July 2018 Lecture Review by **Wendy Knaap**

Speaker: - Dr. Iacopo Vivarelli of Sussex University

Subject: - **"Discoveries At The Large Hadron Collider" - including The Higgs Boson: A Look Beyond the Media Hype**

We were fortunate to receive Dr. Vivarelli as our guest speaker for the month of July, who has done a lot of research on Particle Physics associated with 'The Large Hadron Collider' in Geneva, Switzerland.

Last year I attended 'The SAGAS' Summer Convention at Hampshire, along with a few other members of our Society and heard Dr. Iacopo Vivarelli's excellent talk and very quickly made up my mind to catch him before he left - so I could arrange an appointment for him to talk to us too!.

Iacopo opened his talk by introducing his young daughter to us, by means of visuals and quotes taken from conversations between Father and daughter! They were innocent, inquisitive quotes..such as ..'Why ? How ? and When ?? - She wanted answers and was very keen to learn about everything in our World and Universe as we all strive to do the same.

'ROSETTA'

...Our search included Comet-Chasing..the oldest building blocks of our Solar System. By launching a Spacecraft called 'Rosetta' to orbit a comet and land a probe on it's surface, the ESA Mission endeavoured to find a key to deciphering the origins of the Solar System and quite possibly the Sparks of Life on Earth!

The Spacecraft was aptly named after the Rosetta Stone (a slab of Volcanic Basalt weighing 762 kilos discovered in Egypt, and was inscribed with Hieroglyphics with symbols presumed to be sent from a God) - This became the key to unravelling a long lost culture within the civilisation of Ancient Egypt and nearby countries; and we wanted to examine the nucleus of Comet 67P/C-G at close proximity, yet 4 Billion miles away!

The 'Philae' Lander (named after an inscribed artefact discovered in the River Nile) was the 1st Space Probe to land on the Comet on November 12th 2014 reaching the closest point to the Sun in its orbit as it was heading for it's destination. The mission was a collective effort costing £10 Billion! - with support from several different countries. It was launched in 2004. At one stage after 10 years of traversing the Universe it started to lose power and it's activity became 'frozen' until it was warmed by the Sun and started functioning again.

EARLY UNIVERSE

Iacopo then showed us an animation of 2 Black Holes that had merged Millions of years ago, which then collapsed and released a Huge amount of Energy. This involved Gravitational Waves - invisible ripples which caused disturbance and Curvature of Space-Time in the Early Universe generated by accelerating masses. They move outwards as waves from their source at the Speed of Light.

We continue to learn how The Universe developed by using data from past, present and

future ESA Missions. The Early Universe was very Dense as it had not had a chance to expand much then and had very strong gravitational waves. The closer the objects the stronger the Gravitational Force between them.

PARTICLE MASSES

All the Particles in the Early Universe have had a role in shaping our Universe. ' The Higgs Boson ' in particular, played a major role. An Energy Field that is called ' The Higgs Field ' permeated the Entire Universe. The accelerating masses caused The Higgs Boson to increase in Mass and raised the amount of energy needed to make the Higgs Bosons attract each other - This Elementary Particle helps give Mass to all elementary particles that already have Mass, such as Electrons and Protons. The Electron particle has a Negative Charge and is the smallest yet numerous part of the Atom, whereas The Proton has a Positive Charge and much Greater Mass than an Electron particle. (A Photon does not interact with The Higgs Field at all as it has no mass!)

MICROSCOPIC WORLD

Atoms are the Basic Units of what we know as Matter and consist of 3 basic parts - known as Sub-Atomic Particles ..as they are smaller than the Atom:- a)Protons b)Electrons an c) Neutrons.) The Neutron has No charge at all!

The Standard Model of Particle Physics is an important concept of theories and facts about the Universe and how it came to exist and some of these were observed or predicted long ago. It classifies all fundamental particles which includes sub-atomic particles and even smaller composite particles known as The Building Blocks such as Leptons and Quarks and a whole lot more! It describes how they interact with each other including reactions with The Forces of Nature. Leptons do not interact with the Strong Nuclear Force yet Quarks do.

Matter contains elements and is also built of Molecules - for example 2 Atoms of Hydrogen and 1 Oxygen = The Water Molecule. The Molecular Formula is H20. (H=Hydrogen and 0 =Oxygen). The Oxygen Atom also carries 2 pairs of Electrons.

