Science Vision for European Astronomy

January 23, 2007

- Astronomy
- Predicting the future: ambitious plans
- Developing the Science Vision
- Structure of the Draft Report
- Input for the Roadmap, and Timeline

ASTRONET
www.astronet-eu.org

Astronomical Research - I

- Study of everything beyond the Earth
- Objects far away, hence small and faint
  - Limited information about their nature
  - Need for large instruments: resolution and sensitivity
- Combining different types of observations crucial
  - Images/spectra/time-series

  - Electromagnetic/neutrinos/gravitational waves

Astronomical Research - II

- Exploration is integral component of this field
  - Large numbers of objects, all different
  - Searches and surveys with small telescopes and follow-up by large telescopes
  - Examples: black holes, exo-planets, dark energy
  - *In situ* measurements possible in Solar System
- Physical science driven by observations
  - Test models versus observations: theory and numerical simulations are crucial
  - Links with physics, chemistry, computer science, laboratory experiments, geophysics, and biology

Ground-based Telescopes





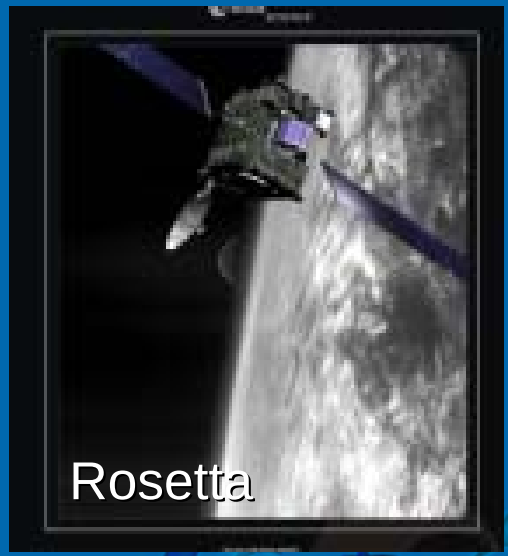


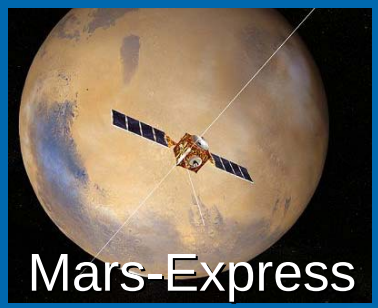




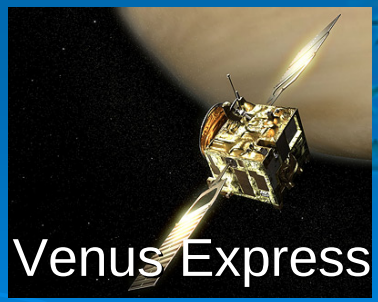


Satellites in Orbit



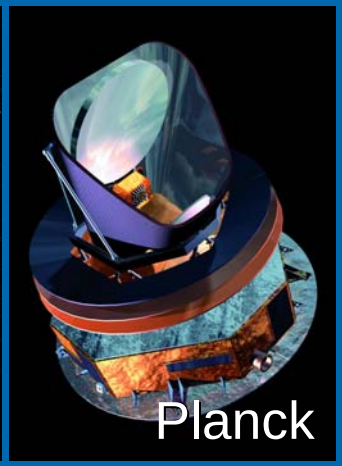


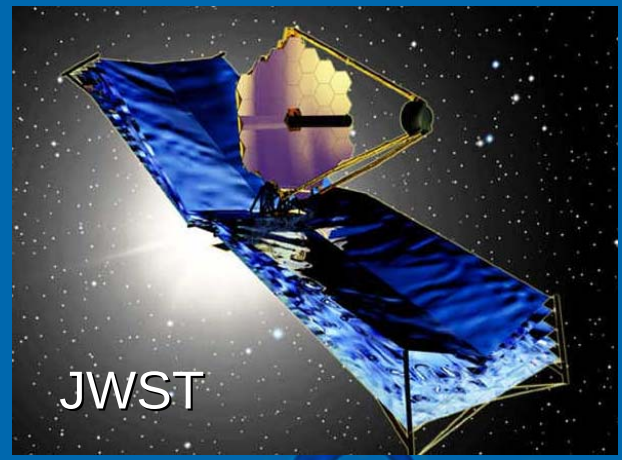
