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News

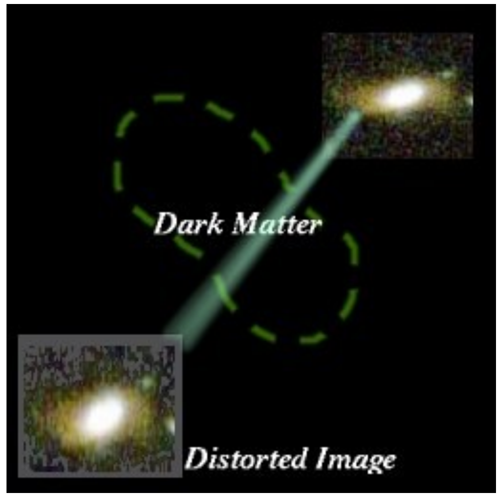
Lensing helps see in the dark

Earlier this year, a group of scientists at Bell Labs announced that they had succeeded in observing the effects of "dark matter" − invisible matter that can be detected only by its gravitational effects. Their paper, published in Nature, is the result of a fifteen year search. So just what is dark matter, why is it important and why is it so difficult to see?

The answer goes back to the question of how much matter is in the Universe. We can make estimates of the Universe's mass based on our understanding of how the it appears to work: how fast it is expanding, for instance. A more direct way of answering the question is to look and see how much matter we can see.

Unfortunately, the two methods do not agree: there "should" be much more matter than we can actually see. To explain this disparity the concept of "dark matter" was invented. The idea is that there must be quite a lot of matter which we can't detect in the usual ways. For example it doesn't radiate any light; hence the name "dark matter".

Thus even though dark matter should be very abundant, it is hard to detect. But not impossible: since it has mass, it must have gravity. We know from Einstein's theory of relativity that gravity distorts space, and therefore light. Our view of distant galaxies should be distorted by the dark matter that, we predict, lies between them and us. For example a circular galaxy will look elliptical, distended in some direction that depends on just how and where the intervening dark matter is arranged.



Exaggerated view of gravitational distortion from dark matter affecting the observed shape of a galaxy

The problem is that this effect, known as "lensing", is very weak. Shapes will be distended in one direction by only a small amount − predictions varied from less than 1 per cent to a few per cent. By contrast, real galaxies are already highly elliptical − typically 30% longer in one direction than the other. Therefore, observing a single galaxy cannot tell us anything about dark matter.

The Bell scientists' solution to this problem was to make observations of not one galaxy, but many −− in fact about 145,000. The point is that light from galaxies that are near each other in the sky must have reached us through the same regions of dark matter, and so have been distended in the same direction. The actual orientation of these elliptical galaxies should be random, but when observed through the dark matter, they should show a very slight tendency to be longer in one direction rather than another.

If randomly arranged galaxies (left) are all distorted in the same direction (right, much exaggerated), the resulting bias can be detected

The effect is so small that attempts to observe it are hampered by other sources of systematic distortion, for example in the telescopes used. But by careful observations and calculations, David Wittman and other members of the group proved that, when all these factors were taken into account, there was still a residual effect that could only be explained by dark matter.

By seeing how the direction and amount of distortion changed from one part of the sky to another, Wittman and company were also able to make deductions about the distribution of dark matter. Thus, besides confirming predictions about the existence of dark matter, their observations provide new information which will help to further our understanding of the structure of the Universe.

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Plus is part of the family of activities in the Millennium Mathematics Project, which also includes the NRICH and MOTIVATE sites.