What have the Romans ever done for us?

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Outline

• The Big Questions - and Answers

• Engaging the public in science

• Spin offs from Astronomy
An understanding of astronomy was crucial for mankind’s development & survival.

Astronomy sets the context in which our view of ourselves & our place in the Universe develops.
A brief history

• The Babylonians (about 16th century BC) predicted solar eclipses based on the Saros cycle of 18 years 11 days.

Astronomers predict the future!

• Ancient societies used alignments of stone circles with the stars to understand the calendar, and therefore the planting and harvesting cycle → development of agrarian society.
Galileo Galilei (1564–1642):
1609: made the first telescopic observations of the heavens: mountains on the Moon, resolved stars in the Milky Way + the Galilean satellites of Jupiter.
1610: `Starry messenger'
1611: Kepler - Jupiter’s satellites obey his laws of planetary motion.
1613: Sunspots, phases of Venus
1632: `Dialogue on the two chief World Systems'
Galileo challenged `received wisdom' and established the scientific method based on hypothesis, experiment and observation.

This is one of the most revolutionary ideas of all time. Driven by astronomical observations!

Our view of mankind's place in the Universe continues to be driven by astronomical investigations eg. the search for extra-solar planets.
Hubble gives us a unique new perspective on the Universe and our place in it.
Rapid discovery

~ Jupiter mass

Metal rich host stars

Eccentric, close in orbits cf. Solar System

\[ \frac{M}{M_{\text{Earth}}} \]

\[ \frac{\text{[Fe/H]}}{ \frac{\Theta}{3} } \]

\[ \Theta \]

\[ \frac{3\Theta}{3\Theta} \]

\[ \text{Semi-Major Axis [Astronomical Units (AU)]]} \]

\[ \text{Orbital Eccentricity} \]

\[ \text{Distribution} \]
April 27\textsuperscript{th} 2014: 1,703 Planets around 1,033 Stars
442 Systems with Multiple Planets

<table>
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<th>Discovery Method</th>
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<td>Other</td>
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http://exoplanetarchive.ipac.caltech.edu/docs/intro.html
What have we learned from astronomy?

The origin of the **chemical elements**: you are star dust!

**Planets** around stars are common

**Dark Matter** controls the motion of stars & gas in galaxies & clusters

**Galaxies** collide & coalesce

The **Universe is expanding** at an accelerating rate \( \Rightarrow \) **Dark Energy**
Engaging the public
Galaxy Zoo

http://www.galaxyzoo.org/

- Galaxy Zoo is a web based tool for classifying images of 1,000,000 galaxies
  - So far ~ 300,000 people have participated generating 130 million classifications!
- New research opportunities ⇒ 44 publications
- Spawned a new development: `Citizen science’
The Institute of Physics asked undergraduates why they came into physics: 53% said because of interest in astronomy. At the end of their studies 73% had a significant interest in astronomy.

Astronomy brings young people into STEM subjects: vital for the economy!
Astronomy’s technological contributions

Navigation: longitude, time standards, GPS
Space weather protection
Telecoms
Detectors & sensors: medical imaging
Airport security
Navigation

- Important from ancient times
- Exploration & trade

The quest for accurate clocks:
Dava Sobel: *Longitude*: John Harrison vs. the astronomers
Modern time standards: atomic clocks vs. pulsars

GPS: microelectronics
    space science
    quantum mechanics: atomic clocks
    Special relativity: moving clocks
    General relativity: clocks in lower gravity

Tested in the 1919 solar eclipse
Sat-nav devices face big errors as solar activity rises

By Jason Palmer
Science and technology reporter, BBC News

Researchers say the Sun is awakening after a period of low activity, which does not bode well for a world ever more dependent on satellite navigation.

The Sun's irregular activity can wreak havoc with the weak sat-nav signals we use.

The last time the Sun reached a peak in activity, satellite navigation was barely a consumer product.

But the Sun is on its way to another solar maximum, which could generate large and unpredictable sat-nav errors.

It is not just car sat-nav devices that make use of the satellite signals; accurate and dependable sat-nav signals have, since the last solar maximum, quietly become a necessity for modern infrastructure.

Military operations worldwide depend on them, although they use far stronger signals than those available to the general public.

An X-ray image shows activity at the Sun's surface

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802.11 protocol
Imaging technology: detectors & sensors

Charged Coupled Devices: used in digital cameras & video cameras were discovered in the late 1960s.

- late 1970s: developed for use on Hubble Space Telescope
- early 80’s used on ground based telescopes.
- 1990 launched on HST
- late 1990s brought into common use
- A major international supplier in the UK is E2V.
- many associated image processing techniques
- the same technology has been developed for X-ray imaging.
Left: 27 keV X-ray emission from a $^{125}$I - labelled mouse tumour (Institute of Cancer Research) taken in the lab.

Right: 0.2-3.5 keV X-ray emission from the Supernova Remnant RCW103 taken by the ROSAT HRI microchannel plate X-ray camera.
Terahertz imaging: for astronomy & security!

- THz (λ~0.5mm-1cm) penetrates the obscuring dust between the stars. Astronomers have developed THz detectors to study how stars form, how the most energetic and distant objects in the universe work.
Terahertz imaging: for astronomy & security!

- THz radiation can penetrate objects such as plastics and clothes but not metals, hence is useful for security checks. The detectors developed for astronomy are now being used in scanners at airports.
- Non ionizing, is not harmful to human body, hence can be used in medicine.

Reveals a concealed knife & gun
What have the Romans ever done for us?

Astronomers
What have the Astronomers ever done for us?

- Addresses **BIG questions**: where did we come from? What is our place in the Universe? Are we alone?
- **The scientific revolution**: inductive thinking.
- The calendar
- **Inspiring** the public about science & attracting young people into science.
- **Navigation** and accurate time: **GPS**
- Monitoring space weather: **insurance for satellites**!
- Breakthroughs in IT & telecoms: eg. **WiFi**
- Imaging technology for medicine.
- Imaging technology for security.
Thank you