FORCES

Without Forces the countless numbers of sub-atomic particles would wander around the Cosmos without interacting with each other! There would not be any Elements or Matter so The Universe as we know it would not exist.

There are 4 types of Forces which interact with The Gauge Boson sub-particle which is The Carrier of The Forces: -

1. The GRAVITATIONAL Force - which holds together The Universe, Atmosphere, Water, plus ourselves to our Planet. The Force could be made up of Particles which travel at the Speed of Light and is a Force of Attraction. Although it had a major role in the Evolution of The Early Universe and caused Matter to clump together, Scientists still have a lot of research to do to enable them to fully understand it, as it is a very weak force compared to

the other forces; therefore it is not part of the Standard Model at the present time.

2. The ELECTROMAGNETIC Force - focuses on Atoms binding Electrons to Atoms and then interacting to one another to form Molecules and Compounds. The subatomic Photon particle or 'Photon' Gauge Boson is the Force Carrier for Light. Electricity and Magnetism are part of the Electromagnetic Force. One example is a Magnetic object that sticks to a fridge door!

3. The STRONG Force - Stronger than The Electromagnetic force and another Force of Attraction that acts between the Protons and Neutrons of Atoms. This is called 'The Gluon' Gauge Boson particle. It binds the Nuclei together with Terrific Force - Nuclear Fusion reactions occur on the surface of the Sun. The Strong Energy produced is Nuclear Power and is used in Nuclear Weapons. Radiation is an effect of an excessive amount of this Power.

4. The WEAK Force - The Sun could have Burnt out if it wasn't for the weak force !..It controlled the 1st stage of the Sun's Fusion Cycle so that it only just keeps alight. It was able to convert Protons into Neutrons and vice-versa, also transferring Momentum. - The Radioactive decay process known as Fission relates to 'W and Z ' Gauge Boson particles working together, to break things down. The Sun continues to burn 'slowly' since 5 Billion years ago!

A Force can cause an object with Mass to Accelerate, either by Pushing or Pulling and can Change the Shape of an Object.

HIGH-ENERGY EXPERIMENTAL RESEARCH

In order to study the basic constituents of Matter - the very small Fundamental Particles in finer detail, a very Large Scientific Centre was constructed in Geneva Switzerland. It is known as 'CERN' and is translated from French as 'The European Organisation for Nuclear Research'. It houses 'The Large Hadron Collider' and at 27 km in circumference it is The Biggest and most Powerful Simulator in the World for conducting tests on small particles and aims to recreate events from The Early Universe.

The purpose of The Circular Mechanism involves a System by which many types of Atoms and Particles such as Protons are injected into The Collider and Accelerated at a Very High Speed to collide and interact with each other to see what evolves and find out more information about them. The particles whirl around in opposite directions and bounce off each other. This process is helped along by the use of the Force of Strong Magnets. Collisions happen at almost The Speed of Light exchanging Energy for Mass.

HOT & COLD

Energy and Temperature are connected to one another and The High Energy Collisions

between the Charged Protons cause Extreme Heat. The phase of Transition of Forces and Temperatures working together known as 'The Grand Unified Theory' is comparable to Ten-16 GeVs and one of the Hottest Laboratory Experiments tested at the LHC was in that range.

173 GeVs (Gigaelectricvolt) = 1 top Quark.

Kinetic Energy related to Motion is measured for its Heat in Joules. (1 unit of Kinetic Energy = 1 Joule 'J ')

'CERN may be one of the Hottest places in the World, in a sense,' - said Iacopo; but also one of the Coldest! - The Extreme heat had to be counteracted by something to Cool down the machinery equipment consisting of cables etc., so Liquid Helium is used for this purpose. Measurements of 1.9 Kelvin were used for the Extreme Differences in Temperature...this was slightly higher than Absolute Zero (- 273 centigrade) which is Colder than Interstellar Space!

PEBBLE ON THE BEACH

Back in the 1960's, Physicist Professor Peter Higgs was the first person to suggest that a certain Elementary Particle, (a Boson) was the Provider of Mass to sub-atomic particles. He reasoned that if a Particular particle with Mass was able to control and slow down some particles through interaction then some of the particles would attain Mass too .. partly related to Einstein's Theory $E = mc^2$ when conversely only Pure Energy takes over when a particle attains the Speed of Light. For many years the Professor was so convinced this particle existed that he initiated a Huge Laboratory to be built to carry out experiments and to prove his Theory. His efforts were worthwhile and so he was originally responsible for CERN and The Large Hadron Collider where they smash Atoms! The cost was €8 Billion.

