Key Stage 4 – Wave or particle?

Notes for teachers

At a glance

Does light behave like a wave, a stream of particles or both? Scientists at the University of Oxford are taking advantage of the particle-wave duality of light to carry out work developing exciting new technologies. This activity is suitable for stretching the more able students as it goes beyond what is taught about light in the KS4 curriculum, but is useful for students who may go on to study physics at KS5. Students will apply their knowledge about wave behaviour to explain the results from Young’s double slit experiment and get first-hand experience of how scientists use experiments to test hypotheses.

Learning Outcomes

- Students learn that light can behave as both waves and particles
- Students make a prediction based on a hypothesis
- Students apply knowledge of wave behaviour to explain the results of the double slit experiment

Each student will need

- Copy of the pupil worksheet

For the teacher demonstration

- Laser – class II optical laser with output 1 mW or less. Ensure laser is used safely and set up so it is not pointed directly into anyone’s eyes.

http://www.oxfordsparksox.ac.uk/run-for-your-light
• Darkened slide with double slit ‘rulings’ (usually 1 mm slit separation). This can be made by painting a microscope slide in Aquadag and etching lines using a blunt pin or needle. See weblink below for further details.
• white screen (wall covered with white paper may be suitable but paper must be matt finish or non-reflective to reduce chances of reflected beams)
• Signal generator and 2 speakers (optional)

Possible Lesson Activities

1. Starter activity
   • Start the lesson with a bit of ‘light’ entertainment. Show the students a video of a firework display or laser show (a suitable example is given in the weblinks below).
   • Question them: how does the light from the display reach your eyes? Ask students to write down a one sentence answer. Invite a few students to read out their explanation and record on the board some of the keywords they use.
   • Because of previous knowledge from KS3, students may mention that light is a wave that travels from the light source to their eyes. Tell them that in the 19th century a debate raged between scientists - some thought that light was a wave but others thought it was a stream of particles. Ask the students for their opinions on this (depending on prior knowledge, students may dismiss the particle theory altogether).

2. Main activity: The double slit experiment
   • Give each student a copy of page 1 of the pupil worksheet and ask them to read through the information about investigations into light.
   • Then, give them page 2 which they will use to gather and analyse results from a version of Thomas Young’s double slit experiment. Go through each section with them, checking understanding before moving onto the next.
   • Carry out the double slit experiment as a demonstration (see weblink below for instructions).
   • You may also like to carry out the double slit experiment with sound waves to see interference. You will need a signal generator and 2 speakers. Plug the speakers both into the same signal and then place about them 1-2 m apart facing into the room. Ask the students to walk along the back of the room. They will be able to hear loud and quiet points where the waves are interfering with each other. This demonstration shows constructive and destructive interference nicely and helps students to make the link to what is happening when light is used.
   • Students should finish by writing a scientific explanation for the results. They should explain why the ‘barcode’ pattern of light was observed, and not just two lines which is congruent with their prediction based on the hypothesis that light is made up of particles. This will require them to apply their knowledge of wave behaviour to new phenomena: diffraction and interference. You can either give each student a copy of page 3 of the pupil worksheet and allow them to use the information on the sheet (and simulations/videos if they have access to the internet), or carry out a more teacher-led activity by showing them one of the suggested videos in the weblink below before discussing as a class.

http://www.oxfordsparks.ox.ac.uk/run-for-your-light
3. Plenary

- Show the class the animation 'Run for your Light' and ask them how it shows that Newton and Young were both correct.
- Discuss we have evidence that supports both models and so scientists have decided that light behaves as both a stream of particles and a wave.

Weblinks

http://www.oxfordsparks.ox.ac.uk/run-for-your-light

Run for your Light animation

https://www.youtube.com/watch?v=uwk-XskXCI4

Laser light show with a computer network theme.

http://www.nuffieldfoundation.org/practical-physics/youngs-slits-light

Instructions on how to set up the double slit experiment.

https://www.youtube.com/watch?v=luv6hY6zsd0

Information on the double slit experiment - suitable for students.