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Dark matter science

October 31 2011, By Steve Nerlich

Dark matter has been found to be (unexpectedly) evenly distributed across dwarf galaxies - rather than clumping together in the centre in the way that we had expected of 'cold' dark matter. Credit NASA.

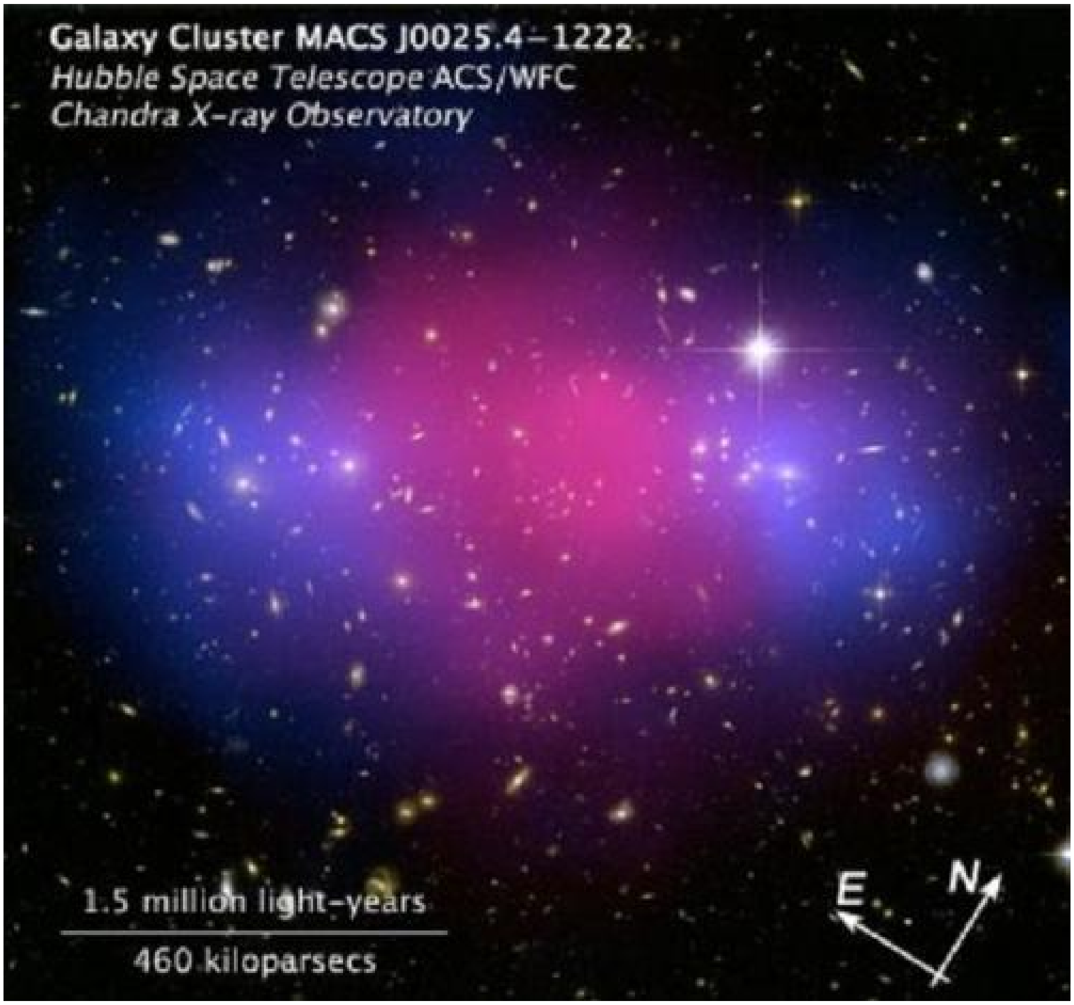
Dark matter – there's a growing feeling that we are getting closer to finding out the true nature of this elusive stuff. At least we are running a number of experiments that seem (on theoretical grounds) to have the capacity to identify it – and if they don't... well, maybe it's time for a rethink of the whole ball game.

There are two arguably quite separate requirements for dark matter to make sense of our current dataset and our theoretical schema for the universe. Firstly, the Standard Model of cosmology (Lambda-Cold Dark Matter) requires that 96% of the universe is composed of stuff of an unknown nature that cannot be directly observed.

About two thirds of this unknown stuff can't possibly be matter since it apparently grows as the universe grows – so we call it dark energy. The remaining component we call dark matter since it represents a component of the dark side that is capable of generating gravity. But that's about it. In this context, dark matter is invoked to balance the math – within a set of formulae which are already straining credibility by telling us that 96% of the universe is invisible and undetectable. So, if that was all there was to argue the case for dark matter, you would be justified if feeling a little skeptical.

But the second requirement for dark matter is much more grounded in sound observation and conventional physics. Galaxies – and the way in which galaxies cluster and dynamically interact – don't make sense if they are composed of only the visible and other known types of matter that lie within them. The Milky Way itself is rotating in a manner that would result in much of it flying apart, if there wasn't additional invisible matter generating additional gravitational attraction. So there are sound reasons to think that there really could be something else out there.

There's been a recent kerfuffle about dark matter in dwarf galaxies – although this is largely about whether dark matter particles clump together at the centre or whether they are energetic particles whizzing about throughout the galaxy. Apparently the data better fit the latter scenario, which challenges the prevalent view that dark matter is 'cold' and prone to clumping.



Similar to the Bullet Cluster, MACS J0025.4-1222 represents the aftermath of the collision of two galaxy clusters. Most of the mass of each cluster remnant is in the cool blue regions - each having already moved beyond the collision point due to being only weakly interacting mass. The pink region represents strongly radiating and strongly interacting mass has been slowed up within the initial collision. Credit NASA.

A recent literature review on Arxiv provides a comprehensive coverage of the current status of dark matter science. Initial data from the PAMELA spacecraft, showing an anomalous cosmic ray flux, encouraged speculation that this might result from dark matter annihilating or decaying. This theory did not receive wide support, but such speculation was more recently revived with FERMI-LAT finding unexpected flows of positrons (i.e. antimatter) – followed by an announcement that FERMI-LAT and other telescopes will undertake a dedicated search for gamma ray lines arising from dark matter annihilation or decay. Here it is presumed – or at least hypothesised – that dark matter can be destroyed within the hot, dense and dynamic centres of galaxies, including our galaxy.

So space science could provide at least circumstantial evidence for one of the biggest mysteries in space science – although all findings to date are inconclusive at best.

Earth-based experiments are looking for more direct evidence of the particle nature of dark matter. For example, the Large Hadron Collider is looking for signs of supersymmetry particle signatures. The hypothesised neutralino would nicely fit the hypothesised characteristics of a dark matter particle (a particle that weakly interacts with other matter, has neutral charge, is stable over cosmic timescales and has no color charge), but there are no signs of the neutralino, or anything else clearly supersymmetrical, so far.

There are also experiments, like DAMA/LIBRA, deep down coal mines and the like, which are designed to directly identify weakly interactive massive particles – although again findings to date are all a bit inconclusive.

And 'all a bit inconclusive' is a statement that aptly represents the current state of dark matter science – we remain confident that there is something out there, but (obligatory play on words coming) we remain as much in the dark as ever about what exactly it is.

More information: Capoziello et al The missing matter problem: From the dark matter search to alternative hypotheses.

Source: Universe Today

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