side through the streets of St. Andrews people would say: "Here come the Sun and Moon." – Walter Ledermann