

Concluding Remarks

Janusz Ziółkowski*

*Copernicus Astronomical Center,
ul. Bartycka 18, 00-716 Warsaw, Poland
E-mail: jz@camk.edu.pl*

After a canonical disclaimer and a general remark, I will make brief comments on five arbitrarily selected topics: cosmology, gravitational waves, astrophysical neutrinos, gamma ray bursts and planetology and astrobiology. I will end with traditional acknowledgements and a call to show up at the next year Vulcano meeting (which should take place on Vulcano!).

*Frontier Research in Astrophysics,
26-31 May 2014
Mondello (Palermo), Italy*

*Speaker.

1. Introduction

As stated above (see abstract), I have to start with a classical statement that the selection of topics for these concluding remarks is based on personal impressions and as such it has to be arbitrary. It has also to be unfair to many exciting topics that are not mentioned here.

2. General Remark

First, I would like to emphasize that we had another very successful conference, this year. The scope of our conferences is always very broad, but this year it became substantially broader. This is due to the fact that a new field made a wide front entry into our workshop. This field is planetology. This fact certainly marks opening of a new chapter in the history of our workshops.

After this general remark, I will now make brief remarks on the topics listed in the abstract.

3. Cosmology

• Cosmology with Sunyaev-Zeldovich Effect (SZE)

Similarly as every year during recent years, Sergio Colafrancesco presented a very strong case for SZE being a really powerful tool in cosmology. As every year, his presentation was very comprehensive and convincing.

• Polarization of CMB

Paolo de Bernardis gave us a fascinating review on CMB polarization. Part of the fascination came from the fact of recent publications of the results of BICEP-2 team which claims that they detected B-type polarization of CMB. These results are still preliminary but, if confirmed, they will have fundamental implications for the inflation theory, gravitational waves physics and elementary particles physics.

4. Gravitational Waves

Dorota Rosinska gave us a nice review of the status quo in this field. We have very strong but still only indirect evidence (binary pulsar!). However, we are tantalizingly close to a real detection! Advanced LIGO and advanced VIRGO should start in 2015. They have chance to obtain first detections within the first few years of operation. For more sophisticated instruments like LISA and ET (Einstein Telescope) we will have to wait until 2018.

Gravitational waves were discussed also by Jean-Luc Atteia in his review of GRBs. He noticed that, according to the present knowledge, the short GRBs are, most likely, associated with the coalescence of two compact objects. Such mergers should be also sources of gravitational waves which could be detected by Advanced LIGO and VIRGO. Jean-Luc noticed that, since gravitational waves are emitted more isotropically than high energy photons, we may expect many detections of a gravitational waves signal without observing an accompanying short GRB ("orphan gravitational waves").

5. Astrophysical Neutrinos

Todor Stanev informed us about detection of new astrophysical neutrinos. These are the first non-solar astrophysical neutrinos since 24 neutrinos from SN87A (28 years ago!). The detection in question comes from IceCube which collected 36 events that are mostly of extraterrestrial origin. These neutrinos are different from earlier known astrophysical neutrinos - they have much higher energies. The energies of the neutrinos detected by IceCube are in the range 40 TeV to 2 PeV (earlier neutrinos, both solar and those from SN1987A, were in a few MeV range). IceCube was devised to detect neutrinos in PeV energy range, so these high energies came as no surprise. The sources of these high energy neutrinos are distributed roughly isotropically on the sky with some preference for the southern hemisphere. So far, no event could be associated with a known astrophysical source (the precision of the location is too low). The possible identification would require a better statistics. There are plans to increase the volume of IceCube by a factor of five (this would increase the number of events from 10 to 50 per year).

6. Gamma Ray Bursts

We listened to two excellent reviews by Jean-Luc Atteia and Giancarlo Ghirlanda. Both presented a wealth of updated observational data concerning GRBs. From the review of Jean-Luc I will mention the investigations of reionization epoch with the help of GRBs. By analyzing the early (few days after the burst) spectra of the high redshift afterglows it is possible to estimate the degree of reionization at the time of the burst. From analyzes of four such spectra (with the redshifts in the range 5.9 to 6.7) the investigators concluded that the Universe was largely ionized around the redshift $z = 6$.

Jean Luc discussed also an interesting topic of GRBs from Population III stars. Such GRBs might have properties very different from typical GRBs observed so far and they might form a special class of GRBs. They might be very energetic, very long and remind soft hour-long transients. They might be difficult to recognize but, if detected, they would bring invaluable data on Pop. III stars, like their redshifts, their birth rate and their environment.

Jean Luc discussed also another interesting topic: the life threatening galactic GRBs. It seems that the most dangerous phenomenon is a UV flash which can extinguish the life even at the distance as large as 100 kpc. It has been suggested that some mass extinctions in the past (e.g. Ordovician 440 Myr ago), could have been caused by a galactic GRB.

Giancarlo discussed, among other things, the distribution of the bulk Lorentz factors Γ_0 and the distribution of the jet opening angles θ_{jet} . The estimate of the average value of the bulk Lorentz factor depends on the nature of the interstellar matter surrounding the jet (the jet interacts with it). For the wind interstellar matter this value is $\langle \Gamma_0 \rangle = 66$, for the homogeneous matter it is $\langle \Gamma_0 \rangle = 138$. As for the opening angle of the jet, it is typically of the order of a few degrees with the average value $\langle \theta_{\text{jet}} \rangle = 3^\circ$.

Giancarlo discussed also the problem of the missing orphan afterglows. He convinced us that the orphan afterglows should exist and that they should be numerous. Yet, we do not detect them and we do not understand why they are missing.

7. Planetology and Astrobiology

First, let me note that extrasolar planets certainly are the frontier objects in astrophysics, so they fit the new name of our workshop. However, they are not high energy cosmic sources, so they would not fit the older name. So, it seems that the change of the name was just on time to welcome the planetology in the scope of our conferences.

We listened to several talks which demonstrated the big progress made in the field of exoplanets during the last decade.

The progress includes both the more sophisticated observations and the better understanding of the physical mechanisms operating during the origin and evolution of the planetary systems.

In the field of observations let me note that the number of the known exoplanets is approaching two thousands and is growing quickly. We start obtaining high contrast images of exoplanets (Riccardo Claudi presented us an ambitious project SPHERE, which plans to reach a contrast of 10^{-6}).

We start also investigations of the chemical composition of the exoplanets atmospheres. Alberto Adriani informed us that on one of them (HD 189733b) water was found. Its amount is by an order of magnitude smaller than on Jupiter but by two and a half orders of magnitude larger than on Saturn.

In the field of the physical mechanisms, we understand reasonably well the different phases of the formation of different types of planets (Jovian and the terrestrial ones) and of their atmospheres. Many important details are still to be worked out. But our understanding of the process is dramatically better than, say, two decades ago. Further substantial progress is expected, both in the observations and in the theory.

8. Acknowledgements

And now, traditionally, let me suggest that we thank Franco, Francesco, all organizers and all participants. Let me also express the hope that I will see all of you again when we meet during the next year "Frontier Research in Astrophysics" workshop - hopefully - on Vulcano island!.