ENHANCED ACTIVITY IN THREE GALAXIES IN THE CLUSTER A1367

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ABSTRACT: radio continuum, 21 cm line and optical observations of three irregular galaxies at the north-west periphery of the cluster A1367 are presented. The asymmetry found in their brightness distributions suggests that they are undergoing ram-pressure sweeping in the dense cluster environment. It is proposed that this mechanism enhances the star formation rate in these galaxies and produces magnetic field amplification.

The origin of the observed morphology segregation in clusters of galaxies is among the most intriguing, yet unsolved questions concerning the origin and the evolution of galaxies. Theories of biased galaxy formation in the CDM cosmological scenario (Davis et al, 1985) give a possible, though not exhaustive explanation of this phenomenon. Other mechanisms, such as merging, tidal disruption or ram-pressure sweeping by strong intergalactic winds provide us with alternative explanations, as this meeting has emphasized (see contributions by Schweizer, Whitmore and Balkowski).

In the present paper we show a case which we consider perhaps the best studied candidate for ram-pressure induced galaxy evolution in a cluster environment. It refers to three galaxies in the N-W periphery of the cluster A1367 (z=0.02) in the Coma Supercluster "wall" which we have reasons to suspect are falling onto the "hostile" cluster environment for the first time.

Since the discovery of unusually bright and extended radio sources associated with three irregular, quite inconspicuous galaxies CGCG 97-073, 97-079 and 97-087 in early Westerbork maps (Gavazzi, 1978), an increasing observational effort was devoted to their study at various wavelengths. The galaxies are faint objects in the visible (m_p=15.6; 15.7; 14.3 mag respectively) but have among the highest radio/optical excess as compared with similar galaxies in the survey presented earlier at this meeting. Their location in the cluster is rather peripheral (about 30 arcmin away from the X-ray cluster centroid), just outside the X- ray emitting region as mapped in the IPC observation of the cluster (Bechtold et al, 1983) (notice however that the apparent absence of X-ray emission in correspondence of 97073 and 79 is an artifact due to the IPC window supporting structure).

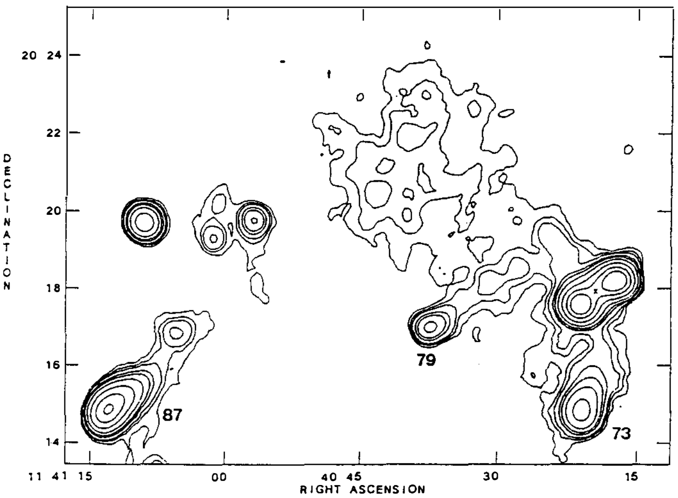


Fig.1: 1.4 Ghz map of the region in A1367 obtained with the VLA in C+D array configuration. The three galaxies under study are labelled 73, 79 and 87. The bright double radio source found at the interception between the tails is associated with a 21 mag quasar at z=1.06. The cluster center is located at S-E of the mapped region.

Repeated observations in the radio continuum (1.4 GHz) with the VLA in C and C+D array configuration (beam FWHM=20" and 40" respectively) (Gavazzi and Jaffe, 1985, 1987) revealed that the three objects show evidences of very asymmetric radio structures with a sharp brightness gradient on the side facing the cluster center and a smooth, low brightness trail on the opposite direction. The total length of the trails is up to 50 kpc (see Fig. 1). This characteristic, often found associated with Elliptical galaxies in clusters (Head-tail radio galaxies) is exceptional in spiral/irregular galaxies, and by itself indicates the presence of an external pressure acting on these galaxies.

