New Challenges for the Oldest Science

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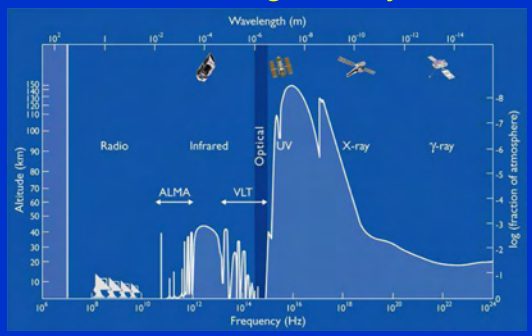
Observing the sky

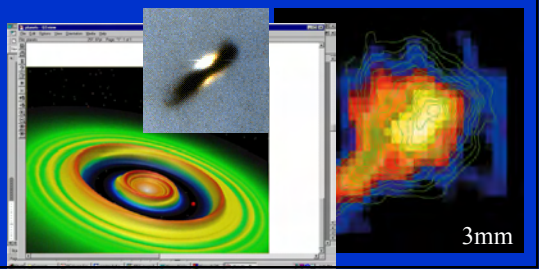


Questions for the 21st Century

- How do planets form and how does life develop on them?
- How does the solar system work?
- What is the universe made of? Have we found all its constituents?
- Do we understand the physical laws that govern the universe?
- How did the universe originate?

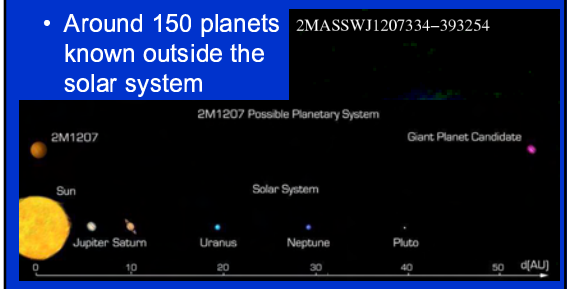
How do planets form?

- Complementarity of optical, infrared and mm observations



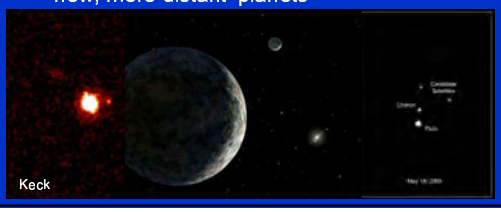
Direct imaging of planets

- Around 150 planets known outside the solar system



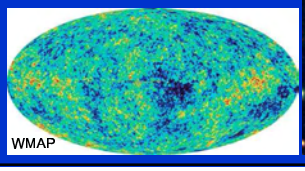
How does the solar system work?

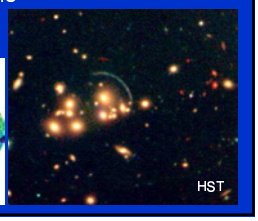
- New members of the solar system have recently been detected
  - moons of Pluto
  - new, more distant 'planets'



What is the universe made of?

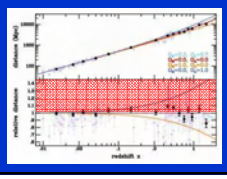
- What is Dark Matter?
  - answers come from cosmology, e.g. neutrino mass, mass of the lightest (stable) supersymmetric particle

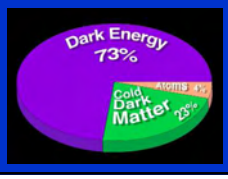




What is the universe made of?

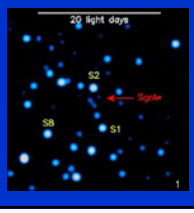
- What is Dark Energy?
  - Was Einstein correct with the cosmological constant?
  - How does the standard model of particle physics need to be extended to accommodate Dark Energy?

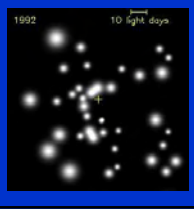




Do we understand the physical laws that govern the universe?

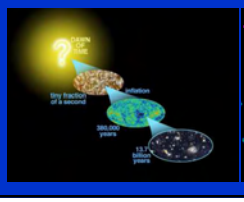
- Do we have the correct theory of gravity?
- Are there other forces out there?

