The Next Decade in Astronomy
The Unanswered Questions
Dr. Jonathan Crass
The Next Decade in Astronomy

• Recent discoveries
  – What have we learnt in the last decade?

• What’s next?
  – What we don’t know
    • The BIG questions
  – Tools for the next decade

• Beyond 2027
Recent Discoveries
Astronomers detect '10th planet'

Astronomers in the United States have announced the discovery of the "10th planet" to orbit our Sun.

The largest object found in our Solar System since Neptune in 1846, it was first seen in 2003 - but important details have only now been confirmed.

Designated 2003 UB313, it is about 2,800km across - a world of rock and ice and somewhat larger than Pluto.

Scientists say it is three times as far away as Pluto, in an orbit at an angle to the orbits of the main planets.

Astronomers think that at some point in its history, Neptune probably flung the small world into its highly inclined 44-degree orbit.

* A comparison of 2003 UB313 and other distant objects

It is currently 97 Earth-Sun distances away - more than twice Pluto's average distance from the Sun.

Bigger than Pluto

Its discoverers are Michael Brown of Caltech, Chad Trujillo of the Gemini Observatory in Hawaii, and David Rabinowitz of Yale University.

David Rabinowitz told the BBC News website: "It has been a remarkable day and a remarkable year. 2003 UB313 is probably larger than Pluto. It is fainter than Pluto, but three times farther away."

"Brought to the same distance from the Sun as Pluto, it would be brighter. So today, the world knows that Pluto is not unique. There are other Plutos, just farther out in the Solar System where they are a little harder to find."
Water in the Solar System
First touchdown 10:34 a.m. EST

Collision with crater rim 11:20 a.m. EST

Second touchdown 12:24 p.m. EST

Final touchdown 12:31 p.m. EST
Are we alone?
The Discovery Exoplanets
3550 confirmed planets

2,763 discovered by transit method
654 discovered by radial velocity
44 discovered by imaging

51 discovered by microlensing
38 discovered using other methods
New Earth-Size Planet Found Around Nearby Star

The potentially habitable world is called Ross 128b, and it sits just 11 light-years away.

Nibiru FOUND? Scientists locate Earth-sized planet Ross 128b just 11 light-years away

The galaxy’s best bet for alien life?

Planet the same size and temperature as our own found just 11 light years away may be the ‘closest known home for life’ (and it’s moving closer to us every day)

The planet, named Ross 128b, was found orbiting a red dwarf star

It is the same size as Earth and has a similar surface temperature

It is currently 11 light years away, and would take 141,000 years to reach

But the planet is slowly moving towards us, and is expected to be closer than Proxima B in 73,000 years

ASTRONOMERS have discovered an Earth-like planet called Ross 128b with similar temperatures which could harbour alien life – the very thing Nibiru conspiracy theorists have alleged in recent years.
Dark Matter

• Up until 2006, we’d only seen the ‘effects’ of there being more mass
  – Galaxy Rotation Curves
  – Fluctuations in the Cosmic Microwave Background
The Big Bang
The Big Bang

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<th>Age of the Universe (Billion Years)</th>
<th>Hubble Constant (km s(^{-1}) Mpc(^{-1}))</th>
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Gravitational Waves
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Einstein’s waves win Nobel Prize in physics

By Paul Rincon with additional Metro
BBC News

3 October 2017 Science & Environment

The 2017 Nobel prize in physics was awarded to Barry Barish, Kip Thorne and Ron Drever "for decisive contributions to the LIGO detector and the observation of gravitational waves across the universe."

Nobel prize in physics awarded for discovery of gravitational waves

CBNO: Prize awarded to Barry Barish, Barry Barish and Kip Thorne for their work on laser interferometers which were able to detect ripples in the fabric of spacetime caused by violent events in distant galaxies such as the merging of black holes.

Press Release: The Nobel Prize in Physics 2017

The Royal Swedish Academy of Sciences announced that it will award the Nobel Prize in Physics 2017 to Barry Barish and Kip Thorne for their decisive contributions to the LIGO detector and the observation of gravitational waves.

