Early-type galaxies with neutral hydrogen in the Virgo cluster from the ALFALFA survey

S. di Serego Alighieri*, M. Grossi*, C. Giovanardi*, S. Pellegrini† and G. Trinchieri**

*INAF - Osservatorio Astrofisico di Arcetri, Firenze, Italy
†Università di Bologna, Bologna, Italy
**INAF - Osservatorio Astronomico di Brera, Milano, Italy

Abstract. We extend our published work on the neutral hydrogen content of early-type galaxies in the Virgo cluster using the catalogue of detected sources from the ALFALFA survey, by showing the 21cm spectra of all the detected galaxies and discussing a deeper analysis of the ALFALFA datacubes, searching for lower S/N sources. A view of the multiphase interstellar medium of M86 is also presented, by comparing images of the cold, warm and hot phases.

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NEUTRAL HYDROGEN IN THE VIRGO ETG

The multi-phase properties of the ISM of early-type galaxies (ETG) in a rich environment, like the Virgo cluster, can provide important information on the influence of interactions (merging, ram-pressure stripping, tidal interactions etc.) on galaxy evolution. The cold phase, of which neutral hydrogen is a major component, has a hard time in surviving in the cluster environment, because of the evaporation induced by the hot ICM and ISM, particularly in the massive ETG, where hot gas is denser. Therefore HI survival in cluster ETG may be the sign of interesting phenomena. Di Serego Alighieri et al. [1] have recently completed a survey of the HI content in the Virgo cluster ETG, using the catalog of HI sources produced by the ALFALFA survey [2]. They find that only a very small percentage (2.3%) of the ETG with $B_T \leq 18.0$ in the Virgo Cluster Catalogue [VCC; 3] have neutral hydrogen above about $3 \times 10^7\ M_\odot$. Most of the detected ETG are dwarf galaxies, which are at the border of the early-type classification.

Figure 1 shows the HI spectra of all the Virgo ETG detected in the published ALFALFA catalog, except for VCC 2062, whose HI line is almost unresolved from the one of the gas rich spiral NGC 4694. For the published catalog the ALFALFA team has adopted a S/N threshold of 6.5 to discriminate between confirmed and spurious detections in the blind search of the survey data-cubes [4]. To search for additional 21-cm sources at lower S/N ratios, we have inspected the survey data-cubes at the optical position and velocity (when available) of each object in our optical sample of Virgo ETG obtained from the VCC. We did not find any additional ETG convincingly detected in HI . The tentative faint HI sources, which we identified at S/N < 5, would need deeper pointed follow-up observations to be confirmed. This negative result reinforces our confidence in the completeness of the published ALFALFA catalog.

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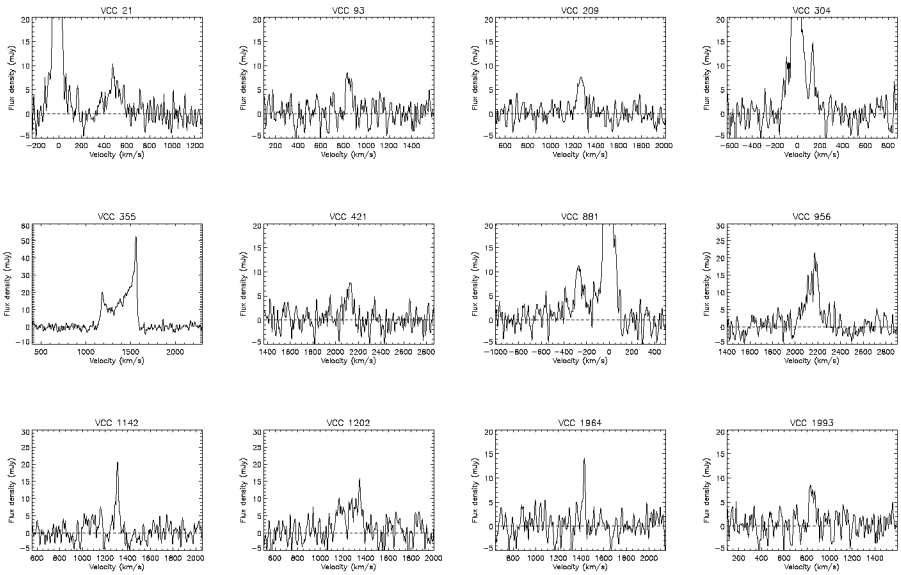

FIGURE 1. The HI spectra of the Virgo ETG detected by the ALFALFA survey.

