Understanding the universe…
is space the only solution?

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Study the Universe…

- From the Big-Bang to today
- Use of space unencumbered by ground constraints
- Universe as a laboratory
Why go to space...for astronomy...?

- i.e. other than for (human or not) exploration
- ‘Early’ days arguments: no atmosphere, no turbulence ➔ new spectral windows, perfect conditions
- Enables multi-wavelength approach ➔ choose scientific topic (e.g. quasars) and observe from $\gamma$ rays to radio
Space and ground
Multi-wavelength
Space ‘platform’, “flying” or not

- **No**: Moon ➔ far-side = ‘final’ protected window to open: VLFs

- **Flying**: micro-g environments
  - research experiments
  - preparation for solar system exploration
  - study (and mitigation?) of radiation and space debris

- **Flying**: satellites

- **Lagrange**
Big science → Planning

• Necessity of “visions”
  – Decadal survey in the US
  – Mandatory ‘long-term’ programmes in Europe
    • Horizons 2000 → what’s now flying
    • Cosmic Vision 2015-2025
  – Solar system exploration

• But visions need sustained efforts (or a doctor)…
European satellites in orbit
Nevertheless, Space Science leads and inspires….

What is it all about?

Space science looks out at the grand questions….

How did our Earth, our solar system evolve?

Where are we in the Universe?

Where did life come from?

Where are we going?

Are we alone?
Missions in Operations

- Hubble
- Integral
- Newton
- SOHO
- Rosetta
- Mars Express
- Cassini/Huygens
- Planck
- Corot
- Double Star
- Chandrayaan
- Proba 2
- Akari
- Hinode
- Herschel
- Venus Express

SCIENCE AND ROBOTIC EXPLORATION
Galactic star-forming regions with Herschel

RCW120 / PACS+SPIRE / Zavagno et al., HOBYS

Galactic plane towards Vulpecula / PACS+SPIRE / Molinari et al., HiGAL

Galactic plane towards Aquila / PACS+SPIRE / Molinari et al., HiGAL

Rosette Nebula / PACS+SPIRE / Motte et al., HOBYS

Online gallery of Herschel images: oshi.esa.int
Contrasting aesthetics
Putting Hubble in a Cultural Context
Venice 2010
Putting Hubble in a Cultural Context
Venice 2010
Research in space

Anything besides beautiful pictures?
Have we made up our mind on what to tell?
...and yet there’s good research done there
Is space the only solution?

• REMINDER: radio-astronomy “syndrome” in the mid-2000s
• NO: ground / space complementarity ➔ two recent examples
Space and ground 1
From survey detection to spectroscopy (physics)

Press release ESO 1040 HST + VLT

z = 8.6!
Space and ground 2
Universe as a laboratory

Herschel + ground-based facilities: digging up magnified galaxies (gravitational lenses)
NASA/JPL-Caltech-T. Pyle (SSC/Caltech)
The future: continue complementarity!

- From detection to morphology
  - Herschel (far-IR, star-forming regions) + ALMA (interferometry)

- From detection to physical and “geometrical” parameters
  - HST/JWST/VLT + E-ELT (high red shifts)
The future: international “coopetition”

• ‘Grand challenges’ ➔ Go Global!
  • GPS, Galileo, GMES, GES
  • No other way than international collaboration

• Decadal survey + Cosmic Vision (but what’s next after 2025 for space astronomy?)

• Solar system exploration (cf. Session 4)

• Emerging countries: what IC model?
Needs - How to…

- Attract young scientists and engineers?
- Maintain expert instrumentation teams?
  - more missions (not the actual trend)…but
  - in Europe: EC FP8?
What do we communicate to the general public?

• Agencies prefer results but also tend to raise expectations in order to generate motivation of the general public

• Anything besides ‘a sense of awe and beauty’?

• For Europe, there is not a single public, not yet

• Outreach and communication: better in the US! ➔ is “more money” the only reason?
THANK YOU VERY MUCH!