

## Recent View of Multispectral Universe: Concluding Remarks III

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**Abstract** Personal impressions of the author about scientific talks and discussions during the Frascati Workshop 2007 on multifrequency behavior of cosmic sources are briefly summarized and discussed in this paper.

**Key words:** high-energy astrophysics — multispectral analyses

### 1 INTRODUCTION

This paper is summarizing some of my personal and subjective impressions during the Vulcano 2007 workshop on Multi-frequency behavior of cosmic high-energy sources. Why subjective: The topic covered by this workshop is so wide (and growing) and so interdisciplinary that it simply cannot be accessed by single person. Only to name all speakers just by names and titles of their talks would take more than half of the pages allocated to this contribution. My apologies to excellent theoretical astrophysicists participating at the workshop as I, as an experimental astrophysicist, can hardly precisely follow their nice ideas in all cases presented during the workshop.

### 2 SUBJECTIVE WORKSHOP HIGHLIGHTS

It is evident that the Čerenkov telescopes start to play an important role in multi-frequency analyses of cosmic high-energy sources (talks by Andrea Santangelo, Marc Ribo and Hendrik Bartko<sup>1</sup>), a consequence of the progress in modern Čerenkov telescopes which started to deliver reliable data analogous to results we know from other astronomical observing techniques. Blazars, extragalactic objects, in which we have the unique opportunity to look directly into the jet, continue to represent a great astrophysical laboratory to test in detail the jets and related physical processes. Multi-frequency analyses are extremely important here, as confirmed e.g. by performed ToO INTEGRAL observations of blazars in outburst (Elena Pian).

Transient radio sky is full of new discoveries. New delivery to HEA ZOO: RRATS - are they musketeers? (Nanda Rea). Unfortunately not, “just” NS...

INTEGRAL satellite (recently finishing 5 years in space after launch in October 2002) is performing well providing detections of numerous hard X-ray sources such as anomalous X-ray pulsars, which proved to be very hard, as shown by Lucien Kuiper (and many others). Also the observations of cataclysmic variables (CVs) and related objects by INTEGRAL (as shown by René Hudec) shows surprising consequences, as the fraction of CVs observable in hard X-rays by INTEGRAL is much larger than originally expected (recently 21 CVs with more expected among the still non-classified sources).

RXTE archival data have been used in many talks and contribute to many fields of HEA, e.g. pulsar astronomy (as shown by Lucien Kuiper). These results surely support the efforts to fly the Lobster Eye X-ray ASM since it will achieve much better limits than RXTE ASM (“Lobster” talk by Rene Hudec).

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<sup>1</sup> All references mentioned in this paper mean talks on the Vulcano 2007 workshop on Multi-frequency behavior of cosmic high-energy sources., i.e. all references of the type Author Name mean Author Name, this volume (2008).

Recently we have an excellent X-ray spectroscopy if data from all available satellites are collected together and accordingly analyzed (Thomas Boller, Lucien Kuiper and many others).

Giant Soft Gamma-Ray Repeater (SGR) flares at a rate estimated to be about one per SGR in 30 years remain spectacular and can even generate transient radio nebulae (Kevin Hurley). Like the (soon expected?) flare of Vulcano and Vulcanello? Optical counterpart of SGR1806–20 was definitely confirmed to be invisible even for large instruments (that's a pity of not having such piece of information about 15 years ago when I spent a lot of time looking for possible flaring Optical Transient (OT) activity for this source on Harvard, Bamberg, and Sonneberg plates, when the physics of the source was completely hidden).

The idea that, at least some, Gamma-Ray Bursts (GRBs) can be in fact distant extragalactic magnetar flares is still alive (Kevin Hurley), however, about 30 years of data would be needed to confirm this hypothesis. New hard bursting source has been reported in the Galactic Centre achieving  $10^{41}$  erg with time profile unlike SGR.

