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2012
SUMMER

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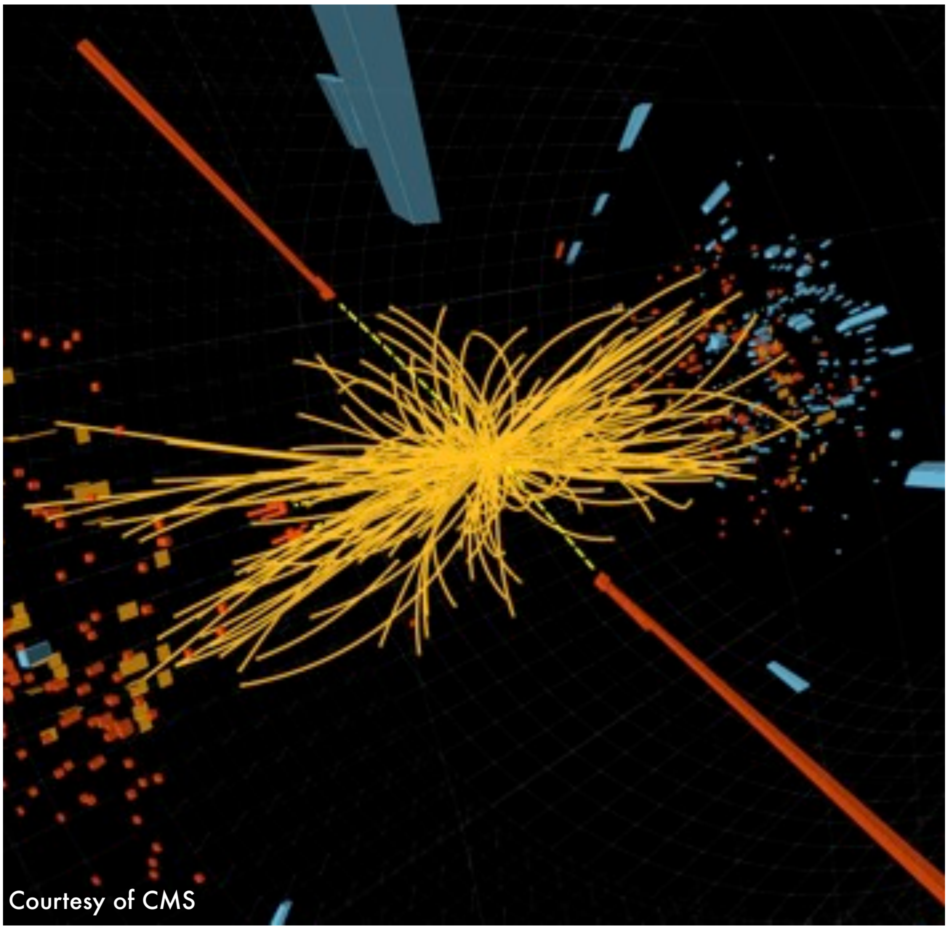
2012 jIAPS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Editor's Note

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Welcome to the ICPS 2012 issue of the journal of the International Association of Physics Students. This issue will be covering all the articles submitted in the academic year 2011 - 2012, covering topics from geophysics to electronics and quantum physics.

This year we are proud to announce that all of our new articles will be going online on a new website: http://jiaps.org

Anyone interested in writing an article related to physics to be published in this journal, please send us an email at editors@jiaps.org If you have any comments or suggestions, please send them to the same email above, or feel free to contact me directly.

In addition, I will be giving a talk on how to write great articles and some tips for jIAPS at the IAPS workshop on the 6th of August at 15:00.

Contents:

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international association of physics students

IAPS Overview

Dear Reader, what you now hold in your hand is the yearly printed version of the Journal of the International Association of Physics Students (IAPS), the organisation responsible for having ICPS organized annually. I hope you will find this an interesting read, and if not, I hope you are motivated enough to help make it better next time! In this article I will summarize what happened in the life of IAPS since the last ICPS and what will happen in the following days, but before I start, I must thank the organizers of ICPS 2012 for the huge amount of work they have already put into this conference and for the even more work they will do until the end of the conference. I hope that in the end they will feel that it was worth every minute and that the participants will feel that the organizers deserve the applause.

Probably the most important thing that has happened to IAPS this year, is that the International Union of Pure and Applied Physics, the umbrella organisation of the world's physical societies, has officially agreed to help IAPS in many ways. This is the culmination of the effort of quite a few years and, if all goes well, by the time you are reading this article we will have the first result of this help.

We have also laid the foundations of change in the happenings of IAPS, by introducing two grants: one can be applied for by our National and Local Committees (the IMAP grant) and one by individuals not living in Europe (the ICPS Worldwide grant). The aim of the first grant is to provide funds for physics students from different countries to meet and one section of the IAPS Workshop will aim to encourage applications for this grant. The other grant is somewhat more simple: it will fund physics students living outside of Europe to attend ICPS.

There were also several events held by our National and Local Committees that were open to all IAPS members, but IAPS itself also organises a now traditional trip to CERN, which was very successful again.

During this ICPS there will be two events related directly to IAPS: the Annual General Meeting (AGM) and the Workshops. The AGM is the institution of IAPS that elects the new Executive Committee (EC), decides where the next ICPS will be held and very importantly, we plan debate over a document that will decide how IAPS is going to operate in the next decade. As a member of IAPS you are more than welcome to attend, and if you are interested in working in the EC, want to know more about IAPS, or want to sound your opinion in the future of IAPS or where the next ICPS will be, you should definitely be there! As for the Workshop, it will cover three topics: organising trips (based on the example of the IAPS CERN trip), jIAPS, and making applications for the IMAP grant. If you are the type that does not only just enjoy the benefits of community, but would like to contribute to it also, then you should drop by.

By Bence Ferdinandy
IAPS EC Vice-President 2011-2012

Radio Frequency Identification (RFID)

By Eric Pace
(ericpace@gmail.com)

History

RFIDs have existed for over 50 years and devices that roughly resemble the operating principles of RFIDs can be traced back to the Second World War [1]. German scientists at the time discovered that by rolling their planes whenever they were returning to base, pilots changed the reflected radio signal and thus the radar crew on the ground could identify the aircraft [1, 2].

This system turned out to be a rudimentary form of a passive RFID. The British were also working on similar technology, and under Watson-Watt, the so-called Identify Friend or Foe system was developed.

The first work exploring these systems was published by Harry Stockman in the paper, “Communication by means of reflected power” [3]. The first patent for an RFID system employing active tags and re-writable storage was received in the 1970s [1].

In the 1990s RFID technology was being deployed commercially, mainly finding applications such as electronic toll collection. Having been successful, other business areas were investing in RFID technology, most notably by Walmart.

Today, a single tag could be used for electronic toll collection, parking lot access as well as access to gated communities [1].

