CURRICULUM VITAE

VINCENZO ANTONUCCIO NATIONALITY: ITALIAN Phone: (+39)-347 366 7984 email: Vincenzo.Antonuccio@inaf.it Web: http://www.oact.inaf.it/users/van/ Mailing address: INAF – Osservatorio Astrofisico di Catania Via S. Sofia 78 I-95123 Catania – ITALY	Latest update: **September 2019**

1 EDUCATION

PhD SISSA-International School for Advanced Studies (Trieste – Italy) October 1992
Astrophysics
Dissertation: "*Dynamical Friction and the Evolution of Galaxy Clusters*"
Advisor: Prof. D.W. Sciama
Committee: Profs. B. Bertotti, D.W. Sciama, F. Lucchin, A. Ferrari, A. Treves, Dr. A. Lanza

MS SISSA-International School for Advanced Studies (Trieste – Italy) September 1986
Advisor: Prod. D. W. Sciama

BS "Laurea" in Physics, University of Catania October 1984
Dissertation: "*MHD Instabilities in confined plasmas*"
Advisor: Prof. A. M. Anile
Graduated Summa Cum Laude (mention: 110/110)

2 HONORS AND AWARDS

Leon Rosenfeld Fellowship 1988-1990
NORDITA, Copenhagen (Denmark)

Blanceflor-Ludovisi-Boncompagni Fellow July-November 1991
Stockholm University Observatory

PI, Marie-Curie Transfer of Knowledge Project "COSMOCT", VI EC Framework Programme for R&D 2004-2008
Participant Institutions: INAF-Catania (Italy), Department of Physics, University of Oxford (UK) and AIP, Potsdam (Germany)

Beecroft Institute for Astroparticle Physics, University of Oxford 2006-2007
Marie-Curie Senior Fellow for 13 months

Theoretical Astrophysics Center – Copenahgen, DENMARK
I was Associated Scientist at TAC, University of Copenhagen(Denmark), since its establishment (September 1994) until the closure of the Center (September 2004). **During the whole period I have been a regular guest of TAC-Copenhagen, where I spent usually 2 months/year.**

Max-Planck Institute for Astronomy, Heidelberg (Germany)
I have been a regular visitor of MPA (2-3 months/year from 2010 to 2014), mostly supervising a IMPRS student (S. Cielo) and collaborating with dr. A. Macciò.

ITA-Institute for Theoretical Astrophysics, Ruprecht-Karl University, Heidelberg (Germany)
I have been a regular visitor of MPA (2-3 visits/year from 2008 until 2013, collaborating mostly with Prof. Dr. M. Bartelmann.

IAP-Institut d'Astrophysique de Paris, Paris (France)
I have been a regular visitor of IAP (2-3 visits/year from 2015 until 2017, collaborating mostly with Prof. Dr. J. Silk and Dr. S. Cielo.

3 RESEARCH EXPERIENCE

Research Themes

My research activity has been dealing with **Theoretical and Numerical Cosmology**, more specifically in the following **four topics**:

1. Development and optimization of computational techniques for N-body and Computational Fluid Dynamics simulations;

2. Origin and evolution of the Large-Scale Structure of the Universe, particularly of galaxies and Clusters of galaxies;
3. Co-evolution of galaxies and Supermassive Black-Holes;
4. Weak gravitational lensing.

Overall, I have always tried to exploit the technical advancements in parallel and vector computing which have followed the development of High performance Computing systems, to create and develop cosmological numerical codes which could significantly advance our knowledge of galaxy formation and evolution. I have not only used public-domain or third-party codes to perform simulations of the LSS of the Universe, but also developed a parallel, message-passing N-body cosmological code.

Two guidelines underlie my scientific activity:

A) **Numerical simulations as experiments**: I find questionable to rely only on raw results from numerical simulations to deduce general conclusions about galaxy formation and evolution, due to the numerous systematics and discretization effects, while they are a significant tool to **validate physical model**, and to determine some parameters of the latter which are determined by the intrinsically nonlinear physics of the underlying galaxy formation and evolution models;

B) **Mathematical and statistical techniques:** the exploitation of exact results and models from Mathematical Physics and Statistics to the modeling of gravitational clustering and galaxy evolution.

I will now present the main results achieved in each of the above mentioned four topics.

1. Parallel numerical code development (11, 16, 20, 22, 23, 26, 29, 32, 36, 41-47, 49-50)

I have contributed to develop a parallel cosmological N-body treecode, **FLY**, by coordinating a small team at INAF-Catania Astrophysical Observatory. This effort began in 1992 and continued for 14 years, during which we have continuously updated the software architecture of FLY in order to achieve ever increasing performances on the rapidly changing HPC hardware architectures. Starting with a Locally Essential Tree parallel implementation we subsequently changed the coding paradigm, from the 1994 PVM (Parallel Virtual Machine) version (36), all the way through the IBM proprietary CRAFT (32, 29, 26) in the quest for more memory and CPU-performing codes. We have also implemented shared-memory paradigms (23, 22) until the most recent MPI-2 version, where particles are cyclically migrated and the tree is left resident. This latter version has a significant scaling on the most recent IBM Blue-Gene and Cray XE* systems, up to ~ 50-60.000 processors.
I have also contributed to develop and test two visualization and analysis tools for astrophysical simulations: AstroMD (42) and VisiVO (11).

At the beginning of my career I worked on galaxy dynamics. In my first paper (40) I exploited the information concerning velocity dispersion gradients in our own galactic disk to constrain the Dark Matter halo mass distribution. In a subsequent work, written in collaboration with dr. J. Sommer-Larsen we studied the velocity dispersion of different stellar populations, showing evidence for a past accretion episode from the existence of a population of stars having systematically higher velocity dispersions (37).

In my PhD thesis (39) I have adopted an exact approach based on the Holtsmark distribution function of the random force to calculate the dynamical friction coefficient in clustered self-gravitating system, and explored the consequences on the dynamical friction coefficients. I have then explored the consequences of the enhanced dynamical friction due to clustering on the collapse and virialization of clusters of galaxies (35), and on the evolution of the bias (33), with collaborators (prof. S. Colafrancesco) and PhD students (M. Gambera and A. Del Popolo, 28).

Since 1994 and until today I have often made use of high-resolution N-body simulations, performed with our `FLY` code, viewed as laboratory experiments to model the gravitational physics of self-gravitating systems. I do not rely exclusively on raw numerical simulation results to draw physical conclusions, but I instead prefer to use simulations to “tune” the parameters of analytical (sometimes even exactly) solvable models, and then to use the latter to interpret observational results.

I have dedicated a particular interest to understand the role of environment in galaxy formation, and in particular to model galaxies in Voids using numerical simulations (34, 31, 27). We exploited the high memory optimization of `FLY` to reach a very high force resolution, which enabled us to obtain during the '90 simulations with large (in excess of ~20.000) samples of simulated galaxies in Voids (21), and to demonstrate a continuity of DM halo properties between clusters and Voids. This was further confirmed by a comparison with SDSS data (18), and allowed us to test J. Peebles' hypothesis concerning the existence of a “Void galaxy population” with distinct dynamical properties. We have also demonstrated that stellar evolution in Low Surface Brigthness disk galaxies like Malin's 1 and 2 objects is compatible with a prolonged star formation activity in the absence of significant mergers (34, 31).

The lack of evident environment effects on galaxy population properties is also evident from the dynamical properties of their DM halos, to which I have dedicated a particular attention (7). The unprecedented accuracy of the spin distribution functions from our recent high resolution cluster simulations allowed us to detect small but statistically significant deviations from the modified lognormal shape predicted by theory, and to study its evolution. In the same work we also have found that correlations between tidal and density fields originate these deviations, which then become tools to trace the temporal evolution of the tidal fields.

I have also contributed to interpret SPH simulations of the evolution of chemical enrichment of galaxies in clusters and groups (14 [17: erratum], together with my then PhD student A. Romeo-Velonà and dr. J. Sommer-Larsen. Using higher resolution simulations we could demonstrate at that time that only significant superwinds can induce a migration towards the red sequence of the galaxy population (14). We have recently extended the analysis to groups , where data on the Mass-Metallicity relation are available (2).
Together with two former PhD students (drs. A. Pagliaro and M. Gambera) I have also explored the application of wavelet techniques to the detection and characterization of substructures in Clusters of galaxies (30). We applied this technique to the Coma cluster, and we discovered 7 substructures in phase space already in 1997 (25).

3. Co-evolution of galaxies and Supermassive Black Holes (1, 3, 4, 5, 8, 9, 12, 13)

Since 2006 I turned my interests towards the analysis of the mutual feedback and co-evolution between galaxies and the Supermassive Black Holes (SMBHs) hosted at their centers. To this end, I have developed a series of modules for the Adaptive Mesh Refinement (AMR) fluid dynamic code FLASH, and performed the first AMR simulations of the propagation of a relativistic jet from an AGN propagating into a two-phase, star-forming Interstellar Medium. The first 2D simulations allowed us a detailed study of the complex interaction between the jet, the hot, low density cocoon it carves inside the ISM and few cold, star forming clouds (13). We were able to demonstrate by direct numerical simulations the negative feedback effects of radio-mode AGNs on star formation. We then performed simulations with a larger number of clouds (12), and analysed in detail the evolution of star formation and color evolution.
Our simulations revealed the existence of a significant backflow of very low angular momentum gas from the tip of the jet back to the central part of the accretion disk. We have subsequently demonstrated that this gas can easily feed the accretion disc around the central SMBH, and thus powering the AGN (9).
More recently I have extended the physical scope of the jet-ISM FLASH module, by adding a realistic thermal equation of state and a radiative cooling module extending down to very low temperatures. Together with mrs. S. Cieloa, a PhD student at MPIA (Heidelberg), we have performed full 3D simulations of jet-ISM interactions (1), which confirm and extend the findings concerning the feeding role of the backflow on the central AGN.
I have used the results of these simulations to model the backflow (9) with an exact solution of the axisymmetric Navier-Stokes equations.

