The Tools of Astronomy
Seeing the whole picture
Jonathan Crass
What tools do we need?

• We need to observe the Universe around us
  – The Solar System
  – Galaxies
  – And beyond

• We need to understand what we see

• We need to predict what is going to happen
The Tools of Astronomy

• The Astronomers Toolkit
  – Ground-based telescopes
  – Space telescopes

• The images we see
  – Do they “really” look like that?
  – What are they telling us
Observing the Universe
Ground-based telescopes
Ground-based telescopes

1. They’re “cheap”
2. They’re easier to maintain
3. You can upgrade them
4. You can use different instruments for different types of science
What can we see on the ground?
Radio Telescopes

- First ‘detectors’ built in 1930s
- First ‘dish’ telescope - 1937
- Rapidly developed with work in Britain and Australia
- By 1957, a 250ft/76 metre fully steerable telescope had been completed
Mk I Telescope – Jodrell Bank
Mk I Telescope – Jodrell Bank
Why are radio telescopes so large?

- Sensitivity
Why are radio telescopes so large?

- All telescopes are limited in resolution

\[
\text{Resolution} = 1.22 \times \frac{\text{Wavelength}}{\text{Telescope Diameter}}
\]

- Depends on:
  - Telescope diameter
  - Wavelength
The Biggest Radio Telescopes

- Largest Filled Aperture

Arecibo Radio Telescope – 305m
The Biggest Radio Telescopes

• Largest Fully Steerable

Green Bank Telescope – 100x110m
The Biggest Radio Telescopes

• Largest Overall

RATAN-600 – 576m
Optical Telescopes

• Galileo – 1609
Optical Telescopes

• Refracting Telescopes
  – Limited by size of lens
Optical Telescopes

- Reflecting Telescopes
  - Easier to make mirrors
Building the VLT

- European Southern Observatory
  - Today made up of 15 member states
- Agreed to build VLT in December 1987
- Problem 1: Choose a site
- Problem 2: Build the site
- Problem 3: Deal with the politics
- Total Cost
  - 602 Million Deutsche Marks
  - 307 Million €
Building the VLT

Cerro Paranal
1991

1994

Paranal Observatory
1999
The problem with big telescopes

• We have an atmosphere...
• There’s a finite size single telescope we can build
Atmospheric Turbulence
Correcting for the atmosphere

• The simple option:
  – Go to space!

• Correct for the effects on the ground
Even bigger telescopes?

• We can combine multiple telescopes together to get even better resolution
Merlin & E-Merlin
Space Telescopes
The beginnings of space telescopes

- First proposed by Hermann Oberth in 1923
- Lyman Spitzer, 1946
  - “Astronomical Advantages of an Extra-Terrestrial Observatory”
The First X-ray satellite - Uhuru
Pix Nixed as Hubble Sees Double
Astronomy Images
What astronomy images mean?

• We’ve all seen the fantastic astronomy images, but what do they mean?
Image processing