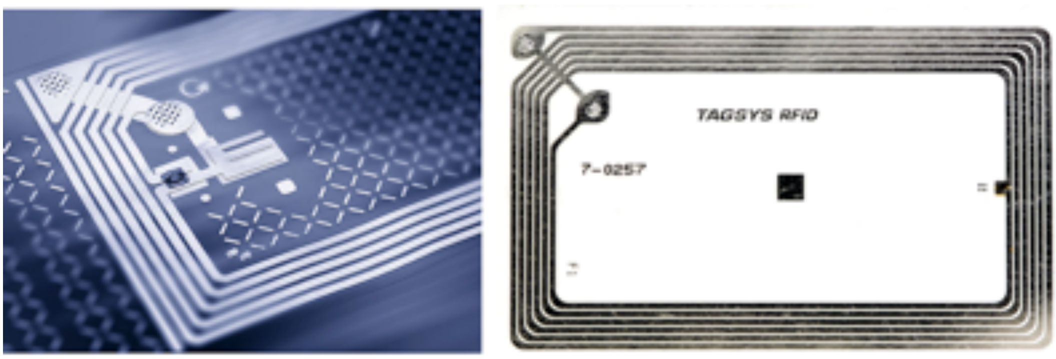

Figure 1: The images above illustrate the circuit and semiconductor chip that form a typical RFID tag [4, 5]

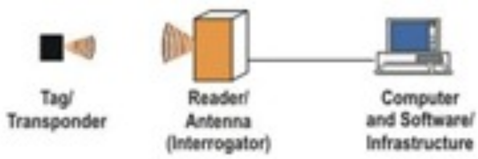

Figure 2: RFID system.[6]

Advantages

Currently, the more traditional barcode system is more widely used than RFID for tagging products and it is still the technology of choice for many applications. This is mainly due to the fact that RFIDs are more expensive. Thus we will not be seeing barcodes disappear any time soon.

However, there are many areas where RFID technology has prevailed. These are mainly industrial areas involving the shipment of goods.

The major advantage of RFID is that it does not require LoS to operate and thus products may be scanned from a distance, even if they are packaged in boxes or containers. While barcode systems are able to scan one item at a time, RFID systems can scan collections of items instantaneously, reducing labor requirements [7]. Further advantages are that they can interrogate multiple items at the same time; they do not incur maintenance costs; they can store large amounts amounts of data (when compared to barcodes).

RFID Types

RFIDs may be categorized according to detection limits that different technologies impose on them.

Close Coupled

RFIDs operating the shortest range are called close-coupled systems. Typical interaction distance ranges from 0 cm (contact) up to 1 cm. At these ranges these systems generally operate in the near-field. Thus the tag and the reader are coupled using both electric and magnetic fields and operate up to a range of 30 MHz.

Close-coupling allows for the transfer of sufficient power to operate microprocessors in the tag. Such systems find application mostly in security strict environments [8].

Remote Coupled

These middle range systems operate mainly in the far-field region and have ranges up to 1 m. They are based on magnetic induction caused reader within the tag and are thus known as inductive radio systems [8].

There are also a few systems employing capacitive coupling, however these form only 10% of the remote coupled category [8].

Long Range

Having the greatest range of operation, these systems operate via ultra high frequency electromagnetic waves. As a result, these systems use a different operating principle known as backscatter[8], and are thus known as backscatter systems. With passive backscatter, distances up to 3 metres may be achieved, while with active backscatter systems, ranges up to 15 metres have been achieved. Apart from backscatter systems, there are systems which use surface acoustic waves in the microwave range [8].

Power

Another way of classifying RFID systems is according to the way they receive power. The main distinction is between passive and active tags, however some sources mention semi-passive tags as well. However for most purposes, the terms active and semi-passive are analogous.

Passive Tags

Passive RFID tags consist of an antenna, a semiconductor chip attached to the antenna and a protective covering to withstand environmental wear and to allow for easy attachment to goods. They are called passive RFID tags for the simple reason that they have no dedicated power source, but are powered completely through the field generated by the RFID reader itself [10]. The tag antenna captures the energy and powers the semiconductor chip just enough to transmit its ID. The covering is usually made out of glass or a laminar plastic substrate [11].

Passive tags can be very small, as they do not require a battery. Passive tags may be as small as a coin, however the smaller the tag, the shorter the read range [12]. Current passive RFID tags contain about 16 to 64 KB of memory [7].

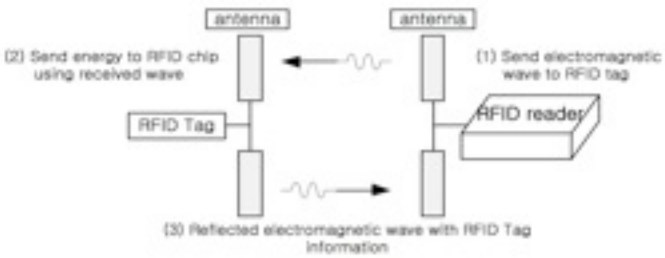

Figure 3: This is an example of a Passive RFID tag[9]

The reader device may be set up to either broadcast its electromagnetic (EM) signal continuously or otherwise broadcast only when necessary. When the read is brought near an RFID tag, the EM signal is received by the tag through its antenna. Using diodes to rectify the radio frequency voltage, a charge within the tag's capacitor is built up. A return signal is sent once the capacitor has built a sufficient amount of charge. This return signal is modulated according the data that is being sent to the reader.

Active Tags

Active tags, unlike their passive counterparts, have their own power source, allowing them to transmit stronger signals which increases their broadcast range significantly. The on-board power source makes these class of tags much more expensive. It also requires the tag to have larger physical dimensions. The typical sizes of active tags vary between the size of car key-fobs to the size of a mobile phone, depending on the ranges required.

Due to these limitations, these tags are used to track large items over large distances, such as container shipments from one country to another. Active tags are also useful when memory requirements and read ranges require the RFID system to operate at higher frequencies of up to 2.45GHz or 5.8GHz [12]. This is not possible with passive tags since they cannot provide sufficient power.

Physical Principles

Near-Field

"Faraday's principle of magnetic induction is the basis of near-field coupling between a reader and a tag" [11]. A reader will establish an alternating magnetic field such that when a tag is placed within it, an alternating voltage is generated across its coils. The voltage may be rectified and accumulated in a capacitor to then be used to power the semiconductor. Tags that use near-field coupling use load-modulation.

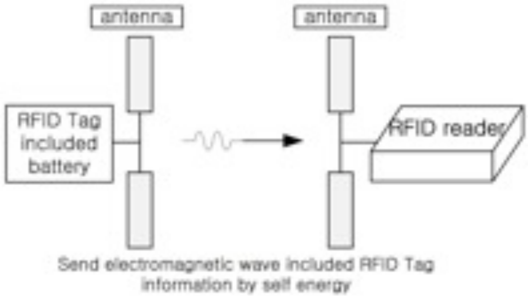

Figure 4: This is an example of an Active RFID tag[9]

Since the tag is powered by the magnetic field, this power consumption may be measured as a voltage drop in the reader antenna. The tag is supplied with a load resistance which may be switched on and off according to what data needs to be transmitted. The toggling of the load resistance will result voltage fluctuations which may be decoded by the reader to identify the data being sent – this technique is known as load-modulation, described below.

The issue with near-field communication is that as we increase the frequency, the distance over which the near-field coupling can operate decreases, according to the equation:

$$r = \frac{c}{2\pi f}$$

where f is the frequency of operation, c the speed of light and r is the usable range. Also the range over which we may transfer energy via the magnetic field drops at a rate of $1/r^3$. Such limitations have led to techniques that make use of far-field coupling.

Far-Field

The tag receives EM waves propagating from the dipole antenna through a smaller dipole antenna attached to the tag. In these systems, the alternating voltage may be accumulated by rectifying it using a diode and charging up a capacitor. However unlike the near-field, the information held in the tag cannot be transmitted back to the reader using load-modulation.

The technique designers use for commercial far-field tags is called back scattering. In this technique the antenna will reflect back some of the energy, depending on its impedance. By varying this impedance with time, the tag's ID pattern may be reflected back. Impedance tuning can be achieved by connecting a transistor across the dipole antenna.

Systems using far-field principles normally operate in the Ultra High Frequency (UHF) band (around 2.45GHz) and these systems' range is limited by the energy that reaches the tag and by how sensitive the reader is to the reflected signal "The actual return signal is very small, because it is the result of two attenuations, each based on an inverse square law. Thus the returning energy is $1/r^4$ [11].

