

NEWS RELEASE

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News release:

Hubble finds ring of dark matter

15-May 2007 **An international team of astronomers using the NASA/ESA Hubble Space Telescope has discovered a ghostly ring of dark matter that was formed long ago during a titanic collision between two massive galaxy clusters. It is the first time that a dark matter distribution has been found that differs substantially from the distribution of ordinary matter.**

Astronomers have long suspected the existence of the invisible substance of dark matter as the source of additional gravity that holds together galaxy clusters. Otherwise, astronomers say, the clusters would fly apart if they relied only on the gravity from their visible stars. Although astronomers don't know what dark matter is made of, they hypothesize that it is a type of elementary particle that pervades the Universe.

In a result just published, astronomers using the NASA/ESA Hubble Space Telescope report the discovery of a ring of dark matter in the cluster ZwCl0024+1652. The ring's discovery is among the strongest evidence yet that dark matter exists.

"This is the first time we have detected dark matter as having a unique structure that is different from the gas and galaxies in the cluster," said astronomer M. James Jee of Johns Hopkins University in Baltimore, USA, a member of the team that spotted the dark matter ring.

The ring, which measures 2.6 million light-years across, was found in the cluster ZwCl0024+1652, located 5 billion light-years away from Earth. The team found the ring unexpectedly while they were mapping the distribution of dark matter within the cluster. Although astronomers cannot see dark matter, they can infer its existence in galaxy clusters by observing how its gravity bends the light of more distant background galaxies.

"Although the invisible matter has been found before in other galaxy clusters, it has never been detected to be so largely separated from the hot gas and the galaxies that make up galaxy clusters," Jee continued. *"By seeing a dark matter structure that is not traced by galaxies and hot gas, we can study how it behaves differently from normal matter."*

During the team's dark-matter analysis, they noticed a ripple in the mysterious substance, somewhat like the ripples created in a pond from a stone plopping into the water.

"I was annoyed when I saw the ring because I thought it was an artifact, which would have implied a flaw in our data reduction," Jee explained. *"I couldn't believe my result. But the more I tried to remove the ring, the more it showed up. It took more than a year to convince myself that the ring was real. I've looked at a number of clusters and I haven't seen anything like this."*

Curious about why the ring was in the cluster and how it had formed, Jee found previous research that suggested the cluster had collided with another cluster 1 to 2 billion years ago. The research, published in 2002 by Oliver Czoske of the Argelander-Institut für Astronomie at Bonn University, was based on spectroscopic observations of the cluster's three-dimensional structure. The study revealed two distinct groupings of galaxies clusters, indicating a collision between both clusters.

Astronomers have a head-on view of the collision because it occurred fortuitously along Earth's line of sight. From this perspective, the dark-matter structure looks like a ring.

The team created computer simulations showing what happens when galaxy clusters collide. As the two clusters smash together, the dark matter falls to the centre of the combined cluster and sloshes back out. As the dark matter moves outward, it begins to slow down under the pull of gravity and pile up, like cars bunched up on a highway.

"By studying this collision, we are seeing how dark matter responds to gravity," said team member Holland Ford, also of Johns Hopkins University. *"Nature is doing an experiment for us that we can't do in a lab, and it agrees with our theoretical models."*

Dark matter makes up most of the Universe's material. Ordinary matter, which makes up stars and planets, comprises only a few percent of the Universe's matter.

Tracing dark matter is not an easy task, because it does not shine or reflect light. Astronomers can only detect its influence by how its gravity affects light. To find it, astronomers study how faint light from more distant galaxies is distorted and smeared into arcs and streaks by the gravity of the dark matter in the foreground galaxy cluster, a powerful trick called gravitational lensing. By mapping the distorted light, astronomers can deduce the cluster's mass and trace how dark matter is distributed in the cluster.

"The collision between the two galaxy clusters created a ripple of dark matter which left distinct footprints in the shapes of the background galaxies," Jee explained. *"It's like looking at the pebbles on the bottom of a pond with ripples on the surface. The pebbles' shapes appear to change as the ripples pass over them. So, too, the background galaxies behind the ring show coherent changes in their shapes due to the presence of the dense ring."*

Jee and his colleagues used Hubble's Advanced Camera for Surveys to detect the faint, distorted, faraway galaxies behind the cluster that cannot be resolved with ground-based telescopes. *"Hubble's exquisite images and unparalleled sensitivity to faint galaxies make it the only tool for this measurement,"* said team member Richard White of the Space Telescope Science Institute in Baltimore, USA.

Previous observations of another cluster, the Bullet Cluster, with Hubble and the Chandra X-ray Observatory presented a sideways view of a similar encounter between two galaxy clusters. In that collision, the dark matter was pulled apart from the hot cluster gas, but the dark matter still followed the distribution of cluster galaxies. ZwCl0024+1652 is the first cluster to show a dark matter distribution that differs significantly from the distribution of both the galaxies and the hot gas.

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Notes for editors

The Hubble Space Telescope is a project of international cooperation between ESA and NASA.

The team's paper will appear in the June 1st issue of the *Astrophysical Journal*.

Image credit: NASA, ESA, and M.J. Jee (Johns Hopkins University)

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