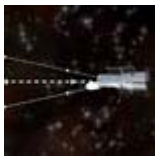
# 1E 0657-56: NASA Finds Direct Proof of Dark Matter

Credit: X-ray: NASA/CXC/CfA/M.Markevitch et al.; Optical: NASA/STScI; Magellan/U.Arizona/D.Clowe et al.; Lensing Map: NASA/STScI; ESO WFI; Magellan/U.Arizona/D.Clowe et al.

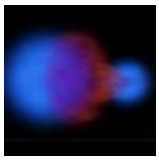
**JPEG (479 kb)** **Tiff (9.2 MB)** **PS (2.8 MB)**

*This composite image shows the galaxy cluster 1E 0657-56, also known as the "bullet cluster."* This cluster was formed after the collision of two large clusters of galaxies, the most energetic event known in the universe since the Big Bang.



**Gravitational Lensing Explanation**

Hot gas detected by Chandra in X-rays is seen as two pink clumps in the image and contains most of the "normal," or baryonic, matter in the two clusters. The bullet-shaped clump on the right is the hot gas from one cluster, which passed through the hot gas from the other larger cluster during the collision. An optical image from Magellan and the Hubble Space Telescope shows the galaxies in orange and white. The blue areas in this image show where astronomers find most of the mass in the clusters. The concentration of mass is determined using the effect of so-called gravitational lensing, where light from the distant objects is distorted by intervening matter. Most of the matter in the clusters (blue) is clearly separate from the normal matter (pink), giving direct evidence that nearly all of the matter in the clusters is dark.



**Animation of Cluster Collision**

The hot gas in each cluster was slowed by a drag force, similar to air resistance, during the collision. In contrast, the **dark matter** was not slowed by the impact because it does not interact directly with itself or the gas except through gravity. Therefore, during the collision the dark matter clumps from the two clusters moved ahead of the hot gas, producing the separation of the dark and normal matter seen in the image. If hot gas was the most massive component in the clusters, as proposed by alternative theories of gravity, such an effect would not be seen. Instead, this result shows that dark matter is required.

**Fast Facts for 1E 0657-56:**

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|---|---|
| **Credit** | X-ray: NASA/CXC/CfA/M.Markevitch et al.; Optical: NASA/STScI; Magellan/U.Arizona/D.Clowe et al.; Lensing Map: NASA/STScI; ESO WFI; Magellan/U.Arizona/D.Clowe et al. |
| **Scale** | Image is 7.5 x 5.4 arcmin |
| **Category** | **Groups & Clusters of Galaxies** |
| **Coordinates (J2000)** | RA 06h 58m 19.85s \| Dec -55º 56' 29.40" |
| **Constellation** | **Carina** |
| **Observation Dates** | 2004: Aug 10, 11, 14, 15, 17, 19, 24, 25 |
| **Observation Time** | 140 hours |
| **Obs. IDs** | 5355-58, 5361, 4984-86 |
| **Color Code** | Energy (X-ray: Pink; Optical: White/Orange; Lensing Map: Blue) |
| **Instrument** | **ACIS** |
| **Also Known As** | The Bullet Cluster |
| **Distance Estimate** | About 3.4 billion light years |
| **Release Date** | August 21, 2006 |

**More Information on 1E 0657-56:**

**Press Room: 1E 0657-56 Press Release**
**More Images of 1E 0657-56**
**1E 0657-56 Animations**
1E 0657-56 Handout: **html** | **pdf**
**Zoom in on 1E 0657-56 (flash)**
**Chandra Chronicles: Bedeviling Devil's Advocate Cosmology**
**Q&A: Astrophysicist Maxim Markevitch on Dark Matter**
**Powerpoint and PDF**
**Download image for your desktop**

**Related Chandra Images:**

Photo Album: **Abell 2029** (11 Jun 03)
Photo Album: **NGC 720** (22 Oct 02)
Photo Album: **1E 0657-56** (20 Feb 02)
Photo Album: **EMSS 1358+6245** (06 Sep 01)

**More Information on Groups & Clusters of Galaxies:**

X-ray Astronomy Field Guide: **Groups & Clusters of Galaxies**
Questions and Answers: **Groups & Clusters of Galaxies**
Chandra Images: **Groups & Clusters of Galaxies**

**Chandra Images:** ' **06** | ' **05** | ' **04** | ' **03** | ' **02** | ' **01** | ' **00** | ' **99** | **Images by Category**

Revised: August 30, 2006