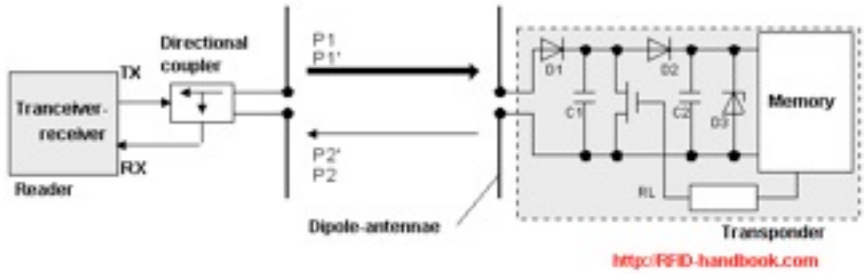

Figure 5: Figure showing how Backscatter works[8]

Today, semiconductors require much less power to operate and with receivers of greater sensitivity, readers employing this system can interrogate tags up to 3 metres away [11].

Backscatter

RFID systems operating at ranges greater than 1 metre operate using the far-field principle and operate in the UHF bands. Such short wavelengths makes it possible to build very small antennae.

"Electromagnetic waves are reflected by objects with dimensions greater than around half the wavelength of the wave. The efficiency with which an object reflects electromagnetic waves is described by its reflection cross-section" [8]. When objects are resonating with the incident wave, such as what occurs when transmitting a signal at the resonating frequency of an antenna, a large reflection cross-section is observed. The reflection characteristics are further changed by varying the antenna's resistance [8].

Figure 5 illustrates the backscatter operation. Power P_1 is emitted from the reader. Following attenuation, power arrives at the antennae of the tag as RF voltage. This voltage is rectified using Schottky diodes and as they have a low threshold voltage. Power is reflected from the tag back to the reader. The amplitude of this power is modulated according to the data being transmitted. Power arrives at the reader after attenuation.

Powers P_1 and P_2 are travelling in opposite direction. Since power is stronger by a few orders of magnitude, it can be suppressed by a directional coupler. The ratio can be estimated using the radar equation.

Surface Acoustic Waves

Surface Acoustic Wave (SAW) devices are based on the piezoelectric effect. A mechanical stress on certain materials results in voltage across them [13]. This effect is also reversible. Usually these devices are operated in the 2.45GHz region.

The reader generates a pulse that is received by a transducer which converts the EM wave into an acoustic wave. The frequency of the surface wave corresponds to the transmission frequency. There are reflective strips affixed to the substrate positioned at varying distances which reflect the acoustic wave back to the transducer.

The number of pulses received by the transducer corresponds to the number of reflective strips. The delay between pulses corresponds to the distance between the strips. These pulses are converted back to high frequency EM waves and propagated back to the reader [8].

The storage capacity of a SAW based tag depends on the length of the substrate and on the minimum realizable distance between reflective strips. Ranges up to 1 to 2 metres may be achieved.

Applications

There are many areas where RFID technology has been found useful, as is mentioned in many articles.

David Dorman discusses library security systems [14]. Designs for communication between covert RFID tags are described in the paper by Pan and Narayanan [15].RFID systems have also found uses in blood banking for automatic inventory check-in [16]. A paper by Ziai and Batchelor discusses how people may be monitored via a new concept of placing ultra thin tags directly on the skin in the form of a tattoo.

Security

Today, most organizations require an efficient access control system.

This is mainly because the organization needs to control access to restricted areas and monitor employee activity within the premises. RFID is a great solution as the tags may be read from great distances away and multiple tags may be read at the same time.

Weapons Tracking

An example of Weapons tracking is the Australian Customs and Border Protection Service. Officers monitor the use of all weapons, vehicles and other gear and thus a system to provide real-time visibility into these assets is required. The initial solution to this problem was to use a flat file system and exchange it between central offices. However such reports were often inaccurate.

HF (13.56MHz) RFID system was adopted to replace the flat file system. With the RFIDs in place, the central office can track exactly where the items are located and immediately address any misplacements or losses.

Animal Tracking

For stock keeping, and in an effort to control epidemics, RFIDs are being used on livestock. There are different types of RFIDs such as collars or injectable tags or ear tags. RFID allows the identification and tracking of individual animals and this allows the owners to manage feeding patterns and generate statistics for each animal in the livestock. Such information helps in the determination of when the animal should be bred or sent to the market.

Animal health is also an area which receives aid from RFIDs. "The ability to trace back through the food chain provides national and international health agencies a valuable tool in controlling the spread of diseases" [17]. RFID systems are also being used in zoos for Real Time Tracking (RTL) of elephants via ankle bracelets [18]. The readers are positioned in towers and track the movement of the elephants.

Clothes Tracking

The best example of clothes tracking is Walmart. The company has been amongst the first to adopt RFID technology in order to be able to track shipments of products through the supply chain [19]. Recently in 2010, Walmart has also decided to adopt a more a rigorous approach as it now tracks individual items, insisting that "the devices are crucial to improving the logistics of inventory management" [20].

Hazards

Radiation

Electric fields may be divided into ionizing and non-ionizing radiation. "If EM energy is considered as a photon, then the energy of the photon depends on the frequency. The higher the frequency, the higher the energy" [21].

"The ionization energy or ionization potential is the energy necessary to remove an electron from the neutral atom" [22]. Photon energy must be higher than 300GHz [21] in order to be considered as ionizing. Thus RFID frequencies (operating between a few hertz up to 2.4GHz) are non-ionizing [23].

In studies of effects of radio waves on humans, two perspectives are considered:

1. the whole body averaged "specific absorption rate (SAR). SAR is the mass-normalized rate at which the energy of an electromagnetic field is coupled into an absorbing body; it has units of Watts per Kg" [23].
2. the RF-energy-induced core-temperature increase, known as thermal effects.

Studies on non-ionizing fields have shown that there are short term thermal effects, however no long term effects such as sterility or cancer have been observed [21].

The concerns regarding thermal effects is mostly localized to parts of the body which have a relative lack of blood flow, such as the eyes. The lack of blood flow means that there is lower heat dissipation. It has been shown that short term exposure (up to an hour) to very high levels of radiation can cause cataracts in rabbits [23].

There is no convincing evidence that exposure to RF radiation shortens the lifespan of human beings or that it is a carcinogen. However, there is evidence that chronic exposure to RF radiation with SAR of about 2 to 3 W/kg resulted in cancer promotion in mice [23].

Tags in Patients

The U.S. Food and Drug Administration (FDA) raised issues that patients implanted with an RFID tag will make them incompatible to MRI [24]. In a study by James Lambert, it was found that the "device is safe inside a patient during MRI testing as far as device movement, heating, and image distortion [are concerned]. However, the device may fail due to the MRI exam."

Also researchers have found [25, 26] that "high-frequency (HF) 13.56 MHz RFID tags do not significantly interfere with the functionality of imaging devices, nor do those devices affect the tags' functionality."

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CAPS 2012 Sheffield

The Conference of Astronomy and Physics Students (CAPS) is open to all students studying in the UK & Republic of Ireland. The conference invites students to present short lectures to their peers on an area of physics that they find fascinating. It aims to bring students together to learn new physics, make friends and gain invaluable experience at presenting their ideas to a larger audience than they would otherwise.

CAPS is a very new event, it started last year in Edinburgh at Heriot-Watt University. This year students from across the country (and even a few from mainland Europe) headed to Sheffield for a weekend to listen to student lectures on interesting topics in physics today – ranging from quantum mechanics to the northern lights. The weekend also featured a guest lecture by Dr Susan Cartwright of the University of Sheffield who was kind enough to give up her time to talk about neutrino physics.

