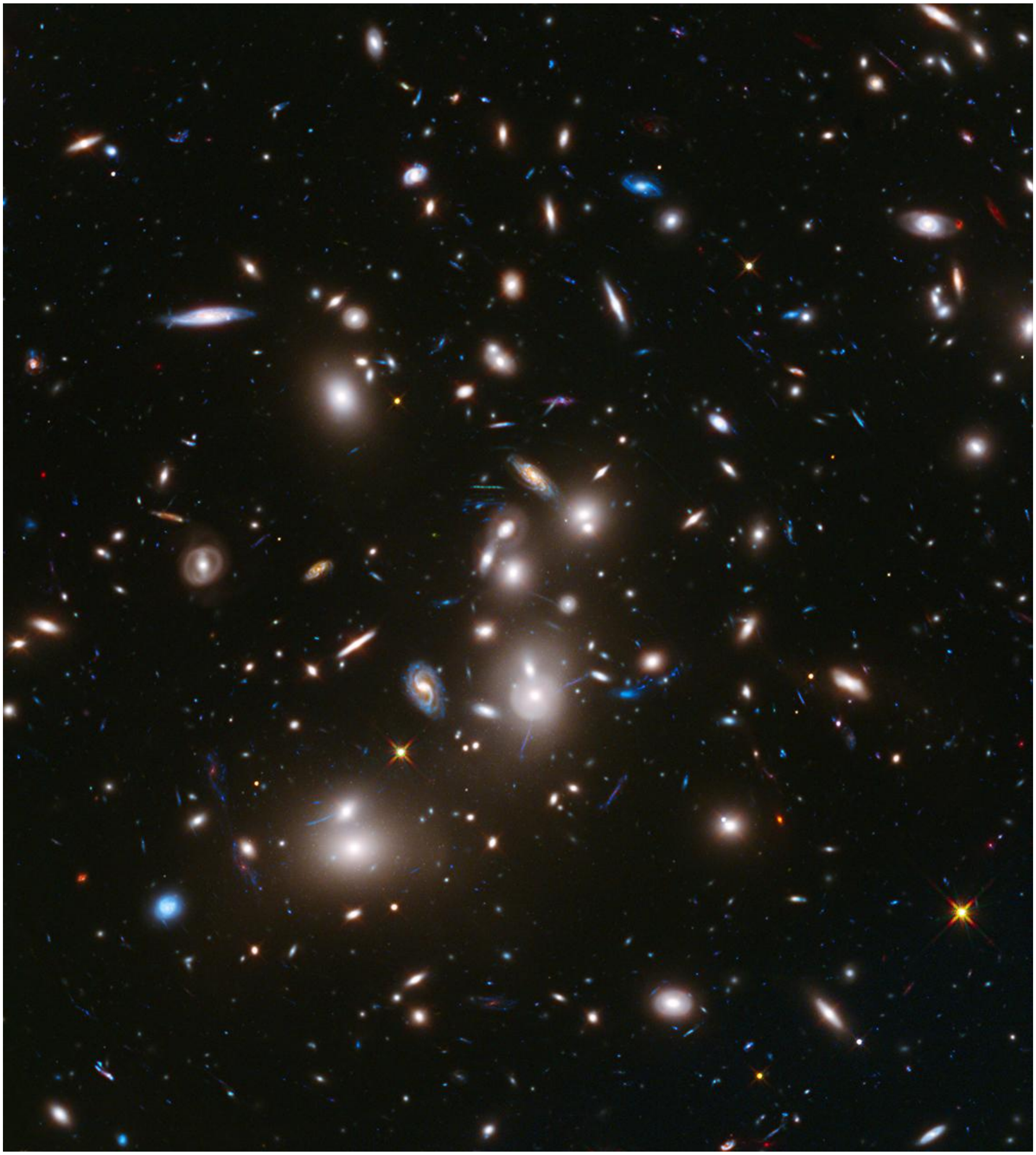
Scientists weigh the balance of matter in galaxy clusters

July 2 2019



This is a long-exposure image from NASA's Hubble Space Telescope of massive galaxy cluster Abell 2744. It shows some of the faintest and youngest galaxies detected in space. Credit: NASA/ESA/STScI

A method of weighing the quantities of matter in galaxy clusters—the largest objects in our universe—has shown a balance between the amounts of hot gas, stars and other materials.