Excellent series of talks on TeV astrophysics have been presented by several speakers, including review talks, confirming that this part of very high-energy astrophysics is more and more important if we want to understand completely the physics in some high-energy sources (Marc Ribo). New valuable data on gamma-ray binaries and other objects have been presented. Some of the TeV sources are INTEGRAL gamma ray sources too, e.g. LSI 61° 303 exhibiting variable emission. New results on microquasars have been presented and discussed. Now we have more than 40 sources on the TeV sky, including new types of sources as well as still unidentified sources. A lot of theoretical work is however needed to properly model these sources. New source in Galactic may be driven by antimatter annihilation.

Almost all 3–8 keV Cosmic X-Ray Background (CXB) has been already resolved by Chandra into discrete sources. A total Black Hole (BH) density is estimated to be equal to  $3 \times 10^6$  solar masses  $\text{Mpc}^{-3}$  (CXB talk by Filippo Frontera).

Identification of high-energy sources is an important task (Nicola Masetti). Many high-energy sources still remain unclassified (INTEGRAL has recently 27% unclassified gamma-ray sources). My personal comment here is that according to the statistics we made, a large fraction of (already identified) gamma-ray sources seen by the INTEGRAL satellite has surprisingly bright optical emission.

The Cannonball model of GRBs was stated that it can be more common in space than most of us assume (Alvaro de Rujula).

Nice cosmology with GRBs and Supernovae (SNe) (Arnon Dar) has been presented. And the conference topics perfectly suits the need of more and more important jets (Jim Beall).

Nearby SNe, such as SN1987A, give additional dimension to multispectral analyses: neutrinos (Nino Panagia).

Pulsar astrophysics also develop rapidly with about 2000 radio pulsars recently but the Crab pulsar, as the best studied young pulsar, still plays a dominant role (Gottfried Kanbach).

Be stars/X-ray transients with their huge outbursts attract attention and fine X-ray light curves exist (Mark Finger). My personal comment: since these objects are in general optically very bright (some are brighter than magnitude  $V=10$  and hence are easily accessible already by small aperture robotic telescopes), a question arises, namely whether are indeed optical observations (with emphasis on monitoring covering the high-energy flares and spectroscopic analyses) inadequate here?

Progress in Quasi-Periodic Oscillations (QPOs) indicates that there are heavy neutron stars (NS) in some systems - and hence representing a need for XEUS to tell the truth about the origin of QPO (but only our children will use these data, taking the recent estimate when XEUS will fly into account, Didier Barret).

Many talks went very deeply into the related physics such as the problem of equation of state of dense matter (Natalie Webb). But we have to further constrain the rotation of NS. My personal comment: does the Webb telescope will help there?

Also masers represent a part of high-energy astrophysics and even more, have many unexpected applications (Kinwah Wu).

There is a need to extend the energy range for next X-ray telescopes (Rosario Iaria), at least for spectroscopy of NS binaries. The recent efforts by several teams to deposit depth graded multilayers (MLs) on astronomical grazing-incidence mirrors to extend the energy response towards higher energies, perhaps up to 100 keV, suits here well.

Also gravitational waves belong to multispectral observations of high-energy sources (Gian Paolo Murtas) where was stated that indications exist that gravitational antennas have seen catastrophic events from the Galactic Center (GC).

Soft X-ray transients (XRT) represent an excellent example of the detailed study taking all available information (including public archives) into account (Vojtech Simon).

Outbursts of super giant fast X-ray transients last only hours, representing an addition to High-Energy Astrophysics (HEA) ZOO (Sylvain Chaty).

The Swift satellite proved to be an efficient tool to detect bursts from Accreting X-ray Pulsars (AXPs) (Gianluca Israel). A question arises, namely: are the magnetars subset of all pulsars (Wolfgang Kundt)?

Some techniques developed for GRBs (such as networks of rapidly responding robotic optical telescopes) could be applied also elsewhere in the multispectral analyses of high-energy sources in general, such as analysis of TeV sources. This technique allows providing optical data (photometry, low resolution spectroscopy) typically within 30 s after receiving the notice.

