Glitter, glue and physics too

Explore physics in a new way by creating a model of particle collisions using craft materials.

By Alison Rivett

If you consider the type of equipment needed for practical activities in a physics classroom, you might think of prisms, crocodile clips or data loggers. Science, and especially physics, is often perceived as different and difficult, with complicated equipment and machines; it’s done in a special place, a laboratory, and it has a language all of its own, with many technical words. However, doing practical work with everyday items can help engage students by giving them a different perspective on the subject.

In this article we introduce an activity using art materials. We originally designed it to be used at public events, like festivals and science fairs, but the mix of creativity and science proved to be a lot of fun for participants of all ages, and teachers who saw their enthusiasm were keen to replicate this enjoyment in the classroom.
Crafting collisions

Researchers often use models to explain phenomena and observations, but these are still just theoretical ideas and only described in words, or perhaps pictures. Using simple craft materials to represent some physical aspect of a process or object can be an excellent way to develop an understanding of abstract concepts. Hands-on activities can also engage students who may otherwise lose interest in what they perceive as a dry, academic subject.

Creative activities in the science classroom are appealing because of their novelty. Unusual activities create ‘situational interest’ – a temporary interest that is triggered spontaneously by the external environment, for example through curiosity or enjoyment (Schraw et al, 2001). Stimulating these reactions in the classroom is a way of hooking students’ attention and getting them to think.

This activity addresses subatomic particle physics and how scientists establish knowledge in this field. It can help students to learn about and understand the standard model of particle physics and the search for the Higgs boson at the Large Hadron Collider (LHC) at CERN. The activity does not create much mess and can be done in a reasonably compact space. It works well with secondary school students but also appeals to older primary school pupils (although the concept of sub-atomic particles may be very new and challenging for them).

The basics of subatomic particles

First discuss the basics of subatomic particles. What is all matter made of? What is inside an atom, a proton and a neutron? Everything around us, from galaxies, the Earth, even ourselves, is made of atoms. Despite the fact that we cannot see them by eye, atoms are not the smallest level of matter. Atoms themselves are composed of tiny particles, which in turn are made of tinier particles that group together, and so on... and we still do not know where it finishes.

That is one of the reasons why scientists are still exploring what comprises atoms: what forces keep the particles linked and whether there are more particles to be discovered. One way that scientists have to explore atoms is by smashing particles together at almost the speed of light using particle accelerators like those at CERN. Ask your students what they think might happen when particles are smashed together very quickly.

Such collisions may break down atoms into their constituent particles, or existing particles may fuse to create bigger particles. These may resemble what existed millions of years ago at the beginning of the Universe when all its matter and energy were concentrated in a tiny space. Scientists can observe the pattern of the particles produced by a collision and use this to determine what they are by the way they move. Analysing the debris from particle collisions, therefore, allows scientists to identify what new parti-
cles have been produced. See Landua 2008a and Landua 2008b for more
details of how particle accelerators
work and how they can help scientists
understand the origin of the Universe
and what it is made of.

Creating a particle collision
mobile

In this activity, students create a
model depicting the products cre-
ated when two particles are smashed
together in a particle accelerator.
The particles will be represented by
coloured beads, their trajectories by
pipe cleaners, and the products of the
collision by pom-poms. In this way,
the craft model will help the students
to visualise the normally abstract
world of particle physics.

Materials

- Coloured elastic thread
  (about 20 cm)
- Coloured beads
- Pipe cleaners
- Pom-poms
- Paper tags
- Glue
- Scissors

Procedure

1. Thread two beads onto the elastic
  thread. These beads represent the
colliding particles.

2. Using the elastic thread, tie a dou-
   ble knot around the beads. Tie an-
   other knot towards the ends of the
   elastic so you have a large loop.

3. Push several pipe cleaners through
   the small elastic loop and around
   the beads.

4. Bend the pipe cleaners in half
   around the small loop of elastic,
   then twist the strands together.

5. Shape the ends of the pipe cleaners
   into particle tracks.

   Explain to your students why
different particles follow different
paths depending on their energy,
charge and mass. Lighter particles
have longer tracks while heavy
particles have shorter tracks. The
tracks of charged particle are curved,
whereas neutral (uncharged) particles
travel in straight lines. Particles with
low energy follow spiral paths. Some
particles may even follow branched
paths.

