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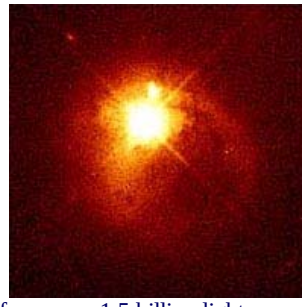
Does Gravity Travel the Same Speed as Light?



Example of a quasar 1.5 billion light years from earth.
This quasar is so bright that it created diffraction spikes on the telescope image.
Photograph courtesy Hubble Space Telescope (HStsci).

September 7, 2002 Charlottesville, Virginia - A billion light years from earth there is a very bright quasar known as JO841+1842. Quasars give off enormous energy from great distances. Tomorrow, Sunday, September 8, Jupiter in our solar system will pass very close to the light's path from that quasar.

Jupiter, the largest planet in our solar system, will pass only
a few arc minutes from the light emanated from the JO841+1842 quasar.
The impact of Jupiter's gravity on those quasar photons will test if gravity travels
the same speed as light. Photograph courtesy Hubble Space Telescope.

Eleven radio telescopes called the Very Long Baseline Array (VLBA) run by the U. S. National Radio Astronomy Observatory (NRAO) will gather data stretching from Hawaii and the Virgin Islands to the Max Planck Institute's radio telescope in Effelsberg, Germany. The huge array of telescopes will videotape what happens to the quasar's light under the gravitational influence of Jupiter as it moves by. No one has measured the speed of gravity before this weekend's combination of the large array of sophisticated radio telescopes and this rare time once-every-ten-years or so that Jupiter passes so closely to the quasar's light.

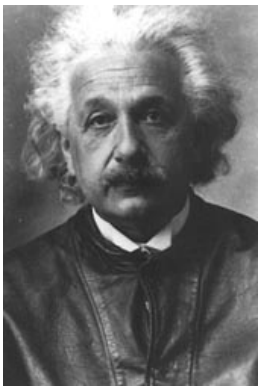
Not only is this a test of gravity's speed, but it is also a test of Albert Einstein's famous theory of General Relativity. Einstein assumed in his calculations that the speed of light cannot be exceeded by anything in the universe, including gravity. The astronomer and physicist who first thought about testing Einstein's

assumption is Dr. Sergei Kopeikin at the University of Missouri in Columbus. Then another astronomer, Dr. Ed Fomalont, at the National Radio Astronomy Observatory in Charlottesville, Virginia, designed this weekend's experiment to see if gravity does travel the same speed as light. Today I talked with him about his groundbreaking experiment.

Interview:

The Robert C. Byrd Green Bank Telescope (GBT), the world's largest fully steerable radio telescope, has 2004 individually adjustable panels. These reflective panels are mounted at their corners on actuators (drive pistons), which can make tiny adjustments to the positions of the panels, keeping the telescope perfectly in focus. Photograph courtesy NRAO.

Ed Fomalont, Astronomer, National Radio Astronomy Observatory (NRAO), Charlottesville, Virginia: "One of the predictions from Einstein's theory of relativity which is his theory of gravitation is that everything is effected by gravity. Of course, we know that a lot of things are, including light. So, for example, if you have radiowaves from a distant quasar or a distant star that passes by a massive object like the sun or Jupiter on its way to our telescopes, then we astronomers would see a slight change in the direction towards this quasar. This change would be caused by a slight bending of the radiowaves by the solar gravitational field.



Albert Einstein (1879-1955). German-born American theoretical physicist who formulated the theories of special and general relativity that included the formula E=mc2 (energy equals mass times the speed of light squared) and said that nothing in our universe could go faster than the speed of light, 186,000 miles per second. Photograph courtesy of Princeton University.

Now, this is from Einstein's prediction of gravity and this was first verified in 1919 and it has been verified with many radio and optical observations over the last thirty years and his prediction of the bending of this light is right on.

About two years ago I'm the experimentalist in this pair of astronomers. Sergei Kopeikin, Ph.D., at the University of Missouri-Columbia, is the theoretician. After discussing things related to Einstein's equation, he decided to ask the question about Einstein's theory: How do some of his (Einstein's) predictions change about gravity if the gravitational force from any object travels outward at a finite speed before affecting other objects or radiowaves? Because most

physicists don't think gravitational force is instantaneous. They think it travels also at the speed of light.