In collaboration mainly with other colleagues, I have contributed to analyze the impact of the hot gas within the cocoons generated by the jet propagation within AGNs' host galaxies on the SZ signal detected by current and future microwave detectors like ALMA and SKA (8, 3). We have demonstrated that this technique could detect high-redshift AGNs with low intrinsic brightness.
I have also contributed with specific simulations and modeling to a recent work aiming at interpreting recent Hubble WFPC2 observations of jet-triggered recent star formation in the Cen A region (5). Another recent work I have contributed dealt with the connection between the recently discovered FERMI hot bubbles within our own Galaxy and the kypervelocity stars (4).

4. Weak Gravitational Lensing (10, 15)

Starting in 2005, in collaboration with a postdoctoral Marie-Curie fellow (Dr. Stephane Paulin-Henriksson) I have contributed to develop a software pipeline to extract the weak gravitational lensing signal from measuring galaxy shapes in deep images (Kaiser-Squires method). We have described the pipeline and applied it to a cluster (Abell 209) in (15). Subsequently, we have applied it to another cluster (Abell 611) (10).

5. Other (41, 48)
I have contributed to develop analysis methods to passively detect small amount of radioactive materials within large containers using cosmic rays as source (41). My contribution consisted in applying the two-point correlation function to detect clusters of scattering events generated by the interaction of cosmic rays with the small clumps of radioactive materials. This classical technique adopted in the study of the LSS turns out to be highly sensitive to detect small amounts of radioactive materials.

4 TEACHING EXPERIENCE

Graduate Course in Cosmology, University of Catania
From A.Y 1992-'93 to 2009-'10, except for A.Y. 1997-'98, 2006-'07 and 2008-'09
Program of the course available from:
http://www.oact.inaf.it/users/van/progcorsoct_cosmo_2000.html

Course on "Introduction to Physical Cosmology", Scuola Superiore di Catania (University of Catania) during A.Y. 2007-2008 and 2008-2009

Course on "Cosmic Rays", University of Catania, A.Y. 2012-2013

M.Sc Course on "High Energy Astrophysics", University of Catania, since A.Y. 2017-2018 (Institutional website: http://syllabus.unict.it/insegnamento.php?id=8727)

Doctoral Students Advised

A. Del Popolo, Thesis: "The evolution of Clusters of galaxies in a Standard CDM model", Graduated in A.Y., Graduated A. Y. 1994-1995, University of Catania

A. Pagliaro, Thesis: "Substructure recovery by three-dimensional discrete wavelet transforms, Graduated A. Y. 1999-2000, University of Catania

A.D. Romeo, Thesis: "Simulating clusters and groups of galaxies : the gas, the galaxy populations and the intra-cluster stars", Graduated A. Y. 2004-2005, University of Catania

S. Cielo, Subject: “AGN mechanical feedback: Simulations and Models”, expected to graduate in November 2014, International Max-Planck Research School for Astronomy and Cosmic Physics, University of Heidelberg (co-advisor)

Masters Students Advised

Thesis titles in Italian/*English*

G. Nicolosi, Thesis: “Deflessione gravitazionale da strutture a grande scala nell`universo*/Gravitational deflections from Large-Scale Structures in the Universe”*, Graduated A. Y. 1997-1998, University of Catania

M Zappalà, Thesis: “Formazione di Strutture a grande scala nell'Universo: metodi Numerici/ *Large -Scale structure formation in the Universe. Numerical methods*”, Graduated A. Y. 1997-1998, University of Catania

A.D. Romeo, Thesis: “Nubi di idrogeno ad alta velocità nel Gruppo Locale di galassie/ *High-velocity Hydrogen clouds in the Local Group of galaxies*”, Graduated A. Y. 1998-1999, University of Catania

D. Ferro, Thesis: “Diffusione di elettroni in Ammassi di Galassie/ *Electron diffusion within Clusters of galaxies*”, Graduated A. Y. 1999-2000, University of Catania

M. Comparato, Thesis: “Lensing gravitazionale debole da strutture a grande scala nell'Universo/ *Weak gravitational lensing from the Large-Scale Structure of the Universe*”, Graduated A. Y. 2002-2003, University of Catania

F. Pulvirenti, Thesis: “Riscaldamento meccanico del Mezzo Intergalattico/ *mechanical heating of the Intergalactic medium*”, Graduated A. Y. 2005-2006, University of Catania

S. Cielo, Thesis: “*Host galaxies of Supermassive Black Holes at high redshif*t”, Graduated A. Y. 2008-2009, Scuola Superiore di Catania

S. Cielo, Thesis: “*Constraints on cosmological models through Maximum Likelihood Methods*”, Graduated A. Y. 2010-2011, University of Catania

5 PATENTS

None

6 Professional Affiliations

International Astronomical Union, 2001-Present

Società Italiana di Fisica, 2005-Present

Società Astronomica Italiana, 2006-present

7 Professional Service

Symposium Co-Organizer

1) International Workshop on "Modelling the Intergalactic and Intracluster Media", Vulcano (Messina), October 1-4, 2003

2) "lNAF-COSMOCT School on Gravitational Lensing: General theory, Weak and Strong lensing", Hotel "La Perla Ionica", Acireale (Catania), October 30-November 4, 2006

3) Oxford-COSMOCT Workshop on "The Interface between Galaxy Formation and AGNs", Vulcano (Messina), May 18-22, 2008

Peer-Reviewer for:

Monthly Notices of the Royal Astronomical Society
Journal of Aerospace Engineering

8 Community Service

European Commission
Expert Reviewer in Physics, Marie-Curie Projects Evaluation Panels, since 2010

ISCRA - Italian SuperComputing Resource Allocation
CINECA (Casalecchio di reno, BO), since 2008

Time Allocation Committee - the Italian High Performance Computing Committee in Astrophysics (since 2002, re-elected until 2008)

9 Languages

Italian: Native Language

English: Advanced Reading and Writing

French: Advanced Reading and Writing

Danish: Intermediate listener, Advanced Writing

10 COMPUTER SKILLS

Programming: Fortran 90 (developer-advanced), Fortran 77 (developer-advanced), C (developer-advanced), C++ (intermediate), OpenMP (advanced), MPI (developer-advanced), Java (basic), Perl (Intermediate), IDL (developer-advanced)

Applications: FLY, FLASH, Ramses, Gadget 2

Platforms: Different HPC systems: IBM Blue gene, Cray XT, Clusters

11

12
13
14

15 PUBLICATIONS (WITH COMMENTS)

1 Books

AGN Feedback in Galaxy Formation, Proceedings of the Workshop held 18-22 May, 2008 in Vulcano, Italy. Edited by Vincenzo Antonuccio-Delogu and Joseph Silk. Cambridge University Press, 2010. ISBN: 9780521192545, pp. xvi-201

2 Journal Publications (refereed)

Legenda:

AMR = Adaptive Mesh Refinement
ETG = Early Type Galaxy
SFR = Star Formation Rate
sSFR = specific Star Formation Rate
SMBH = SuperMassive Black Hole
SPH = Smoothed particle Hydrodynamics
VTK = Virtual ToolKit

1) Cielo, S.; Babul, A.; **Antonuccio-Delogu, V**.; Silk, J.; Volonteri, M., "Feedback from reorienting AGN jets. I. Jet-ICM coupling, cavity properties and global energetics", A&A 617, A58 (2018)

We use numerical simulations to explore four models of AGN jets over several active/inactive cycles. We keep the jet power and duration fixed across the models, varying only the jet re-

orientation angle prescription. We track the total energy of the intracluster medium (ICM) in the cluster core over time, and the fraction of the jet energy transferred to the ICM. We pay particular attention to where the energy is deposited. We also generate synthetic X-ray images of the simulated cluster and compare them qualitatively to actual observations. Results: Jets whose re-orientation is minimal (≲20°) typically produce conical structures of interconnected cavities, with the opening angle of the cones being 15-20°, extending to 300 kpc from the cluster centre. Such jets transfer about 60% of their energy to the ICM, yet they are not very efficient at heating the cluster core, and even less efficient at heating it isotropically, because the jet energy is deposited further out. Jets that re-orientate by ≳20° generally produce multiple pairs of detached cavities. Although smaller, these cavities are inflated within the central 50 kpc and are more isotropically distributed, resulting in more effective heating of the core. Such jets, over hundreds of millions of years, can deposit up to 80% of their energy precisely where it is required. Consequently, these models come the closest in terms of approaching a heating/cooling balance and mitigating runaway cooling of the cluster core even though all models have identical jet power/duration profiles. Additionally, the corresponding synthetic X-ray images exhibit structures and features closely resembling those seen in real cool-core clusters.