The conference targets physics societies in particular so that they can share ideas and organise joint events. A big part of the weekend was the society awards which was set up last year to recognise achievements by societies across the British Isles. Six societies were shortlisted and then had the chance to present to the whole conference on why they should win the award. The delegates then voted for their favourite who this year were the University of Manchester PhysSoc!

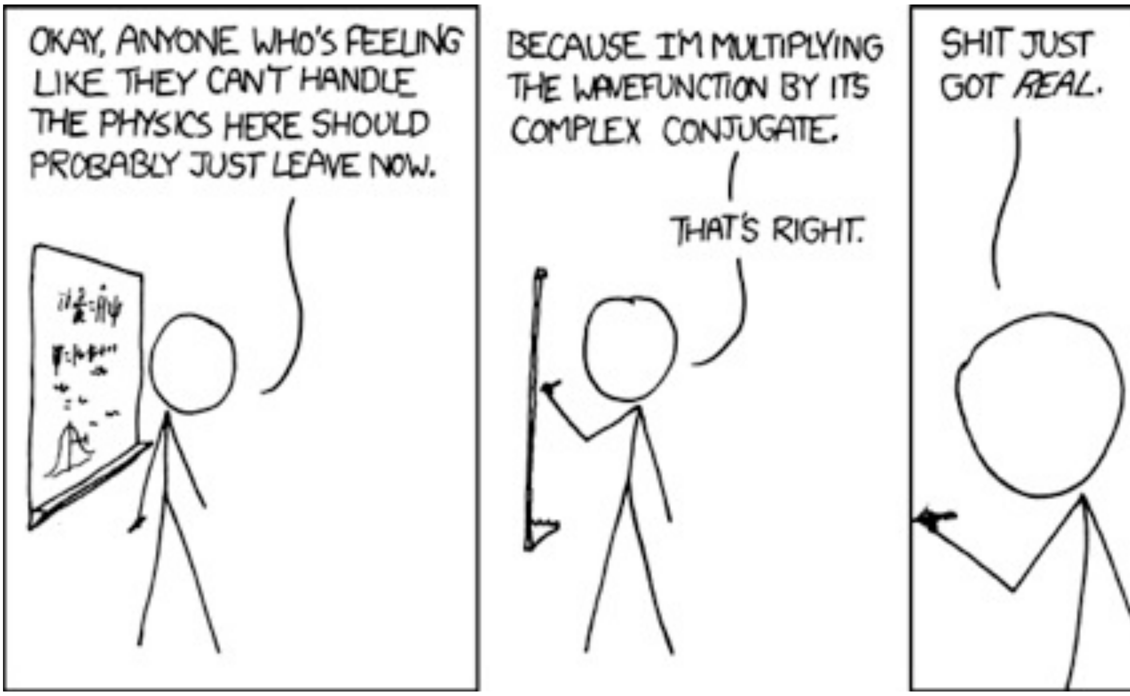
With 80 delegates, 15 student lectures, a guest lecture, a pub quiz, a formal meal and a number of parties the weekend was a huge success! CAPS has now established itself as the national group of physics societies for the UK & Republic of Ireland and the conference can continue to grow next year.

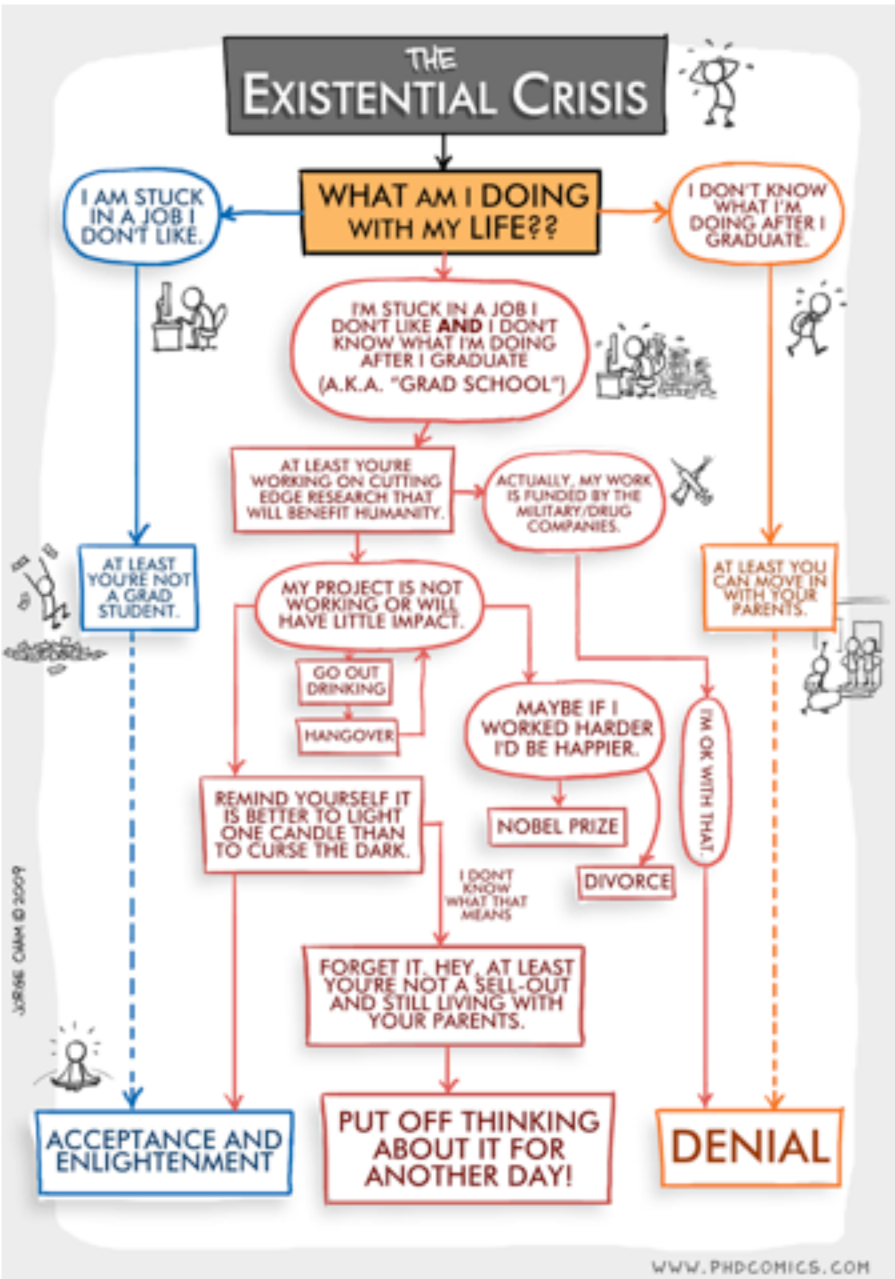
By Charlotte Nicolaou

Pictures by Mischa Stocklin

FUN PAGE

http://xkcd.com/849/





Understanding the Seismic Cycle on the Sunda Megathrust West of Sumatra

By Denise De Gaetano

(denise_de_gaetano@hotmail.com)

The Sumatran plate boundary is a region which is the subject of continuous and ongoing studies (Figure 1). This is mostly due to the fact that it was always prone to great earthquakes and it is also believed that in the near future, it will be the site of another great earthquake [Sieh et al., 2008]. In fact, this area is classified as a high seismic risk area. The unique feature of this region is paleogeodetic records obtained from coral microatolls. Microatolls not only produce paleogeodetic data, but also track the aseimic deformation that occurs between earthquakes [Natawidjaja et al., 2004]. The subduction margin has an abundance of coastline above the locked part of the subduction megathrust. This makes microatolls particularly well suited for studying the cyclic accumulation and relief of tectonic strains. The paleogeodetic studies have shown that the amount of slip that occurred beneath the islands in 1833 was far greater than that which could have accumulated between 1797 and 1833. The strain was not all relieved in the slip of 1797, whereas in 1833 the slip relieved more strain than that accumulated in the years since 1797 [Natawidjaja et al., 2006]. Apart from paleogeodetic records, GPS surveys have been used to obtain data for modeling the megathrust south of the Pagai Islands, which megathrust was found to be creeping at the rate of the plate velocity. This confirms that the 400 km long section beneath Siberut, Sipora and the Pagai islands, is a highly coupled patch [Chlieh et al., 2007].

