Star experiment on ISOLDE

Scalar field theories are just like buses. You wait 50 years for a theory to be proved correct and then another revolutionary theory comes along, right behind it.

Results from an experiment about to start in the ISOLDE facility could be the first step towards proving whether an audacious new theory is correct. The new theory goes beyond Einstein’s Theory of Relativity, and beyond the Standard Models of Cosmology, Astrophysics AND Particle Physics. If the theorist is right, there’s another particle waiting to be discovered…

Supernovae are some of the brightest objects in the Universe. These dying stars are responsible for producing many of the heavy elements that are required to support life. But the processes that take place within the star and lead to its catastrophic explosion are less well understood. Astrophysicists have a theory but due to its complexity, it is impossible to model it successfully on computers. Experimental observations have added to the confusion.

Stars are massive balls of burning gas, with their energy supplied by a series of nuclear fusion reactions.

Stars bigger than about eight times the mass of our own Sun have cores that burn atoms all the way from hydrogen to iron. Fusion of elements lighter than iron releases energy, but fusion of heavier elements requires energy.

Once the burning has reached iron the nuclear fires go out and the core of the star collapses. Such is the weight of the star that atoms are crushed together, and it is only when the tiny nuclei of the atoms begin to overlap that the collapse is suddenly halted.

Following this ‘core bounce’, the star explodes, but not immediately. Astrophysicists know that the supernova gets hotter and that it generates neutrinos, with some current theories suggesting that neutrinos are the key to successful explosions. These are supported by the observation of about 20 neutrinos from supernova 1987a. However, when modelling this on a computer, only very weak explosions occur. This could be down to insufficient computer processing power, our understanding of neutrino physics, a fundamentally incorrect model, or something to do with gravity.

Charles Wang, a theoretical physicist at the University of Aberdeen, and a Visiting Fellow at the STFC Centre for Fundamental Physics, favours the gravity option. As supernovae implode, they release lots of gravitational energy and Charles has proposed a theoretical framework in which a new scalar particle leads to increased energy transfer, giving the extra boost needed to make core collapse supernovae explode. This is radical thinking,
and if Charles is correct, his idea could eventually lead to a Grand Unified Theory.

But a theory remains just that until it can be proved.

Alex Murphy, a nuclear astrophysicist at the University of Edinburgh read Charles’ theory and thought that his planned experiment on ISOLDE might help.

The experiment will use a beam of Titanium 44 (44Ti), an isotope collected from recycled radioactive waste at the Paul Scherrer Institute in Switzerland. Alex’s team will fire the beam of 44Ti at a helium gas target and look for reactions which generate a proton and Vanadium 47.

Titanium 44 is generated right in the core of the supernova as it cools. What’s more, it emits a very specific energy gamma ray, which could be seen by satellites such as Nasa’s NuStar and ESA’s Integral missions. By comparing the amount predicted by the model to what is actually observed, you can do a sensitive test of what’s happening at the core of a supernova.

Alex explains, “So far, the observations made by the satellites and other measurements such as at the T2K neutrino experiment in Japan are not robust enough for us to draw a firm conclusion about the validity of the computer model. There are just too many variables. One of the biggest is the nuclear physics of how the titanium is made. With this tied down we should be able to finally make clear predictions of the amounts of 44Ti produced. Comparing this to the observations might be able to confirm if Charles’ idea is right!”

Whilst many more experiments would be required to prove the existence of the ‘Wang’ particle, this is the first step and Charles Wang is at CERN to see the experiment happen, “As a theoretical physicist, I have the great privilege of working with experimental physicists – I find it very stimulating."

Two of the Edinburgh experimental team are PhD students; Vincent Margerin is in the first year of his PhD, “I didn’t know about Charles’ theory when I started my PhD and it wasn’t until much later that I learnt that my project was linked to such a challenging theory. My PhD consists of several experiments all aiming towards a better understanding of the explosive star phenomena. Our current experiment is wonderful, though very challenging. It’s hard to see where it will carry my PhD; but the fact that its potential results could help shake our understanding of the Universe is fascinating. Whatever happens there are some exciting times ahead!”