2) Dobrotka, A.; **Antonuccio-Delogu, V.**; Bajčičáková, I., "New structures of power density spectra for four Kepler active galactic nuclei", MNRAS 470, 2439 (2017)

In this work, we reanalyse photometric data of four active galactic nuclei observed by Kepler in order to study the flickering activity, with our main goal to search for multiple components in the power density spectra. We find that all four objects have similar characteristics, with two break frequencies at approximately log(f /Hz) = -5.2 and -4.7. We consider some physical phenomena whose characteristic time-scales are consistent with those observed, in particular mass accretion fluctuations in the inner geometrically thick disc (hot X-ray corona) and unstable relativistic Rayleigh-Taylor modes. The former is supported by detection of the same break frequencies in the Swift X-ray data of ZW229-15. We also discuss rms-flux relations, and we detect a possible typical linear trend at lower flux levels. Our findings support the hypothesis of a multiplicative character of variability, in agreement with the propagating accretion fluctuation model.

3) Cielo, S.; **Antonuccio-Delogu, V.**; Silk, J.; Romeo, A. D., "Backflows by active galactic nuclei jets: global properties and influence on supermassive black hole accretion", MNRAS 467, 4526 (2017)

Jets from active galactic nuclei (AGN) inflate large cavities in the hot gas environment around galaxies and galaxy clusters. The large-scale gas circulation promoted within such cavities by the jet itself gives rise to backflows that propagate back to the centre of the jet-cocoon system, spanning all the physical scales relevant for the AGN. Using an adaptive mesh refinement code, we study these backflows through a series of numerical experiments, aiming at understanding how their global properties depend on jet parameters. We are able to characterize their mass flux down to a scale of a few kiloparsecs to about 0.5 $M\odot$ yr-1 for as long as 15 or 20 Myr, depending on jet power. We find that backflows are both spatially coherent and temporally intermittent, independently of jet power in the range 10^{43}-10^{45} erg

s^{-1}. Using the mass flux thus measured, we model analytically the effect of backflows on the central accretion region, where a magnetically arrested disc lies at the centre of a thin circumnuclear disc. Backflow accretion on to the disc modifies its density profile, producing a flat core and tail. We use this analytic model to predict how accretion beyond the black hole magnetopause is modified, and thus how the jet power is temporally modulated. Under the assumption that the magnetic flux stays frozen in the accreting matter, and that the jets are always launched via the Blandford-Znajek mechanism, we find that backflows are capable of boosting the jet power up to tenfold during relatively short time episodes (a few Myr).

4) Romeo, A. D.; Kang, Xi; Contini, E.; Sommer-Larsen, J.; Fassbender, R.; Napolitano, N. R.; **Antonuccio-Delogu, V.**; Gavignaud, I., "A study on the multicolour evolution of red-sequence galaxy populations: insights from hydrodynamical simulations and semi-analytical models", A&A 581, A50 (2015)

By means of our own cosmological-hydrodynamical simulation (SIM) and semi-analytical model (SAM), we studied galaxy population properties in clusters and groups, spanning over ten different bands from the ultraviolet to the near-infrared (NIR), and their evolution since redshift z = 2. We find that the Butcher-Oemler effect is wavelength-dependent, with the fraction of blue galaxies increasing more steeply in optical-optical than in NIR-optical colours. Moreover, a steep trend in the blue fraction can only be reproduced when an optically fixed luminosity-selected sample is chosen, while the trend flattens when selecting samples by stellar mass or by an evolving magnitude limit. We also find that the RS-LFR behaviour, highly debated in the literature, is strongly dependent on the galaxy selection function: in particular, the very mild evolution that is recovered when using a mass-selected galaxy sample agrees with values reported for some of the highest redshift-confirmed (proto)clusters. For differences that are attributable to environments, we find that normal groups and (to a lesser extent) cluster outskirts present the highest values of both the star-forming fraction and LFR at low z, while fossil groups and cluster cores have the lowest values: this separation among groups begins after z ~ 0.5, while at earlier epochs all groups share similar star-forming properties.

Conclusions: Our results support a picture where star formation is still active in SIM galaxies at redshift 2, in contrast with SAM galaxies, which have formed earlier and are already quiescent in cluster cores at that epoch. Over the whole interval considered, we also find that the more massive RS galaxies from the mass-selected sample grow their stellar mass at a higher rate than less massive ones. On the other hand, no dearth of red dwarfs is reported at $z \gtrsim 1$ from either model.

5) Cielo, S., **Antonuccio-Delogu, V.**, Macciò;, A. V., Romeo, A. D., and Silk, J., "3D simulations of the early stages of AGN jets: geometry, thermodynamics and backflow", MNRAS 439, 2903 (2014)

This paper presents the first results of fully 3D, AMR simulations of the mechanical feedback ("radio mode") from AGNs on their own host galaxies. The code is an extended development of FLASH v. 4.2, where we have included radiative cooling (including metal cooling) and a

relativistic thermal equation of state. In this first paper we have followed the jet-ISM system for half duty cycle of the AGN (~ 10 Myr) in its transition from an early, compact source to an extended one including a large cocoon. The results we find confirm and extend those obtained from previous 2D simulations (refs. 13, 12, 9), in particular for what concerns the temporal extent and relevance for accretion of large-scale backflows within the cocoon. We find that these backflows tend to be destabilized by turbulence, rather than by by hydrodynamic (Kelvin-Helmholtz) instabilities. Yet, in the first few hundred thousand years, backflows may create a central accretion region of significant extent, and convey there as much as a few millions of solar masses.

6) Romeo Velona', A. D., Sommer-Larsen, J., Napolitano, N. R., **Antonuccio-Delogu, V.**, Cielo, S., Gavignaud, I., and Meza, A., "Evolution of the Mass-Metallicity Relations in Passive and Star-forming Galaxies from SPH-cosmological Simulations", ApJ 770, 155 (2013)

Our main target in this work was to present a series of SPH-cosmological simulations which included the widest possible number of physical ingredients, including self-consistent modeling of supernova feedback and chemical evolution, for galaxies belonging to two clusters and 12 groups. We reproduced different important relationships, like the mass-metallicity (ZM) relation of galaxies classified in two samples according to their star-forming (SF) activity We also confirmed the anti-correlation between sSFR and stellar mass, pointing at a key role of the former in determining the galaxy downsizing, as the most significant means of diagnostics of the star formation efficiency. We discuss in depth these results in terms of the mechanisms driving the evolution within the high- and low-mass regimes at different epochs: mergers, feedback-driven outflows, and the intrinsic variation of the star formation efficiency.

7) Prokhorov, D. A., Moraghan, A., **Antonuccio-Delogu, V.**, and Silk, J., "Simulating Sunyaev-Zel'dovich intensity maps of giant active galactic nucleus cocoons", MNRAS 425, 1753 (2012)

In this work we extended and improved a previous analysis (ref. 8) of the SZ signal from hot AGN cocoons, by adopting the fully relativistic Wright formalism to compute the SZ spectra. This was necessary after our simulations revealed that the hot gas within the cocoon could easily attain temperatures kT~100 keV, thus requiring a fully relativistic treatment. We presented simulations of the SZ effect from AGN cocoons at various frequencies, and demonstrated that SZ observations at 217 GHz and at higher frequencies, e.g. At 857 GHz, will provide us with knowledge about the dynamically dominant component of AGN cocoons.

8) Silk, J., **Antonuccio-Delogu, V.**, Dubois, Y., Gaibler, V., Haas, M. R., Khochfar, S., and Krause, M., "Jet interactions with a giant molecular cloud in the Galactic centre and ejection of hypervelocity stars", A&A 545, L11 (2012)

In this letter we studied the energetics of the recently discovered FERMI bubbles, to check whether it could be consistent with the generation of the hypervelocity OB stars in the Milky Way Galaxy, which were ejected from the central regions some 10-100 million years ago. We argue that these stars, as well as many more abundant bound OB stars in the innermost few parsecs, were generated by the interactions of an AGN jet from the central black hole with a dense molecular cloud. Considerations of the associated energy and momentum injection have broader implications for the possible origin of the FERMI bubbles and for the enrichment of the intergalactic medium.

