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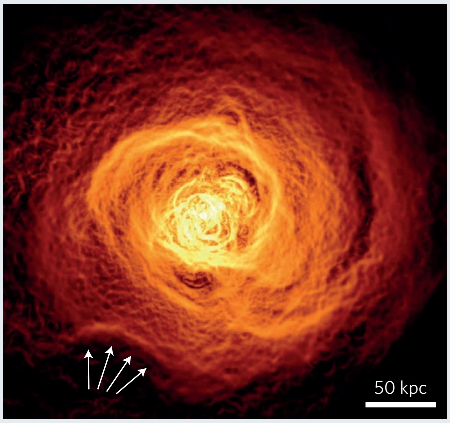
GALAXY CLUSTERS

Waking Perseus

The Perseus cluster contains over 1,000 galaxies packed into a region ~3,500 kpc in extent. It is inevitable that such close-packed galaxies will interact, and the Chandra X-ray Observatory has observed the beautiful result of that interaction (pictured). This is no snapshot — Chandra observed the galaxy cluster for over 16 days in order to capture this image. Stephen Walker and colleagues have retrieved the archival data and processed it to enhance the edges of the surface brightness distribution. This analysis, reported last year (Sanders *et al.*, *Mon. Not. R. Astron. Soc.* **460,** 1898–1911; 2016), highlighted two features in the X-ray emission that are discussed by Walker *et al.* (*Mon. Not. R. Astron. Soc.* **468,** 2506–2516; 2017): the swirling wave corresponding to the hot inter-galactic medium, and the dark region in the lower left of the image, indicated by arrows.



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According to a simulation performed by Harvard astrophysicist John ZuHone (https://www.youtube.com/watch?v=Yu1yF1z7Ins), the spiral wave pattern seen in the image could have been generated by a passing galaxy cluster about ten times smaller in mass than Perseus. In the simulation, gravitational interaction between the two clusters disrupts a reservoir of cool gas at the centre of the Perseus cluster, causing it to ripple outwards and mix with hot, shocked gas. The velocity difference between the two fluids causes a Kelvin–Helmholtz instability, which propagates in the wave direction and causes the dark area indicated in the image. This dark 'bay-like' feature is approximately the size of the Milky Way, and may be the result of a cold front in the cluster gas: an interface where the temperature drops dramatically on scales much smaller than the mean free path.

An advantage of this comparison of observations and simulations is that (unmeasurable) physical quantities can be estimated. In this case, the bay feature only appears in this form when the ratio of the thermal pressure to the magnetic pressure is ~200, and this determination in turn allows the authors to obtain an order-of-magnitude estimate of the magnetic field. Indeed, the overall magnetic field can be estimated for the entire cluster volume, giving this method an advantage over Faraday rotation measures, which are limited to small sight-lines.

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