It was a Huge Investment in terms of Science doing a Wonderful job and could be quoted as ' Accelerating Science! ' .. Peter needed to fill the 'missing gap' in The Standard Model. - At first the chances of finding 1 or two (h) Bosons was so remote that Iacopo said 'the search was compared to a Person picking up the same Pebble On A Beach over a distance from Worthing to Brighton!'. After many years of Research and Countless Collision Experiments for the Elusive particle at CERN, (with support from a few other Scientists) Professor Higgs - and another Physicist, Belgian Professor Francois Englert, finally made a breakthrough!....

it was so 'tiny' and difficult to detect initially, because it decayed very quickly before it could be observed. (It can decay into bottom quarks.) Particle Detectors were placed at 4 different points around the ring. - After a collision between 2 Protons as a result of High Speed Acceleration, the highly energetic 'Gluons' that fused together from the active 'Dancing' Quarks (as Iacopo describes them!) produced a transformation - A Higgs Boson.

The sub-atomic particles that came through after the smash were measured for their Mass. (The Higgs Bosons also interacted with themselves to become more Massive and become part of The Force Field that became known as 'The Higgs Field' that makes particles stick together.) - They were the Mediators. Most of the other particles gathered Mass and became part of 'The Higgs Field' through this Interaction. Quantum Mechanics also plays a Role in the Higgs Field. With the Collisions, Electro Signals in the Detectors alert the Scientists to changes. Higgs Bosons appear as a Flash of Light! The measurement of the Beam of Light was 350 M Joule. I Billion Electron Volts = 1 GeV.

THE NOBEL PRIZE

On 4th July 2012 it was announced that a New Particle in the Mass Region of around 126 GeV was confirmed to be 'The Higgs Boson', named after the Professor - and the following year The Nobel Prize in Physics was awarded jointly to Professor Higgs and Professor Francois Englert for "The Discovery that contributed to our understanding of the Origin of Mass of Subatomic Particles."

WHAT NEXT?

Since the Discovery was revealed to us, we look to the Future to see what else we can Find Out. After all, only 5% is explained of our Universe - 95% is not! - We need to find out So Much More...Looking at Old and New Particles and how they interact; Neutrinos that might actually have Mass after all, Secrets of Dark Energy and Dark Matter ...even Anti-Matter! and Quantum Magic etc. - and CERN is the place to do this. The World Wide Web Network was born from this Technology, Iacopo explained. There is also talk of building an even Greater Collider in the near Future. The World Is BIG!

Iacopo ended his interesting and absorbing talk with Words of Wisdom and Knowledge.. extracts taken from 'Dante's Inferno Cantos' written in the 14th Century: 'Consider your Origins, you were not made to live as Brutes but to follow Virtue and Knowledge' - also - 'Love that Moves The Sun and other Stars'.

It is hard to believe that Once Upon A Time every single particle was just Energy Travelling at The Speed of Light ! (With NO MASS)!

...Meanwhile Iacopo's little daughter will still continue to ask questions? - and wait for the answers!.. (just as we do)!

Forthcoming meetings

September 19th - Dr. David Bacon, University of Portsmouth "Probing the dark universe with a trio of extraordinary telescopes"

October 17th - AGM and other contributions

November 21st - Andy Thomas, Researcher, Author and Broadcaster "Unexplained Mysteries and Cover-Ups" covering UFOs and related phenomena…a lecture guaranteed to spark debate!

December 19th - Professor Andrew Coates; Looking for Life-On- Mars with the Exo Mars 2020 - Rover 116 Mission

January 16th 2019 - WAS Social

February 20th 2019 - Nick Quinn; Amateur Meteor Studies in the 21st Century

March 20th 2019 - William Joyce F.R.A.S. – "Astrobiology"

April 17th 2019 - Dr Dirk Froebrich - Hunting Outbursting Young Stars – a project that WAS members can participate in

May 15th 2019 - Dr Chris Pearson – "A Decade to the Day of the Launch of the Herschel Observatory"

June 19th 2019 - Steve Scott, Mission Director of Gee- Archaeological Survey ; Pyramids, Temples and Sun Worship in Ancient Egypt