9) Crockett, R. Mark, Shabala, Stanislav S., Kaviraj, Sugata, **Antonuccio-Delogu, Vincenzo**, Silk, Joseph, Mutchler, Max, O'Connell, Robert W., Rejkuba, Marina, Whitmore, Bradley C., and Windhorst, Rogier A., "Triggered star formation in the inner filament of Centaurus A", MNRAS 421, 1603 (2012)

In this work we analyzed Wide Field Camera 3 (WFC3) observations of some filaments around Centaurus A to localize and characterize the properties of the stellar populations outside the galaxy itself. We discovered a young stellar population near the south-west tip of the filament, with color-determined age ~ 1-4 Myr. We then explored the possibility that this episode of recent star formation could have been an example of positive feedback, where the relativistic jet from CenA stimulated star formation in some clouds which it crossed during its propagation. I performed a series of simulations using the extension of the `FLASH` *code I had previously developed in (13), to model the color evolution and morphology of the shocked filamentary regions. We found that the model was qualitatively viable, because the shocks induced by the cocoon can overrun a molecular cloud and trigger star formation in the dense molecular cores.*

10) Tortora, C., Romeo, A. D., Napolitano, N. R., **Antonuccio-Delogu, V**., Meza, A., Sommer-Larsen, J., and Capaccioli, M., "Stellar population gradients from cosmological simulations: dependence on mass and environment in local galaxies", MNRAS 411, 627 (2011)

Here we have used N-body+hydrodynamical simulation to explore the effect of environment on the metallicity gradients. Maybe the most noteworthy result we found is that fossil groups are characterized by a tighter distribution of both age and metallicity gradients than in Clusters. We found a good agreement with both local observations and independent simulations. Interestingly, our results suggest that environment differently affects the gradients at low and high masses.

11) **Antonuccio-Delogu, V.**, Dobrotka, A., Becciani, U., Cielo, S., Giocoli, C., Maccio', A. V., and Romeo-Velona', A., "Dissecting the spin distribution of dark matter haloes", MNRAS 407, 1338 (2010)

In this paper we have demonstrated how the combination of very high spatial and mass resolution N-body simulations and sophisticated statistical methods can be used to understand the complexities of gravitational collapse within a cosmological context. The main object was the study of the origin of the very tiny deviations of the spin probability distribution function from a lognormal. To that end, we applied a very general, yet rarely used in a cosmological context, statistical theorem introduced by Cramer (1936). We found that these deviations originate from correlations between two quantities entering the definition of spin, namely the ratio $J/M^{5/2}$ (which depends only on the mass M) and the modulus E of the total (gravitational + kinetic) energy. We also found that these deviations are larger for more rapidly rotating halos, which suggests that they could be connected to the evolution of large-scale tidal fields.

12) Prokhorov, D. A., **Antonuccio-Delogu, V.**, and Silk, J., "Comptonization of the cosmic microwave background by high energy particles residing in AGN cocoons", A&A 520, A106 (2010)

The main idea of this work was that of using the Sunyaev-Zel'dovich (SZ) effect, whose intensity strongly depends on the pressure, to find the hitherto undetected, dynamically-dominant component in the radio cocoons generated by relativistic jets propagating into the host galaxy's ISM. To that end we performed a series of 2D numerical simulations using the same modified FLASH code described in ref. (13). We included a realistic thermal relativistic equation of state, which includes relativistic , compared the results of the simulations with analytic models. We discovered that the spectral function at a frequency of 217 GHz has an absolute maximum at a temperature higher than 10^9 K, therefore the measurement of the SZ effect at this frequency is a powerful tool for potentially revealing the dynamically-dominant component inside AGN jet-driven radio cocoons. We made a series of testable predictions for a series of spectral observable quantities, which could allow to detect and measure the presence of these cocoons at relatively high redshifts.

13) **Antonuccio-Delogu, V.** and Silk, Joseph, "Active galactic nuclei activity: self-regulation from backflow", MNRAS 405, 1303 (2010)

This work began by inspecting the implications of a fundamental theorem of Fluid Dynamics, the Crocco theorem, stating that regions of finite vorticity arise in a laminar flow in presence of entropy discontinuities. We then demonstrated that this condition has to be verified in the downstream region of a jet, immediately before the hotspot, and solved a one-dimensional energy equation integrated along a flow line to determine the relationship between strength

of the shock, rotation and terminal velocity. We then demonstrated that this backflow was indeed present in the simulations presented in (12) and (13), and compared the model predictions with the simulations. This backflow originated from near the "hotspot" and propagated along the bow shock, all the way back to the central region, contributing with a sustained flow of very low angular momentum gas for about ~ 10^6 yrs, after which it declined. almost axisymmetric flow directed in the opposite direction than the jet's direction developed We then argue that these backflows could (at least partially) feed the AGN, and provide a self-regulatory mechanism of AGN activity, that is not directly controlled by, but instead controls, the star formation rate within the central circumnuclear disc.

14) Romano, A., Fu, L., Giordano, F., Maoli, R., Martini, P., Radovich, M., Scaramella, R., **Antonuccio-Delogu, V.**, Donnarumma, A., Ettori, S., Kuijken, K., Meneghetti, M., Moscardini, L., Paulin-Henriksson, S., Giallongo, E., Ragazzoni, R., Baruffolo, A., Dipaola, A., Diolaiti, E., Farinato, J., Fontana, A., Gallozzi, S., Grazian, A., Hill, J., Pedichini, F., Speziali, R., Smareglia, R., and Testa, V., "Abell 611. I. Weak lensing analysis with LBC", A&A 514, A88 (2010)

*My own contribution to this paper consisted in applying the KSB pipeline we had previously developed and applied to A209 in ref. (15). The quality of the images in one filter was much better than the CFHT in (15), and the result turned out to be more robust and consistent with other pipelines adopted. analyses. This made it possible to estimate an accurate mass for Abell 611 within 1.5 Mpc (~3*10^{14} h^{-1} M_{sun}) . It was the first time that the Large Binocular telescope was used for Weak Lensing analyses.*

15) Becciani, U., Costa, A., **Antonuccio-Delogu**, V., Caniglia, G., Comparato, M., Gheller, C., Jin, Z., Krokos, M., and Massimino, P., "VisIVO-Integrated Tools and Services for Large-Scale Astrophysical Visualization", Publ. Astr. Soc. Pacific 122, 119 (2010)

Recently I started to contribute to the development of an integrated software environments to perform, analyze and visualize in a unified way both simulations and observational data. VisIVO is an integrated suite of tools and services specifically designed for the Virtual Observatory. This suite constitutes a software framework for effective visual discovery in currently available (and next-generation) very large-scale astrophysical data sets. VisIVO consists of VisiVO Desktop, a stand alone application for interactive visualization on standard PCs; VisIVO Server, a grid-enabled platform for high performance visualization; and VisIVO Web, a custom designed web portal supporting services based on the VisIVO Server functionality.
My specific contribution was to develop a subset of tools to analyze simulations, using the VTK environment.

16) Tortora, C., **Antonuccio-Delogu, V.**, Kaviraj, S., Silk, J., Romeo, A. D., and Becciani, U., "AGN jet-induced feedback in galaxies - II. Galaxy colours from a multicloud simulation",

MNRAS 396, 61 (2009)

This was the second in a series of papers, based on the same set of 2D simulations presented in (13) and a further one, but here we also distributed a large set of few hundreds cold, star forming clouds in the initial setup. We studied in detail the evolution of star formation under the action of the jet-cocoon system. We confirmed that in a realistic simulation where the jet propagates into a two-phase ISM, star formation (SF) can initially be slightly enhanced and then, on time-scales of few million years, rapidly quenched, as a consequence
both of the high temperatures attained and of the reduction of cloud mass (mainly due to Kelvin-Helmholtz instabilities). We then used the Bruzual & Charlot population synthesis model and our SF history to predict the evolution of galaxy colours and match them to a sample of nearby ETGs showing signs of recent episodes of SF, previously studied by one of us (S. Kaviraj). We found thatg alaxies which had experienced this mechanical feedback recently showed an enhancement of 3 mag in NUV (GALEX) - g, with respect to the unperturbed, no-feedback evolution. Hence, they could easily be identified in large combined near UV-optical surveys.

17) **Antonuccio-Delogu, V.** and Silk, J., "Active galactic nuclei jet-induced feedback in galaxies - I. Suppression of star formation", MNRAS 389, 1750 (2008)

This was the first paper where, using direct numerical simulations, we studied the mechanism of mechanical feedback of a jet arising from an AGN on its own host galaxy. It is based on simulations of jet-ISM interactions done using a fully AMR code, FLASH v. 3.2, which allowed us to reach a very high spatial and temporal resolution. Thus, we were able to resolve the nonlinear Kelvin-Helmholtz and Rayleigh-Taylor instabilities at the jet-cloud interface (small scale), and yet resolving the turbulence within the large-scale cocoon.
We studied the hydro- and thermodynamics of the interaction of a jet-cocoon system with cold,star forming clouds initially in pressure equilibrium within a diffuse, hot ISM. We paid a particular attention to the thermodynamic evolution of the cocoon, presenting the phase diagrams of the hot cocoon, and demonstrating that turbulence within the cocoon keeps a lognormal density distribution for a large part of the inertial regime. We demonstrated that the cloud is both stripped (outer part) and compressed, so that a short enhancement of star formation takes also place on time scales ~ 10^{5-6} yrs, after which star formation from the fragmented cloud is strongly inhibited.
The main limitation of this work lies in the fact that, in order to reach a very high resolution, the simulations were only 2D.

18) Romeo, A. D., Napolitano, N. R., Covone, G., Sommer-Larsen, J., **Antonuccio-Delogu, V.**, and Capaccioli, M., "The evolution of the galaxy red sequence in simulated clusters and groups", MNRAS 389, 13 (2008)

In this paper we used N-body/hydrodynamical simulations of the formation and evolution of galaxy groups and clusters in a LCDM cosmology are to follow the building-up of the color-magnitude relation in two clusters and in 12 groups. This was one of the first attempts to explore the role of environment on modulating the speed with which Ellipticals migrate towards the "red and dead sequence" in the C-M diagrams. The most notable result we found probably lies in the fact that we found that environment plays a role through the efficiency and duration of "secondary infall": galaxies experiencing infall from the outskirts to the central parts keep star formation on until they settle on to the DS of the core galaxies. Merging contributes to mass assembly until z ~ 1, after which major events only involve the brightest cluster galaxies.

