SCIENCE AND CULTURE

VOLUME 85 ❑ MARCH-APRIL 2019 ❑ NOS. 3–4

EDITORIAL

ECLIPSE, EDDINGTON AND EINSTEIN

The solar eclipse that occurred on May 29, 1919 and was observed by a group of British scientists revolutionized our understanding of the physical universe. It was Arthur Eddington who first showed that light rays from distant stars bend by the gravitational field of the sun, confirming Einstein's prediction from the General Theory of Relativity that light rays should bend while passing by a massive object. Einstein was so excited on hearing the news that he wrote a postcard to his mother: "Dear Mother, Good news today. H.A. Lorentz telegraphed me that the British expeditions have definitely confirmed the deflection of light by the Sun." This editorial is to commemorate the centenary of this epoch making experiment which helped us come out of captivity of more than two hundred years in the framework of Newtonian universe.

However, it is not true that no one before Einstein thought of the possibility that light could be bent by gravity. In fact, it was no other than Newton himself who reasoned that light might be bent by a massive gravitating object. In his Optiks, he raised a question: *"Do not Bodies act upon Light at a distance, and by their action bend its Rays; and is not this action…. strongest at the least distance?"*So he was arguing that light rays feel the force of gravity as per the inverse-square law. Johann Georg von Soldner, a German physicist and mathematician, went a step forward in 1801 to answer the question posed by Newton. He calculated the deflection of light by a simple ballistic scattering method considering that light rays consist of a stream of tiny particles. They were right at that time considering that it was not yet known that light has no mass and Newton's theory was not applicable to massless particles. The deflection calculated by him was found to be half of that obtained from Einstein's new concept though interestingly, the estimate is known as Newtonian prediction.

According to Einstein's prediction light rays curved around the sun during an eclipse and thus stars just grazing the sun should appear deflected from their normal position by an angle of about 1.75 second arc while the value as predicted by Newton's law of gravitation was 0.86 second.

It was a group of British astronomers, headed by Arthur Eddington, who was lucky to be the first to observe the bending of light in presence of the sun and proved that Einstein was right. Lucky, because all other expeditions attempted before failed for reasons beyond the control of the scientists. The expedition led by Erwin Finlay-Freundlich, an astronomer at the Berlin observatory, to measure the bending of light during an eclipse in Crimea in 1914 was spoilt because of the beginning of World War I when he was arrested as a spy before the eclipse occurred. Another team from the Lick Observatory in California did reach Crimea but nature played a spoilsport with rain. Worse even that Lick's special eclipse camera was seized by the Russians and was not returned in time for the next eclipse in Venezuela in 1916. The next opportunity to prove Einstein right came in 1918 over the Columbia river between Washington State and Oregon, but their specialized camera did not reach from Crimea and that opportunity was also missed.

The next eclipse to be observed in West Africa was in May 1919. This time, scientists were extremely cautious to prevent any failure and decided to undertake two parallel sets of experiments at two different locations. Frank Dyson, who was the chief architect of the expedition, asked Eddington and Cottingham to go to the island of Principe, off the coast of Africa, and Charles Davidson and Andrew Crommelin to go to Sobral in Brazil. Eddington and his colleagues set sail for Africa in March 1919 to carry out the experiment. Eddington was a professor at Cambridge, a math prodigy and was a strong supporter of the new theory of Einstein. It is said that he was once complimented as one of the three persons in the world who understand the theory of relativity to which Eddington commented, without any show of modesty, that he was wondering who the third person was.

In spite of such precautionary steps, nature was not kind and the mission was about to fail. In Sobral, the weather was cloudy but fortunately the cloud cleared about a minute before totality, the very moment when the moon fully eclipsed the sun. At Principe, it rained for an hour and a half on the morning of the eclipse and Eddington took pictures through layers of flying clouds hoping that at least some stars would show up. At the end there were three sets of plates, from which one had to confirm who was right- Newton or Einstein.

The best data obtained by Sobral telescope indicated a deflection of 1.98 seconds arc which was more than what Einstein had predicted. Another Sobral telescope, known as astrograph, produced blurred star images and the value obtained from this pictures was 0.86 seconds arc which supported Newton's predictions. However, this result had a large uncertainty and was considered to be unreliable.

The experiment at Principe headed by Eddington recorded a handful of stars from which he estimated a deflection of 1.61 seconds arc, which was less than Einstein's prediction. The average of all the three measurements produced a value of 1.48 seconds arc, which lies in between Newton's and Einstein's predictions. It was a tricky situation to decide which result was to be eliminated to arrive at the right value. It was finally decided to discard the Sobral astrograph values on the ground that they were unreliable. Dyson and their colleagues wrote in their official report "both of the remaining plates point to the full deflection of 1.75" of Einstein's general theory of relativity". However, the controversy on the accuracy of the result to conclude decisively that Einstein was correct continued till 1979 when re-analysis of the data supported the decision of excluding the astrographic data from the final report. That Einstein's theory of relativity was correct was proved again by subsequent eclipses and other modern experiments.

But Eddington was blamed for years for fitting the data to the expected result. And, Eddington was not the only scientist subjected to such a criticism. It reminds us of a similar episode regarding the oil drop experiment performed almost at the same time, when Einstein was working on the theory of relativity, by Robert Millikan to measure the charge of an electron. In the oil drop experiment, charged oil drops are allowed to fall by gravity between two metal plates and they are made stationary by applying a suitable electric field opposing gravity between the two plates. The amount of force required to keep a drop afloat was always a multiple of a certain number, and that number was the charge of the electron. In 60 days, with 58 drops and "no single drop being omitted", Millikan had measured the charge of the electron. However, it has been found from his notebook after many years that Millikan had suitably discarded results out of his many drops (115 in number) where the values differed significantly from Millikan's expected value of the charge of the electron. While Eddington was exonerated from ethical misconduct, Millikan was not. Millikan received the Nobel Prize, Eddington did not.

Scientists are believed to be unbiased, especially on subjects related to science. But in reality, no one can have a truly unbiased opinion. It is hard, if not impossible, to go beyond some human traits and scientists are no exception. Still, that the experimental results were so accurate is an amazing coincidence.

Readers will find an interesting article in this issue authored by Rajinder Singh on Einstein's theory of relativity, the arguments, criticism and reception of the theory by Indian scientists and participation of Indian scientists in the eclipse expedition. I hope the article will provide some food for thought for the readers against our commonly known beliefs. ❒

S. C. Roy