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ABSTRACTS OF POSTER PRESENTATIONS

Photometric Properties of Low Redshift Galaxy Clusters

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We have conducted a deep photometric study of 27 Abell clusters in the redshift range of $z = 0.02 - 0.04$ with the 8k CCD mosaic camera on the KPNO 0.9m telescope. Analysis of a sub-sample of twelve clusters indicate that there is a statistically significant increase in the dwarf-to-giant ratio with increasing cluster-centric radius for nine clusters. This result is evident in the increasing steepness of the faint end slope of the R band luminosity function from the inner 0.75 Mpc to the outer 0.75–1.50 Mpc radial bin (for $H_o = 50$ km s^{-1} Mpc^{-1}). These observations are consistent with the dwarf galaxy disruption model of López-Cruz et al. (1997, ApJ, 475, 97L).

A Possible Test for Cluster Mergers

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We analysed the visible galaxy distributions in ten clusters in order to study a velocity diagram character and to carry out a search for those galaxy clusters, which could be formed because of the cluster merger. Values of the anisotropy parameter for these clusters were found. Moreover, the cluster formation problems after the merger and also the evolution problem of the anisotropy parameter for the clusters are considered. The study of the dynamical properties of clusters of galaxies is an important tool both for the understanding of the merger phenomenon and for testing evolutionary schemes of non-stationary self-gravitating systems.

The velocity distribution (VD) of galaxies in the clusters, where a merger did not take place, is rather close to the isotropic one. For these clusters the values of an anisotropy parameter $A = 2 - 2\sigma_t^2/\sigma_r^2$ (where σ_r^2 and σ_t^2 are velocity dispersions in radial and tangential directions respectively) are equal almost to zero. In clusters where a merger took place, the value of A is apart from $A = 0$. In isolated systems and systems with radial collapse motion we have generally $0 \leq A < 2$ (see discussion in Bettwieser and Spurzem 1986, A&A, 161, 102).

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But the theoretical calculations show (Nuritdinov 1995, Astron. Astrophys. Trans.) that the most stable state corresponds to the state with $A = -\infty$ and on the contrary the case $A = 2$ is the most unstable state. We predict that for young galaxy clusters and some other clusters where the merger happened, it is $\sigma_r^2 >> \sigma_t^2$. However, the theory shows a probability of special type of the merger also, that are able to create such state, where we have $\sigma_t^2 > \sigma_r^2$, i.e. $A < 0$.

We have studied the character of VD in ten galaxy clusters by minimization of the function $\Phi(A) = \sum_{i=1}^{N} [F_{theor}(r_i) - F_{obs}(r_i)]^2$ for the case $A \geq 0$, where N is number of galaxy counts zones, $F_{obs}(r)$ is observed surface number density of galaxies and $F_{theor}(r) = -2\beta \int_{r/\alpha}^{\infty} \sqrt{\xi^2 - (r/\alpha)^2} D'(\xi)\, d\xi - F_0$ is a theoretical surface mass density profile. Here α and β are scale factors, F_0 is constant taking into account the infinity radius of the model. The value of A that gives minimum $\Phi(A)$ is adopted as most probable value of A. We determined the value of anisotropy parameter for 10 galaxy clusters and received following values of anisotropy parameter: for A1139 and A2670 $A = 0$, A2256 - $A = 0.2$, A2255 - $A = 0.5$, A151 - $A = 0.8$, A119 - $A = 1.0$, A2666 - $A = 1.2$, Coma and Pegasus - $A = 1.4$, Cancer - $A = 1.8$. The analysis of these results and of clusters structure shows a presence of a certain mutual connection between them. For instance, first 4 clusters, that have almost isotropic velocity distribution, have got enough regular structure. Next two clusters have more complicated structure and more anisotropic VD. The clusters A151 and A2666 are with multiplet structure (cDp) and perhaps therefore both have essentially anisotropic VD. The Coma and Pegasus that already have $A = 1.4$ take extensive regions and have structure with a few density peaks. According to Valtonen and Byrd (1986, ApJ, 303, 523) the Coma has a massive double galaxies system. Finally, the Cancer (Bothun et al. 1983, ApJ, 268, 47) has very irregular structure and consists of five galaxy groups. Perhaps this circumstance determines the strong anisotropic VD ($A = 1.8$) there.