19) Paulin-Henriksson, S., **Antonuccio-Delogu, V.**, Haines, C. P., Radovich, M., Mercurio, A., and Becciani, U., "Weak lensing mass reconstruction of the galaxy cluster Abell 209", A&A 467, 427 (2007)

T*his was the first paper where we presented a new Kaiser-Squires-Broadhurst pipeline for the extraction of WL signals from deep images, and we applied it to a CFHT image of a z~0.2 cluster. At that time this was the first WL pipeline produced by an Italian research Institution. We preferred to do this hands-on exercise, instead of using a third-party one, in order to gain a direct experience of the technical subtleties of the KSB algorithm. This work proved very useful subsequently, in the preparatory studies for EUCLID.*

20) Becciani, U., **Antonuccio-Delogu, V.**, and Comparato, M., "FLY: MPI-2 high resolution code for LSS cosmological simulations", Comp. Phys. Comms. 176, 211 (2007)

In this paper we presented an updated version of the tree N-body parallel code FLY. By explicitly coding into the then recently available MPI-2 standard we made a version which could be run on a large variety of HPC platforms, from Linux commodity clusters up to the Cray T3E. This highly optimized version could run a 64 million particle simulation in less than 15 minutes for each time-step, with a very high code scalability with the number of processors, a very innovative result at that time.

21) Romeo, A. D., Sommer-Larsen, J., Portinari, L., and **Antonuccio-Delogu, V.**, "Erratum: Simulating galaxy clusters - I. Thermal and chemical properties of the intracluster medium", MNRAS 373, 1648 (2006)

22) Sorrentino, G., **Antonuccio-Delogu, V.**, and Rifatto, A., "Galaxy properties from voids to clusters in the SDSS-DR4", A&A 460, 673 (2006)

Here we analyzed the color distribution in a sample of ~ 5000 true Void galaxies extracted from the SDSS) Data Release 4 (DR4). We paid a special attention to single out galaxies far away from the "walls", which are more numerous than true Void galaxies. Our aim was to search for systematic variations in the properties of galaxies with the local galaxy density. We did not find any sudden transition in the galaxy properties with density, which, according to a suggestion by Peebles (2001), should have marked the transition to a population of void galaxies in LCDM models. On the contrary, our results suggested a continuity of galaxy properties, from voids to clusters.

23) Romeo, A. D., Sommer-Larsen, J., Portinari, L., and **Antonuccio-Delogu, V.**, "Simulating galaxy clusters - I. Thermal and chemical properties of the intracluster medium", MNRAS 371, 548 (2006)

This was the first in a series of three papers dedicated to modeling Clusters' ICM temperature and entropy profiles of the ICM, their X-ray luminosity, the cluster cold components [cold fraction as well as mass-to-light ratio (MLR)] and the metal distribution between ICM and stars. Here we used TRE-SPH simulations, using a code mainly developed by J. Sommer-Larsen. For the first time the role of superwind energy feedback induced by strong starburst-driven galactic superwinds was shown to be essential to reproduce the observed X-ray luminosity-temperature distributions in groups.

24) **Antonuccio-Delogu, V.**, Becciani, U., and Ferro, D., "FLY. A parallel tree N-body code for cosmological simulations", Comp Phys. Comms 155, 159 (2003)

This paper presented the reference guide for the public version of FLY, and suggested the path to modify some parts of it (e.g. the equations of motion) to implement other types of equations (e.g. for alternative gravity models).

25) **Antonuccio-Delogu, V.**, Becciani, U., van Kampen, E., Pagliaro, A., Romeo, A. B., Colafrancesco, S., Germanà, A., and Gambera, M., "Properties of galaxy haloes in clusters and voids", MNRAS 332, 7 (2002)

This was the first cosmological paper using simulations performed with FLY 1.1. Our main aim was to adopt a very small softening length and high mass resolution, to produce a statistically significant amount of halos also in underdense regions (Voids), so we could study the impact of environmental effects on Dark matter halo statistics like the mass function and spin distributions. One of the most significant results of this paper was that we demonstrated that, by using a new statistics (the one-dimensional velocity dispersion - mass statistics) we demonstrated that one could deduce that the most appropriate density profile was the Truncated Isothermal Sphere (TIS). Comparing subsamples drawn from over- and underdense regions, for the first time using a N-body simulation we demonstrated the role of tidal fields in moulding the properties of halos, by truncating their spatial extent. No gravitationally bound halo was found having a radius larger than the critical value for gravithermal instability for TIS haloes: a proof of the consistency of this tidally-limited theory of halo growth.

26) Becciani, U. and **Antonuccio-Delogu, V.**, "Are you ready to FLY in the universe? A multi-platform/N-body tree code for parallel supercomputers", Comp. Phys. Comms. 136, 54 (2001)

A Computer Science-oriented presentation of FLY, where we also discuss issues connected to Ewald summation in parallel treecodes, and how it affects the accuracy of the orbit integration. In addition to the presentation of our previous paper (23) here we discuss the advantages deriving from the one-sided communication paradigm, which was already implemented in the Cray proprietary SHMEM package (but not yet into the few MPI-2 implementations available at that time). Version 1.1 was made publicly available in the software repository of this Journal.

27) Becciani, U., **Antonuccio-Delogu, V.**, and Gambera, M., "A Modified Parallel Tree Code for N-Body Simulation of the Large-Scale Structure of the Universe", Journal of Comp. Phys. 163, 118 (2000)

This was the final paper where we exhaustively describe the Work and Data Sharing version of our Parallel Treecode FLY. Here we presented the results of extensive weak and strong scaling tests, mostly performed on Cray T3E and similar Non-Uniform Memory Access architectures. Here our main focus was on memory optimization, to produce CPU-effective codes which could handle very large number of particles by reducing the memory overload.

28) Colafrancesco, S., Mullis, C. R., Wolter, A., Gioia, I. M., Maccacaro, T., Antonelli, A., Fiore, F., Kaastra, J., Mewe, R., Rephaeli, Y., Fusco-Femiano, R., **Antonuccio-Delogu, V.**, Matteucci, F., and Mazzotta, P., "An X-ray and optical study of the cluster A33", A&AS 144, 187 (2000)

My contribution here consisted in reducing some X-ray spectra using XSPEC, and in modelling of the mass distribution.

29) Pagliaro, A., **Antonuccio-Delogu, V.**, Becciani, U., and Gambera, M., "Substructure recovery by three-dimensional discrete wavelet transforms", MNRAS 310, 835 (1999)

This is the 3D generalization of the previous 2D wavelet analysis method to detect substructures, previously applied to the Coma cluster (ref. 30 below). Tests on mock galacy catalogs showed that the method was able to identify and single out the existing substructures provided that: (a) the subclumps are detached in part or all of the phase space, (b) one has a statistically significant number of redshifts, increasing as the distance decreases due to redshift distortions; (c) one knows a priori the scale on which substructures are to be expected.

30) Antonuccio-Delogu, V., **Becciani, U.**, Gambera, M., and Pagliaro, A., "Parallel Tree Algorithms for N-Body Simulations", Lecture Notes Computer Sciences 1557, 579 (1999)

Yet another improvement over refs. (29) and (32). Here, in addition to the load balancing mechanism, we introduced a "grouping" in the force-calculation part, by letting particles which share the same tree path to inherit the large-range component of the force. This resulted in a significant boost of code's performance.

31) **Antonuccio-Delogu, V.** and Becciani, U., "Abundance evolution of high-z clusters", Physica Scripta T77, 117 (1998)

32) Del Popolo, A., Gambera, M., and **Antonuccio-Delogu, V.**, "The collapse of a spherical density perturbation in the presence of dynamical friction", A&AT 16, 127 (1998)

In this paper we considered the collapse of a shell of baryonic matter falling into the central regions of a cluster of galaxies taking into account the presence of the substructure, inducing dynamical friction. We solved numerically the equation of motion of the shell of calculated the evolution of the expansion parameter, a(t), of the perturbation using a coefficient of dynamical friction. The effect of the dynamical friction was to slow down the collapse, producing a variation of the parameter of expansion of the shell.

33) Becciani, U., Ansaloni, R., **Antonuccio-Delogu, V**., Erbacci, G., Gambera, M., and Pagliaro, A., "Parallel tree code for large N-body simulation: Dynamic load balance and data distribution on a CRAY T3D system", Comp. Phys. Comms 106, 105 (1997)

The continuation of the work started in ref. 32 below. Here we presented an exhaustive series of tests to find an optimal data distribution in the Cray T3D memory, and to identify a strategy for the Dynamic Load Balance in order to obtain good performances when running large simulations (more than 10 million particles). Although these results are nowadays outdated, we devised an automatic work redistribution mechanism which provided a good Dynamic Load Balance at the price of an insignificant overhead, and which proved to be still adopted these days.

