Astronomers report that dark matter 'halos' may contain stars, disprove other theories

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Could it be that dark matter "halos"—the huge, invisible cocoons of mass that envelop entire galaxies and account for most of the matter in the universe—aren't completely dark after all but contain a small number of stars? Astronomers from UCLA, UC Irvine and elsewhere make a case for that in the Oct. 25 issue of the journal *Nature*.

Astronomers have long disagreed about why they see more light in the universe than it seems they should—that is, why the infrared light they observe exceeds the amount of light emitted from known galaxies.

When looking at the cosmos, astronomers have seen what are neither stars nor galaxies nor a uniform dark sky but mysterious, sandpaper-like smatterings of light, which UCLA's Edward L. (Ned) Wright refers to as "fluctuations." The debate has centered around what exaclty the source of those fluctuations is.

One explanation is that the fluctuations in the background are from very distant unknown galaxies. A second is that they're from unknown galaxies that are not so far away, faint galaxies whose light has been traveling to us for only 4 billion or 5 billion years (a rather short time in astronomy terms). In the *Nature* paper, Wright and his colleagues present evidence that both these explanations are wrong, and they propose an alternative.

The first explanation—that the fluctuations are from very distant galaxies—is nowhere close to being supported by the data the

astronomers present from NASA's Spitzer Space Telescope, said Wright, a UCLA professor of physics and astronomy.

"The idea of not-so-far-away faint galaxies is better, but still not right," he added. "It's off by a factor of about 10; the 'distant galaxies' hypothesis is off by a factor of about 1,000."

Wright and his colleagues, including lead author Asantha Cooray, a UC Irvine professor of physics and astronomy, contend that the small number of stars that were kicked to the edges of space during violent collisions and mergers of galaxies may be the cause of the infrared light "halos" across the sky and may explain the mystery of the excess emitted infrared light.

As crashing galaxies became gravitationally tangled with one another, "orphaned" stars were tossed into space. It is these stars, the researchers say, that produce the diffuse, blotchy scatterings of light emitted from the galaxy halos that extend well beyond the outer reaches of galaxies.

"Galaxies exist in dark matter halos that are much bigger than the galaxies; when galaxies form and merge together, the dark matter halo gets larger and the stars and gas sink to the middle of the the halo," said Wright, who holds UCLA's David Saxon Presidential Chair in Physics. "What we're saying is one star in a thousand does not do that and instead gets distributed like dark matter. You can't see the dark matter very well, but we are proposing that it actually has a few stars in it—only one-tenth of 1 percent of the number of stars in the bright part of the galaxy. One star in a thousand gets stripped out of the visible galaxy and gets distributed like the dark matter.

"The dark matter halo is not totally dark," Wright said. "A tiny fraction, one-tenth of a percent, of the stars in the central galaxy has been spread out into the halo, and this can produce the fluctuations that we see."

In large clusters of galaxies, astronomers have found much higher percentages of intra-halo light, as large as 20 percent, Wright said.

For this study, Cooray, Wright and colleagues used the Spitzer Space Telescope to produce an infrared map of a region of the sky in the constellation Boötes. The light has been travelling to us for 10 billion years.

"Presumably this light in halos occurs everywhere in the sky and just has not been measured anywhere else," said Wright, who is also principal investigator of NASA's Wide-field Infrared Survey Explorer (WISE) mission.

"If we can really understand the origin of the infrared background, we can understand when all of the light in the universe was produced and how much was produced," Wright said. "The history of all the production of light in the universe is encoded in this background. We're saying the fluctuations can be produced by the fuzzy edges of galaxies that existed at the same time that most of the stars were created, about 10 billion years ago."

The research was funded by the National Science Foundation, NASA and NASA's Jet Propulsion Laboratory.

Future research, especially with the James Webb Space Telescope, should provide further insights, Wright said.

"What we really need to be able to do is to see and identify the galaxies that are producing all the light in the infrared background," he said. "That could be done to a much greater extent once the James Webb Space Telescope is operational because it will be able to see much more distant, fainter galaxies."