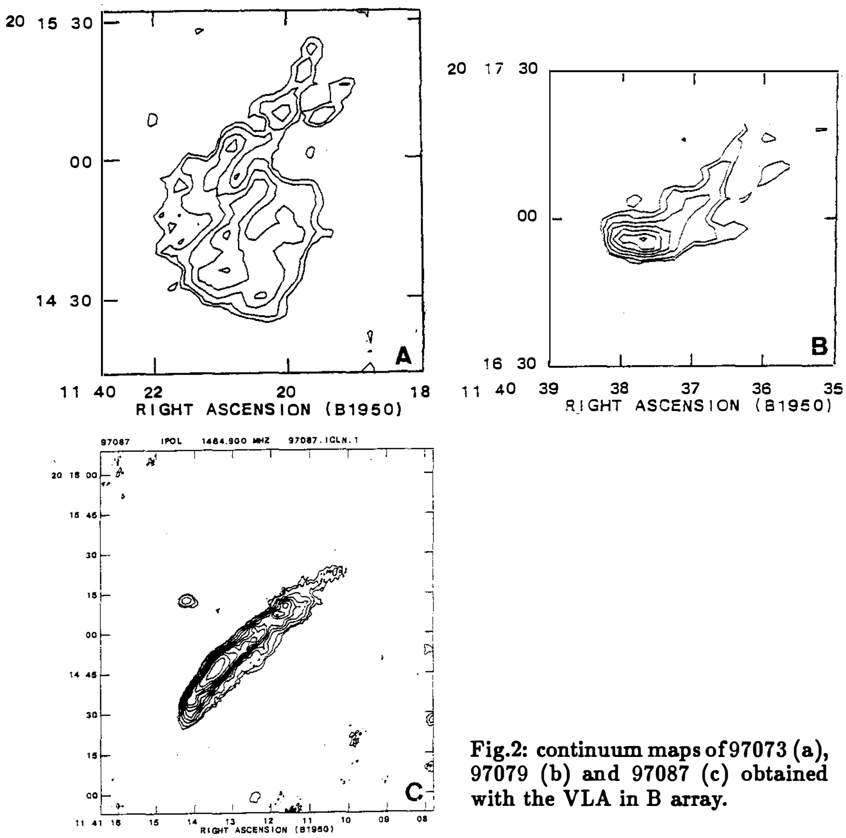
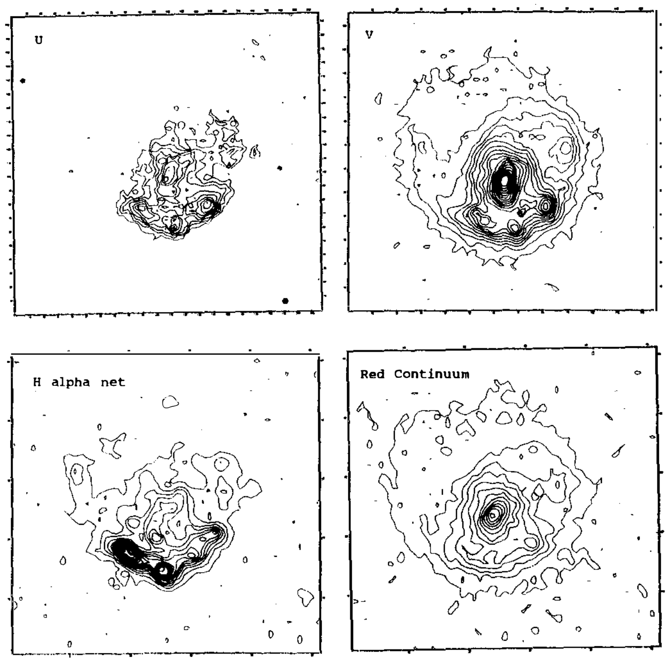


Fig.2: continuum maps of 97073 (a), 97079 (b) and 97087 (c) obtained with the VLA in B array.

Recently the galaxies were observed with the VLA in the B array configuration with a resolution comparable with that of optical observations. Preliminary maps are shown in Fig. 2. Also at this resolution 97073 and 79 show clearly an asymmetric brightness distribution with a low brightness feature trailing in the N-W direction (more about the comparison of these maps with the optical frames below). Follow-up 21 cm line observations done at Arecibo (Gavazzi, 1989) and at the VLA (Dickey and Gavazzi, 1991) revealed that in the three objects the distribution of the neutral gas is also asymmetric, with most of the HI content being found in the galaxy side coincident with the radio trail and with strong HI deficiency on the "head". The transient character of the observed HI asymmetry (which should be smeared out by differential



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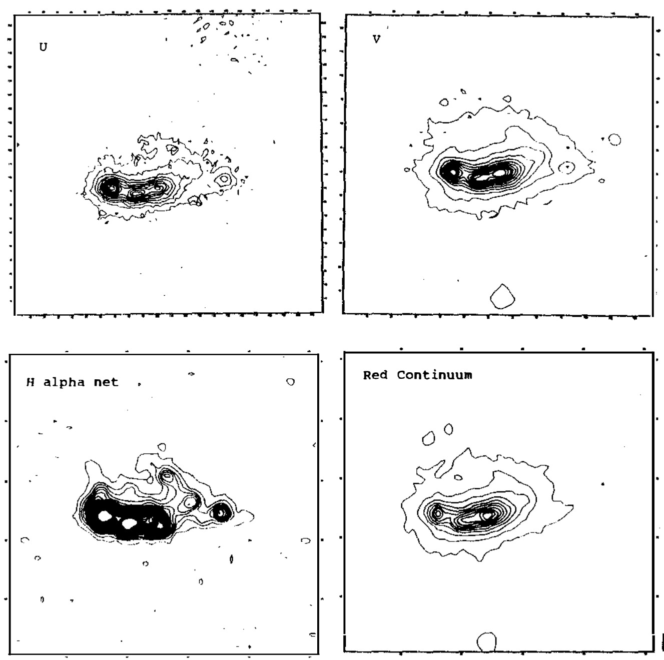

