

Synchrotron Investigations

3.4 Interaction with matter

The interaction of EMR with matter

Synchrotrons provide immensely intense EMR which is used to investigate or construct structures. The way radiation interacts with matter provides researchers with crucial information used to carry out their studies and develop understanding of how things are made and how they function.

The following information will help you gain a better understanding of EMR and its interaction with matter.

A general observation about these interactions is the closer the EMR wavelength is to the size of the structure being investigated the greater the interaction between the EMR and the matter being studied. This means you get more information from the result of the interaction.

The following websites are outstanding and provide information on the science behind the interactions different EMR frequencies have with matter.

- <http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html>
- <http://resources.yesican-science.ca/trek/radiation/final/>

Radio waves	Information
How is the radiation produced?	Oscillating electrons in a conductor
Natural sources of the radiation	Stars
Man-made sources of the radiation	Radio transmitters and Power transmission
Uses of the radiation	Communications
What is transparent to it? What can it pass through?	Most materials are transparent to radio waves. They pass through walls and people to get to your radio.
How does it interact with matter?	Causes electrons to oscillate in metals
How is it detected?	Radio-receivers, crystals

Microwaves	Information
How is the radiation produced?	Accelerating free electrons in a magnetron. Nuclear and electron spin.
Natural sources of the radiation	Stars and background radiation leftover from the Big Bang
Man-made sources of the radiation	Microwave ovens, radar, communications systems
Uses of the radiation	Heating and cooking. Radar and information transfer through air.
What is transparent to it? What can it pass through?	Most non-metals
How does it interact with matter?	Metals will strongly absorb microwaves causing electrical currents and heating. Microwaves interact with non-metals by causing the molecules to oscillate, producing heating.
How is it detected?	Silicon-diode rectifier crystals

Infrared (IR)	Information
How is the radiation produced?	Molecular vibration
Natural sources of the radiation	All matter
Man-made sources of the radiation	Heaters, light globes, motors etc.
Uses of the radiation	Radiant heating, remote controls. Infrared radiation penetrates the skin further than visible light and can therefore be used for photographic imaging of subcutaneous blood vessels.
What is transparent to it? What can it pass through?	Infrared is absorbed more strongly than microwaves, but less strongly than visible light.
How does it interact with matter?	The result of infrared absorption is heating because it increases molecular vibrational activity.
How is it detected?	Thermometers, nerves in skin, thermocouples.

Visible	Information
How is the radiation produced?	Electron transitions in atoms and atom vibration of high enough frequencies.
Natural sources of the radiation	Stars, fire, volcanoes, lightning, bioluminescence
Man-made sources of the radiation	Light bulbs, lasers, fluorescent tubes, fireworks
Uses of the radiation	To see with, produces electricity
What is transparent to it? What can it pass through?	Air, water, glass and some plastics
How does it interact with matter?	Strongly absorbed by most solid materials
How is it detected?	Eyes, photoelectric cells

Ultra violet (UV)	Information
How is the radiation produced?	Electron transitions in atoms
Natural sources of the radiation	Stars, such as our sun
Man-made sources of the radiation	Fluorescent tubes, arc welding
Uses of the radiation	Tanning and production of vitamin D in humans, security systems, sterilisation (killing germs).
What is transparent to it? What can it pass through?	Very little
How does it interact with matter?	Strongly absorbed in electron transitions. Ozone in the earth's upper atmosphere absorbs large amounts of UV and protects us on earth.
How is it detected?	Sunburn, photodiodes, bluepaper, UV sensitive beads

X-rays	Information
How is the radiation produced?	Electron collision with nucleus of some metals
Natural sources of the radiation	Stars
Man-made sources of the radiation	X-ray machines
Uses of the radiation	Medical imaging, molecular structure analysis, cancer treatment
What is transparent to it? What can it pass through?	Non-metals
How does it interact with matter?	Ionises
How is it detected?	Photographic film

Gamma rays	Information
How is the radiation produced?	Nuclear reaction
Natural sources of the radiation	Stars, radioactive decays
Man-made sources of the radiation	Fission and fusion processes
Uses of the radiation	Cancer treatment
What is transparent to it? What can it pass through?	All matter to some degree
How does it interact with matter?	Ionises matter
How is it detected?	Scintillator