**Takeaway Science**
*The Large Hadron Collider, the moon and some space scientists' heroes of science*

**Mike Bullivant**
Welcome to takeaway science, another in the series of short podcasts produced by BLAST! at the Open University. This time there is a definite physics and astronomy theme to the podcast. Later on Dave Rothery from the Open University's Department of Earth and Environmental Sciences, talks with Mahesh Anand, Academic Fellow at the OU's Centre for Earth, Planetary Space and Astronomic Research. You may have heard these two on another takeaway science podcast talking about the planet Mercury. This time they are going to be discussing the moon and how it was formed. After that two space scientists, Professor Andrew Coates and Elizabeth Seward tell us who their science heroes are, but first I get the chance to talk with Dr Tara Shears from the University of Liverpool about the large Hadron collider at Cern.

**Mike Bullivant**
So Tara you are involved with what has been described as the world's biggest physics experiment, the large Hadron collider, what is the large Hadron collider and how does it work?

**Dr. Tara Shears**
Well the large Hadron collider, or LHC for short, is basically the most powerful particle accelerator in the world, its 27 kilometres long and it's a circular particle accelerator and we are going to use it to basically just try and understand the universe a little bit better than we do already. What we want to do basically is to try and work out what the universe is made of, at its very deepest level of matter and we want to know what holds these pieces of the universe together and why ultimately the universe is the way it is.

**Mike Bullivant**
And what does it comprise the large Hadron collider, huge circular beams of photon isn't it?

**Dr. Tara Shears**
That's right. So what's going to happen inside the LHC when it's, when it's going is that there will actually be two beams of subatomic particles that circulate round it, but in opposite directions and what the LHC does is it takes these two beams of particles and it accelerates them to – until they are going incredibly fast, you know practically at the speed of light and then once it's done that, it takes these two beams of particles and it brings them into collision with each other at the four points around this 27 kilometre long ring and this is the interesting bit, because when you smash these beams together that are incredibly energetic, what you do for a very tiny instant of time and a very tiny area of space, is you have basically recreated the conditions of the universe about a billionth of a second after the big bang. And why that's interesting to us is that if you could see back into the universe at that time, if you could somehow magically go back to the big bang, it would look very different. You would find that it would be this sort of seething mass of fundamental particles, like electrons, like quarks, the ingredients of atoms if you like.

**Mike Bullivant**
Wow, well there is one particle in particular that I think that certain people are interested in – that's the Higs Bozon, this rather mysterious hypothetical particle at the moment?

**Dr. Tara Shears**
Yes, the Higs is really interesting because it really is the missing link in our understanding of the universe at the moment and its really frustrating because we have this fantastic theory that we use to describe the universe and the theory is really good, it's so good that we haven't yet made a measurement in any of our experiments that disagree with any of its predictions,

it’s so good in fact we call it the standard model and yet one thing the standard model has predicted that we have not yet found is the existence of this elusive Higs particle.

**Mike Bullivant**
And what is it, what’s it responsible for?

**Dr. Tara Shears**
We think the Higs particle is responsible for basically for giving mass to our fundamental particles, that’s its job, it makes the top quark much, much more mass, much heavier if you like than tiny itty little bitty particles like the electron. That’s its job and yet it has a much deeper role as well in that inside our theory its responsible not just for doing that but it keeps the whole theory on track, it makes us able to make predictions with our theory because without the Higs the whole theory breaks down, the whole understanding of the universe breaks down and that’s why it’s of such fundamental importance to us to look for it and to establish whether it exists or not, because if it doesn’t then we are going to have to really re-think our understanding of everything.

**Mike Bullivant**
Its back to the drawing board for you particle physicists isn’t it – yeah. But if you don’t, if you don’t detect the Higs Bozon, it doesn’t necessarily mean that it doesn’t exist does it?

**Dr. Tara Shears**
You are right, it doesn’t mean it doesn’t exist, but it does mean that it doesn’t exist in the form that we predict it to in our theory. So it is possible that we could have a more sort of exotic version of it around if you like that our experiments just wouldn’t be able to detect, but in that case then it still means that our understanding of the universe isn’t quite the way we thought it was and there would be a – there would be a bit of work for us to do then to try and work out exactly what was happening.

**Mike Bullivant**
You must be terrifically excited. As are the multitude of people working on this project aren’t there, give us an idea of the scale of the thing.