XMM-Newton

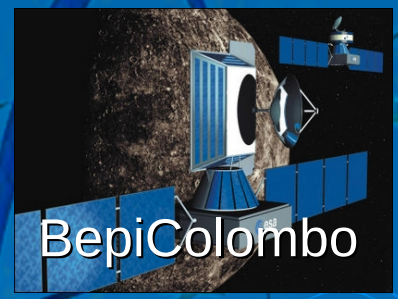


Also: Chandra, Spitzer, SWIFT, Akari, Spirit/Opportunity, MRO, Messenger, …

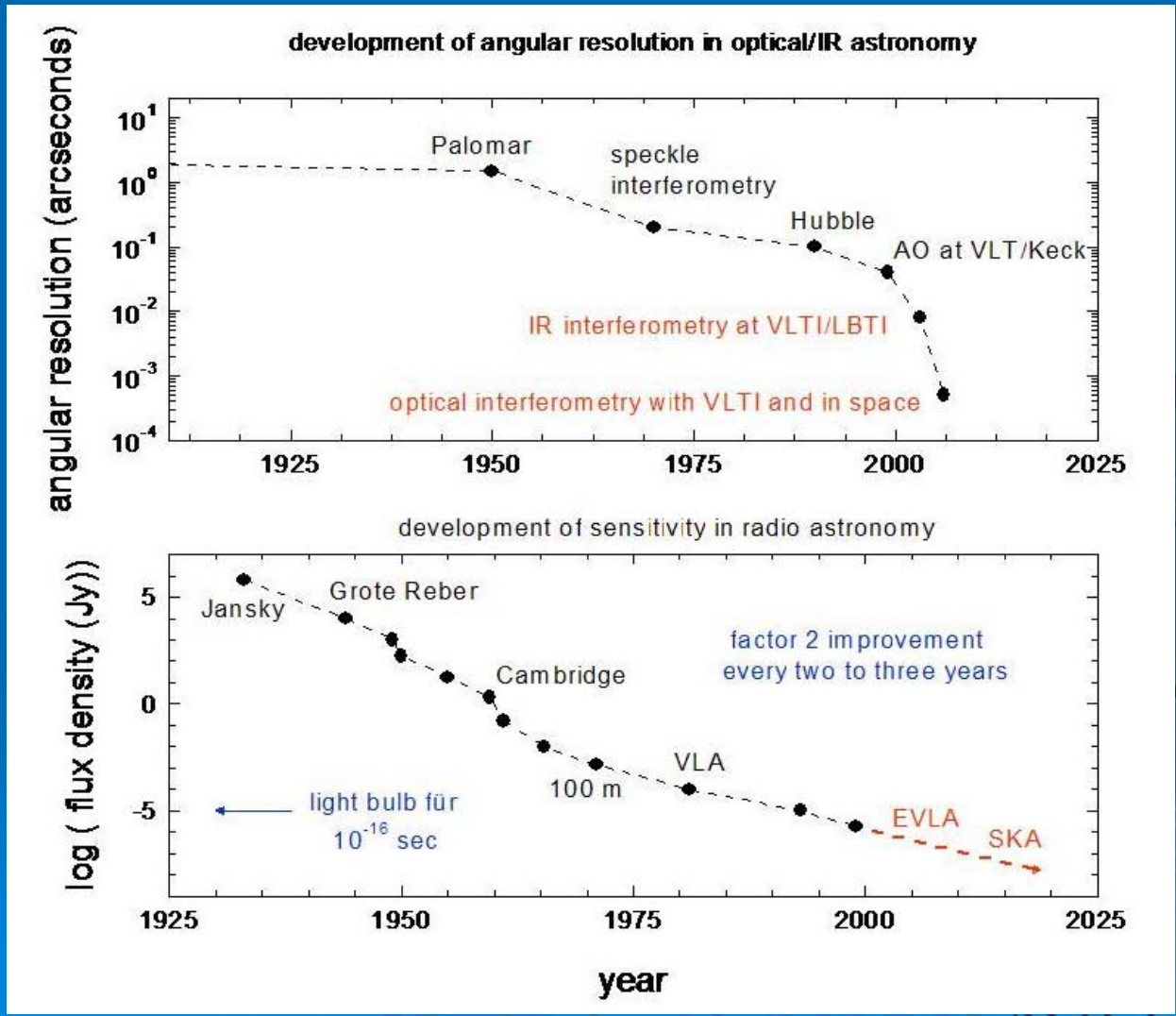
Under Development





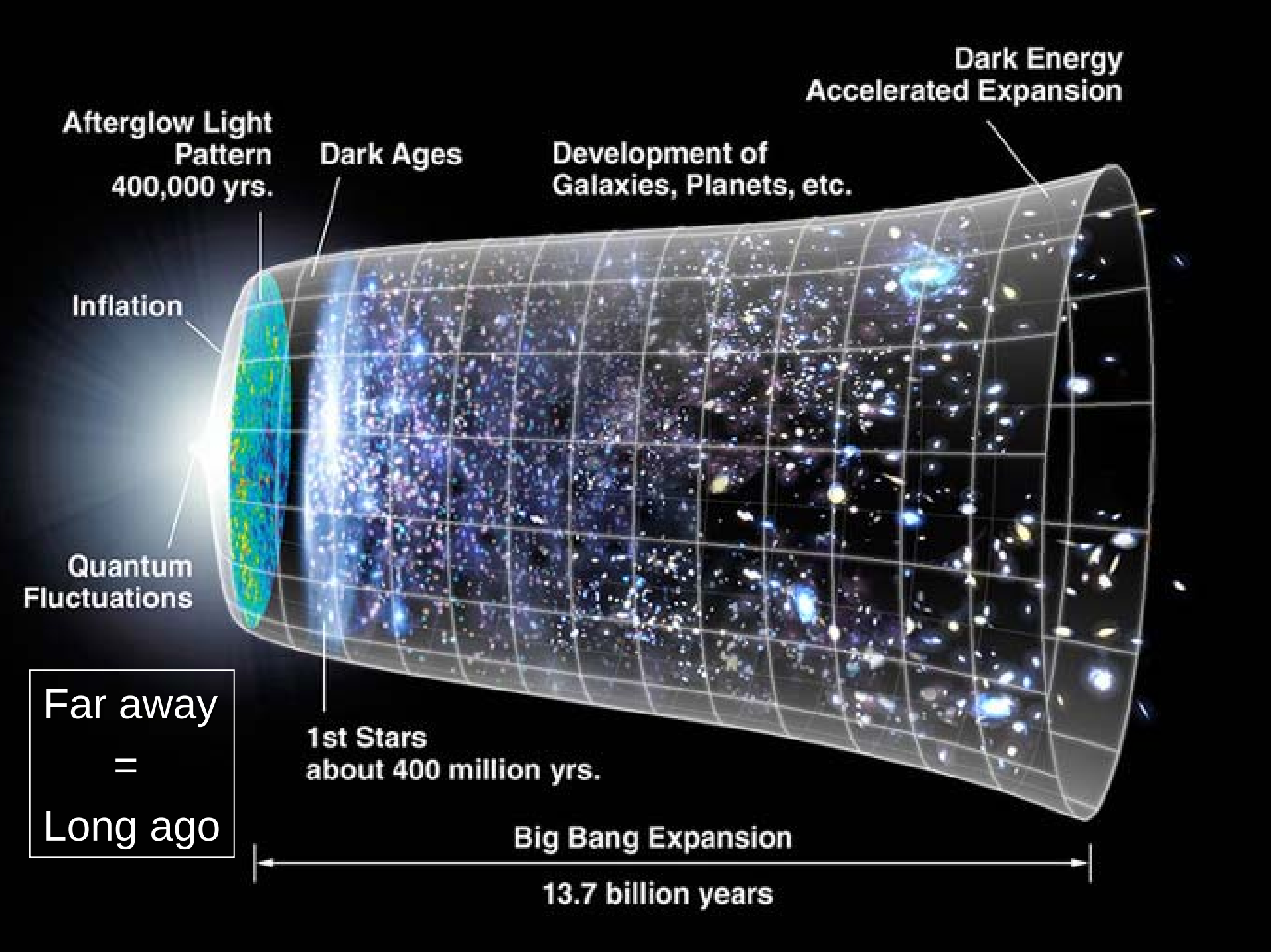


Angular Resolution & Sensitivity



Astronomy and Technology

- Astronomy benefits from *and* drives advances in technology
- It is now possible to
  - Study objects over 95% of the age of the Universe
  - Detect and study planets around other stars
  - Use particles (and gravitational waves) to study objects
  - Explore Solar system objecs in situ
- And also to
  - Simulate complicated astrophysical processes
  - Analyze large data streams



