The physics of climate science

CERN is full of surprises. On paper, you would not expect a laboratory that concentrates on particle physics to have an interest in climate science. However, the rigorous approach used in particle physics experiments is being applied to an unconventional experiment that is looking at the formation of clouds.

The CLOUD collaboration, led by Jasper Kirkby and including the Universities of Leeds and Manchester, is investigating how cosmic rays affect cloud formation.

Clouds play an important role in regulating the radiative balance on Earth by reflecting sunlight and emitting infrared radiation. Cloud droplets form on aerosols – tiny solid or liquid particles suspended in the air. Globally, around half of these aerosol cloud ‘seeds’ are thought to ‘nucleate’ (form) from the condensation of trace atmospheric vapours, rather than being directly emitted into the atmosphere, like dust or sea spray. Cosmic rays (an area of CERN’s wider research programme) may enhance the formation of these cloud seeds. And, since cosmic rays are affected by the solar wind, this provides a potential mechanism for how solar variability may affect climate.

The collaboration’s experiments take place inside a 3m diameter chamber at atmospheric pressure, believed to be the cleanest in the world, and use a secondary beam of pions from CERN’s PS accelerator to replicate cosmic rays.

Cleanliness is essential says Jasper; “The experimental chamber is a precision instrument and just one part per trillion of certain impurities in the chamber could ruin the measurements. We take extraordinary measures to keep the chamber clean. We even make synthetic air, and will soon be making synthetic water, to suppress the contaminants. CERN know-how has been crucial to reach the unprecedented performance of the chamber.”

“There are so many processes going on in the atmosphere that it is difficult to isolate exactly what controls the formation and growth of these cloud seeds,” explains Jasper. “However, we need the atmospheric observations to narrow down the list of prime suspects (candidate vapours) so that CLOUD can carry out detailed forensic investigations.

“We have created a very clean environment in which to put precise amounts of known vapours, carry out controlled experiments and quantify the fundamental mechanisms responsible for atmospheric aerosol nucleation and growth – including the effects of cosmic rays - for the first time.”

In the first experiments from CLOUD, reported in Nature in 2011, the team added ammonia and sulphuric acid vapours to the cloud chamber.
Whilst they succeeded in making the first molecule-by-molecule measurements of the formation of embryonic clusters, they found that the nucleation rate was much lower than had hitherto been expected and it failed to account for atmospheric observations by a factor of ten to one thousand.

“In some ways, our results were a giant step backwards,” says Jasper. “These vapours were thought to account for all atmospheric nucleation but we found that we don’t even understand which gases are responsible, let alone how quickly they form new aerosol particles.”

So, in more recent experimental runs, the team has looked at the effects of organic vapours. The results are being prepared for publication later in 2013 and Jasper would not be drawn on their findings.

What we do know is that the University of Leeds team in CLOUD is feeding their results into the kind of sophisticated analytical models that particle physicists would recognise. The Intergovernmental Panel on Climate Change periodically assesses the understanding of climate change for the world’s governments and states that the impact of aerosols and clouds represents the largest uncertainty in climate change. CLOUD aims to reduce this uncertainty by providing global models with precise quantitative data on the fundamental processes involved and, in particular, the role of cosmic rays.

Climate science is an emotive topic in the media and Jasper is keen to emphasise the empirical nature of CLOUD. “We’re not following a theory – we’re conducting rigorous, repeatable experiments and observing what happens. We won’t resolve the science of climate change by more passionate debate; what we need are better experimental data.”

**Head start for UK companies**

Finding new customers has never been more important for UK companies and a recent trade visit to CERN has enabled eleven businesses to introduce themselves, their products and services to CERN. At the same time, they were able to find out more about CERN’s requirements and its purchasing procedures.

The two-day trade visit was organised by UK Trade and Investment (UKTI) and STFC. Eleanor Baha is the Trade Attaché at the British Embassy in Switzerland. Her role is to help UK companies develop or increase their sales in Switzerland. Around 30% of her work relates to CERN.

“When we organise trade visits, we arrange everything - the companies can concentrate on promoting their products and services. The challenge of supplying CERN is the level of precision required for components, and the amount of technical information that companies need to provide. We work closely with STFC to match people at CERN who have specific buying requirements to British companies that can meet their needs – we’re a little like a dating agency!”

The visit included presentations on CERN activities and purchasing procedures to put the companies in the best position to be able to submit successful bids for contracts. The representatives were also given a tour to help them get a sense of the breadth and scope of activities at CERN. The most important part of the visit was the individual programme of one-to-one meetings that Eleanor and her colleagues arranged for the company representatives with CERN staff. There is no doubt that these personal contacts increase the chances of a company being invited to tender.

Colin Woolger, Managing Director of Magnetic Shields Ltd, has found the trade visit valuable, “With such a large organisation as CERN, it is extremely helpful that UKTI and STFC work with us to find the right contact partners within CERN. This is our second such visit and we are hugely impressed with the planning and organisation which enables us to focus totally on high quality meetings. We gained orders after our first visit and this visit looks even more promising with larger potential projects being discussed.”

The importance of the trade visit was underlined by the presence of HM Ambassador to Switzerland, Sarah Gillett, at the reception at the
end of the first day, “Science and innovation are massively important to the British economy. CERN is not only one of the most exciting scientific frontiers in the world today; it also offers wonderful opportunities for collaboration between science and industry.

“The UK’s share of CERN business has increased from CHF20 million in 2011 to CHF30 million in 2012. I believe there is still plenty of scope for this to increase further, and I am most grateful for the way in which CERN’s top management is as keen as I am to see more British companies working with CERN. I found UK@CERN one of the most inspiring receptions I have been to this year, because it confirmed my belief that the UK has some of the world’s best companies, and that CERN wants more good British companies working with it.”

The next trade visit to CERN is scheduled for early 2014. For more information on becoming a CERN supplier, please contact Eleanor Baha, Julie Bellingham or Alan Silverman.

Social workers

Young researchers are an essential part of CERN’s community, playing active roles in every aspect of the experiments as they develop their skills and knowledge. Nevertheless, arriving at CERN as a student, it can be difficult to get to know people, especially if you’re from an institute that only has a small team based here. Fortunately, there is a very active network ready to help you settle in.

Young@CERN is for anyone in the CERN community aged 18 – 30. With more than 5600 on its mailing list and an active Facebook community of 1400, it provides a forum for meeting new people and encouraging social interaction.

Steve Ogilvy (University of Glasgow) is one of the organisers. In his day job, Steve is a PhD student making precision measurements of charmed baryons (composite particles made up of three quarks, one of which is a charm quark) as part of the LHCb collaboration. He is also one of the convenors of the LHCb-UK student meetings.

“Many of us work irregular hours, especially if we’re working in the run-up to an analysis deadline,” says Steve, “and it can be difficult to maintain an active social life. Young@CERN enables us to socialise with people who understand our lifestyle, and the Facebook page enables small groups with common interests to get together.”

Whilst there are certainly parties (some of them legendary), the network also aims to make the students more aware of research going on around CERN. “CERN is huge and it can be difficult to keep track of other experiments when you have your head down concentrating on your own project,” explains Steve.

“Through Young@CERN, I’ve met a more diverse set of people than I might have done without the network, and I’ve seen and done more of CERN and Geneva. I know that many of the friendships I’ve made are going to last well beyond my time here – they’re also part of my professional network.”

Anyone with a CERN ID aged between 18 and 30 years should be automatically added to the Young@CERN mailing list. You can also find the group on Facebook.

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Diary dates

CERN Council week – 18–22 March
LHC on Tour in Belfast – 6–10 May
CERN public open day – 29 September