2017 Nobel Laureates

Barry Barish
Kip Thorne
Ronald Drever

The New York Times

Nobel Prize in Physics Awarded to LIGO Black Hole Researchers

Barry Barish, a professor at the California Institute of Technology; Kip Thorne and Ronald Drever, Nobel laureates in 2017, were the key figures in the development of the Laser Interferometer Gravitational-Wave Observatory (LIGO) and its detection of gravitational waves.
What we don’t know
Decadal Surveys

- 1964: Ground-based Astronomy: A Ten Year Program
- 1972: Astronomy and Astrophysics for the 1970s
- 1982: Astronomy and Astrophysics for the 1980s
- 1991: The Decade of Discovery in Astronomy and Astrophysics
- 2001: Astronomy and Astrophysics in the New Millennium
- 2010: New Worlds, New Horizons in Astronomy & Astrophysics
Decadal Surveys

2010:

New Worlds, New Horizons in Astronomy and Astrophysics
Other Roadmaps

The ASTRONET Infrastructure Roadmap: A Strategic Plan for European Astronomy

Enduring Quests Daring Visions
NASA Astrophysics in the Next Three Decades
The current and future priorities

• Identification and characterization of nearby habitable exoplanets

• Studying how the universe changes:
  – “Time-domain astronomy”

• Understanding how the universe formed:
  – How do we create the galaxies we see today?
The epoch of reionization
The epoch of reionization
What does **DARK** mean?
The BIG Questions

• Are we alone?
  – Exoplanets
  – The search for life

• How did we get here?
  – Stars and the elements
  – Galaxies and their history

• How does our Universe work?
  – The extremes of nature
Tools for the Next Decade
Future Missions

Space Based Missions

- James Webb Space Telescope (JWST) – Launches 2018
- JUNO – Jupiter – Arrived 2016
- Juice – Jupiter – Launches 2022
- New Horizons – Kuiper Belt – January 2019
- Dawn Mission – Vesta & Ceres – Arrived 2015
- InSight Lander – Mars – Launches 2018
- ExoMars – Astrobiology mission – Orbiter, stationary lander (2016 launch) and Rover (2020)
- Mars Exploration Program: 2020 Rover
- Europa Flyby Mission – 2020s
- OSIRIS-Rex – Sample from asteroid - 101955 Bennu – Launches 2016
- Parker Solar Probe – Launches 2018
- ESA Solar Orbiter – Launches 2019
- ESA BepiColombo – Mercury – Launches 2018
- ESA Euclid – Map geometry of dark universe – Launch 2020
- ESA CHEOPS – Exoplanets – Launches 2018

Ground Based Missions

- Transiting Exoplanet Survey Satellite (TESS) – Launches 2018
- Athena launch – 2028
- WFIRST – 2020s
- ESA LISA – 2034
- ESA PLATO - 2026
- Upgrades to existing telescopes - Ongoing
- Large Synoptic Survey Telescope – 2021
- Square Kilometer Array (SKA) – From 2019
- Extremely Large Telescopes – 2020s
  - European Extremely Large Telescope (E-ELT)
  - Thirty Meter Telescope
  - Giant Magellan Telescope
Beyond 2027
Beyond 2027

• Science missions take many years to plan, specify and develop the collaborations between scientists
• There is still however always one important factor...
Beyond 2027

• Many missions have been suggested but two were recently selected:
  – The Advanced Telescope for High-energy Astrophysics (Athena+)
  – Laser Interferometer Space Antenna (LISA)

• Looking beyond the upcoming James Webb Space Telescope
  – Concepts such as LUVOIR:
    • Large UV/Optical/Infrared Surveyor
“There are known knowns. These are things we know that we know. There are known unknowns. That is to say, there are things that we know we don't know. But there are also unknown unknowns. There are things we don't know we don't know.”

Donald Rumsfeld