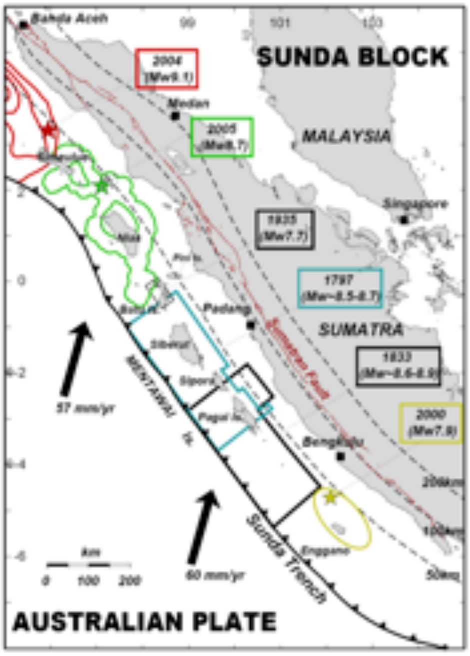


Figure 1 [Chlieh et al., 2007]: Map of the major structural elements and seismicity of the Sumatran plate boundary. Oblique subduction of the Indian and Australian plates beneath Sumatra is accommodated principally by slip on the Sumatran subduction zone and the dextral Sumatran fault. The green and red contours are 5m contours of slip for the 2004 Sumatra-Andaman and 2005 Nias-Simeulue Earthquakes. The black and blue rectangles are the limits of rupture during the great 1797 and 1833 earthquakes, from elastic dislocation models based upon uplift of coral microatolls. Dashed lines are the 50, 100 and 200 km depth of the megathrust.

GPS surveys have contributed to the study of trench-normal convergence rates, which amounts to about 5 cm/yr [Subarya et al., 2006] (Figure 2). This implies that strain released on the northern part of the Sumatra section could be greater than 10 m, whilst the southern part slip could be as great as in 1833, up to 10 m. Through experience of the Sumatra–Andaman and Simeulue–Nias events, this indicates that it could be nearing the end of its seismic cycle, and therefore there may be a threat of another large magnitude earthquake [Nalbant et al., 2005]. The Simeulue–Nias earthquake has altered appreciably the stress in the region. The section near Banda Acech, was only affected slightly, but increases of stress on the Sumatra fault south of the region has been recorded. [McCloskey et al., 2005] have calculated a stress increase of up to 5 bars (Figure 3) in the 50 km of the Sunda trench next to the rupture zone and also a strong positive loading of up to 9 bars for about 300 km on the Sumatra fault near the city of Banda Aceh. Due to viscoelastic relaxation in the lower crust, this stress may be expected to migrate further south over time [Nalbant et al., 2005]. The increased stress on the distributions of coseismic stress and on the vertical strike–slip Sumatra fault increases further the earthquake hazard. There is an increased potential for a large subduction-zone event [McCloskey et al., 2005].

Figure 2: Setting and sources of the giant earthquakes of 2004 and 2005, illustrating the convergence rates, where Sm, Simeulue island; Ni, Nias island; Bt, Batu islands; Mt, Mentawai islands [Sieh 2006].

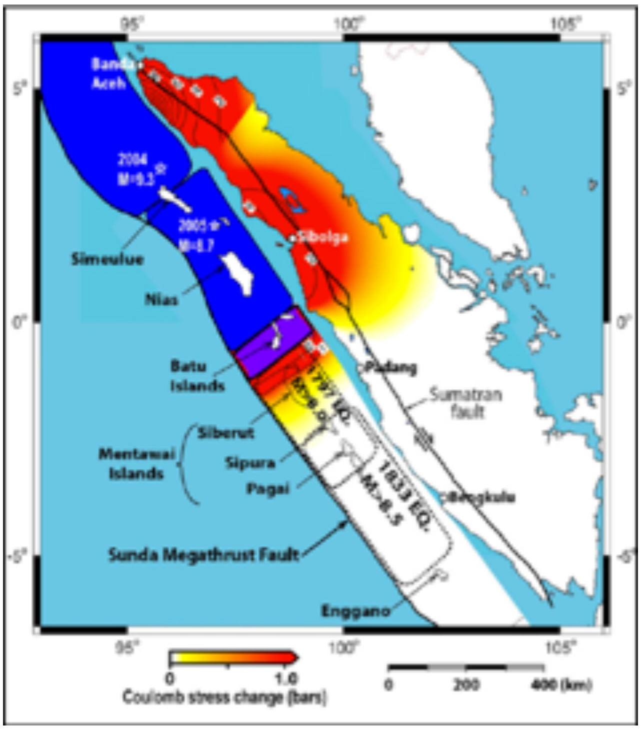


Figure 3: Historical earthquakes and interaction stresses on the Sunda megathrust. The traces of important faults are indicated by solid lines. Main historical earthquake ruptures are shown with dotted lines. Stars indicate epicentres and dark blue areas indicate extent of recent great earthquake ruptures. The yellow-red colour scale indicates the current interaction stresses [McCloskey et al., 2008].

Monte Carlo modeling was used to get a better understanding of the state of the Sunda megathrust to forecast the range of possible tsunamis which might be experienced following the next great Mentawai Island earthquake [McCloskey et al., 2007]. Details of slip distribution and interaction of slip with the local and regional bathymetry determine the tsunamigenic potential of future ruptures beneath the Mentawai Islands [McCloskey et al., 2008]. Such modeling and results obtained may help in the preparedness strategies throughout the western Sumatran forearc complex [McCloskey et al., 2007]. The simulations have clearly shown that the resulting tsunamis result from details of the bathymetry and the distribution of the slip on the earthquake. In order to prepare communities in Sumatra for such future events, further studies must be carried out on strain accumulation, earthquake nucleation and rupture propagation and termination.

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Conformal Gravity:
Possibly the Next Revolution in Gravity Research

By Jackson Levi Said
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The problem of gravitation in all likelihood goes back to the very first questions Man asked about the world, however to this day problems persists with our understanding of the how and why it works the way it does. What is and was clear at the time is that that mass is attracted to the ground but for a very long time indeed it was taboo to even ponder whether the dots on the sky are subject to the laws that govern this mechanism. In fact Giordano Bruno an Italian Friar was burned at the stake in 1600 for holding the view that the Sun is just one of a class of many such objects, stars, that may also harbor planets with worlds similar to this one.

It was not until Isaac Newton came along with his idea of Gravitation that the problem was given its first real empirical solution. There are scholarly disputes as to whether Newton should be accredited with first proposing the model, but as far as science is concerned the important thing is that the idea was taken on by the community. This model of how neutral matter attracts works by taking a direct proportionality with the product of the two masses in question interacting and more importantly an inverse proportion to the square of the distance between the objects, all with a gravitational coupling constant G to represent the strength of the force

$$F_1 = F_2 = G\frac{m_1 \times m_2}{r^2}.$$

The inverse distance squared part is very important, if this were just an inverse relation then the Universe would have collapsed before we had a chance to evolve and on the other hand if this were a one on distance cube then the Universe would be much more sparse and objects such as the Earth would have to be much bigger to produce the gravity they do now. Another interesting part of this model is that the force measured by either object is equal which eludes to one important facet of gravity, that the force, that is the product of the mass and the resulting acceleration, must be equal for either object involved.