THE MULTI-PHASE INTERSTELLAR MEDIUM OF M86

The brightest ETG detected in HI in the Virgo cluster is M86 (VCC 881, NGC 4406), an S0/E3 galaxy with a long plume of X-ray emission to the North-West, which is thought to be due to hot gas swept back by the ram pressure caused by the motion of M86 through the intracluster medium [5]. M86 is also the ETG with the largest Hα luminosity found in the survey of ionised gas in a sample of ETG with hot gas by [6]. The rings and filaments visible in their Hα image, reproduced in Fig. 2 (*center*), suggest that the gas might result from a recent interaction with a gas rich object. This possibility is reinforced by an estimate of the evaporation time for a cold gas cloud embedded in the hot ISM of M86, which is of the order of 1 Gyr. Therefore cold gas cannot survive for very long in M86 and, if present, must have been accreted less than a gigayear ago.

A candidate gas-donor could be NGC 4406B (VCC 882), a dE galaxy located at a projected distance of 1.4 arcmin to the North-East of the centre of M86. This galaxy is also located at one end of a $\sim$28 kpc long dust trail in the halo of M86, which is thought to be stripped material from the dwarf [7]. A less likely candidate gas-donor could be the Virgo spiral galaxy NGC 4388, which is thought to be the origin of the 110 kpc long plume of HI by stripping in the hot intracluster medium [8]. This plume of HI passes at a projected distance of 2 arcmin to the South-East of M86, but has a radial velocity of about 2200 km s^{-1}, very different from the -280 km s^{-1} measured with the VLA for the HI cloud coincident with the ionised gas (Fig. 2 *right*) and from the HI velocity measured from ALFALFA for M86 (-302 km s^{-1}).

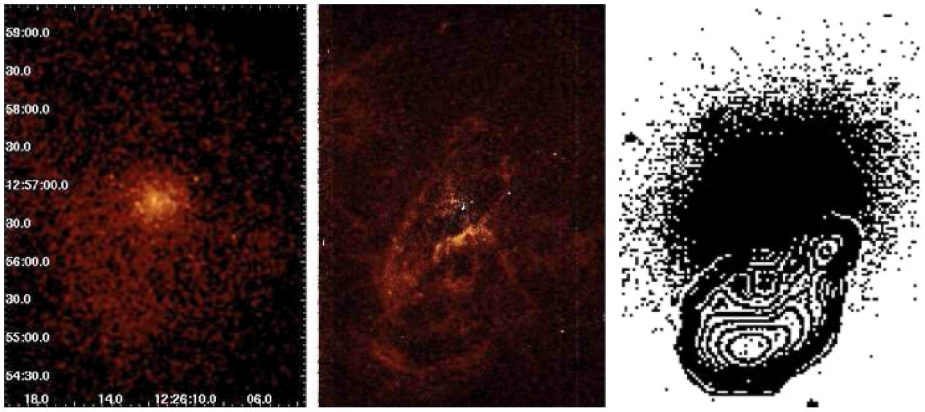

FIGURE 2. A comparison between the Chandra 0.5-2 keV (*left*), Hα [*center*; 6], and VLA 21-cm maps [*right*; 9] of M86 (VCC 881). All images have the same scale and cover the same area of the sky. Used by the kind permission of the ASP Conference Series.

CONCLUSIONS

Only very few ETG in the Virgo cluster (2.3%) contain neutral hydrogen. The relatively short evaporation time for the cold gas embedded in a hot halo is a good reason for the scarcity of HI in the bright ETG with an X-ray halo. The exceptions, like M86, show evidence for an interaction with a companion, which could have recently supplied the cold gas. The few dwarf ETG detected in HI are in fact at the border of the ETG classification and could be later type galaxies, for which part of the gas has been stripped away by the hot intracluster medium.

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