Seeing is believing? Not always



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We tend to rely on our eyes as reliable witnesses of events taking place before us. In contrast to the information conveyed by other senses like ear or nose, we trust what we see. There are glitches in this reasoning, of course. The curved mirrors in the hall of mirrors of a fair present us with our distorted images, which we know to be far from reality. Travellers across hot deserts see illusions of water reservoirs reflecting images of trees. These mirages are caused by the bending of light as it travels down from the source towards the sandy base, the bending being caused by refraction of light travelling through successively hotter, and hence less dense, layers of air. This bending ultimately leads to reflection of light and hence to the illusory presence of water.

In short, the proverbial statement that light travels in a straight line seems to have occasional contradictions. Light can bend in special circumstances leading to sights that we would not ordinarily expect to see. And the person who needs to be very careful about this situation is the astronomer.

All his evidence collected through telescopes is brought by light. If that light somehow got bent, the evidence would be distorted. Fortunately, there are very few agents known to cause such distortion through bending. Amongst those the most likely culprit would be gravity.

Isaac Newton, the originator of the law of gravitation, had indeed wondered if gravity could bend light. Will a light ray passing close to a massive body feel the gravitational attraction of that body? If it did, the light ray would bend round the body; and if it didn't, it would continue in a straight line oblivious of the proximity of that body. Newton had no observational or experimental evidence for either possibility. As he refused to speculate, he left this problem as one of his unresolved queries.

In 1915, some two and a half centuries later, his query was answered by Einstein who had his own theory of gravity, which clearly predicted that light rays are bent by gravitational pulls. But how to verify that claim? Fortunately, there appeared on the scene Arthur Stanley Eddington, an astronomer who was one of the few scientists who could understand Einstein's theory. Eddington proposed an experiment: photograph a star when its light ray graze the Sun and compare it with the image when the Sun is nowhere near the ray from the star. The star image should appear shifted in the former case if light ray was bent by the gravity of the Sun. The expected effect was very small, about 2,000th part of the degree used to measure angles.

However, as can be seen, the main difficulty of carrying out such an experiment lies in seeing the star with the Sun in the sky. How can a star be seen in broad daylight? There is one special circumstance when this is possible. During a total solar eclipse, the Sun is covered completely and there is momentary darkness in the sky. In those fleeting moments the astronomer must perform all his experiments and finish taking measurements. And since the total eclipse is seen only in select sections of the Earth, the observer must be present in one such place with the necessary paraphernalia. Eddington decided to use the opportunity provided by the 1919 solar eclipse and chose two such spots, one in Sobral in Brazil and the other in the island of Principe in Guinea.

The story of Eddington's expedition to test Einstein's prediction, when seen in retrospect, reads like a comedy of errors. Because it had a better weather pattern, he chose the Principe site for his own observation and sent his colleague Andrew Crommelin to observe from Brazil. However, on the day of the eclipse, May 29, there were thunder showers at the Principe site and it looked as if the whole operation would be a washout. But fortunately for him, the sky cleared by early afternoon and he was able to perform observations through thin clouds. Crommelin at the Sobral site was more fortunate with the weather, but he had another problem to face. The telescope he had taken with him from Oxford had been set by him the previous night; but during the day time the rising temperature had brought in distortions, thus making the telescope unusable! However, a stand-by telescope of inferior quality which he had brought just in case, proved its worth. He used that to observe and got the best results of all, better even than those obtained by Eddington.

Then there was another problem. To measure the image shift of a star, its position in the sky also needs to be recorded when the Sun was well away from it. To reduce experimental errors, it was really desirable to carry out these measurements from the same place at night. This required remaining in the same place for a few days. As the schedule of boats was such that it required a long wait, Eddington and Crommelin decided to carry out those measurements in England instead. This made the control of errors rather uncertain.

On his return to homeland, Eddington carried out the analysis of data and chose to announce the result at a meeting of the Royal Society on November 6, 1919. Frank Dyson, the Astronomer Royal, presided over the meeting which had attracted a large crowd, excited and curious. Would Eddington announce the observed shift in star directions as per Einstein's prediction or would he find support for Newton whose theory predicted half that value? Or, would he come out with the rather uninteresting conclusion that the observations were not decisive?

Today's analysis done in retrospect would perhaps support the last option, going by the various uncertainties under which the experiment was done. But on that historical day, the assessment by Eddington and others was in favour of Einstein.

And, later more accurate observations did bear out that conclusion. Yes, light does bend under gravity and the astronomer had better check his observed images of heavenly bodies to figure out the truth amid distortion.

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