Gamma-ray background still represents an interesting issue, as shown in another excellent review by Tanja Kneiske.

The X-ray coded-mask instrument JEM-X on INTEGRAL satellite has provided valuable results on peculiar long X-ray bursts like GX 3+1 (Niels Lund). Does the XTEJ1739–285 represents the fastest spinning NS?

SNIa related issues have been also presented and discussed - the two populations of progenitors were discussed in detail (Filippo Mannucci).

Also normal galaxies represent interesting object for multiwavelegth investigations. (Dong-Woo Kim), as confirmed by Chandra satellite (Pepi Fabbiano), albeit shown that the subject is very complex (but, which one is not very complex in the high-energy astrophysics?).

We have a comeback, with new UV, X, and gamma ray observations, of cataclysmic variables (CVs) (Franco Giovannelli, Chris Mauche and others). The bright CV SS Cyg was claimed to be in fact an intermediate polar (IP) (Franco Giovannelli).

Accretion disks are there in many astrophysical high-energy objects and they are illuminated, but more work is needed to explain the related physics completely (Bozena Czerny).

Solutions for advective disks exist for all luminosities and the optical thin region can be responsible for the hard tails (Gennady Bisnovaty-Kogan).

Black Hole (BH) masses are within the range of 2.5 to 20 solar masses (Janusz Ziolkowski). But Galaxies/AGN have supermassive BHs in their centers ranging from  $4 \times 10^6$  up to  $6.6 \times 10^{10}$  solar masses.

New BH models give very precise mass estimates, perfectly consistent with recent observations, of BHs, such as for 1915+105 (Bernd Aschenbach).

Precessing jets are still alive in alternative explanations of GRBs (Daniele Fargion) and GRB precursors should support this hypothesis. This contribution has originated a very heavy discussion.

### 3 MULTISPECTRAL OBSERVATIONS - RECENT STATUS

In the GeV-TeV energy range, the Čerenkov telescopes have started to deliver excellent results comparable to those provided by other astronomical observational devices.

In the gamma rays, valuable results have been discussed obtained by INTEGRAL and Swift satellites. In X-rays, very valuable results by Chandra, Newton, RXTE, Suzaku, etc., have been presented and discussed. In the infrared (IR): nice results by COBE, IRTS, etc., have been obtained and discussed. As for the optical range, ironically, there is a lack of data, especially of monitoring data. Example: 21 CVs seen by gamma-ray imager IBIS on INTEGRAL (as presented by Rene Hudec). Usually monitoring is provided only for brighter objects, for magnitudes fainter than V 16 is the situation unsatisfactory, despite of many related efforts (robotic telescopes, sky surveys, etc.).

My personal suggestions are given below. In my opinion, a better link of Čerenkov community to other observers would be highly advisable. E.g., follow-up optical observations by robotic telescopes could be organized for flaring episodes in analogy to follow up to GRBs. The Swift follow up to TeV observations provides excellent results (Elena Pian). This is a nice example how to proceed in the future.

Although very ambitious projects are considered for the future such as XEUS (ESA), Constellation X and Generation X (NASA), no one is obviously definitely approved for final funding. Probably the requirement “larger, better, and cheaper” cannot be easily fulfilled here.

It is time to try to change the conservatism of the X-ray astronomy community and to start to consider and use new designs already available but not yet used (e.g. Lobster Eye instead of coded mask) in new projects. The preferences of new designs and new instruments if compared to the traditional ones are to be carefully examined. Obviously, the future wide-field monitors and instruments with optics have the preference of achieving higher sensitivities and better signal/noise ratios than those without optics. At the same time, new approaches appear extending the possibility of use of focusing optics for higher energies. This could in future lead even to better efficiency and higher outputs from the high-energy astronomy satellites, as the recently wide used coded mask instruments usually require very long observing times in order of  $10^5$  to  $10^6$  s in order to provide scientifically reliable and reasonable results.