Cluster Merger in A3667? New Radio Observations Shed More Light

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The ACO Cluster A3667 presents an important opportunity to examine merger scenarios in clusters of galaxies. The morphology of the cluster presents bi-modal optical galaxy distribution with two large diffuse regions of radio emission straddling the X-ray emitting gas. These data, combined with other evidence, such as the large velocity dispersion and distortion of the X-ray morphology, have been interpreted as evidence of a cluster merger. We present new high

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resolution, high dynamic range radio images of A3667 including spectral index data and first results of our polarization analysis. These data taken with the Australia Telescope Compact Array at 20 & 13cm present the most sensitive radio map of the entire cluster to date and provide important clues as to the nature of the merger. Higher resolution images, taken at 6cm, of the core part of each diffuse region will also be presented. We will discuss the filamentary versus sheet structure of these regions and their connection to the cluster magnetic fields.

The Effects of Cluster Mergers on the Properties of Radio Galaxies

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Our multifrequency study, from the radio band (ATCA observations) to optical spectroscopy to the X-ray energies, of merging clusters in the core of the Shapley Concentration led some interesting results with respect to the radio properties of early-type galaxies. The radio luminosity function (RLF) for elliptical galaxies in the A3558 complex is significantly lower than the RLF derived by Ledlow and Owen (LO96, 1996 AJ 112, 9) for ellipticals not selected to be in merging environments. Conversely, the RLF in the A3528 cluster complex is in very good agreement with LO96. We propose that the different shapes and normalizations of the two RLFs could be due to the different stages of cluster merger in the two regions, i.e. pre-merger in A3528 and advanced merger in A3558.

Statistical Study on Radio Sources in Clusters

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In this contribution, preliminary results on studies of radio sources in clusters are reported. The goals of this study are 1) radio source spatial distribution to the cluster center, 2) spectrum distribution as a function of flux density, angular size, and spatial distribution.

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The Magnetic Field in Abell 514

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Polarized radiation from radio galaxies embedded in cluster of galaxies may be rotated by Faraday effect if magnetic fields are present in the Intra Cluster Medium (ICM). We analyze the evidence of a magnetic field in Abell 514 through the study of polarized emission from radio sources located inside or behind the cluster. Abell 514 is characterized by the presence of six extended radio galaxies located at different projected distances from the cluster center. These six radio galaxies are studied in total intensity and polarization and the data presented here were obtained with the Very Large Array (VLA) at 3.6 and 6 cm in the AnB and BnC configuration. All these source are polarized, therefore they are suitable for a study of the Rotation Measure (RM). A preliminary analysis gives a magnetic field of 2-3 μG along the line of sight in the cluster central region.

Faraday Studies of Intracluster Magnetic Fields

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Intracluster magnetic fields are probed through Faraday studies of radio sources viewed through the cluster gas, as well as through observations of cluster-wide synchrotron halos and relics. A statistical Faraday study of sources viewed through the intracluster medium (ICM) of 16 Abell clusters shows that the ICM magnetic field strength is $\sim 5\ \mu$G, ordered on scales of 10 kpc, and the fields extend to radii of over 500 kpc (well beyond the cluster core region). We also present Faraday maps of the Mpc scale highly polarized radio relic in Abell 2256 as well as new high sensitivity maps of the (unpolarized) radio halo in this cluster. The maps reveal ordered fields on scales of > 100 kpc which appear to trace the bright ridges in the relics.

