Vulcano Workshop 2016 - Frontier Objects in Astrophysics and Particle Physics

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Cospar Working Group (April 2011)
The Future of Space Astronomy:
A Global Road Map for the Next Decades

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Prologue

Space satellites have given astrophysicists a unique opportunity to explore the invisible part of the electromagnetic spectrum and drastically improve our knowledge of the Universe.

From the discovery of the first X-Ray source, in 1962, a factor of $10^7$-8 improvement in sensitivity have been achieved in X-Ray astronomy and of $10^7$ in Cosmic microwave background data!

...and we have now the first detection of Gravitational Wave, 100 years after their predictoin: a new window open

The increasing size, complexity and cost of large space observatories places a growing emphasis on large international collaboration.
SPECTACULAR RESULTS FROM SPACE OBSERVATORIES
The multicolor Universe as was known 20 years ago and nowdays

Radio Continuum: 408 MHz, Bonn, Jodrell Bank, and Parkes

Microwave: W-band 94 GHz, NASA and the WMAP Science Team

Near Infrared: 1.25, 2.2, 3.5 micron wavelength CORE/DIRBE

X-Ray: 0.25, 0.75, 1.5 keV ROSAT/PSPC

ESA – INTEGRAL Galaxy Plane: more than 1000 sources

NASA’s Fermi telescope reveals best-ever view of the gamma-ray sky

Credit: NASA/DOE/Fermi LAT Collaboration
The different views of the Galaxy

INTEGRAL detects “antimatter” in the centre of our Galaxy.

Herschel detects the “birth of the Stars”.

INTEGRAL detects BH and NS in the Galaxy Plane: the “death of the Stars”.

Open issues:

- Which is the role of SMBH in the Large scale structure formation (Clusters, QSOs), and finally stars and planets?
- And what about our Galaxy centre BH...
- Which is the astrophysical counterpart of the just detected Gravitational Wave, what we expect at other wavelengths...
- And which are the Cosmological implications...
INTEGRAL UL on γ-ray emission from GW150914

ΔT = 0.4s

Fig. 1.— INTEGRAL/SPI-ACS lightcurve in ±10 s around GW150914 trigger time. Light red symbols represent the measurements at the natural instrument time resolution of 50 ms; dark red points are rebinned to 250 ms. The dashed black curve is the background level estimated from a long-term average.

PICSIT Spectral Timing data
260 keV – 2.6 MeV
16ms time resolution
Upper limits/detection fluence at the time of the event $\approx 10^{-8}$ erg cm$^{-2}$ in the 75 keV-2MeV energy range, i.e. promptly released in $\gamma$-rays

$$E_\gamma/E_{GW} < 10^{-6}$$

What are the implications of this energetic constraint?

At 240 Mpc this is $L_\gamma=7\times10^{46}$ erg in 1s, if isotropic, or $10^{44}$ if strongly beamed. Lot of energy to be extracted from disk.
What's next:

OP2 \(\rightarrow\) 1 trigger/week

- Lobster eye X-Ray + gamma-ray trigger
  - 10-50 grb High Z
  - 10y dev. Cost 200-500M€

- Cubesat swarm constellation Arcsec positioning
  - Short turnaround
  - Moderate cost, modularity: 100 cubesat

INTEGRAL-SWIFT
Large Observatories
>10 years operations

INTEGRAL and SWIFT operation mode has been changed to IMMEDIATELY follow-up the NEXT GW trigger

LOBSTER (NASA)
Theseus (ESA)

The HERMES mission
High Energy Rapid Modular Experiment Satellites
We end this short review of the powerful tools given by modern Space Observatory the Universe. Just one example the multicolor view of Andromeda Galaxy seen at different wavelengths, i.e. enhancing different states of its evolutionary history.
Visible light: the living stars: living from 6-7 My (100 Ms) to 13 By (0.9 MS)

Infrared: the ‘birth’ of the stars

X-Rays: the final stage of stars

..in a picture the whole time history of a galaxy..

Powerful space observatories give you the full story of the different components of the Universe at a glance....scientists can do much better understanding the physical processes active in place....
We need to probe the very early stages of the Universe, to understand how it evolved from the Big Bang, i.e. from the (almost) pure hydrogen in form of gas (and dark matter?), to the ‘monster’ and ‘mini’ BHs, cluster of Galaxies, Galaxies, Stars, Proto-Planetary systems Planets and finally life!....

✓ how and when the ‘first stars’ were built is one of the fundamental question now compelling in view of the GW detection 100Ms??

→ Need for more powerful Space Observatories

✓ there is a need to maintain a FULL ACCESS to the whole electromagnetic spectrum from Space

⇒ There is a solid plan for Ground Based facilities that must be complemented by the space-segment to get the full picture of how the Universe originated and what is it made off.

At the WG time we had a unsecured future for Large missions
We have now an impressive fleet of Space Observatories

ESA'S FLEET ACROSS THE SPECTRUM

Thanks to cutting edge technology, astronomy is today unveiling a new universe around us. With ESA’s fleet of spacecraft, science can explore the full spectrum of light, see into the hidden infrared universe, visit the untamed and violent universe, chart our galaxy and even look back at the dawn of time.

The ESA fleet is aging
The community need a new high energy Observatory class mission

• HERSCHEL
  Unveiling the cool and dusty Universe

• PLANK
  Looking back at the dawn of time

• GAIA
  Surveying a billion stars

• HST
  Expanding the frontiers of the visible Universe

• XMM-NEWTON
  Seeing deeply into the hot and violent Universe

• integral
  Seeking out the extremes of the Universe

Mission ended...

Scheduled 2018

10 December 1999

17 October 2002

24 April 1990
The short term perspective: an aging fleet!
2015-2020

Adapted from Ubertini et al.
Multi Colour Eyes >

>2020

Echo
ESA M2

Plato
ESA M3

ATHENA
ESA L2

JWST
ESA M2

ASTRO-H

Euclid
ESA M2

ALMA
LMT
CCAT

SKA
GBT EVLA

LOFAR

CTA, ACIS
HAWC

Adapted from Ubertini et al.
In the last 5 years COSPAR-IAU-IAF Commissions common action have been implemented to find synergies, common actions, Proseltism, herding the astrophysics community...

**L2 Athena & L3 eLISA**

programs has been decided and they will drive the next 2-3 decades scientific activity in space astrophysics and planetology!
...what's next?

At the IAU GA in Honolulu (2015) was held a Focuss Meeting on Global Coordination. After several days of open discussion the result was the Establishment of a WG on:

**Global Coordination of Ground and Space Astrophysics**

under the IAU Executive Committee

Members and Contact Details

**Chairs:**
Roger Davies (Roger.Davies@physics.ox.ac.uk) - UK – co-chair
David Spergel (dns@astro.princeton.edu) - USA – co-chair
The new IAU-WG will play a key role in the coordination activity → What’s missing’
A new Gravitational Wave Observatory?

To achieve good positioning capability
3 arms seems necessary (see MB talk)

Large effort = ESA+NASA endeavour?
Who will lead? HST/JWST like cos >> B$?
Thanks for your attention