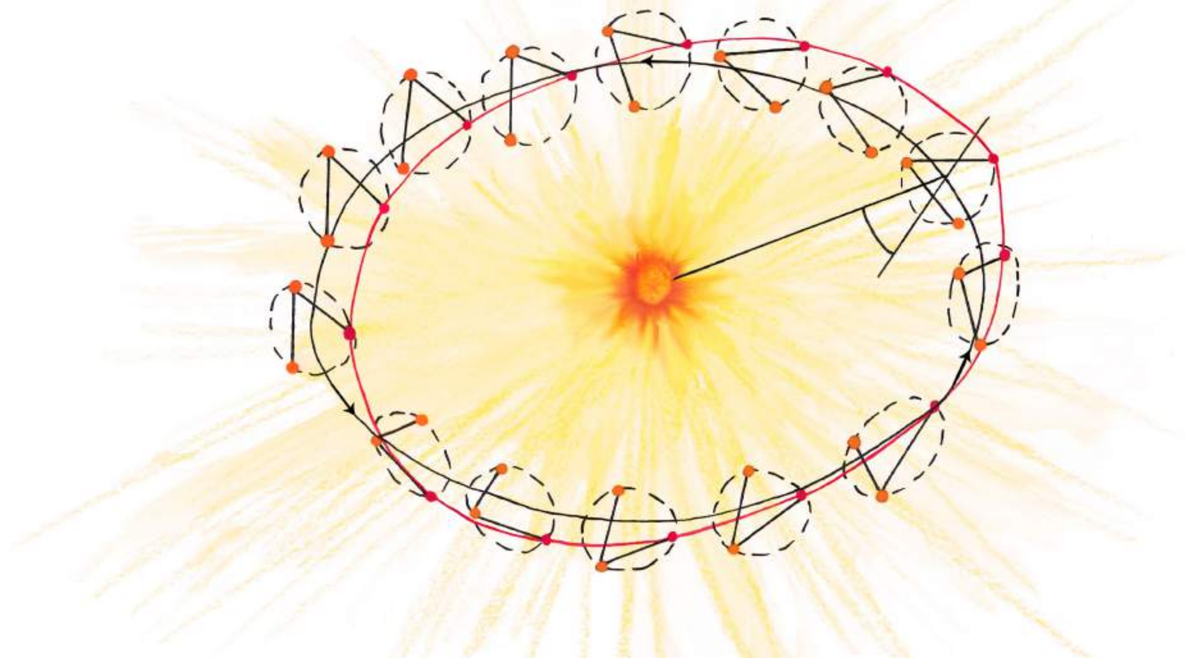
2015

The Gravity of The Situation: A Hunt for Gravitational Waves

Jacob Turner

The Gravity of the Situation:



Ellie Masters

A Hunt for Gravitational Waves

Jacob Turner

At the surface level, gravity may appear to be one of the simplest phenomena in the universe; what goes up must come down, large objects attract one another, perception comes in the form of acceleration, etc. In reality, we honestly know next to nothing about gravity. It is by far the least understood out of the four fundamental forces, the other three being the electromagnetic and the strong and weak nuclear forces, and was the first to split from the other forces after the Big Bang. For over 200 years, gravity was simply considered an accelerative force that caused objects to become attracted to one another. This interpretation was originally formulated by Isaac Newton to describe planetary motion, and since it agreed so well with everyday experiences, there wasn't any need to tamper with the mathematics behind it.

However, all of that changed in 1915 when Albert Einstein published his landmark first paper laying the foundations of general relativity, the modern theory of gravity. This marked one of the largest turning points in scientific history, as it forced physicists to abandon all preconceived notions about how the universe worked and accept mathematical results that defy common sense on the grandest scales. Through his work, Einstein was able to show that gravity wasn't just a force that existed in three dimensional space, but was actually the curvature of four dimensional spacetime, with time being the extra dimension. One of the simplest ways of describing the relationship between gravity and spacetime is this adage: gravity tells space how to curve; space tells matter how to move.

To date, experiments on general relativity has successfully agreed with many of its predictions, which include such phenomena as the gravitational bending of light to the existence of black holes. However, there are still a few aspects of general relativity that remain unconfirmed, one of the most important being the existence of gravitational waves. Much like the ripples in a pond created by throwing a stone, gravitational waves are ripples in the curvature of spacetime caused by the acceleration of moving objects. Because it's next to impossible to detect gravitational waves in our everyday lives due to the lack of noticeable changes in our experience of spacetime, we need to observe extreme sources of gravity such as binary systems of white dwarfs, pulsars, or black holes in order to have any chance of detection. It's actually because of observations in changes of orbital periods of binary pulsars that we already have indirect evidence, but direct evidence of a passing wave would be much more conclusive and further strengthen validity of general relativity.

There are currently many differently efforts taking place around the world hoping to detect gravitational waves, such as pulsar timing arrays. Another important method uses a technique called interferometry, which uses incredibly precise lasers to measure minute changes in the distances of objects that can be a few kilometers apart. This effort is about to get a huge boost in detecting power, thanks to the upgrade of the Laser Interferometer Gravitational-Wave Observatory, or LIGO. After undergoing extensive renovations, LIGO should be able to detect waves with amplitudes as small as 10-20 meters even though the strongest waves will only change the distance between LIGO's arms by a mere 10-18 meters.