Chin. J. Astron. Astrophys. Vol. 8 (2008), **Supplement**, 415–417
(*http://www.chjaa.org*)

Chinese Journal of
Astronomy and
Astrophysics

Some Personal Conclusions

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Abstract I present here some personal remarks that I have drawn at the 2007 Vulcano Meeting.

Key words: Cosmology: Large Scale Structures

1 A NEW VISION OF COSMIC STRUCTURE EVOLUTION IS EMERGING

Various successful aspects of this Meeting have been related to the following issues:

- A deeper understanding of high-E cosmic sources is being developed by including more detailed physical description into a wider vision of their evolution
- This cognitive process makes the "standard" lore of the evolution of cosmic structures no longer satisfactory
- Such emerging new vision of high-E cosmic sources is a process driven by the achieved successes of X-ray, γ-ray and TeV experiments
- The enhanced knowledge of the structure and evolution of cosmic structures allows also to make attempts to probe fundamental physics in cosmic sources.

In such a context, the new look of cosmic structure evolution that is driven by the present and ongoing experimental strategy tells us that large-scale structures in the universe are indeed complex astrophysical environments. There are, in fact, some general features that have been shown at this meeting to be common to all cosmic structures:

- The presence of Black Holes (BH) the cores of cosmic structures;
- The production of high-E particles (e.g. cosmic rays CRs) and their subsequent effects on the atmospheres of cosmic structures;
- The presence of Dark Matter (DM) that dominates the gravitational evolution of cosmic structures from large-scales down to stellar-system scales.

Black Holes (BH) sitting in the cores of cosmic structures can reveal themselves as Active Galactic Nuclei (AGN) thereby producing sources dominated by non-thermal radiation (Blazar-like) or a complex combination of non-thermal and thermal processes (like many AGNs as well as the central regions of several ordinary galaxies). However, it has been shown that many BHs are quiescent thereby producing Quiet Galactic Nuclei (QGN). Scenarios of a merging-driven activity do not provide an entirely viable solution to this transition since merging in cosmic structures has been overestimated. The reason for the transition from QGNs to AGNs is not yet known but it seems a crucial ingredient to understand the evolution of galaxies and of their active engines.

A promising point of view that could be taken to unveil the evolution of active engines in cosmic structures is a full multi-frequency analysis of their emission processes from radio to gamma-ray and TeV energies. Such an analysis could be able to provide insights on various aspects of the physics of BH-dominated

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sources like, e.g., the acceleration of particles up to extremely high energies in principle, the sites where this acceleration is taking place, the evolution of various ejecta from the central engine and their relation to the time variability observed at different wavelengths, the jet-disk (acceleration vs. accretion) relation, the evolution of the late-stage remnants of the energetic jets (say the outer jets and the lobes observed in radio galaxies) and their feedback on the surrounding medium. In this context, the correlation between the high frequency part of the e.m. spectrum (gamma-rays, TeV) and the lowest part of the e.m. spectrum (radio and especially microwaves) can prove the same kind of non-thermal dominated physical processes. The next coming large sky area surveys in both the gamma-ray range (GLAST) and in the microwaves (OLIMPO, PLANCK, and other experiments) will allow to improve by order of magnitudes the statistics of BH-dominated sources and our knowledge of the basic physical mechanisms responsible for their energetic activity. In turn, such observations will also provide a crucial understanding of the impact of BHs on cosmic background radiation fields (fro microwaves to gamma-rays and TeVs) and of the impact of BHs in the evolution of large-scale structures in the Universe.

The high-E particles (e.g. **cosmic rays, CR)** that are present in the atmospheres of cosmic structures are required to attain energies from the sub-relativistic to the highly relativistic regimes. Various mechanisms have been proposed to this aim:

i) Shock acceleration needs to be very efficient to beat thermalization and other relaxation mechanisms operating in the same environment, and such high efficiency is not ensured in many cosmic environments;

ii) Jets are certainly operating in several cosmic environments (from stars to the most distant AGNs) and they can be effective sites of high-E particle injection in the atmospheres of cosmic structures;

iii) Jets seem to be very knotty and for from being continuous systems. In this respect, the "cannonball theory" might offer an appealing solution to the origin of cosmic rays;

iv) The effects of jets and particle acceleration in cosmic structures is becoming a relevant aspect of their evolution.

The high-E particles accelerated and/or injected in cosmic structures provide a feedback on their atmospheres (like testified by the interaction between the environment and the jets or their late-evolution stages in the form of buoyant bubbles of relativistic plasma floating in the halos of galaxies and galaxy clusters. This is another proof of the relevant role of BHs and of their ejecta on the evolution of large-scales in the universe, as clearly observed in many galaxy clusters nowadays.

CRs have a clear role in determining the evolution of these cosmic structures being able to modify their thermal and pressure structure by heating efficiently the thermal atmospheres thus providing a viable solution to the cooling-flow catastrophe and a set of non-thermal emission phenomena (from radio halos to gamma-ray halos and hard-X-ray emission excesses) which are observable but in turn requiring to reconsider the standard lore for the evolution of cosmic structures by inserting in a consistent evolutionary picture both the CR particle field and the magnetic field which is intimately related to the confinement and diffusion of the high-E particles.

Dark Matter is considered to be the dominant form of matter in the universe and it dominates the gravitational evolution of cosmic structures from large-scales down to stellar-system scales, but it is yet elusive since we don't have a clear detection of the fundamental DM particles.

From the fundamental physics side we have already viable DM candidates like a SUSY neutralino or a massive sterile neutrino, but the available direct detection techniques have not yet provided a clear detection of these fundamental cosmogonical particles. From an astrophysical side, the physical nature of DM put in the context of the astrophysics of cosmic structures may provide phenomena that can be recorder by astronomical techniques. Neutralino annihilation in DM-dominated cosmic structures, for instance, inevitably produces ordinary high-E particles (protons, electrons, pions, etc.) that might contribute to determine the high-E properties of cosmic structures themselves, like radio, X-ray and gamma-ray emission, beyond SZ effect and gas heating. But such downgraded view of DM particles renders them, in turn, much more interesting in an astro-particle context because it offers a way to test its composition through "standard" astronomical observations in the largest available laboratory, i.e., our Universe.

2 EPILOGUE

The enhanced comprehension of the structure and of the evolution of cosmic structures in the universe allows us, finally, with an attempt to probe even fundamental physics in the best known cosmic laboratories:

the nature of DM, the origin of CRs and UHECRs, neutrinos, magnetic fields, gravitational waves, as well as aspects of Lorentz Invariance, Fundamental constant variations, Quantum space-time, and the nature of a possible for of Dark Energy.

In this context, I personally consider as extremely stimulating and productive the assembly of scientists with different expertises and activities in a common frame-work like the one offered by the Vulcano Meeting.

Acknowledgements S.C. thanks F. Giovannelli and L. Sabau-Graziati for the opportunity to present my own view of some of the most relevant aspects of the 2007 Vulcano meeting.