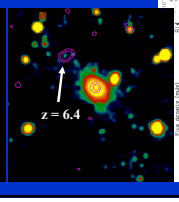


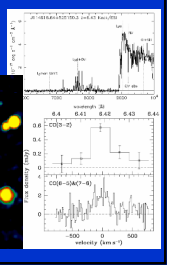


How did the universe originate?

- Did inflation happen?
- What was before the Big Bang?
- How did the universe evolve?

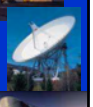


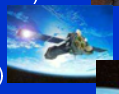




Current facilities

- Optical 8 to 10m telescopes
  - Very Large Telescope, Gemini, Large Binocular Telescope, Gran Telescopio de Gran Canarias
- Radio telescopes
- Atacama Large Millimeter Array (2008+)
- Space missions
  - Hubble Space Telescope (optical/UV)
  - Integral (γ-rays)
  - XMM/Newton (X-rays)
  - Herschel (mm-rays; launch 2007)
  - Planck (micro-waves; launch 2007)





Development path

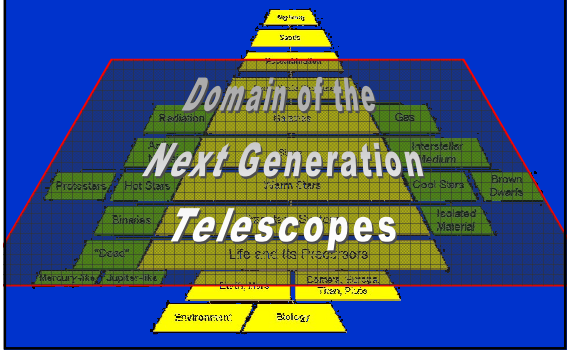
- 8m telescope → extremely large telescopes (30 to 40m+)

- Hubble Space Telescope
  → James Webb Space Telescope
- ESA Cosmic Vision Programme
  - IR telescope
  - X-ray telescope

Extremely Large Telescopes

- Complement ALMA and JWST
- Require ELT with >30m diameters
  - spatial resolution *and* sensitivity
  - need adaptive optics
- Science Drivers
  - characterise planetary systems
  - find the first luminous objects
  - follow the evolution of galaxies over time
  - probe the evolution of stars in other galaxies

The Scientific Opportunities

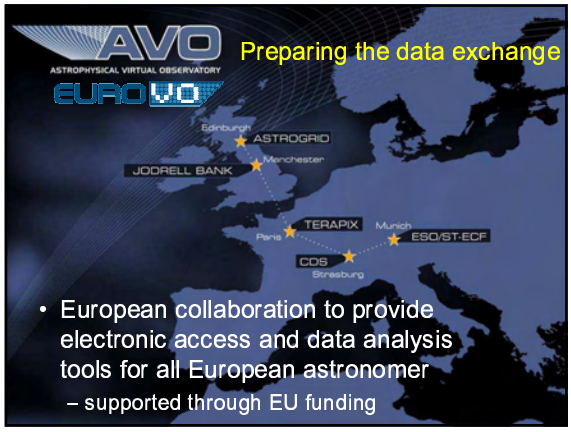


Preparing the scientific future

- Science cases are developed by the community
  - OPTICON ELT science case
  - ESA Cosmic Vision programme
  - typically involves several hundred astronomers
  - provide the scientific and technical requirements

Preparing the future

Preparing the data exchange



- European collaboration to provide electronic access and data analysis tools for all European astronomer
  - supported through EU funding

Multipurpose Facilities

- Telescopes can be used for many scientific applications
  - same instruments observe the solar system and the most distant objects
  - applications range from the hottest to the coldest, the densest to the least bound material
  - detection and characterisation of particles
  - the universe as a laboratory

The Future

- 2009 marks 400 years since the invention of the telescope and Galileo's first use to discover the moon around Jupiter
- Extremely large telescopes will open up new frontiers in sensitivity and resolution
  - Complement other planned facilities
    - JWST, ALMA
- Data will be shared by everybody through the Virtual Observatory