University of Leicester
Department of Physics and Astronomy
Lecture Notes
Communicating Physics - Big Science

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Contents

1 Introduction

We are using 2 topics, "Life in the Universe" and "Big Science" as a vehicle to develop your written and oral communication skills. The science in these topics is important but you are also expected to consider the social, political and financial aspects of the physics/science involved.

Timetable

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Fri  12/10  09:00-10:00 room E  GAW Intro 1
Thu  01/11  14:00-15:00 room E  RW  Intro 2
Thu  08/11  14:00-16:00 room E  GWF Writing w/s
Thu  22/11  14:00-16:00 room E  DJR Debating and reviewing w/s
Thu  29/11  14:00-16:00 room E  GAW Presentation preparation w/s
Thu  13/12  15:00-18:00 room E  GAW, TKY, RW, Presentation
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Presentation Titles

Extra Solar Planets

Notes

These notes are on the WWW at:

`http://www.star.le.ac.uk/~rw/courses/`

2 Topic II - Big Science

The public perception of the scientist is usually of an individual working alone in a laboratory. Modern physics, however, is increasingly "Big Science", with enormous teams working on large, expensive international projects. This topic traces the rise (and possible fall?) of Big Science, with examples from the fields of particle physics and space science.

2.1 Key Elements - what constitutes Big Science?

- Big expenditure
- Big teams of people
- Big (fundamental) question(s)

I would argue that all 3 of these Bigs are required to qualify for Big Science.

Economic, technological and scientific developments in the 20th Century have combined to make Big Science possible.

2.2 Is Big Science Successful?

What has Big Science achieved?

- Particle Physics - the world of the very small - the world of the very energetic. The ultimate end-point of reductionism. Big machines to answer fundamental questions. The development of the cyclotron. Modern particle accelerators.
- Space Research - Man on the moon. Earth Observation Science. Missions to the planets. X-ray Astronomy. Astronomy with HST. NGST?

2.3 Is Big Science Necessary?

Does science have to be Big in the sense defined above?

Is it inevitable?

Is there another way?

Who decides what should be done?

What really drives Big Science?

2.4 What is the Future of Big Science?

We are now at the start of the 21st Century. What does the crystal ball have to say about Big Science?

Will all the fundamental questions be answered in the near future?

Will everything become too expensive?

Will the number of people involved become so large that no one person knows what is really going on?

3 An Example - Big Telescopes

3.1 Astronomy, Astrophysics, Cosmology

- We want to see things a long way away. Not much light gets to us from a long way away so we need to use very big eyes to collect the light.
- We need very high acuity. There are a very large number of things a long way away so we need very sharp eyes to tell things apart.
- We need colour vision. Light, electromagnetic radiation, comes in a very wide range of colours covering many orders of magnitude of energy or wavelength. Colour tells us about the source of the light.

3.2 Physics, Engineering, Technology

- Very large - collecting areas to gather the light
- Very precise - control of dimensions at the microscopic level
- Very complicated - many intricate components
- Very expensive - many man-years of effort are required to build modern telescopes

- Very focused - a great deal of effort concentrated on a very specific problem

3.3 Human benifits

- Intellectual excitement, fascination. Physics and cosmology.
- Technological development. New machines, new horizons. Spin-off into other areas of science and technology, medicine, communications, computing...
- Employment. A vast infrastructure of technological activity. Economic investment and growth.

3.4 Downfall

- Too expensive, too complicated. Money better spent elsewhere.
- Too risky. Instruments may not work. Results may not live upto expectation.
- Too focused. If anything fails then all is lost.
- Irrelevant. The frontiers of knowledge are too far removed from everyday life. Who cares?
- Unsustainable. Human society and the Earth environment may not stand up to the onslaught of technology and growth.

3.5 The X-ray Astronomy Group at Leicester

- $\sim$ 100 people, academics, technicians, post-graduate students
- $\sim$ 10 major international big science projects
- $\sim \pounds 2M$ per annum research grant income

3.6 XMM - The biggest X-ray telescope yet

- ESA mission - collaboration of all member states
- Cost $\sim \$500M$
- $\sim$ 13 years to design and build. Started 1986, Launch 1999

- Collecting area 3000 cm^2
- Angular resolution 15 arc seconds
- Energy band (colour) $0.1 - 10keV$ soft X-ray
- Focal length 7.5 m, overall length 10 m
- Total mass 3900 kg
- Electrical power 1.5 kW from solar panels

3.7 The Hubble Space Telescope

- NASA mission - Space Shuttle launch and refurbishment - used by the international astronomy community
- Cost $\sim \$4000M$ including refurbishment etc.
- Mass 12000 kg
- Length 13 m, width 4.2 m
- 2.4 m aperture (area 4.5 m^2)
- Ritchey-Chretien Cassegrain optics
- focal ratio f/24, focal length 57.6 m folded to 6.4 m
- Angular resolution 0.1 arc seconds
- Wavelength range $1100 - 11000$ Å, UV-visible-IR

Optical systems failure

- Blurred vision - 0.7 arc seconds instead of 0.1 arc seconds
- The primary mirror is the wrong shape. Very accurately made to exactly the wrong shape!

NASA pulls the plug!

- On 16th January 2004 NASA decided to cancel the fifth servicing mission SM4.

3.8 The Next Generation Space Telescope

Now called the James Webb Space Telescope (JWST)

- Replacement of Hubble Space Telescope (HST) launch c.2011
- Mirror diameter : 8 metre (c.f. 2.4 metre for HST)
- Cost to build : $ 825 million (30% of HST cost)
- Operating cost per annum : $ 40 million ($<$ 20 % HST)

For more info see:

`http://ngst.gsfc.nasa.gov/`

4 Another Example - Particle Accelerators

The development of particle accelerators from the cyclotron through to synchrotron rings, CERN, SLAC and the failed bid for the SSC.

Can you think of another example?

You should do your own research to compile notes on this subject similar to the preceding notes on Big Telescopes.