<table>
<thead>
<tr>
<th>Trajectory</th>
<th>Particle</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long straight tracks</td>
<td>Photon</td>
<td>Pure energy</td>
</tr>
<tr>
<td>Short straight tracks</td>
<td>Neutrino or anti-neutrino</td>
<td>Small and light</td>
</tr>
<tr>
<td>Long curved tracks</td>
<td>Muon or anti-muon</td>
<td>Larger and charged</td>
</tr>
<tr>
<td>Short curved tracks</td>
<td>Electron or positron</td>
<td>Smaller and charged</td>
</tr>
<tr>
<td>Spiral tracks</td>
<td>Pion</td>
<td>An up–down quark pair</td>
</tr>
<tr>
<td>Jets (tracks starting together then branching out)</td>
<td>Quark pairs and gluons</td>
<td>Gluons stick quarks together</td>
</tr>
<tr>
<td></td>
<td>Z-bosons and W-bosons</td>
<td>Heavy particles that carry force</td>
</tr>
</tbody>
</table>

Table 1: Detailed trajectories of each particle type
Show your students a couple of examples and then let them discover the remaining types once they have finished building their mobile.

6. Fix pom-poms to the end of the pipe cleaners using glue or by curling the pipe cleaners round the pom-poms.

Put results together: has anyone ‘found’ the Higgs Boson?

The last step in creating the particle mobile is to attach labels to the particles. To guide the labelling, provide the students with something similar to table 1, which specifies the exact trajectories of each particle type.

Once the students have added the labels to the particles in their models, discuss the different types of particles they have made. Perhaps they came up with a trajectory that does not appear in the table. If so, you can discuss what happens in particle accelerator experiments when new trajectories are found. Ask the students to give a name to their newly discovered particle.

Now that students have made the subatomic particles visible, you can extend the discussion, for example to cover what the Higgs boson is (see Hayes, 2012).

Teaching science through craft

The finished pieces can be displayed in the classroom or around the school to highlight the topic of particle physics to the school community, in the same way that artwork is exhibited publicly. Alternatively, students can take their creations home to prompt discussions about science with their families. The models are also easy to replicate should your students wish to show their parents or siblings how to make them too.

These craft activities make excellent outreach demonstrations, for example at a school open evening or science fair. Students can demonstrate the activities to their peers, younger children or visitors. This is an excellent opportunity to boost students’ confidence and communication skills and allow them to share an enthusiasm for science.

An evaluation of the activity when used with the public (Durbin, 2011) showed that the combination of craft-based creativity with facilitated discussion results in increased understanding and interest. Similarly, in the classroom, allowing students to use their own imagination when exploring a topic captures their interest and helps them to understand it. Above
all, by making the abstract more comprehensible, the wonder of science can be shared and enjoyed by everyone.

Acknowledgement

The author would like to thank the Institute of Physics and Samantha Durbin who helped develop and test the activities.

References


This article is freely available online and can be found at: http://tinyurl.com/nqx2473

Web reference

w1 – Instruction leaflets about this and two additional craft activities exploring galaxies and planets can be found on the Institute of Physics website (www.iop.org) or via this direct link: www.tinyurl.com/creativephysics

The three activities are suitable for a wide range of ages and do not require any pre-existing ability.

The science behind the activities involves topics that are regularly in the news and still being actively researched, providing an opportunity to make links with real-world physics.

Resources

Further pictorial instructions on the particle physics model can be found on the Physics.org website. See: www.physics.org/creativephysics

To learn more about CERN and the search for the Higgs boson, see: www.cern.ch

The CERN education site provides lesson plans and resources on particle physics. See: http://education.web.cern.ch/education

To build your own particle accelerator, see:


Encourage your students’ interest in these topics with citizen science projects from the Zooniverse, which enable your students to discover their own Higgs boson using real scientific data. See: www.HiggsHunters.org

Some simple learning strategies to promote situational interest in the classroom can be found here: http://singteach.nie.edu.sg/issue48-research04

Alison Rivett is an educational consultant for the Ogden Trust and a primary science outreach consultant for Bristol ChemLabs, both in the UK. Alison supports and develops physics & chemistry outreach activities aimed at school pupils for both organisations.

www.scienceinschool.org