Could primordial black holes be dark matter?

September 21 2011, by Miranda Marquit

(PhysOrg.com) -- “We know that about 25% of the matter in the universe is dark matter, but we don’t know what it *is*,” Michael Kesden tells *PhysOrg.com*. “There are a number of different theories about what dark matter could be, but we think one alternative might be very small primordial black holes.”

When many of us think about black holes, we think of a huge cosmic event, sucking in everything around it. However, there is also the possibility of small black holes. “Einstein’s theory of relativity allows for black holes,” Kesden, a theoretical physicist at New York University, explains, “but doesn’t stipulate a size. It’s very possible that the early universe produced very small black holes. These would gravitate like massive black holes, floating through the universe and clustering.”

Kesden worked with Shravan Hanasoge, from Princeton University and the Max Planck Institute for Solar System Research, to work out method of using solar oscillations to determine whether a small, primordial black hole passed through a star. If the data can show that these small black holes formed near the beginning of the universe do exist, they might make good candidates for dark matter. Their work can be seen in Physical Review Letters: “Transient Solar Oscillations Driven by Primordial Black Holes.”

“Our approach is to consider what happens if you have dark matter made of primordial black holes passing through the sun,” Kesden says. “It’s been thought of before, but no one has actually done the calculations that

we have."

Kesden explains that the sun creates energy from the nuclear fusion at its center: "There is a balance between the outward pressure gradient due to the energy released by fusion and the inward force of gravity. If the sun, or any star, is perturbed it would shake a little."

"A small, primordial black hole would be the size of an atom but have the mass of an asteroid," he points out. "Its strong gravitational field, as it cut through the sun, would squeeze it, then release, and cause the sun to oscillate before ultimately settling down."

The idea is to measure the oscillation, and determine what would cause it. "Shravan Hanasoge wrote a program to help us with a simulation to see what the sun would look like if a primordial black hole passed through. The smallest mass detectable is 10^21 grams," Kesden continues.

Now that Kesden and Hanasoge know what to look for, it is possible to measure the oscillations of different stars. Since these primordial black holes are thought to be moving through the universe, it should be observable in different stars. "By inferring the total amount of dark matter in the universe, it should be able to determine how often a primordial black hole would pass through the sun – if it's dark matter," Kesden says. Unfortunately, dark matter would only pass through the sun every millions of years. "That's a long time to stare at our sun, waiting for the event."

Instead of waiting millions of years for a primordial black hole to pass through our sun, it is possible to monitor millions of stars; one of these stars would likely encounter a primordial black hole every few years. Kesden points out that current and future space missions could collect the needed data. "It is possible to look at the data collected from

asteroseismic missions for these events, now that we know what to look for. Someone could even look through data collected in the past to try to spot these oscillations."

"At the Large Hadron Collider, some scientists are trying to determine if supersymmetry is dark matter," Kesden says. "But if it isn't found at the LHC, people will begin looking for other alternatives, and primordial black holes might be the answer to the outstanding question of what dark matter is."

More information: Michael Kesden and Shravan Hanasoge, "Transient Solar Oscillations Driven by Primordial Black Holes," *Physical Review Letters* (2011). Available online: link.aps.org/doi/10.1103/PhysRevLett.107.111101