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The Reason of Absence of Strong Radio Sources in HCGs

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The radial velocity dispersion (RVD) of HCGs depends on the elongation of the group. Hence, HCGs are real physical formations. Members of loose groups around HCGs are not galaxies gravitationally unrelated to HCGs. The dependence of the RVD of the faint members on the elongation of the whole group shows that they also rotate around the common gravitational center. HCGs are very flat systems, and contain many dozens of fainter members. Hence, HCGs are more stable configurations than it has been assumed. In such systems the interaction and merging processes may be very rare. Hence, the curious absence of strong radio and FIR sources in them is not surprising. HCGs are detected as compact groups, if the line of sight makes small angle with the plane of the system. The vast amount of others form, probably, the foreground of field galaxies.

Galaxy Evolution and Dynamical State of Clusters from HI Imaging Surveys

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From a VLA HI survey in Coma we show that for nearby clusters this technique enables to analyze environmental effects as a function of position and velocity. We compare the observed HI distribution in galaxies with those predicted by 3-D numerical simulations. For those HI non-detected starbursts and post starbursts in Coma we analyze the HI mass upper limits, the radio continuum emission (detected in a few cases), and morphological information, in order to explain the possible mechanisms triggering the starburst and stopping it. Additionally, we were able to discriminate between gas rich and gas poor groups in Coma that can be isolated in space and velocity, supporting the study of the dynamic state of clusters using HI imaging.

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Evidence of Tidally-Induced Star Formation in Cluster Spirals from Sub-Cluster Merging

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A survey of Hα emission in 377 galaxies of types Sa and later in nine low-redshift Abell clusters shows an enhancement of circumnuclear starburst emission with increasing cluster central galaxy density. The emission strongly correlates with a disturbed galaxy morphology (significance level, 8.7σ), and its enhancement in the clusters is most likely due to tidal interactions (either galaxy–galaxy, galaxy–group or galaxy–cluster). From X-ray studies, the two richest clusters in the survey (Abell 1367 and Coma) show evidence of being postmerger systems. This suggests, in accord with theoretical modelling, that the time-varying potential associated with sub-cluster merging in these clusters has led to greater rate of tidal interactions for the galaxies and consequent enhancement of tidally-induced circumnuclear starburst emission. Such tidal interactions are a likely mechanism for the transformation of the cluster spiral population to S0s.

The Diffuse Magnetic Field in Clusters Generated by Galaxy Stripping

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It is suggested that the vorticity generated in the intracluster medium due to continuous gas-mass loss from cluster galaxies as a result of gas-dynamical interactions may provide sufficient turbulence to feed a turbulent dynamo. This mechanism is complementary to large-scale collisions between clusters for the creation of the observed diffuse magnetic field strengths in clusters of galaxies, but it bears different signatures. Some implications on the expected synchrotron emission and on the density of diffuse cosmic rays in clusters are discussed.

Electron Distributions in Cluster Halos and Relics

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The advent of new X-ray observations of Inverse Compton emission from cluster relics and other sources holds great promise for establishing their physical conditions. However, the synchrotron/Compton comparisons needed for such analyses face some serious questions. First is the true spectral shape of the synchrotron electrons, which is easily distorted, e.g., by magnetic field or other

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gradients or inhomogeneities within the beam. Second is the decoupling between regions of high electron densities (yielding Compton emission) and high magnetic fields (yielding synchrotron emission) that is found in numerical simulations. I will illustrate the effects of these factors and suggest approaches to dealing with them.

Confirming the Extended EUV Excess of A2199: Re-Observation with In Situ Measurement of Background by Offset Pointing

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The EUV excess emission from the clusters A2199 and A1795 remains an unexplained astrophysical phenomenon. There has been many unsuccessful attempts to 'trivialize' the findings. In this poster, we present direct evidence proving that the most recent of such attempts, which attributes the detected signals to a background non-uniformity effect, is likewise excluded. We address the issue by a re-observation of A2199 which features a new filter orientation, usage of a more sensitive part of the detector, and, most crucially, the inclusion of a background pointing at $\sim 2^o$ offset - the first *in situ* measurement of its kind. We demonstrate quantitatively two facts: (a) the offset pointing provides an accurate template for the cluster observation, while (b) data from arbitrary blank fields do not. We then performed point-to-point subtraction of the in-situ background from the cluster field, with propagation of background errors. The resulting cluster radial profile is consistent with that obtained by the original method of subtracting a flat asymptotic background. The emission now extends to a radius of 20 arcmin; it confirms the rising prominence of EUV excess beyond ~ 5 arcmin as previously reported.

