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Galaxy Cluster Models Cast Doubt On The Evidence for **Dark Matter**

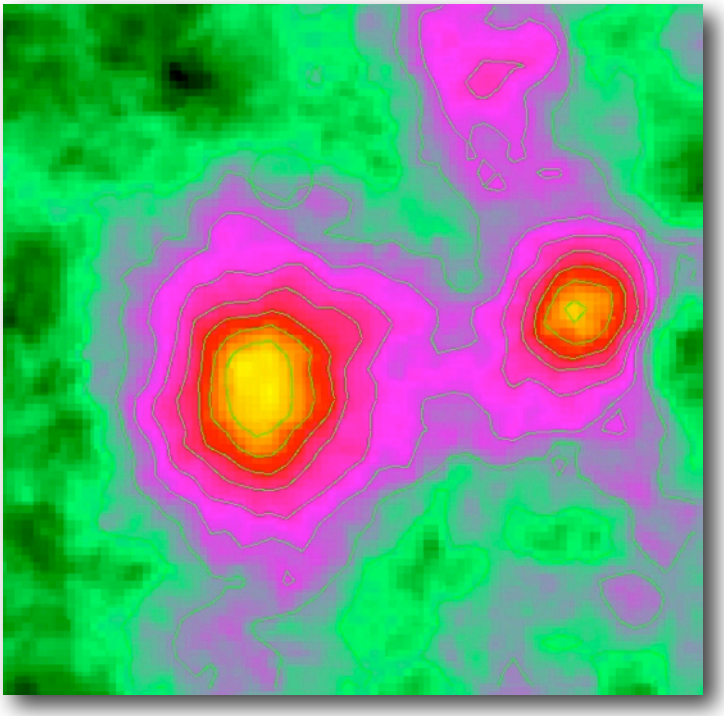

FIG. Contour plot of the dark matter in the Bullet Cluster. The data shows a significant amount of dark matter remains between the main cluster and the subcluster.

For almost 75 years, astronomers have believed that the Universe has a large amount of unseen or 'dark' matter, thought to make up about five-sixths of the mass of the Cosmos. With the conventional theory of gravitation, based on Newton's ideas and refined by Einstein 92 years ago, dark matter helps to explain the motion of galaxies, and clusters of galaxies, on the largest scales.

Overhauling Newton's Theory reveals new means to detect **Clusters of Galaxies**

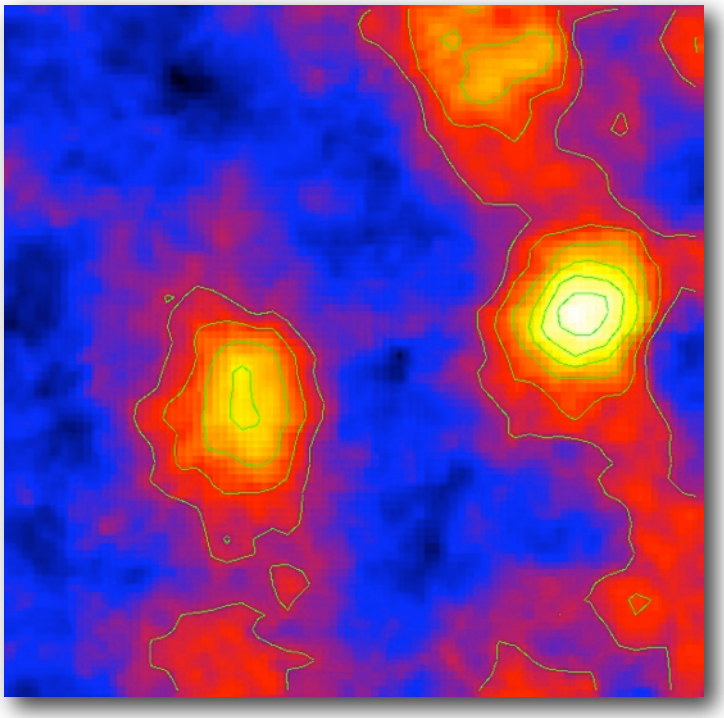

FIG. Contour plot of the galaxies predicted by MOG theory. There is a complete separation of the galaxies in the main cluster and the subcluster.

Now two Canadian researchers at the Perimeter Institute for Theoretical Physics suggest that the motion of galaxies in a distant cluster is more easily explained by a Modified Gravity (MOG) theory than by the presence of dark matter. Graduate student Joel Brownstein and his supervisor Professor John Moffat of the University of Waterloo present their results in a paper in the 21 November edition of Monthly Notices of the Royal Astronomical Society (Online early from 24 October).

The two scientists analysed images of the 'Bullet Cluster' of galaxies made using the Hubble Space Telescope, Chandra X-ray and Spitzer infrared observatories and the Magellan telescope in Chile. The Bullet Cluster consists of two merging clusters of galaxies (a main and a subcluster) - and lies at a distance of over 3 billion light years in the direction of the southern constellation of Carina.

This arsenal of instrumentation gave them maps of the 150 million degree hot gas between the galaxies and the effect of gravitational lensing, where gravity from an intervening object – here the Bullet Cluster - deflects the path of light emitted by a more distant galaxy.

Previous studies suggested that the Bullet Cluster clearly demonstrates the presence of dark matter. But when Brownstein and Moffat compared the observed distribution of gas and gravitational lensing with predictions made using their MOG theory, they found no evidence for this. In other words, it is more natural to explain the appearance of the Bullet Cluster using a revised theory of gravitation than by including dark matter.

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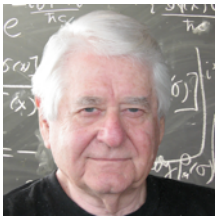

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MOG theory emerges from a generalization of relativity that eluded even Einstein, has been developed by Moffat for nearly thirty years and is now yielding astronomical and cosmological results. Brownstein and Moffat have used it to successfully explain the movement of stars in over 100 galaxies and the motion of galaxies in more than 100 clusters. MOG theory may also explain the apparent anomalous deceleration of the Pioneer 10 and 11 space probes, launched in the early 1970s and now more than 12000 million km from the Sun.

The two physicists are enthusiastic, Brownstein comments, "Using our Modified Gravity (MOG) theory, the normal visible matter in the Bullet Cluster is enough to account for the 'extra' gravity previously attributed to dark matter. So without any need for dark matter, our model suggests that the visible galaxies and material between them is enough to account for the observed gravitational lensing effect. In time, better observations will lead to higher resolution pictures of the systems we are studying. Continuing the search and then analysing other merging clusters of galaxies will help us decide whether dark matter or MOG theory offers the best explanation for the large scale structure of the Universe."

Professor Moffat adds, "If the multi-billion dollar laboratory experiments now underway succeed in directly detecting dark matter, then I will be happy to see Einstein and Newtonian gravity retained. However, if dark matter is not detected and we have to conclude that it does not exist, then Einstein and Newtonian gravity must be modified to fit the extensive amount of astronomical and cosmological data, such as the bullet cluster, that cannot otherwise be explained."