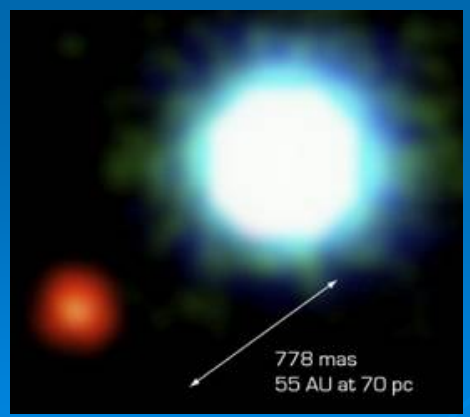
Far away

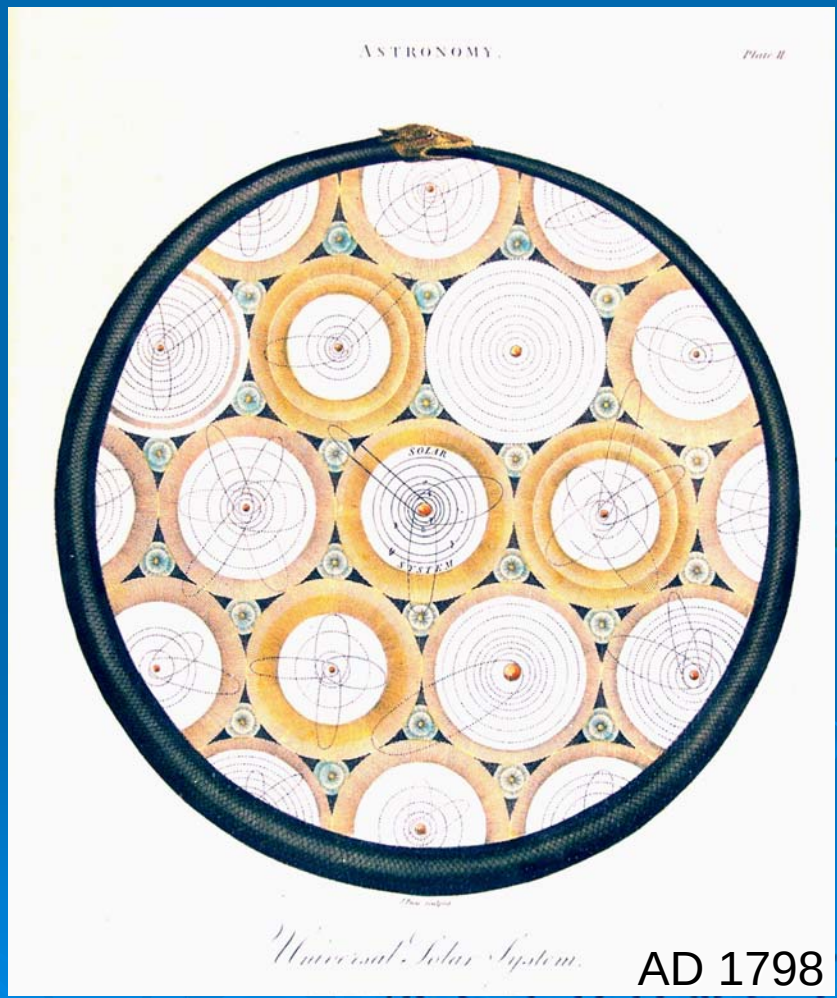
=

Long ago

Extra solar planets

- Predicted for centuries
- Technology now available to detect and characterize them
- Wide range of properties





AD 1798

Astronomy and Society

- Important for society and culture
  - Navigation, mobile phones
  - Asteroid impacts
  - Existence of other worlds, development of life
- Important for education
  - Attracts young people to physical sciences
  - Many universities opening astronomy departments
- Many exciting discoveries to come