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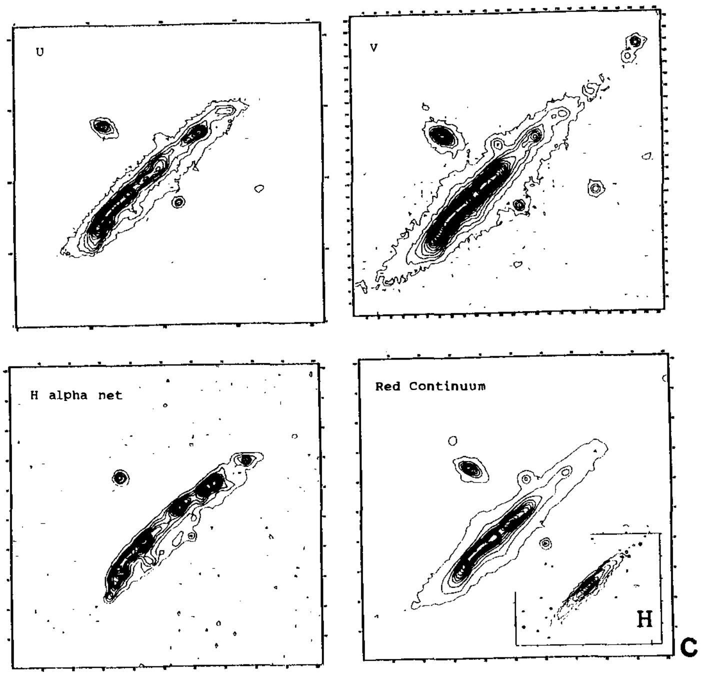

Fig. 3: V, U bands, H_α net and continuum near H_α frames of galaxies 97073 (a); 97079 (b) and 97087 (c). The inset shows an IR H band frame of 97087. The figures are on the same scale as Fig.2. (North is up, East to the left)

rotation in few 10^8 years), led Gavazzi (1989) to argue that gas ablation is actually presently taking place.

Early observations in the visible (broad-band V, B and H_α surface photometry) were obtained at KPNO by Gavazzi et al, 1984. Deeper frames in the V, U bands obtained at the 1.5m Loiano telescope (Italy) and at the 2.1m San Pedro Martir telescope (Mexico) and H_α+[NII] frames obtained with the 2.3m telescope of the Steward Observatory (Arizona) are displayed in Fig. 3. These observations reveal that in the three galaxies a prominent peripheral chain of giant HII regions (L=10^{40-41} erg s^{-1}) is formed at the galaxy side where the steep radio gradient is observed. The red narrow band continuum near H_α is also given in Fig. 3 to indicate that the distribution of the old stellar population is more centrally peaked than that of blue stars and generally tends to anticorrelate with the luminosity of the HII regions. An IR H band frame of the central region of 97087 is also shown to emphasize this last property. This frame was obtained during some test time of a new IR array at the San Pedro Martir Observatory. The frame shows a single peak symmetric feature, which on the basis of the its red excess can be identified with the galaxy nucleus. Notice that no sign of the absorption feature visible near the nucleus at other wavelengths is present in the IR frame.

The spatial coincidence between the regions of intense star formation (Fig. 3) and the peaks of the non-thermal radio emission (Fig. 2) is striking. This coincidence leads to the firm identification of the cosmic ray electron sources with regions of massive star formation (e.g. supernova explosions).

Altogether the multiwavelength material in our hands perhaps gives the best evidence for galaxies presently undergoing ram-pressure in the cluster environment. Not only there is strong evidence that the studied objects moving at high velocity ($V \sim 1000$ Km s^{-1}) in the dense intergalactic medium ($\rho \sim 10^{-3} cm^{-3}$ from X-rays estimates) are suffering from HI depletion, but also that the magnetic field structure is accordingly disturbed, producing enhanced synchrotron emission on the "head" and large scale line stretching on the "tail". Moreover the signature of a shock, possibly formed on the interface between the galaxy and the IGM is revealed by the elongated appearance of the regions of abnormal star formation.

We wish to stress that the evidence we collected seems to indicate that in the early phases of infall of galaxies on clusters the dynamical processes might trigger, instead of inhibiting, processes of violent star formation, contrary to the general wisdom on this subject. The time scale of this phase, however, is short compared with the cluster crossing time due to rapid gas consumption and ablation, and the future fate of these cluster "intruders" is certainly that of a progressive evolution toward more anemic and earlier morphological types.

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