Dave Mountford is in his final year and is at CERN to provide an extra pair of hands during the experiment. “The results of this experiment will be very exciting. They could lead to a fundamental change in the way we think the Universe works. If Charles is right, I will be able to look back and say that I played a small part in a massive scientific discovery!”

Get involved!

A new citizen science project called **Feynman’s Flowers** is inviting members of the public around the world to analyse data that will help researchers in the UK understand more about magnetic molecules whose properties could be exploited in the next generation of electronic devices – devices that could do more and use less energy. Anyone can take part, and only a few clicks of the computer mouse are required to collect valuable information.

Traditional electronic devices work by moving charge around a circuit. This has produced astounding results over the last half century, but we are now at a point where further reducing the size of circuit elements is difficult because it would create too much heat in too small a space.

The London Centre for Nanotechnology (a joint venture between UCL and Imperial College London) is studying magnetic molecules to
understand how they can be used to make the smallest possible ‘spintronic’ devices, in which charge (electronic) and spin (magnetic) properties can be used together.

In collaboration with the Citizen Cyberscience Centre, a partnership between CERN, the UN Institute for Training and Research, and the University of Geneva, the LCN is inviting volunteers to analyse images from a scanning tunneling microscope of individual molecules, which have characteristic flower shapes.

The data will contribute to a research project run by Cyrus Hirjibehedin at the LCN focused on exploring the behaviour of phthalocyanine molecules. In the past, these were used as dyes for fabrics, but scientists now realise that they also have interesting electronic and magnetic properties that make them potentially useful for creating nanoscale devices that can manipulate or store information.

Ben Warner, a PhD student at the LCN who is leading the analysis of the work, explained: “Using individual molecules as circuit elements is the ultimate challenge in nanoscale science and engineering. Devices made this way could have a huge impact on society because they would store and process larger amounts of data in a smaller space using less energy. Through the development of this website, we are letting the general public directly participate in this exciting work.”

Science Britannica

Part of a new BBC science series has just been filmed at CERN. Presented by Brian Cox (University of Manchester and the ATLAS collaboration), Science Britannica will explore the concept of scientific method, starting with Newton and coming right up-to-date with ATLAS, CMS and their search for the Higgs. The filming included lots of ‘talking heads’ from the two experiments, including Jo Cole (Brunel University) and Sam Harper (STFC Rutherford Appleton Laboratory).

Science Britannica is due to go out on BBC2 in spring 2013.

Scientific stocking filler

If you’re stuck for an original Christmas present idea, look no further!

The cream of musical talent from the ATLAS collaboration has released ‘Resonance’, a 36-track double CD covering every genre from classical to heavy metal.

- Marvel at the melancholy melodies of Genevieve Steele (Glasgow) playing the Celtic harp
- Groove to the Canettes’ ATLAS Boogie featuring CERN’s Connie Potter, Simon Baird and Chris Thomas
- Sympathise with the TLA’s Points of Order, a plaintive ditty about love, loss and the futility of meetings, featuring Nick Barlow (Cambridge) and Martin White (Melbourne)
- Taste the edge of oblivion [editor: his words, not mine!] with Jon Butterworth (UCL) on rhythm guitar and backing vocals for ‘gut’ rockers, The D’Anglerz.

Download or order your copy now – all proceeds support the Happy Children’s Home in Nepal started by a former member of CERN staff.

How to subscribe

To subscribe to (or unsubscribe from) UK News from CERN, please contact jill.little@stfc.ac.uk.

Back issues of UK News from CERN are available from the archive.

Diary dates

CERN Council – 10-13 December
Brits@CERN meeting – 13 December (5pm)
LHC shutdown – mid February 2013
CERN public open day – 29 September 2012