The results are the first to use observational data to measure this balance, which was theorized 20 years ago, and will yield fresh insight into the relationship between ordinary matter that emits light and dark matter, and about how our universe is expanding.

Galaxy clusters are the largest objects in the universe, each composed of around 1,000 massive galaxies. They contain vast amounts of dark matter, along with hot gas and cooler "ordinary matter," such as stars and cooler gas.

In a new study, published in *Nature Communications*, an international team led by astrophysicists from the University of Michigan in the US and the University of Birmingham in the UK used data from the Local Cluster Substructure Survey (LoCuSS) to measure the connections between the three main mass components that comprise galaxy clusters—dark matter, hot gas, and stars.

Members of the research team had spent 12 years gathering data, which span a factor of 10 million in wavelength, using the Chandra and XMM-Newton satellites, the ROSAT All-sky survey, Subaru telescope, United Kingdom Infrared Telescope (UKIRT), Mayall Telescope, the Sunyaev Zeldovich Array, and the Planck satellite. Using sophisticated statistical models and algorithms built by Dr. Arya Farahi during his doctoral studies at the University of Michigan the team was able to conclude that the sum of gas and stars across the clusters that they studied is a nearly fixed fraction of the dark matter mass. This means that as stars form, the amount of hot gas available will decrease proportionally

"This validates the predictions of the prevailing cold dark matter theory.

Everything is consistent with our current understanding of the universe," said Dr. Farahi, currently a McWilliams Postdoctoral Fellow in the Department of Physics at Carnegie Mellon University.

Dr. Graham Smith of the School of Physics and Astronomy at the University of Birmingham and Principal Investigator of LoCuSS, says: "A certain amount of material within the universe collapses to form galaxy clusters.

"But once they are formed, these clusters are 'closed boxes.' The hot gas has either formed stars, or still remains as gas, but the overall quantity remains constant."

"This research is powered by more than a decade of telescope investments," adds Professor August E. Evrard, of the University of Michigan. "Using this high quality data, we were able to characterize 41 nearby galaxy clusters and find a special relationship, specifically anti-correlated behavior between the mass in stars and the mass in hot gas. This is significant because these two measurements together give us the best indication of the total system mass."

The findings will be crucial to astronomers' efforts to measure the properties of the universe as a whole. By gaining a better understanding of the internal physics of galaxy clusters, researchers will be able to better understand the behavior of dark energy and the processes behind the expansion of the universe.

"Galaxy clusters are intrinsically fascinating, but in many ways still mysterious objects," adds Dr. Smith. "Unpicking the complex astrophysics governing these objects will open many doors onto a broader understanding of the universe. Essentially, if we want to be able to claim that we understand how the universe works, we need to understand galaxy clusters."

Data of the kind studied by the team will grow by several orders of magnitude over the coming decades thanks to next-generation telescopes such as the Large Synoptic Survey Telescope (LSST) which is currently under construction in Chile, and e-ROSITA, a new X-ray satellite. Both will begin observations in the early 2020s.

"These measurements are laying a foundation for precise science with clusters of galaxies," says Professor Alexis Finoguenov, a member of the team based at the University of Helsinki.

More information: Arya Farahi et al. Detection of anti-correlation of hot and cold baryons in galaxy clusters, *Nature Communications* (2019). DOI: 10.1038/s41467-019-10471-y.
doi.org/10.1038/s41467-019-10471-y

Provided by University of Birmingham

Citation: Scientists weigh the balance of matter in galaxy clusters (2019, July 2) retrieved 20 April 2024 from https://phys.org/news/2019-07-scientists-galaxy-clusters.html