



STFC Cosmic Rays Poster – additional notes for teachers

Cosmic rays receive mention in school physics as a component of background radiation when tackling the topic of radioactivity. Their role in the production of carbon-14 in the upper atmosphere might also be touched upon, and the 1941 Rossi-Hall experiment that tested special relativity with muons can be introduced in post-16 studies (<http://hyperphysics.phy-astr.gsu.edu/hbase/relativ/muonex.html>). [Also relevant for post-16 studies, investigating cosmic rays was the precursor for modern particle physics experiments like the LHC at CERN, as they provided the first evidence for new sub-atomic particles such as the muon and pion, as well as proving the existence of antimatter when the positron was discovered in cosmic ray tracks in 1932 – studying the fraction of positrons in cosmic rays is also very relevant today as it may provide evidence for Dark Matter in our Milky Way galaxy (<http://pamela.roma2.infn.it/index.php>).]

The production of aurorae could be referred to when discussing the magnetic field of the Earth (and other planets), and the latter's importance in protecting us from a great deal of cosmic ionising radiation is well worth a mention. With space weather and missions to Mars in the news, there is opportunity to point out what a hostile environment awaits, no more than a few hundred kilometres from the Earth's surface.

In principle the detection of secondary cosmic rays in school laboratories is easy: watch a charged gold leaf electroscope slowly discharge (as early pioneers in the field had done) – but pupils are hardly likely to be impressed! As a powerful way of visualising ionising radiation, a simple diffusion cloud chamber cannot be matched. Some schools may still have small purpose built chambers, but they are hard to find nowadays, though this company is worth a try:

<http://www.scichem.com/productinfo.aspx?kw=cloudchamber&tier1=Atomic+%26+Nuclear&tier2=Equipment&catref=XAR150010>). Small quantities of the dry ice needed can be readily manufactured on site with carbon dioxide cylinders and a dedicated expansion attachment, but there are plenty of local suppliers (e.g. <http://www.dryiceuk.com/>).

It is, however, completely feasible to make your own chamber out of a plastic fish tank, some self-adhesive felt and a baking tray. Instructions can be found here: <http://m.iopscience.iop.org/0031-9120/47/3/338/article>, but look out for IOP Physics Network 'make and take' workshops if you feel in need of assistance. While tiny radium sources are the norm in the traditional chambers, it has been found that thoriated tungsten welding rods, which are easy to purchase, work well in the home made kits. While the chambers are primarily used for the observation of alpha particle tracks from the sources, 'rogue' tracks can always be seen if you wait long enough, a few of which might be due to cosmic intervention.

The dry ice is needed to produce a layer of air saturated with (normally) isopropyl alcohol near the bottom of the chambers, so obviously once all of the solid CO₂ has sublimed recharging is necessary. There are some Peltier cooled models on the market that can operate continuously (e.g. http://www.pasco.com/prodCatalog/SE/SE-7943_diffusion-cloud-chamber-15-cm-diameter/), and at the top end the German firm PHYWE sells astonishing pieces of equipment that are terrific for displays and exhibitions: <http://www.phywe.com/1398/Campus/Info-Center/Exhibition-Area/The-PHYWE-Diffusion-Cloud-Chamber.htm>.

The detection of cosmic rays in particular (as opposed to ionising radiation in general) in schools can be carried out by coincidence techniques, though this is more difficult and expensive to achieve. A suggestion as to how two GM tubes with suitable electronics can be used in this way is to be found here: http://www.blackcatsystems.com/GM/products/coincidence_box.html; but a more common approach is to use photomultiplier tubes connected to slabs of scintillating plastic. This approach has been successfully rolled out in the US via the Quarknet project based at Fermilab (<http://quarknet.fnal.gov/>), and – on a bigger scale – by projects such as ALTA across the border in Edmonton, Alberta. The triangular arrangement of three one-metre square slabs of scintillator has crossed the Atlantic to be trialled by King's College London in the UK, as well as by CZELTA (<http://www.utef.cvut.cz/czelta/czelta-en>) in the Czech Republic.

Other universities in the UK have been promoting cosmic ray projects in schools – e.g. Durham, Sheffield, Leeds, Birmingham and Bristol – and, as mentioned on the poster, there is currently a move to unify these efforts. Meanwhile on the continent there are particularly active groups in Holland (<http://www.hisparc.nl/en/>) and in France (<http://www.sciencesalecole.org/nos-actions-didactiques/cosmos-a-lecole.html>), for example.

Some of you may have been lucky enough to see the spark chamber firing in the Microcosm exhibition at CERN. Such things are probably beyond the capabilities of schools to manufacture, but both Birmingham and Bristol Universities have models that you might be able to get to see. Schools in the south-east of the UK might be able to share in the exciting work being carried out at the Star Centre in the Simon Langton School in Canterbury, also mentioned on the poster (<http://www.thelangtonstarcentre.org/>).

For more information on the workshops offered by the IOP Teacher Network go to: www.iop.org/network

These notes were produced by David Smith, Highgate School, London, with suggestions from Colin Lally, Cranbrook School, Kent.