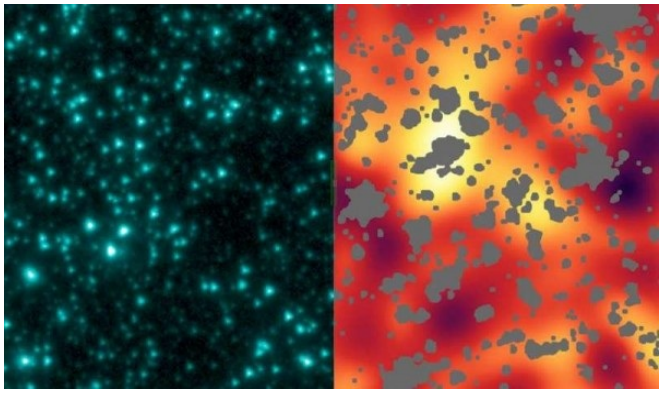
**IS DARK MATTER MADE OF BLACK HOLES?**

What if if dark matter consisted of a population of black holes similar to those detected by LIGO last year? A new study analyzes this possibility.



Left: This image from NASA's Spitzer Space Telescope shows an infrared view of a sky area in the constellation Ursa Major. Right: After masking out all known stars, galaxies and artifacts and enhancing what's left, an irregular background glow appears. This is the cosmic infrared background (CIB); lighter indicate brighter

**Modern astronomers believe a substantial portion of our universe exists in the form of dark matter**. Like all matter, dark matter appears to exert a gravitational pull, but it can't be seen. If it exists, it emits neither light nor any other form of radiation that scientists have detected. Scientists have theoretical models using exotic massive particles, but so far there's no observational evidence that this is the case. On May 24, 2016, NASA announced a new study bolstering the idea of an alternative hypothesis:

**dark matter might be made of black holes**.

**Alexander Kashlinsky**, an astrophysicist at NASA Goddard, led the new study, which is:

> *… an effort to bring together a broad set of ideas and observations to test how well they fit, and the fit is surprisingly good. If this is correct, then all galaxies, including our own, are embedded within a vast sphere of black holes each about 30 times the sun's mass*.

There are several ways to form black holes, but they all involve high densities of matter. The black holes of Kashlinsky's study are what are called primordial back holes, thought to have formed in the first fraction of a second after the Big Bang, when pressures and temperatures were extremely high. During this time, tiny fluctuations in the density of matter might have pocked the early universe with black holes, and, if so, as the universe expanded, those primordial black holes would have remained stable, existing until our time.

In his new paper, Kashlinsky points to two primary lines of evidence that these black holes can account for the missing dark matter thought to pervade our universe. His statement explains that this idea:

> *… aligns with our knowledge of cosmic infrared and X-ray background glows and may explain the unexpectedly high masses of merging black holes detected last year*.

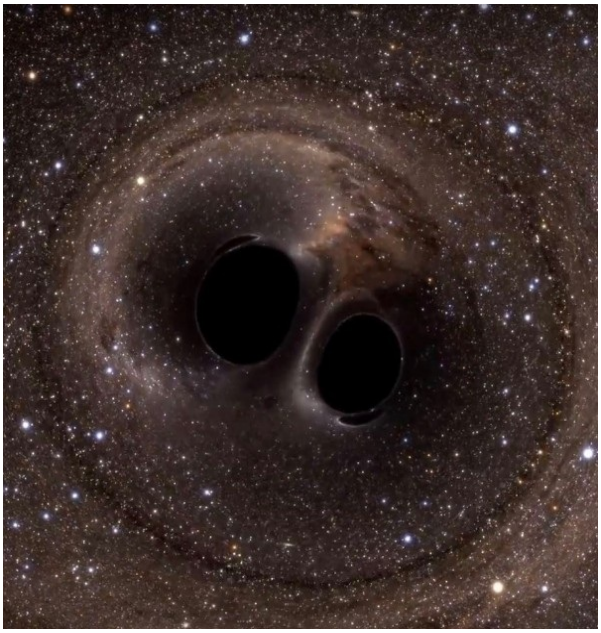
The first line of evidence is an excessive patchiness in the observed background glow of infrared light. In 2005, Kashlinsky led a team of astronomers using NASA's Spitzer Space Telescope to explore this infrared background glow in one part of the sky. His team concluded that the observed patchiness was likely caused by the aggregate light of the first sources to illuminate the universe more than 13 billion years ago. **Then the question becomes … what were these first sources? Were primordial black holes among them?**

Follow-up studies confirmed that this cosmic infrared background (CIB) showed similar unexpected patchiness in other parts of the sky. Kashlinksy's statement said:

*… the irregular glow of low-energy X-rays in the [cosmic x-ray background] matched the patchiness of the infrared background quite well.* ***The only object we know of, that has such a luminosity range is a black hole***.

**The 2013 study concluded that primordial black holes must have been abundant among the earliest stars**, at least one out of every five sources of the CIB.

When on September 14, 2015 scientists at the Laser Interferometer Gravitational-Wave Observatory (LIGO) facilities in Hanford, Washington, and Livingston, Louisiana made a first-ever detection of gravitational waves, this event also marked the first direct detection of black holes and their masses. .Kashlinsky pointed out that the two masses of 29 and 36 times the sun's mass, are in the range primordial black holes are expected to be. **He suggests that what LIGO might have detected was a merger of two primordial black holes.** AK with EarthSky Notes



This computer simulation shows what this merger would have looked like up close. The ring around the black holes, called an Einstein ring, arises from the stars in a small region directly behind the holes whose light is distorted by gravitational lensing