34) Gambera, M., Pagliaro, A., **Antonuccio-Delogu, V.**, and Becciani, U., "A Three-dimensional Wavelet Analysis of Substructure in the Coma Cluster: Statistics and Morphology", ApJ 488, 136 (1997)

This was the first application of a new method to detect substructures in position-radial velocity maps of clusters of galaxies, based on the wavelet decomposition. We compiled a catalog of 798 galaxy redshifts from published surveys of the region of the Coma Cluster. We found strong evidence of multiple hierarchical substructure, on scales ranging from a few hundreds of kiloparsecs to about 4 h-1 Mpc. The morphology of these substructures is rather spherical. These results were later confirmed and strengthened by deeper surveys.

35) Padoan, Paolo, Jimenez, Raul, and **Antonuccio-Delogu, Vincenzo**, "Are Low Surface Brightness Disks Young?", ApJ 481, L27 (1997)

We reconsidered the problem of the age of the stellar disks of late-type giant low surface brightness galaxies (LSBs) by making use of a new IMF derived from numerical fluid dynamics simulations (Padoan, Nordlund, & Jones 1997), and a new synthetic stellar population code, based on Jimenez & MacDonald (1997) evolutionary tracks and Kurucz atmospheric models (Kurucz 1992). Interestingly enough, we found that the disks of LSBs, although very blue, did not necessarily form very recently. Their colors seemed to indicate that they started form stars about 7-9 Gyr before the current epoch, thus they could be quite old, although their SFR was very low and continuous.

36) Becciani, U., **Antonuccio-Delogu, V.**, and Pagliaro, A., "A work- and data-sharing parallel tree N-body code", Com. Phys. Comms. 99, 9 (1996)

In this paper we moved from the original message-passing parallelization scheme based on PVM for our parallel N-body cosmological code CAPANIC to a shared-memory algorithm,, based on Cray Research Corporation's CRAFT programming environment. For the first time here we adopted different data distribution schemes for bodies' and tree's structures. Tests performed for two different types of initial distributions showed that the performance scales almost ideally as a function of the size of the system and of the (low, at that epoch) number of processors.

37) Colafrancesco, S., **Antonuccio-Delogu, V.**, and Del Popolo, A., "On the Dynamical Origin of Bias in Clusters of Galaxies", ApJ 455, 32 (1995)

Here we continued to explore the effects of granularity of CDM models, which results in an excess of low-amplitude density peaks, on the collapse and virialization of larger, galaxy-sized density peaks. We showed that the gravitational collapse of the latter is slowed down by the dynamical friction induced by the presence of the former, and this effect is mass dependent. This introduces a systematic, mass-dependent bias which breaks the original self-similarity of the DM distribution. Using this physical selection mechanism, we can calculate the values of the bias coefficient on cluster scales for any hierarchical clustering scenario. We show that the dynamical bias could account for a substantial part of the total bias required by observations on cluster scales.

38) **Antonuccio-Delogu, V.**, "On the origin of Low-Surface-Brightness galaxies", Astrophysics Letters 31, 131 (1995)

Following the then recent discovery of giant low-surface-brightness galaxies by Malin, I explored the possibility that these galaxies originated from low overdensity DM peaks of the density field.

39) **Antonuccio-Delogu, V.** and Colafrancesco, S., "Dynamical friction, secondary infall, and the evolution of clusters of galaxies", ApJ 427, 72 (1994)

In this paper, for the first time we studied the effects caused by dynamical friction on the collapse of shells of matter falling onto the central regions of groups and clusters of galaxies. We could demonstrate that shell motions were slowed down due to dynamical friction, the magnitude of the effect being proportional to the clustering coefficient. We also computed the collapse times and typical orbits of shells in phase space, and found that dynamical friction affects the statistics of the mass distribution, N(M, t), of those clusters of galaxies that might

have undergone a substantial secondary infall.

40) **Antonuccio-Delogu, V.** and Becciani, U., "A Parallel Tree N-Body Code for Heterogeneous Clusters", Lecture Notes in Computer Sciences 879, 17 (1994)

The first paper were we described the Parallel Virtual machine (PVM) implementation of the parallel algorithm for tree construction, based on the Locally Essential Tree parallelization scheme introduced by Salmon (1990). The code described here was called CAPANIC, a direct predecessor of FLY. We then used PVM, a public-domain message passing package which was just the predecessor of MPI.

41) Sommer-Larsen, Jesper and **Antonuccio-Delogu, Vincenzo**, "A model for the formation, evolution and structure of the solar cylinder", MNRAS 262, 350 (1993)

This was my second and last work specifically dealing with galaxy dynamics. The main idea was that of constraining the secondary infall in the solar neighborhood and the buildup of the "solar cylinder" using ages and metallicities of a sample of old, late type stars, which at that time (1993, pre-GAIA epoch) was a large one. We found clear indications that indicates that the age of the metal-weak halo was 14 +/- 1 Gyr, in agreement with previous estimates of the absolute ages of metal-weak Galactic globular clusters.

42) **Antonuccio-Delogu, V.** and Atrio-Barandela, F., "Gravitational field fluctuations in weakly clustered systems", ApJ 392, 403 (1992)

In this work we considered the effects of clustering on the dynamical friction coefficient. We demonstrated that the modified Holtsmark distribution of the stochastic force can be computed analytically, and from this the correction terms to the dynamical friction coefficients for clustered systems. The force probability distribution is remarkably influenced by the clustering of substructure: the profile is more strongly peaked, and the asymptotic decay is almost suppressed, resulting in an enhanced probability near the average value.

43) **Antonuccio-Delogu, V.**, "Dynamical Friction and the evolution of Clusters of Galaxies", PhD Thesis (SISSA, 1992)
This was my PhD thesis.

44) **Antonuccio-Delogu, V.**, "The velocity dispersion gradients in spiral galaxies. I - The Galaxy and NGC 3198", A&A 247, 45 (1991)

In this work I explored the usage of the velocity dispersion profile as a tool to constrain the geometry of Dark Matter halos around spiral galaxies. I made no usage of the epicyclic approximations, so that this method can be applied quite generally to model the velocity dispersions also for "hot" axisymmetric collisionless systems.

45) Riggi, S., **Antonuccio-Delogu, V.**, Bandieramonte, M., Becciani, U., Costa, A., La Rocca, P., P. Massimino, Petta, C., Pistagna, C., Riggi F. et al., "Muon tomography imaging algorithms for nuclear threat detection inside large volume containers with the Muon Portal detector", Nucl. Instrum. Meth. A728, 59 (2013)
This recent work deals with the reconstruction of 3D tomographic images of cosmic rays muon detectors of radioactive materials. My contribution has been that of devising a detection method based on the Autocorrelation function and clustering algorithms, which are customarily utlised to quantify the LSS of the Universe, to reach high sensitivities in the detection.

3 Technical Papers

46) Becciani, U., Costa, A., Antonuccio-Delogu, V., Caniglia, G., Comparato,
M., Gheller, C., Jin, Z., Krokos, M., and Massimino, P., "VisIVO: Integrated Tools and Services for Large-Scale Astrophysical Visualization",
Astrophysics Source Code Library, record ascl:1011.020 11020 (2010)

Abstract: VisIVO is an integrated suite of tools and services specifically designed for the Virtual Observatory. This suite constitutes a software framework for effective visual discovery in currently available (and next-generation) very large-scale astrophysical datasets. VisIVO consists of VisiVO Desktop - a stand alone application for interactive visualization on standard PCs, VisIVO Server - a grid-enabled platform for high performance visualization and VisIVO Web - a custom designed web portal supporting services based on the VisIVO Server functionality. The main characteristic of VisIVO is support for high-performance, multidimensional visualization of very large-scale astrophysical datasets. Users can obtain meaningful visualizations rapidly while preserving full and intuitive control of the relevant visualization parameters. This paper focuses on newly developed integrated tools in VisIVO Server allowing intuitive visual discovery with 3D views being created from data tables. VisIVO Server can be installed easily on any web server with a database repository. We discuss briefly aspects of our implementation of VisiVO Server on a computational grid and also outline the functionality of the services offered by VisIVO Web. Finally we conclude with a summary of our work and pointers to future developments.

47) Becciani, U., Antonuccio-Delogu, V., Gheller, C., Calori, L., Buonomo, F., and Imboden, S., "AstroMD: A Multi Dimensional Visualization and Analysis Toolkit for Astrophysics", Astrophysics Source Code Library, record ascl:1010.078 10078 (2010)

Abstract: Over the past few years, the role of visualization for scientific
purpose has grown up enormously. Astronomy makes an extended use of visualization techniques to analyze data, and scientific visualization has became a fundamental part of modern researches in Astronomy. With the evolution of high performance computers, numerical simulations have assumed a great role in the scientific investigation, allowing the user to run simulation with higher and higher resolution. Data produced in these simulations are often multi-dimensional arrays with several physical quantities. These data are very hard to manage and to analyze efficiently. Consequently the data analysis and visualization tools must follow the new requirements of the research. AstroMD is a tool for data analysis and visualization of astrophysical data and can manage different physical quantities and multi-dimensional data sets. The tool uses virtual reality techniques by which the user has the impression of travelling through a computer-based multi-dimensional model.