Many beautiful computer simulations were presented during the workshop showing how powerful computers contribute to theoretical modelling and simulations. The simulation of an intra-cluster medium with extra (non-planned) voice effects (heavy wind) (Sabine Schindler) can serve here as an example. We have heard an excellent review on metallicity issues (very complex) but many others, too.

#### **4 THE POSITIVES AND NEGATIVES OF THE VULCANO WORKSHOP**

The Vulcano workshops are by many considered to be extraordinary scientific workshops, so I have tried to list some positives and negatives, according to my personal view, below.

- Proximity of (almost) active volcano
- Long travel to the destination (some from us left our homes at 4 h in the morning to arrive evening, some even had to stay over night during their travel)
- Excellent wine
- No beer
- Extremely beautiful (and changing) view of the sea and islands from the hotel terrace

#### **5 SPECIFICS OF THE WORKSHOP**

In addition, there obviously are few specifics of the Vulcano workshops which I tried to summarize below.

- Proceedings in a special volume of Journal of Chinese Astronomy and Astrophysics. I think this is very positive - as it is an internationally recognized and refereed journal with reasonable impact factor
- Excellent preparation of proceedings, as all necessary details were known already before the workshop
- Long tradition
- Franco Giovannelli and his team providing perfect organization in all aspects
- Long lunch breaks - definitely positive
- Plenty time for discussions
- Some “rare” excellent talks many of us have never heard before (example: John Beckman on galaxy mergers, but many others as well).
- The workshop is interdisciplinary, but still well focused. We met colleagues we would never met on dedicated workshops but their talks are still important for us.
- Some colleagues are very good swimmers (Gennady, Stefano, Natalie, and many others).
- Two gentlemen - Vojtech and husband of Tanja (biologist) - even went with me in the 2 m high aggressive stormy sea waves on Tuesday afternoon (and survived).
- The talks here are not easy. We speak both to the colleagues in our own field of research as well as to colleagues who work in the fields far away. Many performed perfectly!

#### **6 CONCLUSIONS**

To conclude, many of the presentations on the workshop have confirmed and justified the recent efforts as well as scientific justifications for development of future experiments and projects.

Perhaps the most amazing is the recent development in ground-based gamma-ray TeV astronomy with about 70 galactic and extragalactic sources detected and ability to provide results we know from other

areas of astronomy such as images, spectra, and light-curves. Availability of these data makes the recent astrophysics really multi wavelength.

### 7 SELECTED PICTURES COLLECTED DURING THE WORKSHOP

With the few selected pictures collected during the workshop and shown below I would like to give to all participants as well as to someone else a memory and a view of productive meeting we had in Vulcano.

**Acknowledgements** I would like to thank all the organizers for organizing this productive and pleasant meeting. In my opinion, the work in the field of multispectral analyses of cosmic high-energy sources is a really interdisciplinary and at the same time international one, hence personal contacts are extremely important here. And the meetings like the Frascati Workshops (held in Vulcano) provide in this respect an excellent chance to meet, to discuss, to establish new contacts, and personal friendships. I would like also to thank all speakers for their excellent and almost entirely carefully prepared talks, and all participants for coming and joining us for discussions and for creating the friendly atmosphere during the whole workshop. My participation to the workshop was partly supported by the project ESA PECS INTEGRAL 98023.



**Fig. 1** The important feature of the Vulcano workshops is ample time for having scientific discussions.



**Fig. 2** Dining during the workshop: mostly the scientific discussions continued here.



**Fig. 3** The boat trip: it was very windy and the sea stormy.



**Fig. 4** Coffee breaks: only in the last two days it was possible to enjoy the coffee on the terrace, as it was very windy before.



**Fig. 5** The organizers and the complete GRB cannonball community (with waiter Mauro who served our meals almost from the beginning).