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Space-time ripples

Thinking about gravity in the same way as electric forces may lead one astray, says S.Ananthanarayanan.

The force between electrically charged objects and the force between things that have mass have this in common that both grow smaller by the square of the distance between the two objects. But electric forces have other properties that forces of gravity do not share.

Electromagnetic waves

A special thing about electric charges is that if a charge moves, that is if there is a current, then there is also a magnetic force. And again, if the magnetic force changes, this sets electric charges in motion, which is to create electric currents. Now these currents, in turn, would give rise to magnetic effects, and so on.

It was worked out, quite exactly, early in the nineteenth century, that an oscillating electric charge should radiate a wave of electric and magnetic effects, rather like the waves that spread out when we drop a pebble into water. This has been verified and proved and is now commonplace in its application in radio and television and so many other marvels of our times.

These features had not been noticed with masses. Another difference is that there are two kinds of charges, but we cannot conceive of ‘negative mass’!

Einstein and Gravity

During the early 20th century Einstein developed a new way of thinking about distances and time intervals in such a way that measurement of lengths and times by persons in relative motion depended on how fast they were moving. While reconciling a tangle about the speed of electromagnetic waves, this new theory threw up things like ‘time moves slower for fast moving systems’, the speed of light being nature’s speed limit and the ‘energy – mass equivalence’.

When applied to gravitation, which was a property of mass, it turned out that gravity could be seen as a ‘curvature’ in a four-dimensional space, a space made up of not just our ‘north-south, east-west and up-down’ but also the dimension of ‘when’. This is like saying that mass is a kind of energy that ‘space-time’ has when it is curved!

This notion meant the path of a comet was bent when it passed a planet, quite naturally, because space itself was curved because of the planet’s mass. This was also elegantly verified during solar eclipses by looking for stars that should be hidden behind the sun’s disk. Because of space being curved near the sun, light from the stars turned and came into view!

Gravity Waves

Going a step further, any change in the curvature of space at a point should cause aberrations in the surrounding space, and these aberrations should have their own effects and so on. In this way, the mathematics behind Einstein's theory of gravity said periodic movement of large masses should send out 'gravity waves', like ripples across the 'pond of space-time'.

Such waves would be detected by fluctuations in lengths and distances, as space itself stretched and shrank while the wave passed by. But the extent of change, due to even cataclysmic events in the cosmos, is of the order of the 'size of an atom, over the distance from the earth to the sun'! Naturally, we have not detected anything like it.

Indirect test

When charged particles emit radio waves, they do it at the cost of slowing down themselves, because the energy has to come from somewhere. In the same manner, the gravity waves that rapidly moving masses, like a pair of neutron stars spinning around each other, would give off would result in an increasing rate of spin, as the system loses energy and closes in. In cases of such pairs, where one of the neutron stars is a pulsar, which can be detected and its movement can be traced, the slow speeding up has been observed to be exactly as much as predicted by theory!