48) Becciani, U., Antonuccio-Delogu, V., Costa, A., and Comparato, M., "Nbody Simulations and Weak Gravitational Lensing using new HPC-Grid resources: the PI2S2 project", Astronomical Data Analysis Software and Systems ASP Conference Series, Vol. 394, Proceedings of the conference held
23-26 September, 2007, in Kensington Town Hall, London, United Kingdom. Edited by Robert W. Argyle, Peter S. Bunclark, and James R. Lewis., p.269 394, 269 (2008)

Abstract: We present the main project of the new grid infrastructure and the
researches, that have been already started in Sicily and will be completed by next year. The PI2S2 project of the COMETA consortium is funded by the Italian Ministry of University and Research and will be completed in 2009. Funds are from the European Union Structural Funds for Objective 1 regions. The project, together with a similar project called Trinacria GRID Virtual Laboratory (Trigrid VL), aims to create in Sicily a computational grid for e-science and e-commerce applications with the main goal of increasing the technological innovation of local enterprises and their competition on the global market. PI2S2 project aims to build and develop an e-Infrastructure in Sicily, based on the

grid paradigm, mainly for research activity using the grid environment and High Performance Computer systems. As an example we present the first results of a new grid version of FLY a tree Nbody code developed by INAF Astrophysical Observatory of Catania, already published in the CPC program Library, that will be used in the Weak Gravitational Lensing field.

49) Comparato, M., Becciani, U., Antonuccio-Delogu, V., and Costa, A., "FLY: a code for LSS cosmological simulations for a PC Linux Cluster", Astronomical Data Analysis Software and Systems XV ASP Conference Series, Vol. 351, Proceedings of the Conference Held 2-5 October 2005 in San Lorenzo de El Escorial, Spain. Edited by Carlos Gabriel, Christophe Arviset, Daniel Ponz, and Enrique Solano. San Francisco: Astronomical Society of the Pacific, 2006., p.216 351, 216 (2006)

Abstract: We developed FLY with the main goal of maximizing the number of particles that can be simulated in an MPP system without data replication. FLY builds a tree that is shared among all the processes that execute a simulation, each process having the same number of bodies which evolve during each time-step. Now we present the new version of the code that runs on a PC Linux Cluster using the one side communication paradigm MPI-2 and the performance results obtained.

50) Antonuccio-Delogu, V., Becciani, U., Ferro, D., and Romeo, A., "A software interface between Parallel Tree- and AMR Hydrocodes.", Memorie della Società Astronomica Italiana Supplement, v.1. , p.109 (2003) 1, 109
(2003)

Abstract: We discuss the problems arising when one tries to create a software
interface between a parallel treecode (modelling the collisionless, Dark Matter component) and Adaptive Mesh Refinement (AMR) hydrodynamical schemes (which model the gaseous phases). Such an interface would allow one to perform N-body/Hydro simulations in those situations where the N-body and hydrodynamical codes are loosely coupled, and the gravitational influence of the dissipative, gaseous component on the DM component can be neglected. We discuss similarities and differences between the tree- and AMR hydrocode data structures, restricting ourselves to two particular examples which are widely used in these days: the oct-tree Barnes-Hut and the cartesian structured grid AMR schemes. Finally, we present a simple scheme for such a software

interface which we are beginning to use in cosmological simulations.

51) Becciani, U., Antonuccio-Delogu, V., Costa, A., and Ferro, D., "FLY: a
Tree Code for Adaptive Mesh Refinement", Astronomical Data Analysis Software and Systems XII ASP Conference Series, Vol. 295, 2003 H. E. Payne,
R. I. Jedrzejewski, and R. N. Hook, eds., p.423 295, 423 (2003)

Abstract: <A href="http://www.ct.astro.it/fly/">FLY</A> is a public domain parallel treecode, which makes heavy use of the one-sided communication paradigm to handle the management of the tree structure. It implements the equations for cosmological evolution and can be run for different cosmological models. This paper shows an example of the integration of a tree N-body code with an adaptive mesh, following the PARAMESH scheme. This new implementation will allow the FLY output, and more generally any binary output, to be used with any hydrodynamics code that adopts the PARAMESH data structure, to study compressible flow problems.

52) Di Matteo, P., Capuzzo Dolcetta, R., Miocchi, P., Antonuccio-Delogu, V.,
Becciani, U., Costa, A., and Rosato, V., "Astrocomp: A Web Portal for High
Performance Computing on a Grid of Supercomputers", Astronomical Data Analysis Software and Systems XII ASP Conference Series, Vol. 295, 2003 H. E. Payne, R. I. Jedrzejewski, and R. N. Hook, eds., p.17 295, 17 (2003)

Abstract: Astrocomp is a project based on a collaboration among the University of
Roma La Sapienza, the Astrophysical Observatory of Catania and ENEA. The main motivation of the AstroComp project is to construct a portal, which allows to set up a repository of computational codes and common databases, making them available and enjoyable, with a user-friendly graphical web interface, to the international community. AstroComp will allow the scientific community to benefit by the use of many different numerical tools implemented on high performance computing (HPC) resources, both for theoretical astrophysics and cosmology and for the storage and analysis of astronomical data, without the need of specific training, know-how and experience either in computational techniques or in database construction and management methods. An essential feature of Astrocomp is that it makes available to subscribers some CPU time on large parallel platforms, via specific grants. Astrocomp is partly

financed by a grant of the Italian national research Council (CNR).

53) Lanza, A. F., Rodono, M., Becciani, U., and Antonuccio Delogu, V., "A Parallel Procedure for the Analysis of Long-term Sequences of Light Curves", Astronomical Data Analysis Software and Systems VII, A.S.P. Conference Series, Vol. 145, 1998, R. Albrecht, R.N. Hook and H.A. Bushouse, eds.,p. 67 145, 67 (1998)

Abstract: We present a parallel procedure which allows us to speed up the modelling of photometric and spectroscopic observations of active binary stars with brightness inhomogeneities on their surfaces. The procedure has been implemented using PVM and is suitable to run on a cluster of non-homogeneous, non-dedicated computers. It is optimized to recognize and assign the data sets requiring the largest computational effort to the most powerful CPUs of the cluster, taking into account the evolution of their performances during the calculation in a fully dynamical way. We report on several tests made with the workstation cluster of Catania Astrophysical Observatory and discuss the advantages of this kind of procedure for data analysis in Astrophysics.

54) Becciani, U., Antonuccio-Delogu, V., Gambera, M., Pagliaro, A., Ansaloni, R., and Erbacci, G., "Parallel Tree N-body Code: Data Distribution and DLB on the CRAY T3D for Large Simulations", Astronomical Data Analysis Software and Systems VII, A.S.P. Conference Series, Vol. 145,
1998, R. Albrecht, R.N. Hook and H.A. Bushouse, eds.,p. 7 145, 7 (1998)

Abstract: We describe a strategy for optimal memory and work distribution. We have
performed a series of tests to find an {\it optimal data distribution} in the Cray T3D memory, and to identify a strategy for the {\it Dynamic Load Balance} (DLB). The results of tests show that the step duration depends on two main factors: the data locality and the network contention. In a very large simulation, due to network contention, an unbalanced load arises. To remedy this we have devised an automatic work redistribution mechanism which provided a good DLB.

55) Antonuccio-Delogu, V., Rognvaldsson, O., Becciani, U., Pagliaro, A.,

and Gambera, M., "Cluster Formation with Parallel Tree-MFD Codes", Galactic Halos: A UC Santa Cruz Workshop, proceedings of a Conference held on the campus of UC Santa Cruz 11-15 August 1997 Edited by Dennis Zaritsky,
ASP Conference Series #136, p. 430. 136, 430 (1998)

Abstract: Not Available

56) Antonuccio-Delogu, Vincenzo and Silk, Joseph, "AGN Feedback in Galaxy Formation", AGN Feedback in Galaxy Formation, by Vincenzo Antonuccio-Delogu
, Joseph Silk, Cambridge, UK: Cambridge University Press, 2010 (2010)

Abstract: Part I. AGNs, Starbursts and Galaxy Evolution: 1. The effect of mass and
star-formation timescale on galaxy evolution C. Harrison and M. Colless; 2. Suppressing cluster cooling flows by multiple AGN activity A. Nusser; 3. Starbursts and AGN activity in Spitzer-selected sources at high-z M. Polletta, A. Omont, C. Lonsdale and D. Shupe; 4. Star formation in galaxies hosting active galactic nuclei up to z

57) Antonuccio-Delogu, V. and et al., "Physical models of AGN feedback", AGN Feedback in Galaxy Formation, Proceedings of the Workshop held 18-22 May, 2008 in Vulcano, Italy. Edited by Vincenzo Antonuccio-Delogu and Joseph Silk. Cambridge University Press, 2010. ISBN: 9780521192545, p.111-156 111 (2010)

Abstract: Not Available

58) Antonuccio-Delogu, Vincenzo and Silk, Joseph, "AGN Feedback in Galaxy Formation", AGN Feedback in Galaxy Formation by Vincenzo Antonuccio-Delogu and Joseph Silk. Cambridge University Press, 2010. ISBN: 9780521192545 (2010)

Abstract: Not Available

59) Becciani, U., Antonuccio-Delogu, V., Costa, A., and Comparato, M., "Nbody Simulations and Weak Gravitational Lensing using new HPC-Grid resources: the PI2S2 project", Astronomical Data Analysis Software and Systems ASP Conference Series, Vol. 394, Proceedings of the conference held
23-26 September, 2007, in Kensington Town Hall, London, United Kingdom. Edited by Robert W. Argyle, Peter S. Bunclark, and James R. Lewis., p.269 394, 269 (2008)

Abstract: We present the main project of the new grid infrastructure and the
researches, that have been already started in Sicily and will be completed by next year. The PI2S2 project of the COMETA consortium is funded by the Italian Ministry of University and Research and will be completed in 2009. Funds are from the European Union Structural Funds for Objective 1 regions. The project, together with a similar project called Trinacria GRID Virtual Laboratory (Trigrid VL), aims to create in Sicily a computational grid for e-science and e-commerce applications with the main goal of increasing the technological innovation of local enterprises and their competition on the global market. PI2S2 project aims to build and develop an e-Infrastructure in Sicily, based on the grid paradigm, mainly for research activity using the grid environment and High Performance Computer systems. As an example we present the first results of a new grid version of FLY a tree Nbody code developed by INAF Astrophysical Observatory of Catania, already published in the CPC program Library, that will be used in the Weak Gravitational Lensing field.

