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Gravity can create illusions

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Travellers in a hot desert sometimes see a vast expanse of water showing the reflection of shrubs or trees. In dire need of water to quench their thirst, they head for the tempting reservoir, only to discover that there was no water at all. The reflection that they saw gave the impression of water.

Mirages, as these illusions are called, actually arise from the fact that there is temperature inversion, with lower layers close to the hot sand becoming hotter and lighter than the upper layers. Light rays descend into such layers and get reflected close to the bottom layer. This creates the reflected image of any ambient object.

So the proverbial straight-moving light ray can get bent as it encounters varying degree of transparency. This property is used in making optical instruments with lenses and curved mirrors.

It was Isaac Newton whose work on optics started this science. Being the originator of the law of gravitation, he had wondered whether light was subject to the same law. In short, just as matter attracts matter, does matter attract light? Newton did not have an answer, and this question remained on his list of unsolved problems.

Two centuries later, in 1915, Albert Einstein provided the answer. According to his general theory of relativity, light should change its direction when it encounters the gravitational pull of a massive object. But, how could one test this claim?

Cambridge astronomer Arthur Stanley Eddington took up the challenge. If one could observe a star just behind the Sun, its light would pass close by the Sun and then if the Sun's gravitational pull did bend its track, the star's image would shift. For, a bent light ray would mean a shift in the direction of the source.

This was a difficult experiment to perform and as was realised, it could not be done except when there was a total solar eclipse. For, a star close to the Sun could not be seen unless the Sun was totally eclipsed by the Moon.

A solar eclipse was due in the year 1919. Realising the importance of the experiment, the British science establishment made liberal funds available and Eddington was spared wartime duties so that he could plan his expedition. (This turned out to be convenient for him since he was a pacifist.)

Eddington arranged to make measurements from two locations, Sobral in Brazil and Principe in Guinea. He was able to collect enough data on the stars in the neighbourhood of the darkened Sun, to be able to reach a definite conclusion. On November 6, 1919, he

announced to a crowded auditorium at the Royal Society that Einstein's prediction was correct: that light does get bent by the pull of gravity.

While this confirmation placed Einstein on a pedestal as the most famous scientist of the 20th century, the important discovery of

bending of light by gravity, surprisingly remained an isolated curiosity.

For most astronomers, this result was too small to be of any real consequence. The change of direction produced by the Sun was by an angle, at most around 2000th part of the degree used for measuring angles.

However, a maverick but experienced astronomer, Fritz Zwicky, expressed the view that bending of light on a much larger scale might be observed in the universe, where the gravitational pull on light might come not from a star like the Sun but from much bigger systems like galaxies and clusters of galaxies. A typical galaxy may contain as many as a hundred billion stars.

Zwicky's ideas were largely ignored until 1979, when their validity hit astronomers unexpectedly. In that year, astronomers found what they first called 'twin quasars'. Quasars are powerful sources of light, a typical quasar emits as much light as a galaxy. Like identical human twins, these two quasars were very similar in appearance and other physical properties.

It was indeed a puzzle that such twins could exist in space, until astronomers recalled Zwicky's conjecture. Could these images be of one and only one source? If light from the source was bent by an intervening galaxy in such a way that it got divided into two parts, one coming from the left of the galaxy and the other from the right, an observer on the Earth would see two images.

Bizarre though this finding was, it was confirmed that like lenses of glass and other transparent media, here was gravity that was bending light.

Since 1979, astronomers have found many examples of gravitational lensing: in some cases, three or four images are seen from a single source.

So, seeing is not necessarily believing! Like travellers in the Thar desert, astronomers have to put up with optical illusions in the sky.

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