



Herschel Space Observatory

The Multiwavelength Universe

Activity Outline

This is a brief introduction to the “Multiwavelength Universe” classroom activity. There is at least 2-2.5 hours of material here, so pick and choose accordingly, or split across wavelengths and cover in multiple sessions. Slides are provided for the teacher to illustrate all the sections.

Introduction

- **What is EM radiation?** (5-10 minutes)
 - Inc. list of wavelengths in EM spectrum (few minutes)
 - Wavelength and frequency
- Optional extra: Herschel introduction (variable length)
- **Black Body Radiation** (A-level only – 10-15 mins)
 - Inc. Wein’s displacement law
- Optional extra: Draw Black Body curves on the board
- Optional extra: telescope resolutions (A-level only – 10-15 mins)
 - Introduce $\theta \sim \lambda/D$
 - Calculate resolution for e.g. Hubble, Lovell, Spitzer, Herschel

Spectrum activities (optional)

- Emission examples at each wavelength (15-20 mins)
 - Fill in wavelength summary sheet
 - Frequency and temperature suggested for A-level students only
 - Ask for examples in real life
 - Ask and/or give examples in astronomy

Online Wavelength matching activity (recommended)

- Match objects at different wavelengths (20 mins)
 - Suggest groups of 2-3 students
 - Suggested illustrative examples (easier): Crab Nebula, or Cas A
 - X-ray and Radio are quite hard to match
 - Overall score is in the bottom right
 - Paper version also available (requires a lot of colour printing!)
 - Answers at the end of this pack

Additional research (optional)

- In their groups of 2-3, or individually
- Use links provided to find more information about objects (30 mins)
 - Suitable questions suggested in question sheet
 - Possible homework activity...
 - Optional: introduce them to Chromoscope www.chromoscope.net
- Optional extra: report back to class
- Optional extra: design poster about objects (template available in package)

For any questions, or to get more details, please contact:

Chris North

School of Physics and Astronomy

Cardiff University

Email: chris.north@astro.cf.ac.uk

Tel: 02920 870 537

Or visit <http://herscheltelescope.org.uk/education>



Herschel Space Observatory

The Multiwavelength Universe



Herschel Space Observatory

The Multiwavelength Universe

Multiwavelength Objects

For the objects below, write down the numbers of the corresponding images at other wavelengths.

Crab



X-ray

Ultraviolet

Far-Infrared

Radio

Centaurus A



X-ray

Mid-Infrared

Far-Infrared

Radio

Antennae



X-ray

Mid-Infrared

Far-Infrared

Radio

Cassiopeia A



X-ray

Mid-Infrared

Far-Infrared

Radio

Large Magellanic Cloud



X-ray

Ultraviolet

Far-Infrared

Radio

Triangulum



X-ray

Ultraviolet

Mid-Infrared

Radio



Herschel Space Observatory

The Multiwavelength Universe

Orion



X-ray

Near-Infrared

Mid-Infrared

Far-IR

M81



X-ray

Ultraviolet

Far-Infrared

Radio

M87



X-ray

Mid-Infrared

Far-Infrared

Radio

Sombrero



X-ray

Near-Infrared

Mid-Infrared

Radio

M82



X-ray

Mid-Infrared

Far-Infrared

Radio

Andromeda



X-ray

Ultraviolet

Far-Infrared

Radio



Herschel Space Observatory

The Multiwavelength Universe

Links to Objects

Below are links to the various objects. The codes in brackets are the name you may find it under.

Links are given for finding the object in Chromoscope, as well as a few other links to more details.

Using Chromoscope:

- Click the link to open Chromoscope with the object centred.
- Use the "+" and "-" keys (or buttons on the screen) to zoom in and out, and drag the sky around to explore the region.
- Turn on and off constellation labels by pressing "L"
- Use the slider in the top right to fade between wavelengths shown.
- You can re-order the wavelengths by dragging their names in order to easily compare different wavelengths.
- For more help, press the "h" key.

Crab (M1)

Chromoscope: <http://www.chromoscope.net/?l=-175.4429&b=-5.7847&w=2.00&o=g,x,v,a,f,m,r&z=6>

Wikipedia: http://en.wikipedia.org/wiki/Crab_Nebula

Cool Cosmos:

http://coolcosmos.ipac.caltech.edu/cosmic_classroom/multiwavelength_astronomy/multiwavelength_museum/m1.html

Chandra: <http://chandra.harvard.edu/photo/1999/0052/>

Spitzer: <http://www.spitzer.caltech.edu/Media/mediaimages/sig/sig05-004.shtml>

Herschel: <http://herschel.cf.ac.uk/results/crab-nebula>

Centaurus A (NGC 5128)

Chromoscope: <http://www.chromoscope.net/?l=-50.4844&b=19.4172&w=2.00&o=g,x,v,a,f,m,r&z=6>