Predicting the Future

- Key questions in astronomy
  - The nature of dark matter and dark energy, and physics in extreme conditions (black holes, gamma-ray bursts)
  - Formation & evolution of galaxies: first light ⇒ Milky Way
  - Formation of stars and planets, and the origin of life
  - How do we (and the Solar System) fit in?
- Amongst most fundamental questions in science
  - Of interest to broad community and general public
- To be answered by
  - Observations with telescopes on the ground and in space
  - Combined with interpretation & theoretical development

Ambitious Plans

- European astronomy plans through 2025:
  - May need several GEuro new investment/operations
  - EU may fund a modest fraction
  - Bulk of the support to come from funding agencies
- Funding agencies request comprehensive plan:
  - Covering all of astronomy, ground and space, including links with neighbouring fields
  - Founded ASTRONET to develop this plan together with entire European astronomical community
  - Prototype for equivalent of US Decadal Surveys

Developing the Science Vision

- Look broadly at key science questions in all of astronomy for the next two decades
  - Observations, simulations, laboratory experiments, interpretation and theory
  - Identify key types of facilities needed to make progress
  - Twenty year horizon
- Make use of available documents
  - National plans, ESA's Cosmic Vision, ESA-ESO studies
- Input for Infrastructure Roadmap and subsequent implementation plan

Science Vision Working Group

- Appointed by the Funding Agencies
  - Four supporting panels (about 50 persons in total)
  - Good distribution of expertise, gender, nationalities
- Panel chairs and co-chairs:

  A: John Peacock, Claes Fransson

  B: Jacqueline Bergeron, Robert Kennicutt

  C: Leonardo Testi, Rafael Rebolo

  D: Oscar von der Luhe, Therese Encrenaz
- Members at large:

  Michael Bode, Reinhard Genzel, Michael Perryman, Alvio Renzini, Rashid Sunyaev, Catherine Turon, Tim de Zeeuw (chair)

Structure of the Draft Report

- Introduction
  - Astronomy in society, and role of technology
- Four broad science questions
  - A: Do we understand the extremes of the Universe?
  - B: How do galaxies form and evolve?
  - C: How do stars and planets form?
  - D: How do we fit in?
- Recommendations
- Appendix with abbreviations and web-links

Panel A: Do we understand the extremes of the Universe?

How did the Universe begin?

What is dark matter and dark energy?

Can we observe strong gravity in action?

How do supernovae & gamma-ray bursts work?

How do black hole accretion, jets and outflows operate?

What can we learn about the Universe from energetic radiation and particles?

Recommendations coordinated with ASPERA

Panel B: How do galaxies form and evolve?