Alas in 1859 Newton's theory of gravitation met its first in a series of problems with astronomy at the hands of Urbain Le Verrier. The perihelion or closest point of Mercury to the Sun was found to move between every solar cycle in a way that was not predicted using Newtonian gravity. Despite quite sincere efforts the problem was not resolved in a satisfactory way until relativity came along.

Enter Einstein and his General Theory of Relativity in 1915 which revolutionized the very concept of gravity and utilized the modern techniques of describing geometry at the time. In general relativity the Universe is described as a collection of points traversed by a four dimensional coordinate system thus linking the three dimensions of space with the time dimension. Relativity allows for this so called background fabric to be curved and twisted by means of its foundational principle, that spacetime is curved in an exact relation to the mass-energy of objects lying on it. This begs the question of how can we talk about this curvature in a precise way? Which brings us back to the ancient Greek school of Pythagoras and the theorem with its namesake.

$$\Delta s^2 = 1 \times \Delta x^2 + 1 \times \Delta y^2.$$

In flat spacetime, where no mass-energy exists and spacetime is as we would imagine it namely completely flat, this relation holds, however introduce a little mass-energy and the background becomes curved as given by Einstein's General Relativity theory which can be thought of as Pythagoras' equation becoming a little off. In fact the amount that the theorem is off by lets us calculate precisely the amount of mass-energy a system has.

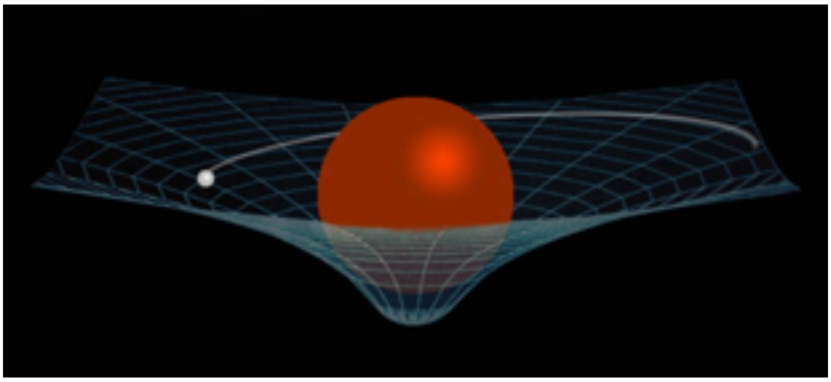

Fig 1. Curvature of spacetime.

This idea implies that there exists a background fabric that gets updated, in a sense, by changes in the mass-energy distribution about the Universe, in this way a big problem with Newtonian theory is solved, namely in general relativity we can see how gravity is felt by one object continuously. Whereas in Newtonian theory gravity is observed by a recipient object simultaneously which contradicts the speed of light information speed limit.

Again problems were found, first by Fritz Zwicky and later by many others, on the galactic scale (order of size, for galaxies this is between 1000 and 100 000 light years in general) the predicted value of angular velocity of stars rotating about the center of the galaxy, given the luminous matter observed, fell very much short of the necessary value required to produce the measured speed. The first method of resolution was to consider the Right-Hand-Side of the general relativity principle equation.

$$\text{Geometry} \equiv \text{Mass-Energy}$$

Furthermore when the Universe scale is considered an even worse scenario is discovered. In 1998 it was found observationally that the expansion of the Universe is accelerating, that is the distance between stars is becoming larger at an increasing rate! And it is not that the stars and galaxies are themselves accelerating away from each other by some means but that the very fabric of the background geometry is expanding between them and everything else.

The simpler solution is to fix the Right-Hand-Side of Eq. 3, for galaxies input a small amount of Dark Matter to make up the extra mass-energy is needed, while on the Universe scale a totally unknown substance is proposed called Dark Energy. Both of these substances are introduced to fill in a gap in our model and this gap exceeds 95% of all supposed mass-energy in the Universe.

Another way is the work on the Geometry part of this equivalence principle equation. Currently many researchers are exploring the possibility of adding terms to this part of the equation that only become significant at such high scales, especially in the gigantic voids between galaxies. Such ideas have shown promise however it is unclear how the choice of these terms is made in the sense of where do they come from.

The idea our team is investigating is to allow for local conformal invariance meaning that at each point we can make the transformation

$$g_{\mu\nu} \rightarrow \Omega^2 (x)\, g_{\mu\nu},$$

so that our Pythagoras' Theorem equation can change in a special way (as above) without changing the mass-energy content implied by our new version of Eq. 3. A visualization is shown in Fig. 2. This idea is borrowed from quantum physics and indeed provides a much closer link to quantum physics and gravity, possibly even quantum gravity one day soon.

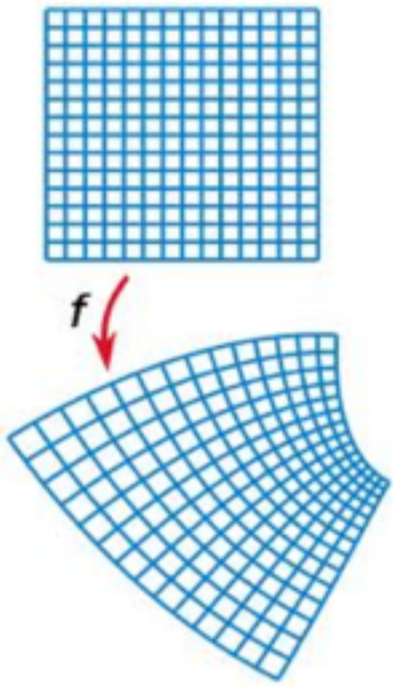

Fig 2. Conformal Visualization of a flat two dimensional geometry.

What about the problems of General Relativity? Well conformal gravity provides a consistent way of describing the Universe without the need of Dark Energy. Considering galaxies it can describe quite well the angular velocities of the stars contained therein, given a small amount of dark matter as would be expected given that a small amount of each galaxy does not emit electromagnetic radiation such as dead stars and small black holes.

