Supernovae put dark matter in the right place

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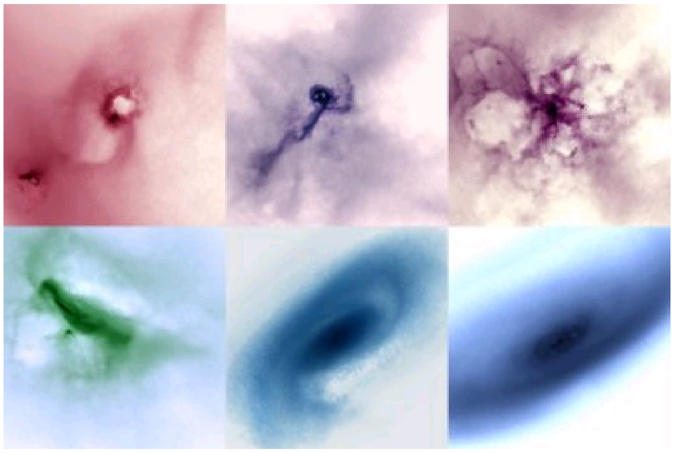

A bulgeless dwarf galaxy emerges in simulation

It may account for more than 80% of the matter in the universe and provide the "gravitational glue" that keeps galaxies together, but dark matter remains a mystery – despite tantalizing hints obtained by researchers in the US late last year. The current best bet is that it consists of slow-moving (or "cold") particles that do not interact with electromagnetic radiation. Indeed, this "cold dark matter" (CDM) is so abundant that astrophysicists can simply use it to predict the shape of some types of galaxies – completely ignoring the tiny effects of visible matter that makes up the stars.

However, this CDM-only approach has failed spectacularly when it comes to studying "dwarf" galaxies – bodies with less than 10% of the mass of the Milky Way. CDM-only simulations suggest that the central regions of these dwarf galaxies should contain a dark-matter core that gets rapidly denser towards the middle. However, observations reveal no such central cusp but a constant density of dark matter throughout the core. Even worse, CDM-only models also predict that the centres of dwarf galaxies should include a dense bulge of stars, which is not seen in real life either.

Although some astrophysicists see these discrepancies as proof that CDM does not exist, others had suspected that they are the result of ignoring star-formation processes involving visible matter. But confirming the latter has not been easy because it requires a vast amount of computing time. Now, however, a new simulation has been carried out by an international team of astrophysicists that suggests that supernovae – massive stellar explosions – play an important role in the formation of dwarf galaxies. CDM, it appears, is indeed the best way of describing the invisible matter that appears to permeate the universe.

The real thing

Carried out by Chris Brook of the University of Central Lancashire in the UK and colleagues in Switzerland, the US and Canada, the simulation is the first to model not only star formation throughout an entire dwarf galaxy but also the gravitational effects of CDM. It suggests that some of the energy given off by supernovae in the core of a dwarf galaxy causes a wind of visible matter to flow out of the core. This movement of mass is significant enough to pull dark

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matter away from the core, smoothing out the density and making the simulated galaxy look more like the real thing.

The simulation was carried out using about 250 processors running for about two months. The calculation was then repeated using different initial conditions – which yielded a similar result. According to Brook, supernovae have a significant effect on the evolution of dwarf galaxies – but not galaxies the size of the Milky Way – because the overall gravitational potential energy of a dwarf is small. To confirm this, however, the team would have to simulate larger galaxies to see if the effect went away. This would be a major undertaking because a larger galaxy would require at least ten times the computational resources.

Richard Bower, a cosmologist from the University of Durham in the UK, bills the research as "one of the best papers I have ever seen". He adds that the key to the team's success was its ability to simulate the different phases of hydrogen gas that make up much of the visible matter in a galaxy. "[The result] bodes very well for CDM," says Bower. The work is reported in *Nature* **463** 203.

About the author

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