Wikipedia: http://en.wikipedia.org/wiki/Centaurus_A

Cool Cosmos:

http://coolcosmos.ipac.caltech.edu/cosmic_classroom/multiwavelength_astronomy/multiwavelength_museum/cenA.html

Chandra: <http://chandra.harvard.edu/photo/2008/cena/>

Herschel: <http://herschel.cf.ac.uk/results/centaurus>



Herschel Space Observatory

The Multiwavelength Universe

Antennae (NGC 4038)

Chromoscope: <http://www.chromoscope.net/?l=-73.0444&b=42.4614&w=2.00&o=g,x,v,a,f,m,r&z=6>

Wikipedia: http://en.wikipedia.org/wiki/Antennae_Galaxies

Cool Cosmos:

http://coolcosmos.ipac.caltech.edu/cosmic_classroom/multiwavelength_astronomy/multiwavelength_museum/ant.html

Chandra: <http://chandra.harvard.edu/photo/2000/0120/>

Spitzer: <http://spitzer.caltech.edu/images/1266-ssc2004-14a%20-Fire-Within-the-Antennae-Galaxies>

Cassiopeia A (Cas A)

Chromoscope: <http://www.chromoscope.net/?l=111.7353&b=-2.1299&w=2.00&o=g,x,v,a,f,m,r&z=6>

Wikipedia: http://en.wikipedia.org/wiki/Cassiopeia_A

Cool Cosmos:

http://coolcosmos.ipac.caltech.edu/cosmic_classroom/multiwavelength_astronomy/multiwavelength_museum/casA.html

Chandra: <http://chandra.harvard.edu/photo/2006/casa/>

Spitzer: <http://www.spitzer.caltech.edu/Media/releases/ssc2005-14/release.shtml>

Large Magellanic Cloud (LMC)

Chromoscope: <http://www.chromoscope.net/?l=-79.5344&b=-32.8887&w=2.00&o=g,x,v,a,f,m,r&z=6>

Wikipedia: http://en.wikipedia.org/wiki/Large_Magellanic_Cloud

Cool Cosmos:

http://coolcosmos.ipac.caltech.edu/cosmic_classroom/multiwavelength_astronomy/multiwavelength_museum/lmc.html

Herschel: <http://herschel.cf.ac.uk/results/centaurus>

Triangulum (M33)

Chromoscope: <http://www.chromoscope.net/?l=133.6106&b=-31.3308&w=2.00&o=g,x,v,a,f,m,r&z=6>

Wikipedia: http://en.wikipedia.org/wiki/Triangulum_Galaxy

Cool Cosmos:

http://coolcosmos.ipac.caltech.edu/cosmic_classroom/multiwavelength_astronomy/multiwavelength_museum/m33.html

Spitzer: <http://spitzer.caltech.edu/images/2625-sig09-003-Multispectral-Triangulum-Galaxy-3-Channel>



Herschel Space Observatory

The Multiwavelength Universe

Orion (M42)

Chromoscope: <http://www.chromoscope.net/?l=-150.9866&b=-19.3813&w=2.00&o=g,x,v,a,f,m,r&z=6>

Wikipedia: http://en.wikipedia.org/wiki/Orion_Nebula

Chandra: <http://chandra.harvard.edu/photo/2007/orion/>

Spitzer:

<http://www.spitzer.caltech.edu/Media/releases/ssc2006-21/ssc2006-21a.shtml>

Vista: <http://www.eso.org/public/news/eso1006/>

M81

Chromoscope:

<http://www.chromoscope.net/?l=142.0920&b=40.8999&w=2.00&o=g,x,v,a,f,m,r&z=6>

Wikipedia: http://en.wikipedia.org/wiki/Messier_81

Cool Cosmos:

http://coolcosmos.ipac.caltech.edu/cosmic_classroom/multiwavelength_astronomy/multiwavelength_museum/m81.html

Chandra: <http://chandra.harvard.edu/photo/2008/m81/>

Spitzer: <http://spitzer.caltech.edu/images/2126-sig07-009-Multiwavelength-M81>

M87

Chromoscope: <http://www.chromoscope.net/?l=-76.2224&b=71.4990&w=2.00&o=g,x,v,a,f,m,r&z=6>

Wikipedia: http://en.wikipedia.org/wiki/Messier_87

Cool Cosmos:

http://coolcosmos.ipac.caltech.edu/cosmic_classroom/multiwavelength_astronomy/multiwavelength_museum/m87.html

Chandra: <http://chandra.harvard.edu/photo/2008/m87/>

Sombrero (M104)

Chromoscope: <http://www.chromoscope.net/?l=-61.5396&b=51.1494&w=2.00&o=g,x,v,a,f,m,r&z=6>