**Dr. Tara Shears**
Its absolutely enormous, the LHC is a truly global collaboration, would you believe that half the particle physicists in the world come to Cern to work on the LHC and they are from over 85 nationalities round the globe, its a huge number of people. And the experiments are huge as well. If I can just pick out a couple of examples, the atlas and CMS experiments have over 2,000 people collaborating on each of them and on the one hand you think, gosh how on earth would you ever make this many people work together, especially if they’re physicists because you know we all like to think we are right and – but in fact it turns out that you need this many people to design and build such complicated and costly experiments because everybody shares the cost as well and you also need all these people to actually make the experiments run when we do get data, because we all had to take our turn in taking night shifts to make sure that experiments – taking data, we all take our turn in making the particle detectors inside run perfectly – writing bits of software. So really it does take the efforts of all of those 2,000 people in a particular experiment to make the data come out in a form that we can try and understand and then use for our research. So if you like collaboration at that scale is really inbuilt into the whole enterprise, you can’t escape it, it has to work, it’s the only way it can work.

**Mike Bullivant**
Um and what's in it for you on a personal level, as far as the research that you are doing?

**Dr. Tara Shears**
I just think it’s the most interesting stuff you could be doing, I am so glad I can do it for my day job. I can’t – I can’t imagine anything more interesting than trying to understand what the universe is all about, what it really is made of at the subatomic level, you know what makes it tick. It’s a very exciting time, not just because it’s a great leap into the unknown that we have

been working for years to sort of make happen, but also because we have actually physically built the bits for it and we are dying to see what they do inside.

**Mike Bullivant**
Is there a website, are you aware – that you can give us where listeners can go for further information about the LHC and what its doing?

**Dr. Tara Shears**
One of the best places where you can go to to learn more is to go to the website at Cern itself, so just get your browser up and go to www.Cern.CH and Cern is just C E R N.

**Mike Bullivant**
Good luck Tara and thanks very much for your time.

**Dr. Tara Shears**
No problem.

**Mike Bullivant**
Tara Shears there, who is lucky enough to be working on one of the most exciting and it has to be said, expensive science projects ever undertaken, the large Hadon collider at Cern. Well, if you have an interest in the fundamental laws of modern physics and the ways in which mathematics is used to state and apply these laws, then you will probably find the Open University third level course 'The Quantum World' right up your street. It's a course that surveys the physical principles, mathematical techniques and interpretation of quantum theory. The Schrödinger equation, the uncertainty principle, the exclusion principle, Firmions and bozones, measurement probabilities, entanglement, perturbation theory and transition rates are all covered in the course. Applications include atoms, molecules, nuclei, solids, scanning tunnelling, microscopy and quantum cryptography. The Quantum World also presents recent evidence relating to some of the most surprising and non classical predictions of quantum mechanics. You can check the course out by logging onto ww3, that's the numeral three, ww3.open.ac.uk/study, click on the link to science on the right hand side of the page and follow the link to physics and astronomy courses. And now as promised, here is Dave Rothery, Senior Lecturer in the OU's department of Earth and Environmental Sciences, talking with his OU colleague Mahesh Anand about what we have learned from the lunar rock samples brought back to earth by the Apollo space mission. Here's Dave.

**Dave Rothery**
Hello I am Dave Rothery from the Open University and I am going to be talking to my colleague Mahesh Anand, now its 39 years since we first landed on the moon with Apollo 11 Mahesh, what was so exciting about what Apollo discovered?

**Mahesh Anand**
Well Dave as you know we collected a lot of samples when we went to the moon in 1969 and thereafter. We collected about 382 kilograms of lunar sample and only a fraction of which has been actually studied in great detail so far and what the analysis of Apollo samples revealed to us, er was that the moon actually formed through a giant impact, um, of two bodies, one which was the size of – of the Mars and one was about our own earth and the resulting body was the moon and what we also found out that the, er, rocks that we found on the moon, er, were really ancient – there were two main types of rocks, one that formed the lunar highland which were almost as old as the age of the moon at about four and half billion years, whereas there were volcanic rocks on the moon that were mainly in the age ranges of about three to four billion years.

**Dave Rothery**
Now we are going to be learning a lot more about the moon in upcoming years because there are several missions to the moon, either already there or planned to go, now what can we say about those Mahesh?

**Mahesh Anand**
I think we are in really exciting times, we already have a lunar orbit from two countries each – one from Japan called Kaguya and one from China called Chang'e 1 and we are in the process of sending another lunar orbital called Chandrayaan-1 which is an Indian mission and of which, as you know both you and I are co-investigator on one of the instruments that will be flown on this instrument and basically we are going to learn a lot more about the global geology of the moon which actually we lack because you know 39 years ago, er we did not have these technologies er, we went to the moon to – to small areas, we collected samples and we came back and really after that that has been acquiescent, so now is the time that we going to learn a whole lot more about the moon and perhaps use that to study even other planets.