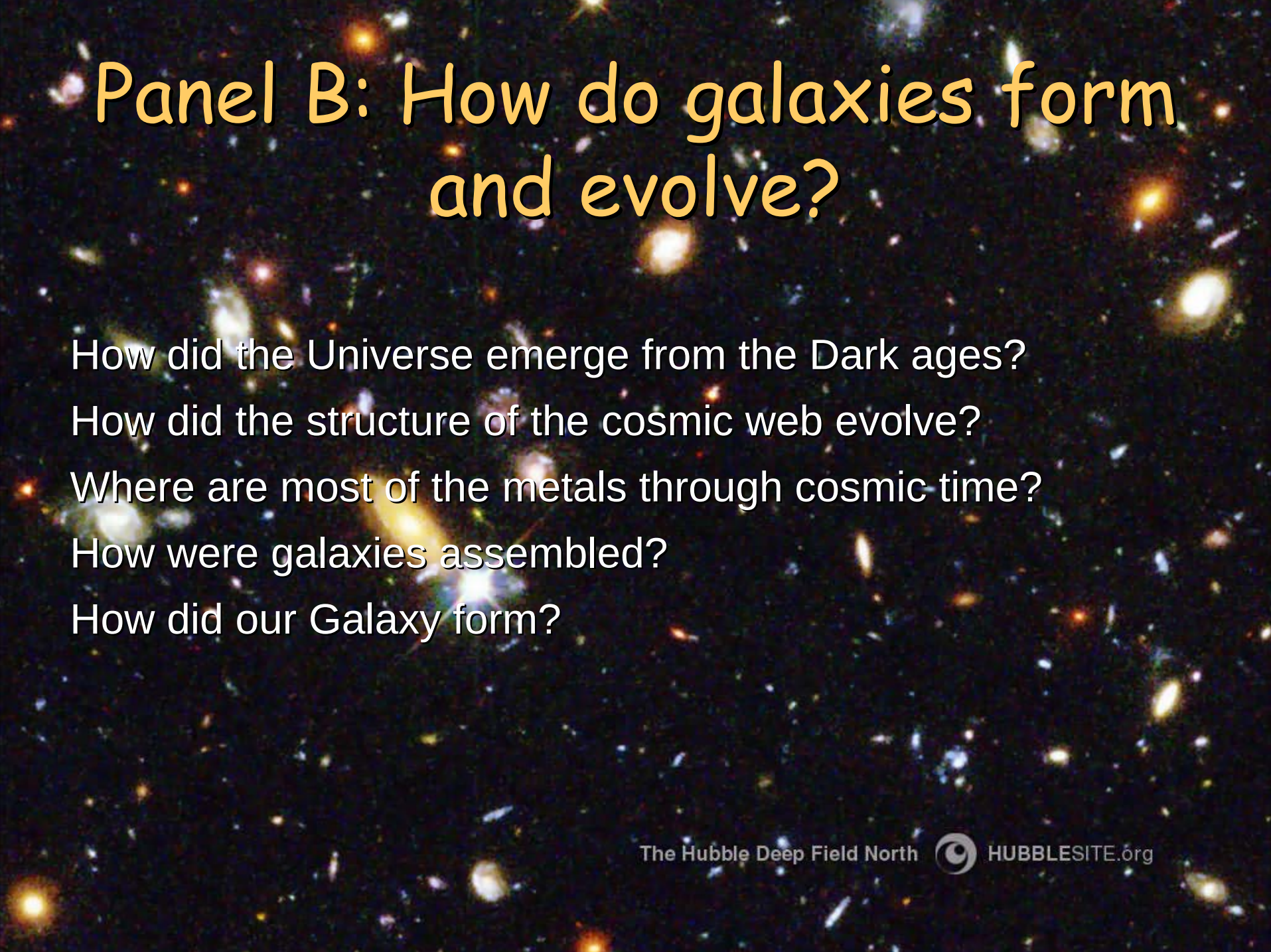
How did the Universe emerge from the Dark ages?

How did the structure of the cosmic web evolve?

Where are most of the metals through cosmic time?

How were galaxies assembled?

How did our Galaxy form?



Panel C: What is the origin and evolution of stars and planets?

How do stars form?

Is the initial mass function of stars universal?

What do we learn by probing stellar interiors?

What is the life-cycle of the interstellar medium and stars?

How do planetary systems form and evolve?

What are the demographics of planets in the Galaxy?

How do we tell which planets harbour life?

Orion Nebula

Panel D: How do we fit in?

What can the Sun teach us about astrophysical processes?

What drives Solar variability on all scales?

What is the impact of Solar activity on life on Earth?

What is the dynamical history of the Solar System?

What can we learn from Solar System exploration?

Where should we look for life in the Solar System?

Approach

- Four main chapters organized in similar way
  - Brief introduction with background and identification of key sub-questions
  - Each of these is introduced, and specific science questions summarized
  - Most promising approaches described
  - Distinguish Principal and Supporting facilities
- Science vision is input to Road map
  - Existing facilities and those under construction named
  - Not yet approved projects described (mostly) generically
  - Specific proposals/projects to come after Roadmap

Developing Recommendations

- Answering key science questions requires
  - Optimal use of existing facilities + those being constructed!
  - Next generation optical and radio telescopes
  - Specific space observatories/missions (cf Cosmic Vision)
  - Dedicated surveys, and investigation of time-domain
  - Supported by theoretical program, numerical simulations and laboratory experiments
- Integrated vision is part of a world-wide endeavour
  - Involves other communities and (space) agencies
  - Opportunity for Europe to take leading role

Timeline

- *Draft* Science Vision report public 12-2006
  - Community input via web and email
- Discussion at this Science Vision Symposium
  - Presentation of current plans by Panel chairs (Jan 23)
  - Panel discussions aimed at sharpening plans (Jan 24)
  - Important to *focus on science and retain coherence*
- Final report to be delivered in Spring 2007
- To be followed by Road-mapping, 2007-2008
  - Implementation plan for development of infrastructures that enable European astronomy to deliver the Vision