Particle Reacceleration in Clusters of Galaxies: Radio, EUV and Hard X-ray Emission

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We examine a scenario in which relativistic particles have been injected in clusters of galaxies at relatively high redshift and are more recently reaccelerated. We find that if the energetic of the electrons during the injection phase is $\geq 10^{60}$erg thus moderate turbulence, probably powered by a recent merger, can efficiently reaccelerate the relic electrons. We have applied the model to the case of the Coma cluster and find that the synchrotron and inverse Compton spectra

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emitted by the reaccelerated electrons can well reproduce the radio and hard X-ray properties for central values of the magnetic field up to $\sim 1 - 3 \cdot 10^{-6}$G. Furthermore, we find that if a recent minor injection of relativistic electrons (probably from AGNs) is considered in the framework of the above scenario, also the EUV properties can be well reproduced by inverse Compton emission from the additional population.

Radio Halos of Galaxy Clusters from Hadronic Secondary Electron Injection in Realistic Magnetic Field Configurations

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We investigate the possibility that radio halos of clusters of galaxies are caused by synchrotron emission of cosmic ray electrons (CRe) produced by cosmic ray protons (CRp) hadronically interacting with the intra-cluster medium (ICM) protons. In order to have a realistic model of the gas and magnetic field distribution, needed to predict the CRe production rates, their cooling, and their synchrotron emissivity, we perform cosmological magneto-hydrodynamics (MHD) simulations to obtain a sample of ten magnetized galaxy clusters. We assume a CRp population inside the ICM, which have an energy density which has everywhere a constant ratio to the thermal ICM one. This ratio is adjusted so that one simulated Coma-like cluster reproduces the radio luminosity of the radio halo of the Coma cluster of galaxies. Our model exhibits also the low observed degree of radio polarization and a similar radial emission profile. The necessary energy ratio is 4 ... 14 % $(E_{\mathrm{p,min}}/\mathrm{GeV})^{-0.375}$ (in the range of magnetic field strength suggested by Faraday measurements), where $E_{\mathrm{p,min}}$ is the lower kinetic energy cutoff of the CRp with spectral index $\alpha_{\mathrm{p}} \approx 2.375$. Assuming this ratio to be the same in the whole set of simulated clusters predicts a $T_{\mathrm{x}} - L_{\nu}$ relation which follows well the observed relation.

The Role of Mergers in the Formation and Evolution of Clusters of Galaxies

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The evolution of galaxies is strongly driven by dynamical processes including internal instabilities, tidal interactions and mergers. The cluster environment is a useful laboratory for studying these effects. Using cosmological N-body simulations (at large z) combined with N-body simulations with mass transfer (at low z, for galactic overdensities), we present recent results on simulations of interacting populations in the cosmological collapse of a cluster. The formation of the cen-

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tral, brightest cluster galaxies through merging, the effect of tidal interactions and merging on galaxy morphology over cosmic history, the distribution and kinematics of the tidal debris field are also discussed. As application, we try to investigate the evolution of the Coma cluster using a chemo-spectrophotometric and dynamical model.

Orbital Trends in Cluster Mergers

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X-ray spectra of dense clusters of galaxies indicate the presence of huge amounts of heavily processed ionized gas; indicative of being ejected through collision in the subclustering stage. During cluster evolution subclustering occurs; subclusters continue to merge until two main subclusters are formed, which finally merge. An analytical study of the orbital evolutionary trends in synchronous binary motion of two subclusters of galaxies, using a condition which favours minimization of energy of the system indicates that after tidal capture the equilibrium thermal distribution function favors high eccentricities (Magalinsky and Chatterjee, Astronomy and Astrophysical Transactions, 2000). This indicates that subclusters, which feel their mutual two-body force, will fall radially towards each other in orbits of high eccentricities and interact extensively before merging.