Wikipedia: http://en.wikipedia.org/wiki/Sombrero_Galaxy

Cool Cosmos:

http://coolcosmos.ipac.caltech.edu/cosmic_classroom/multiwavelength_astronomy/multiwavelength_museum/m104.html

Chandra: <http://chandra.harvard.edu/photo/2007/sombrero/>

Spitzer: <http://www.spitzer.caltech.edu/Media/releases/ssc2005-11/release.shtml>



Herschel Space Observatory

The Multiwavelength Universe

M82

Chromoscope:

<http://www.chromoscope.net/?l=141.4094&b=40.5667&w=2.00&o=g,x,v,a,f,m,r&z=6>

Wikipedia: http://en.wikipedia.org/wiki/Messier_82

Cool Cosmos:

http://coolcosmos.ipac.caltech.edu/cosmic_classroom/multiwavelength_astronomy/multiwavelength_museum/m82.html

Chandra: <http://chandra.harvard.edu/photo/2006/m82/>

Andromeda (M31)

Chromoscope: <http://www.chromoscope.net/?l=121.1741&b=-21.5727&w=2.00&o=g,x,v,a,f,m,r&z=6>

Wikipedia: http://en.wikipedia.org/wiki/Andromeda_Galaxy

Cool Cosmos:

http://coolcosmos.ipac.caltech.edu/cosmic_classroom/multiwavelength_astronomy/multiwavelength_museum/m31.html

Chandra: <http://chandra.harvard.edu/photo/2006/m31/>

Spitzer: <http://www.spitzer.caltech.edu/Media/releases/ssc2005-20/release.shtml>

Herschel: <http://herschel.cf.ac.uk/results/andromeda-galaxy>



Herschel Space Observatory

The Multiwavelength Universe

Further Research

1) What object are you looking at? Describe what it looks like at first sight.

2) Describe where it is in the sky. Is it in the Northern or Southern hemisphere as seen from Earth? Are there any nearby constellations?

3) How far away is it? Is that inside or outside our Galaxy?

4) Describe what type of object it is. Can you find any other pictures of it?

5) Does it look particularly different in any particular wavelengths? Does that tell you anything about it?



Herschel Space Observatory

The Multiwavelength Universe

6) What can you learn by comparing the appearance of the object at different wavelengths? What is it made of?

7) What is happening to the object? Is it doing anything?



Herschel Space Observatory

The Multiwavelength Universe

Wavelength Summary Table

Spectral regime	Wavelength	Frequency	Temperature	Types of objects
Gamma Ray	<20 pm	>1500 PHz	>15,000,000 K	
X-ray	0.02-10 nm	30-1500 PHz	300,000-15,000,000 K	
Ultraviolet (UV)	10-400 nm	0.75-30 PHz	7000-300,000 K	
Visible	400-800 nm	375-750 THz	3500-7000 K	
Near-Infrared (NIR)	0.8-3 μ m	100-375 THz	1000-3500 K	
Mid-infrared (MIR)	3-30 μ m	10-100 THz	100-1000 K	
Far-infrared (FIR)	30-300 μ m	1-10 THz	10-100 K	
Sub-mm and millimetre	0.3-3 mm	0.1-1 THz	1-10 K	
Microwave	3-30 mm	10-100 GHz	0.1-1K	
Radio	>30 mm	<10 GHz	<0.1 K	



Herschel Space Observatory

The Multiwavelength Universe

Multiwavelength Objects (Answers)

For the objects below, write down the numbers of the corresponding images at other wavelengths.

Crab



X-ray

X4

Ultraviolet

U5

Far-Infrared

F7

Radio

R9

Centaurus A



X-ray

X3

Mid-Infrared

M7

Far-Infrared

F8

Radio

R7

Antennae



X-ray

X5

Mid-Infrared

M6

Far-Infrared

F1

Radio

R8

Cassiopeia A



X-ray

X6

Mid-Infrared

M2

Far-Infrared

F2

Radio

R11

Large Magellanic Cloud



X-ray

X1

Ultraviolet

U4

Far-Infrared

F3

Radio

R10

Triangulum



X-ray

X8

Ultraviolet

U1

Mid-Infrared

M4

Radio

R2



Herschel Space Observatory

The Multiwavelength Universe

Orion



X-ray	X2	Near-Infrared	N1
Mid-Infrared	M3	Far-IR/Microwave	F9

M81



X-ray	X12	Ultraviolet	U2
Far-Infrared	F5	Radio	R1

M87



X-ray	X9	Mid-Infrared	M5
Far-Infrared	F4	Radio	R4

Sombrero



X-ray	X10	Near-Infrared	N2
Mid-Infrared	M1	Radio	R3

M82



X-ray	X11	Mid-Infrared	M8
Far-Infrared	F6	Radio	R5

Andromeda



X-ray	X7	Ultraviolet	U3
Far-Infrared	F10	Radio	R6