EVIDENCE OF A LARGE SCALE MAGNETIC FIELD IN THE COMA - A1367 SUPERCLUSTER

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1. Observations and Results

The Coma cluster is a rich cluster of galaxies nested in an even larger supercluster of galaxies. The plane of the supercluster appears to be defined by the Coma cluster itself and another galaxy cluster, Abell 1367, that lies about 40 Mpc ($H_0 = 75$ Mpc km^{-1}s^{-1} ($\equiv h_{75}$)) farther west (Tifft and Gregory 1976).

From new radio observations at 326 MHz, we present evidence for the existence of a very large scale radio feature which extends more than one Abell radius and connects the halo source Coma C (Willson, 1970) with the extended radio source 1253+275 (Andernach et al., 1984). The emission consists of a $\sim 1.4 h_{75}^{-1}$ Mpc bridge, extending from the core region of the Coma cluster toward A1367. It is very faint, and not apparently associated with any individual galaxy system in the Coma complex.

The Coma cluster was observed for a total of seventy two hours in May and June 1986 at 326 MHz, using the Westerbork Synthesis Radio Telescope (WSRT). The baselines covered by the 10 fixed and 4 movable antennas were SB + n72 m, where n = 0 to 37 and SB (the shortest baselines), were 36, 48, 60, 72, 84, and 96 m for the six surveys. The synthesized beam of the final map was $2' \times 1'$ elongated N−S, and the rms noise level of the CLEANed map is 1.1 mJy/beam. Short VLA observations at 327 MHz in the A and B configurations were used to find and subtract discrete sources present in the bridge region. The residuals are at a very low level, and we can rule out the possibility that the bridge region is an artifact of the low-order interferometer spacings. After removal of the small-diameter sources in this area, the residual map was convolved to a lower resolution ($4' NS \times 2' EW$) to enhance the signal-to-noise ratio of the diffuse emission (Figure 1). The size of the 'bridge' is estimated to be $\sim 50' \times 20'$ ($\sim 1.4 h_{75}^{-1}$ Mpc in projection) and it is elongated in position angle about 50°. The total flux density contained in the region is 760±100 mJy at 326 MHz. The large extent, and especially the radio morphology of the 'bridge' implies that it is not a blend of numerous unresolved weak radio sources located in the same region, but that it is rather related to the extension of the cluster and is most likely, as we suggest, a feature of the Coma/A1367 supercluster.

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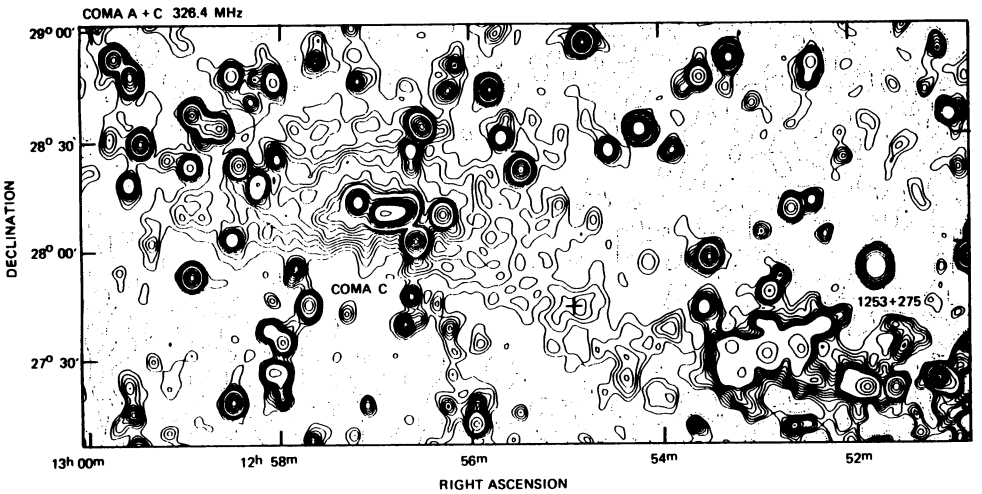

Figure 1: Contour map of the Coma cluster at 326 MHz corrected for the primary beam attenuation. Small diameter sources, which are seen on the 'bridge' region, were all removed and the residual map was convolved with a beam of resolution of $4' \times 2'$. The location of NGC 4839 is marked with a + symbol. Contours are shown at -1,1,2, ... 9,10,20,30, ...90,100,200,400 times 4 mJy/beam.

2. Discussion

Because synchrotron radiation is the only plausible radiation mechanism for the bridge radio emission, it implies the existence of a large-scale *inter* -cluster magnetic field. The physical parameters of the bridge region can be estimated using the observed flux density and size at 326 MHz, an assumed spectral index, $\alpha = -1.5$ ($S_\nu \propto \nu^\alpha$) and the assumption of equipartition between the energy density of the relativistic protons and electrons and the magnetic field. If we also assume a volume filling factor of unity, and a proton/electron ratio of 1, the equipartition field strength is $0.3\mu G$ if we model the bridge as a cylinder 1900 kpc long and 800 kpc in diameter. On any reasonable assumption, the magnetic field strength must be a few tenths of a microgauss over the large volume of space which defines the plane of the Coma-Abell 1367 Supercluster. Our new observations thus provide firm evidence for the existence of a magnetized intergalactic medium on an *inter-cluster* scale. The origin of these large scale magnetic fields is not yet known. The magnetic field which we are detecting is probably the modified "fossil" of a primordial magnetic field which may have played an important role in forming the giant voids and superclusters. The primordial magnetic field has been substantially amplified in the proto-galactic medium as the galaxies and clusters evolved from their early state. The large extent of the intergalactic magnetic field revealed in Fig. 1 suggests that magnetic fields have played a more important role than previously believed in the formation of galaxies, and of larger hierarchical structures such as superclusters and voids.

References

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PERLEY: Do you have any measurement of polarization in the bridge? Without polarization, you cannot claim the fields are of large scale – they may be tangled on a small scale. Indeed, could the emission be not synchrotron?

GIOVANNINI: At present we do not have polarization measurements of the bridge. In our WSRT 327 MHz data no polarized flux is available. We have 610 MHz WSRT data but the reduction is still in progress. I agree with your comment on the scale of the magnetic field but at present we can only estimate the equipartition magnetic field. The emission of the "bridge" has a steep spectral index (comparing our data with 408 MHz data of Kim et al. and 430 MHz data of Hanisch (1980) with the Arecibo telescope). We are at the Northern Galactic Pole and no Galactic emission is visible in the 408 MHz all-sky map (Haslam et al.), therefore we are confident that the "bridge" is synchrotron emission.

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