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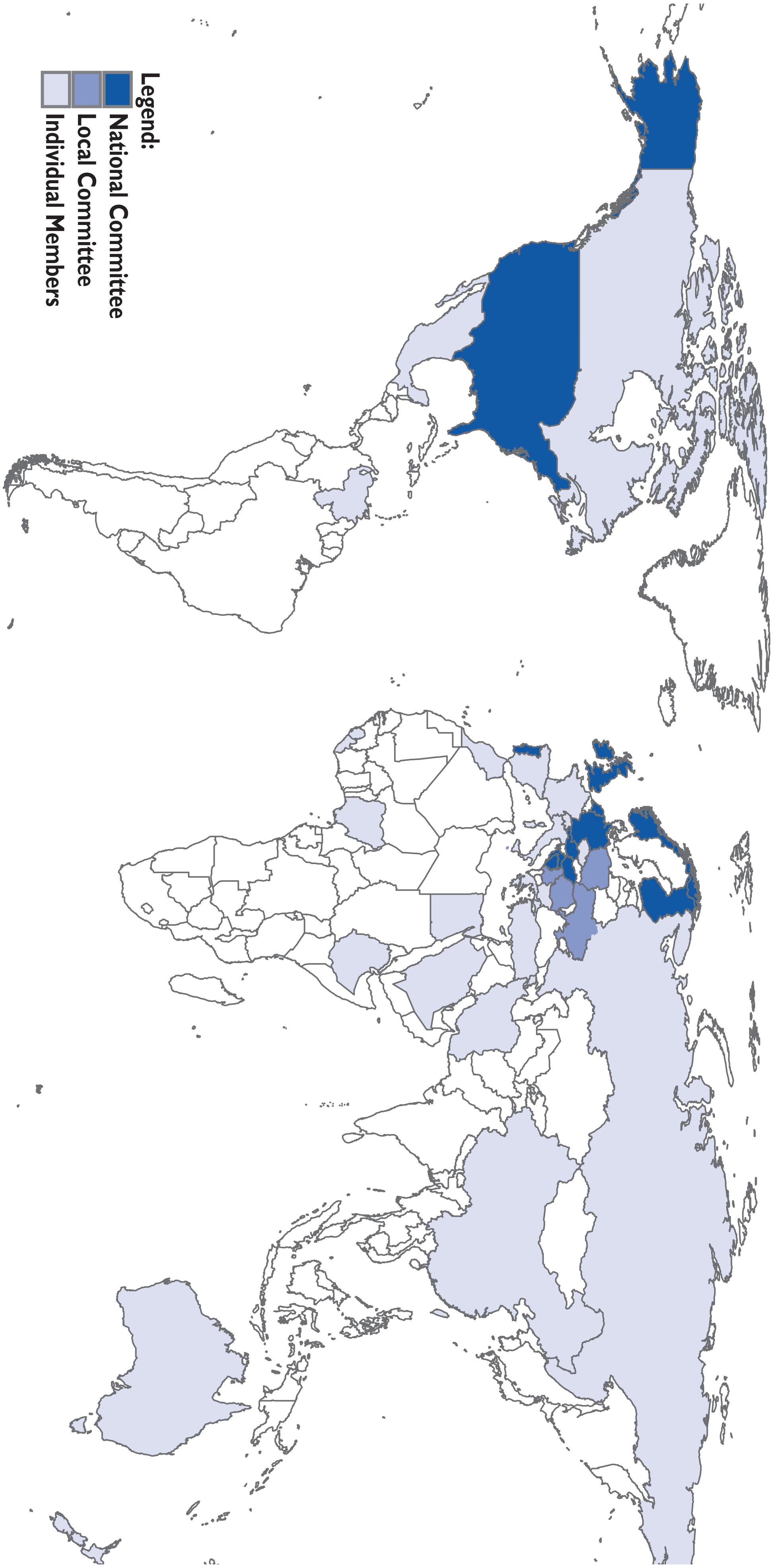

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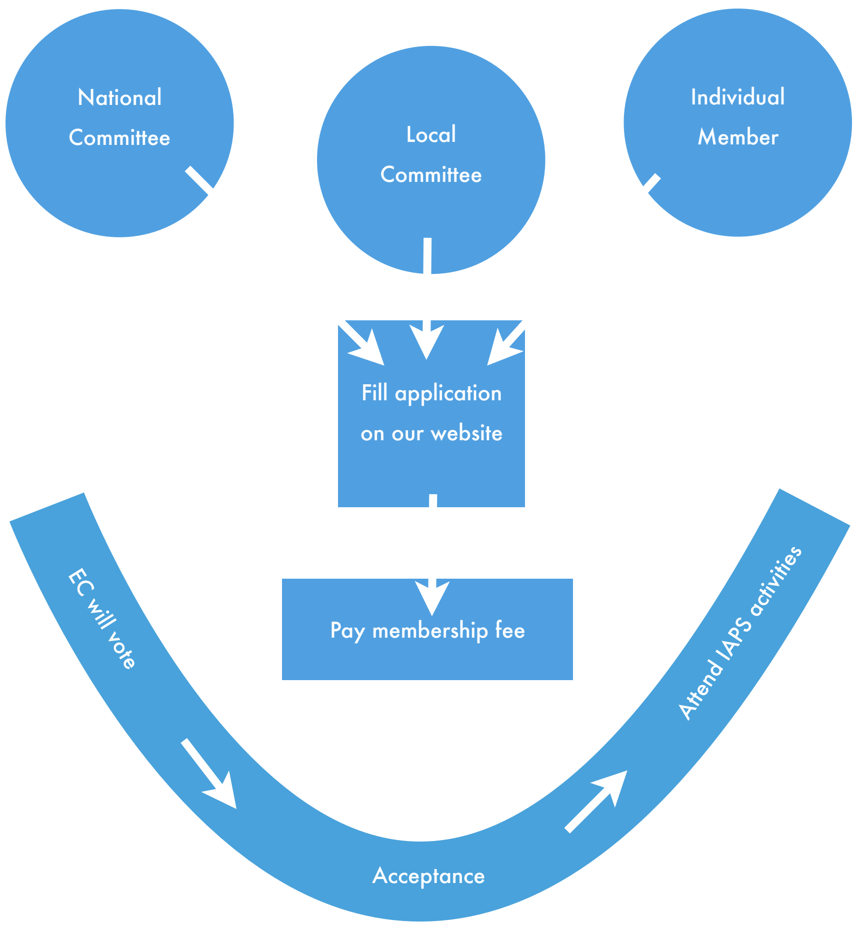

Terrestrial Impact Craters: A Short Review

By Denise De Gaetano
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Impact craters are geological structures formed when large meteoroids, asteroids or comets collide into a planet or a satellite. A number of these structures have been recognized on Earth as Terrestrial Impact Craters. This short review investigates the occurrence of these structures on the Earth's surface, especially the most prominent ones, their geological effects, categorization, possible links with events in Earth's history, and major impact events amongst others.

Introduction

Planetary exploration has shown that virtually all planetary surfaces are cratered from the impact of interplanetary bodies. The primordial atmosphere and hydrosphere may have been generated by outgassing of Earth's initial crust, due to heat by early impacts. Additionally, the impacting bodies themselves may have contributed to the Earth's budget of volatiles. A mass extinction event notably that of the dinosaurs, which is estimated to have happened about 65 million years ago, is linked to global effects. Impacts may also contribute to the economy of the particular impact site such as the vast copper-nickel deposits at Sudbury, Canada which are likely a related result of a large-scale impact 1850 million years ago. [1] Impact structures in sedimentary rocks have also provided suitable reservoirs for economic oil and gas deposits. An impact crater is "an approximately circular depression, sometimes surrounded by a raised rim. Craters are typically formed by explosion during meteorite impact". [2] A palimpsest of a crater is left behind when an ancient crater relief disappears. It might be assumed that a major impact on Earth would leave behind unmistakable evidence, but in fact the gradual processes that change the surface of the Earth tend to cover the effects of impacts. Erosion by wind, water, sediment and lava flow, make it difficult to study craters, since these tend to bury craters left by impacts.

Impact craters start out as circular structures bound by a raised rim and bottomed by a depression which may have a central uplift or peak. By time craters wear down to scars also known as astroblemes. These still include the in situ features of craters, namely shatter cones and breccias. Figure 1 illustrates the stages in the formation of an impact crater. First an impact hits the ground, which forces shock waves to spread through the rock and ejecta to be thrown out of the crater. [3]

Figure 1: Stages in the formation of an impact crater: (a) the impact; (b) the projectile vaporizes and a shock wave spreads through the rock; (c) ejecta are thrown out of the crater and (d) most of the ejecta material falls back to form secondary craters, rays and the ejecta blanket. [3]

Formation and Structure of a Crater

Two primary regions make up a crater, the excavation zone and the deposition zone. The excavation zone is geologically concave. This is the region carved out by the force of the impact. The deposition zone is convex in shape. A crater is usually surrounded by an ejecta blanket, while its floor is covered with breccia, a coarse-grained rock, composed of broken rock fragments. The floor of the crater can be bowl-shaped or with a central uplift, while around it the walls form a raised rim. The target rock and the impactor both melt during an impact, forming what is called an impact melt. The majority of these craters usually form circular in shape, but a few also have a non-circular shape. The reasons for non-circular craters include the degradation or modification of the crater with age, the material strength of the target compared to the energy of the impact and the angle of impact. The average impact angle is usually around 45 degrees, making perpendicular impacts quite rare. Since most bodies in the solar system orbit the sun and each other within a plane ecliptically, the spread of impact angles isn't entirely random due to gravity well effects. The angle can have an influence on the shape of a crater, but this effect is reduced when the angle is less than 20 degrees (Figure 2). When the impact angle is less than 10 degrees, crater distortion is more noticeable. [4]

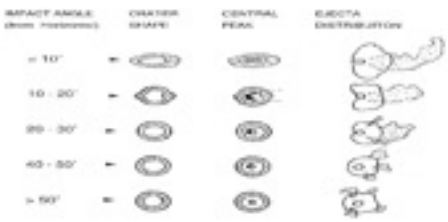

Figure 2: A visual guide to the morphology of craters and their debris peaks and ejecta at different impact angles. [4]

Crater Categorization

Crater Identification

The pressure, which can be up to 900 GPa and temperatures produced upon impact are sufficient to completely melt and even vaporize the impacting body and some of the target rock.