SO, WHAT YOU ARE TRYING TO DO IS TEST THE QUESTION: DOES GRAVITY HAVE A SPEED, SO TO SPEAK, AS LIGHT TRAVELS 186,000 MILES PER SECOND AND TAKES EIGHT MINUTES TO GET HERE FROM THE SUN TO THE EARTH, FOR EXAMPLE.

That's right.

DO YOU MEAN THAT WHAT YOU ARE GOING TO TRY TO TEST THIS WEEKEND AND SUBSEQUENTLY IS IF THE SUN WERE SUDDENLY REMOVED, WOULD IT TAKE EIGHT MINUTES FOR THE EARTH TO KNOW THAT?

That's exactly right. We know it takes 8 minutes for the earth to know there is no more light coming from the sun. But we also want to test whether it also takes 8 minutes before the earth stops orbiting and just travels away if the sun were magically moved away.

In order to get the position discrimination or accuracy (as Jupiter passes the quasar's light), we need, we are using 11 radio telescopes stretching from Germany to the Virgin Islands all the way to Hawaii. So we have this colossal array that did not exist in the 1970s. And you need something very big in order to measure this very accurately this position of the quasar. So this is the main new technology we have now we didn't have the last time this passage occurred.

TOMORROW ON SUNDAY, SEPTEMBER 8, WILL THEN BE A COMBINATION OF TWO THINGS: YOUR ADVANCED RADIO TELESCOPE EQUIPMENT AND THE PASSING OF JUPITER PAST THIS QUASAR THAT IS GOING TO ALLOW YOU TO SEE IF YOU CAN MEASURE FOR THE VERY FIRST TIME THE SPEED OF GRAVITY?

That's right. Over about ten hours as Jupiter and the quasar are observed with all of these telescopes. They are connected as one big telescope. We will see the position of the quasar actually move slightly in the sky in response to Jupiter's gravitational field. We will compare it to Sergei Kopeikin's theory, which is Einstein's theory, but with the added wrinkle that Jupiter is moving and by comparing what we measure to what Einstein and Sergei's theory say we should get, we will then be able to determine the speed of gravity.

WHAT IF IT TURNS OUT TO BE SLOWER OR FASTER THAN THE SPEED OF LIGHT?

Well, that's a good question. If it turns out to be faster or slower or infinite than the speed of light, this clearly would be very surprising. Again, because in modern physics, especially gravitational theory and electromagnetic theory, one of the cornerstones is that the speed of light is this limiting velocity that anything not only light that everything can obtain. If we show that that is not true for gravity, some of the basic postulates of relativity theory and some of the other theories and ideas about how the universe evolved when there were very large gravitational fields would have to be modified.

So, gravity is an important force in the universe. No one yet has made a serious measurement on how fast gravity travels from the objects producing the gravity to influence other objects further away.

With light, we have been measuring its speed for hundreds of years. We know it to one part in a million and it's constant. It's the limit as far as we know.

SO TOMORROW, NOT ONLY ARE YOU TESTING THE SPEED OF GRAVITY, BUT YOU ARE TESTING ALBERT EINSTEIN'S THEORY OF GENERAL RELATIVITY?

Yes, we are. This is another. There have been many tests of Einstein's theory. He has come through with flying colors. And this is another test that we will make.

It's quite a bit different than some of the others, but it is another test of Einstein's theory. That's correct.

HOW LONG WILL IT TAKE YOU TO KNOW WHAT THE RESULTS ARE?

These telescopes record the data at the sites they are. The data or signals from the quasar are recorded on videotape similar to what is used for television. Then those tapes are federal expressed to a central processing station in Socorro, New Mexico where we have what is called a correlator. What the correlator does is take the signals received from each antenna and puts them together. It in a sense focuses the signals and it makes a focal point, a focus, from all of these different antennas and makes up a fictitious very large antenna. Basically, we get an image of the quasar every minute of time and through the day we can monitor the position of our quasar from the image we are getting and see how it changes and compare it to the predictions of Einstein and Kopeikin. Our goal is to have a preliminary answer by mid-November.

Gravity is one of three fundamental forces and is the least understood of all the forces in the universe. And it's possible it might have some surprising properties. If the speed is in fact faster than the speed of light it will be very surprising and very interesting.

IT WOULD KIND OF TURN PHYSICS A LITTLE UPSIDE DOWN, WOULDN'T IT?

I believe it would, yes. Yes, it would."

Websites:

http://www.nrao.edu/

http://oposite.stsci.edu/pubinfo/PR/96/35.html

Credits