Astronomy

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for the Astronomy Working Group

Answers to the call for ideas

Illustration of the strong expectation of the community from the ESA Science Programme:

<table>
<thead>
<tr>
<th>Year</th>
<th>Programme</th>
<th>Proposals</th>
</tr>
</thead>
<tbody>
<tr>
<td>1983: Horizon 2000</td>
<td>Astronomy</td>
<td>29</td>
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<tr>
<td>1993: Horizon 2000+</td>
<td>Astronomy</td>
<td>28</td>
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<tr>
<td>2004: Cosmic Vision 2015-2025</td>
<td>Astronomy</td>
<td>47</td>
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</table>
Context, ESA satellites

- In operation: HST (with NASA), XMM-Newton, Integral
- In development: Herschel, Planck, Corot (with CNES), Astro-F (with JAXA)
- In preparation: GAIA, JWST (with NASA)

Context, science

- discovery of 134 exo-planets (118 systems), down to ~ 15 \( M_{\text{Earth}} \)
- very different from the planets in the Solar System
- high diversity

- observations at higher and higher redshifts
- new cosmological parameters, more and more accurate
- dark energy dominates the Universe, now

- cosmological nature of \( \gamma \) ray bursts
- diagnostics of strong field gravity
- discovery of binary black holes
Evaluation of Cosmic Vision proposals

Proposals evaluated for prime scientific objectives, by the Astronomy Working Group

* What is new?
* What is the likely impact in the domain?
* What is the likely impact on science?
* What is the expected range of application?
* What is the added value of space?
* Short (around 2015), medium (2020), long (2025) or very long (> 2025) term?

Three main themes identified in Astronomy

1. Other worlds and life in the Universe
   Placing the Solar System into context
   - Formation of stars and planetary systems
   - Detection, census and characterization of exo-planets
   - Search for extraterrestrial life

2. The Early Universe
   - Probing inflation
   - Investigating Dark Energy
   - The observable Universe taking shape

3. The evolving violent Universe
   - Black holes and galaxy evolution
   - Matter under extreme conditions
   - Supernovae and the life cycle of matter
4 grand themes for the Science Programme

Working Groups objectives merged into 4 grand themes by the Space Science Advisory Committee

* What are the conditions for life and planetary formation?
  - From gas and dust to stars and planets
  - From exo-planets to bio-markers
  - Life and habitability in the Solar System

* How does the Solar System work?

* What are the fundamental laws of the Universe?

* How did the Universe originate and what is it made of?
  - The early Universe
  - The Universe taking shape
  - The evolving violent Universe

Astronomy roadmap (1)

What are the conditions for life and planetary formation?

Up to 2015

- Search for terrestrial planets: Corot, (Kepler)
- Star formation, molecular spectroscopy: Herschel, JWST
- Statistical census of extrasolar giant planets: GAIA, (SIM)

2015 - 2020

- Direct detection of a planet & search for biomarkers: Near-mid-IR nulling interferometer - Darwin

2020 - 2025

- Resolve protostars and protoplanetary disks: Far-IR observatory

> 2025

- Census of terrestrial planets within 100pc: Super-GAIA
- Atmosphere studies: High resolution optical-UV spectroscopy
- Imaging of exo-planets & exo-earths: Large optical interferometer (e.g. Hypertelescope)
Astronomy roadmap (2)

How did the Universe originate and what is it made of?

Up to 2015
- The Universe taking shape: HST, XMM, (Spitzer), Herschel, JWST
- The evolving violent Universe: (Chandra), XMM, Integral
- Initial Density fluctuations: (WMAP), Planck

2015 - 2020
- Clusters of galaxies back to their formation epoch, interactions black holes - galaxies: Large-aperture X-ray observatory - XEUS
- Probing Dark energy: Optical and near-IR wide-field imager
- CMB fluctuations: All-sky CMB polarisation mapper

2020 - 2025
- Resolve far-IR background: Far-IR observatory

> 2025
- Isotope abundances, physics of SN: Hard-X / γ-ray observatory
- Warm/hot IGM, physics of SN: High resolution UV spectroscopy