**Mike Bullivant**
Dave Rothery there talking with Mahesh Anand, Academic Fellow at the OU's Centre for Earth, Planetary Space and Astronomical Research. If you are interested you can catch them in another take away science podcast discussing Dave's research on the planet Mercury and if that isn't enough, then you might also like to know that the OU offers a short level one introductory course for budding astronomers called, oddly enough, "Introducing Astronomy". It looks at some of the topics that regularly crop in newspaper reports, such as violent Stella explosions, distant galaxies and the big bang. "Introducing Astronomy" aims to develop an understanding of topics like these with sections on planets, stars, galaxies, extraterrestrial life and the origin of the universe and even if you are a newcomer to science, don't worry because the course introduces new scientific ideas as and when you need them, progressively developing more sophisticated concepts and skills along the way. If you are an amateur astronomer or just interested in reading popular books on astronomy, you will find that "Introducing Astronomy" will improve your understanding of the subject and perhaps introduce you to areas of astronomy that you might not have met before. To find out more about this or any of the OU's other short science courses, log onto ww3.open.ac.uk/study, click on the link to science on the right hand side of the page and follow the appropriate links. And so to the final sequence in this take away science podcast. Earlier this year we paid a visit to the 2008 Royal Society Summer Exhibition where we got the chance to eavesdrop on two space scientists, Professor Andrew Coates from the Mullard Space Science Laboratory at University College London and Elizabeth Seward, a space mission scientist at EADS Astrium. They were discussing their science heroes, let's hear what they have got to say.

**Professor Coates**
I think one of my heroes of space science is James Van Allen, so this is one of the real pioneers of the space age, he was involved at the beginning, the very first satellites which were going up into orbit and he discovered something which was completely unexpected um and you had to go into space to do it and that was the earth's radiation belts, we didn't know until Van Allen's work with the first scientific satellites that they were there. And they turned out to be even today a very important um thing to know about in terms of commercial satellites in space and other satellites in space because this um ring of radiation around the Earth is there and so that's sort of one of the things that as you go further and further into space you find of course things that er you hadn't expected in the past. And just at the moment in planetary exploration its a really interesting and er and er stimulating time because we have Cassini-Huygan's Saturn, we have Mars express, Mars Venus express and Venus and so even in Europe in space science its a wonderful time with getting data and we are also looking forward to the future with ExoMars. But you know the beginnings of space exploration were really sort of pioneering days and I think that's where some of my heroes lie.

**Elizabeth Seward**
I am Elizabeth Seward from Astrium, we are a space company so we build and design satellites, but also the whole range of space services from launches to operating satellites in space. My space hero, or my science hero would actually be Arthur C Clarke who is more well known for his science fiction books, but he was in fact a physicist who came up with the idea of geostationary satellites, so this is the orbit where satellites take 24 hours to orbit the earth, which means they hover over the same point on the earth if you put them above the equator. But he was my hero, not really for that, but because he wove all of this science into his science fiction novels so it was all true and accurate and it gave me my first taste of space

and science which is what made me become interested in it and go on to work for a satellite company.

**Mike Bullivant**
Space scientists Andrew Coates and Elizabeth Seward there. You know there is a second level Open University course called “Planetary Science and the Search for Life” which tackles some of the really fundamental questions about our solar system. For instance how did the solar system form and how has it evolved, why aren’t all the planets like earth, how and why did life arise on earth, has life arisen elsewhere in the solar system or beyond and could it be intelligent? “Planetary Science and the Search for Life” takes a close look at the exploration of the solar system by space craft, planetary processes such as volcanism and impacts, the structure of planets and their atmospheres and asteroids, comets and meteorites. The course comprises two modules each consisting of a full colour book supported by DVD and web based materials. To find out more about planetary science and the search for life, or any other OU course for that matter, log onto ww3.open.ac.uk/study, as ever click on the link to science on the right hand side of the page and follow the links to astronomy. Well that’s the end of this particular take away science podcast brought to you by BLAST! at the Open University. For other podcasts in the series, revisit the Open University Science Faculty website at open.ac.uk/science and if you want to find out more about some of the science outreach work carried out by the OU, visit the BLAST! web pages at blast.open.ac.uk. But that’s all from now, so from me Mike Bullivant, adios amigos.