60) Sorrentino, G., Rifatto, A., and Antonuccio-Delogu, V., "Galaxy properties from voids to clusters in the SDSS-DR4", Galaxy Evolution Across
the Hubble Time, Edited by F. Combes and J. Palous, Proceedings of the International Astronomical Union 2, IAU Symposium #235, held 14-17 August, 2006 in Prague, Czech Republic. Cambridge: Cambridge University Press, 2007., pp.243-243 235, 243 (2007)

Abstract: We investigate the environmental dependence of galaxy populations
properties in a complete volume limited sample of galaxies in the SDSS-DR4. Our aim is to search for systematic variations in the

properties of galaxies with the local galaxy density in order to find hints that can be related to the presence of a void galaxy population. We find that galaxies in underdense regions (voids) are fainter (M(r) > -21.0) and bluer than cluster galaxies. Moreover, the transition from underdense to overdense regions is smooth, as well as the percentage of late-type galaxies decreases while the percentage of early-type galaxies increases smoothly from underdense to dense environments. In conclusion, we don't find any sudden transition in the galaxy properties with density, as suggested by Peebles (2001, ApJ, 557, 495) for void galaxies.

61) Antonuccio-Delogu, V., Coppola, G., Becciani, U., Busarello, G., and Merluzzi, P., "Environmental properties of Galaxy Populations in the Halo model .", Memorie della Società Astronomica Italiana Supplement, v.9, p.402
(2006) 9, 402 (2006)

Abstract: We study the relationship between mass and luminosity in a given photometric band using data coming from large surveys (2dF and SDSS), and results from high resolution N-body simulations. We have undertaken a critical reappraisal of the derivation of this M-L relationship, using additional constraints coming from Tully-Fisher relations and a restricted mass range. This formalism can be regarded as a recipe to derive M-L relationships for any given photometric band for which a Luminosity Function (LF) can be assigned. We apply it to two independent problems: the derivation of the Mass Function (MF) of Sab galaxies and the dependence of the LF on local density. Both these tests give very encouraging results. This fact implies then the validity of the two implicit assumptions of this model: the existence of a universal ML relation for galaxies and the circumstance that environmental properties can be entirely described by local variations of the MF.

62) Antonuccio-Delogu, V., Ferrigno, C., and Pagliaro, A., "Storing extreme
energy cosmic rays in voids", Frontier Objects in Astrophysics and Particle
Physics, Vulcano Workshop 2008, held 20-25 May, 2002 in Vulcano, Italy. Edited by F. Giovannelli and G. Mannocchi, 2003., p.539 539 (2003)

Abstract: Not Available

63) Padoan, Paolo, Jimenez, Raul, and Antonuccio-Delogu, Vincenzo, "The age
of LSB discs", The seventh astrophysical conference: Star formation, near and far. AIP Conference Proceedings, Volume 393, pp. 315-318 (1997). 393, 315 (1997)

Abstract: The UBVRI colors of LSB discs seem to indicate that these galaxies are
older than 7 Gyr, and their that mean age is probably about 9 Gyr.

64) Gambera, M., Pagliaro, A., and Antonuccio-Delogu, V., "A Wavelet Analysis of the Coma Cluster: Statistics and Morphology", Generation of Cosmological Large-Scale Structure. Edited by David N. Schramm and P. Galeotti. Dordrecht: Kluwer Academic, 1997., p.261 261 (1997)

Abstract: Not Available

65) Antonuccio-Delogu, V., Becciani, U., Pagliaro, A., and Erbacci, G., "Experimental cosmology on massively parallel system: a new N-body treecode.", PC'96 - 8th Joint EPS-APS International Conference on Physical Computing, p. 159 - 162 159 (1996)

Abstract: The authors have designed and tested a new parallel N-body code to
perform simulations of the formation and evolution of the large-scale structure of the Universe. At variance with the molecular dynamics case, N-body codes are able to deal with the complexities of the truly long-range, gravitational interaction. the code is based on a work- and data-sharing scheme, and has been tested on Cray T3D in Bologna (CINECA) and Edinburgh (EPCC). It scales as O(N_{bodies}) for N_{bodies} ≥ 2×10⁵, and a load-balancing scheme has also been implemented. The authors present their results also with a video realized at CINECA with the first outputs of a large (N_{bodies} > 10⁶) simulation performed with this code, showing the formation of a rich cluster of galaxies.

66) Antonuccio-Delogu, V., "Large Scale Simulations in Dark Matter Scenarios (contribution not received)", The Dark Side of the Universe; Experimental Efforts and Theoretical Framework, Proceedings of the Second Workshop held 13-14 November, 1995 in Roma, Italy. Edited by Rita Bernabei and Antonella Incicchitti. Singapore: World Scientific, 1996., p.22 22 (1996)

Abstract: Not Available

67) Antonuccio-Delogu, V., "Gravitational Collapse in a Clumpy Environment", Mapping, measuring, and modelling the universe. Astronomical Society of the Pacific Conference Series, Volume 94, Proceedings of a workshop held in Valencia, Spain, 18-22 September 1995, San Francisco: Astronomical Society of the Pacific (ASP), |c1996, edited by Peter Coles, Vincent Martinez and Maria-Jesus Pons-Borderia, p.63 94, 63 (1996)

Abstract: Not Available

68) Antonuccio-Delogu, V., Colafranceso, S., and Del Popolo, A., "Substructure, dynamical friction and the origin of gravitational bias in hierarchically clustered cosmological models", Memorie della Società
Astronomia Italiana, Vol. 66, p.195 66, 195 (1995)

Abstract: Not Available

69) Colafrancesco, S., Antonuccio-Delogu, V., and Vittorio, N., "Cosmology
with clusters of galaxies", Memorie della Società Astronomia Italiana, Vol.
66, p.183 66, 183 (1995)

Abstract: Not Available

70) Antonuccio-Delogu, V. and Colafrancesco, S., "Physical Mechanisms for Biased Galaxy Formation", Large Scale Structure in the Universe, Proceedings of an International Workshop, held in Potsdam, Germany, 18-24 September 1994. Edited by Jan P. Mücket, Stefan Gottloeber, and Volker
Müller. Singapore: World Scientific, 1995, p.278 278 (1995)

Abstract: Not Available

71) Antonuccio-Delogu, V. and Atrio-Barandela, F., "Stochastic field fluctuations in galaxies and clusters.", "Physical Cosmology, Proceedings of the 2nd Rencontres de Blois: "25th 525 (1991)

Abstract: Stochastic fluctuations of the gravitational field in a forming protostructure are induced by small radius, high density peaks. The authors compute the probability distribution of the gravitational field induced by a population of randomly placed peaks, for a power law spectrum of density fluctuations. A net enhancement of the probability for large F is produced by the clustering. The authors shortly stress the consequences of this on the dynamical evolution of forming protostructures.

72) Antonuccio-Delogu, V. and Atrio-Barandela, F., "Smallscale Structure and Angular Momentum Transfer in Protostellar Environments", Angular Momentum Evolution of Young Stars. Proceedings of the NATO Advanced Research Workshop on Angular Momentum Evolution of Young Stars, held in Noto, Sicily, Italy, Sept. 17-21, 1990. Editors, S. Catalano, J.R. Stauffer; Publisher, Kluwer Academic Publishers, Dordrecht, Holland; Boston, Massachusetts, 1991. ISBN # 0-7923-1316-X. LC # QB843.E2 A54 P. 27,
1991 27 (1991)

Abstract: Not Available

73) Antonuccio-Delogu, V., "Angular Momentum Transport in a Two-Component Protogalaxy", Large Scale Structure and Motions in the Universe, Proceedings of an International meeting held in Trieste, Italy, April 6-9,

1988. Edited by M. Mezzetti, G. Giuricin, F. Mardirossian, M. Ramella.
ISBN 0-7923-0082-3; 1989, Astrophysics and Space Science Library, Vol.
151,
p.319 151, 319 (1989)

Abstract: Not Available