Several techniques have previously been used to measure the integrated magnetic-field magnitude, but never the orientation of a field in the ICM[3]. Yet galaxy clusters, after all, contain a lot of galaxies (as well as dark matter and the ICM), so Pfrommer and Dursi have used observations of these galaxies running into the ambient plasma to determine the magnetic field. The galaxies sweep up ambient ICM magnetic field as they orbit in the cluster, such that the field becomes 'draped' around the galaxy clusters. This draped magnetic field has been dubbed "bubble wrap for bullets", as it insulates the galaxies from the surrounding cluster gas and prevents instabilities from mixing the galaxy with its surroundings[4]. Meanwhile, observations of the polarized radio emission in the galaxies themselves have revealed the orientation of the galactic magnetic field (although this technique does not work in the dilute ICM)[5]. Pfrommer and Dursi[1] have correlated the draping effect with these measured galactic magnetic fields to extract the orientation of the swept-up magnetic fields.

The scientific method used here would be unrecognizable to your eighth-grade science teacher. For example, to measure the gravitational acceleration, g, in a lab on Earth, you could drop weights from various heights and time their falls, quickly discovering that $g \approx 9.8\ \mathrm{m\ s^{-2}}$. Now imagine that you had to determine the strength of gravity by looking at various snapshots of falling weights — a much harder task. This is how the Universe presents data to us. Instead of formulating and testing a hypothesis using repeatable experiments, in astronomy it's necessary to synthesize a variety of observations at a fixed time.

Pfrommer and Dursi have in effect performed a series of experiments, using numerical simulations based on magnetohydrodynamics. The novelty is that they simulated a set of galaxies being draped by the ICM and then used these sets of simulations as a calibration for understanding observational data. In the absence of the numerical study, there would be no way to connect observations of the magnetic field in the galaxies to the orientation of the magnetic field in the ambient ICM. A major caveat is in order here, however, as it is always difficult to be certain that the physics contained in the simulation captures all the important physical processes present in nature. But, as computers become more powerful, we should expect to see the interplay of theory, simulation and observations become far more prevalent.

For galaxy clusters, this cycle of discovery has now come full circle. It was shown several years ago that the so-called magnetothermal instability would operate in the outer parts of galaxy clusters[6]. Numerical simulations predicted that this instability would saturate by reorienting the magnetic field to be preferentially radial[7]: Pfrommer and Dursi's work seems to confirm that the magnetic fields indeed seem to be radially aligned in the Virgo cluster. Next there is the exciting prospect of extending their technique to the study of the geometry of magnetic fields in the central regions of clusters, where the cooling time is short, and making the first measurements that show how thermal conduction could potentially solve the cooling flow problem at the heart of galaxy clusters. ❐

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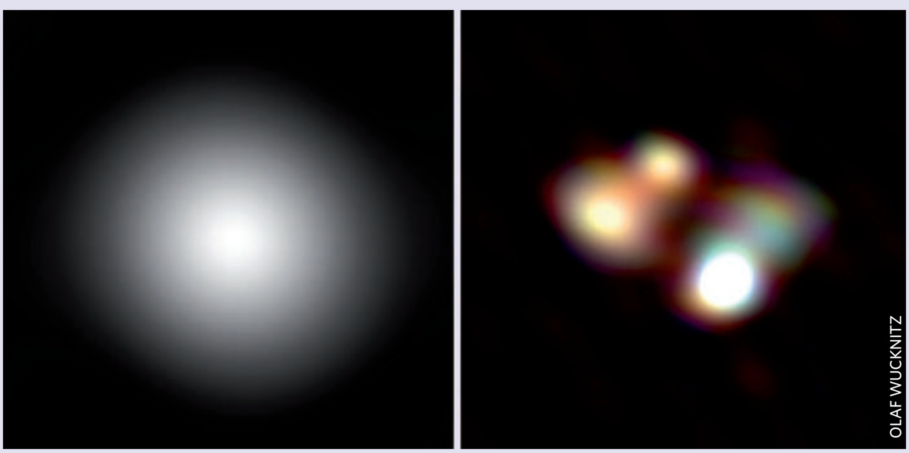
RADIO ASTRONOMY

More stations tune in

To improve resolution, individual telescopes can be arranged into an array of telescopes. By means of interferometry the telescopes are then able to reach resolutions equivalent to that of a single enormous dish. At present, the largest such array is the Low Frequency Array (LOFAR). It is under construction across Europe and instead of individual telescopes — which would have to be very large to be sensitive to the long wavelengths measured — it employs array stations consisting of many low-cost antennas.

The figures illustrate the effect of long-baseline interferometry. With five stations spread across the Netherlands, the quasar 3C 196 looks like a featureless blob in the 4–10-m-wavelength range (left). Now add three stations in Germany, the farthest being near Munich: suddenly the resolution improves tenfold and details emerge (right); in fact, the image on the right zooms into the central region of the quasar, so the actual difference between the two images is a factor of 40. The quasar is a strong radio emitter, but even so, it is 7 billion light-years away.



LOFAR will soon include other stations, not to mention shorter-wavelength data, to further improve the resolution. In addition to probing mysteries of the early Universe, it will also have geophysical and agricultural applications.

MAY CHIAO