

Black holes influence knowledge of the universe

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Black holes have a reputation for voraciously eating everything in their immediate neighborhood, but these large gravity wells also affect electromagnetic radiation and may hinder our ability to ever locate the center of the universe, according to an international research team. "Any attempt to discover what was happening a long time ago at the beginning of our universe must take into account what gravitationally assisted negative refraction does to the radiation being viewed," said Akhlesh Lakhtakia, distinguished professor of engineering science and mechanics at Penn State.

Electromagnetic radiation is affected by the material through which it travels. A material with a negative index of refraction transmits light or other wave energy differently than one with a positive index of refraction. Natural materials have positive index of refraction. When an energy beam -- light, radar, microwaves -- passes through water or glass or some other natural material, the material displaces the beam in the same direction. The amount of displacement depends upon how different the material is from air or vacuum. The displacement, due to a material with negative index of refraction, is in the opposite direction.

Previously, Lakhtakia and Tom G. Mackay, lecturer in mathematics at the University of Edinburgh, used Albert Einstein's Special Theory of Relativity to examine refraction by moving materials. They calculated that negative refraction can be concluded to have occurred by an observer moving at a very high relative velocity in certain directions.

Later they showed that no material is needed for negative refraction in outer space. Instead, when a beam passes through the gravitational field of a massive object such as a rotating black hole, negative refraction theoretically is possible.

When it comes to the influence of gravity caused by rotating black holes or other massive objects, it really depends on where one stands. A local observer can see only a very small piece of the universal picture of how large gravitational forces influence electromagnetic radiation. To the local observer, gravity is uniform and does not cause negative refraction.

However, Lakhtakia and Mackay, assisted by Sandi Setiawan, a postdoctoral researcher at the University of Edinburgh, decided to look at a global observer -- one who stands in space-time as described by Einstein in his General Theory of Relativity. A global observer sees a region around rotating black holes, called the ergosphere, as possibly bending electromagnetic radiation according to a negative refractive index.

These new derivations, reported in the March 7 issue of *Physics Letters A*, indicate that not only do the effects of the minute stuff of the universe have to be considered when mapping the universe, but the existence of large gravity wells also must be considered.

"When we are tracking light, we must take into account gravitational forces," said Lakhtakia. "Although the effect is only significant very close to rotating black holes."

The three researchers have extended their theory of negative refraction to even more general scenarios, in a paper published today (March 8) in the *New Journal of Physics*, an electronic journal. As we reach out in extrasolar space, for example via Pioneer 10, scientists are getting more interested in the actual existences of such scenarios.

Normal light bending by a gravity source such as our Sun is known as gravitational lensing. It has been suggested since Einstein's time and was experimentally shown by a British team of scientists in 1919. This gravitational lensing sometimes causes multiple images to be seen. The effect is taken into account in global positioning systems. However, this light bending is positively refracted.

When researchers search for the origin of the universe, multiple black holes and other massive objects can make the light beams bend in unexpected and unpredictable ways.

"We should not be disappointed if we cannot discover the origin of the universe," said Lakhtakia. "The gravitational effect probably makes it so that we do not really know where we are looking."

Nevertheless, Lakhtakia and his collaborators are optimistic that scientists eventually will overcome many of the obstacles put forward by negative refraction in outer space.

Source: Penn State

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