In such cases, the recognition of a characteristic suite of rock and mineral deformations, termed "shock metamorphism" (Figure 3), which is uniquely produced by extreme shock pressures, is indicative of an impact origin. "Conical fractures known as shatter cones, microscopic deformation features in minerals, particularly the development of so-called planar deformation features in silicate minerals such as quartz, the occurrence of various glasses and high pressure minerals, and rocks melted by the intense heat of impact", are very common examples of shock effects. [5]

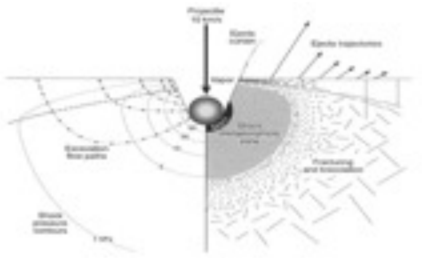

Figure 3: Diagram illustrating the shock metamorphism which occurs at an impact origin. [5]

CRATER MORPHOLOGY

The crater diameter has a direct correlation with the morphology of impact craters. Slumping of the inner walls and rebounding of the depressed crater floor create progressively larger rim terracing and central peaks, as the crater diameter increases. Furthermore, one or more peak rings, make up larger diameters resulting in the formation of impact basins. The interiors of these structures are partially filled with breccia and rocks melted by the impact. Impact structures on Earth include two types; simple structures, which are up to 4 km in diameter, "with uplifted and overturned rim rocks, surrounding a bowl-shaped depression, partially filled by breccia and complex impact structures and basins". On the other hand, complex structures are generally 4 km or more in diameter, "with a distinct central uplift in the form of a peak, an annular trough and a slumped rim".[1]

IMPACT CRATER SIZES

Craters exist in a variety of sizes. Craters up to 25 Kilometres in diameter are termed as small craters having a typical deep bowl structure (Figure 5). Surface material thrown out of the impact site leaves a classic deep hole shape surrounded by a wall of loose debris. [4]

Figure 5: An illustration of a small impact crater. [4]

Medium craters are those between 25 kilometres and 130 kilometres in diameter (Figure 6). They are usually made up of a central peak and a shallow excavation zone. This is due to the fact that instead of excavating a proportional amount of material, some of the impact force is absorbed. The existence of a central peak is unique to medium size craters and is the result of matter thrust upward immediately after the impact. An enormous amount of energy is required to thrust matter upward into these "mountainous shapes". Such energy cannot be sourced from a gradual returning or reforming of the planet's surface since, rebounding must be rapid. This action catapults central matter upwards. [4]

Figure 6: An illustration of a medium impact crater. [4]

Large craters are those over 130 kilometres in diameter. The floors are very shallow and convex in shape, following the planet's natural surface curvature. Their inner regions are terraced by concentric rings.[4]

Figure 7: An illustration of a large impact crater. [4]

Impact Events

Evidence for an impact catastrophe is best demonstrated by the K-T boundary, which is the time horizon between the Cretaceous [K] and Tertiary [T]. The Chicxulub impact in the Yucatan Peninsula is classified as one of the largest short-term natural events known in the geological record. This huge structure has no evident surface expression, being covered by younger sedimentary rocks. It however appears subsurface as a strong gravity anomaly. It was discovered almost accidentally through oil drilling, in which core samples, containing so-called volcanic rocks, showed distinct shock effects.

Another event is the Chesapeake Bay impact crater which was formed by a giant asteroid or comet that impacted the eastern shore of North America about 35.5 million years ago, in the late Eocene epoch. It is one of the best-preserved marine impact craters, and the second largest impact crater in the U.S. Several aspects of the Chesapeake Bay impact structure, apart from its size and preservation, make it an intriguing subject for scientific investigation. The impactor struck a rheologically layered wet target that consisted of a neritic water column, water-saturated sediments and crystalline rocks. The variations in target strength profoundly affected the excavation and collapse and the final geometry and size of the resulting crater. [7]

The most significant recorded impact in recent times was the Tunguska event, which occurred in the region of Tunguska, Russia in 1908. [8] A recent terrestrial impact crater occurred on the 17th of September 2007, in Peru. A remote part of Peru was struck by a meteorite and carved a large crater that emitted noxious odours.

Conclusion

Due to constant research in the field, terrestrial impact craters are being identified almost immediately, therefore even though as has been described in this review Earth's active surface processes quickly destroy the impact record, those identified are being submitted to the Earth Impact Database. These craters can range in diameter from a few tens of metres up to about 300 km, and they also range in age from recent times to more than two billion years. Major impact structures include the Chicxulub impact, which marked the precise K-T boundary between the last rocks of the Cretaceous Period and the first sediments formed in the younger Tertiary Period and the Chesapeake Bay impact crater. Finally, as discussed in this review the hazard due to an impact crater depends primarily on the size of the meteorite impacting the Earth.

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That trip to the place where the discovery of the Higgs boson was confirmed

For me, this year's CERN trip started off at my cousin's house on Wednesday 11 April 2012. My early arrival gave me enough time to introduce myself to the hostel we were staying at, ensure there were no problems with the booking and cancel the beds for the few people that could no longer attend the trip. I was able to visit the CERN reception to confirm the 2-day booking that I had made in person back in August 2011 and I could visit the United Nations to confirm the bus routes. I was woken up on Friday morning by my cousin to make sure I stayed at home to babysit only to hear, via a phone call 2 hours later, that she had just given birth.

On Friday night, I welcomed the first participant in Geneva, Neil O'Neil, who had driven all the way from London, UK. We had dinner at the Italian restaurant close to the hostel where I learned that he had a fascinating job as an ethical hacker. Over the weekend, more participants including Helen Khotenko and Kostiantyn Pylypenko from Kiev, Ukraine and one of the speakers, Jason Tam, from Wurzburg, Germany arrived in Geneva and I was there to welcome them.

Monday morning involved waking up very early to go to the Geneva Youth hostel and welcome everybody else, tick their name off the register, hand them over their room keys and transport cards, and ensure their payment of the participants' fee. It was brilliant to see some familiar faces and even more exciting to meet new people. Jason very kindly arrived at around 12:00 to join the participants, which allowed them to ask him questions about what he does at CERN.

The last participant, Ivaylo Panayotov from Bulgaria, arrived at 01:00. For those who had arrived early that first day, I encouraged them to go explore what the city of Geneva had to offer them and see the sights, enjoy the scenery and buy presents for their loved ones. In the evening, we all sat around the picnic area in the hostel for some icebreakers. Everyone had to give their name, university, the country they came from, and what their favourite particle was; this was a particle physics trip after all!

Tuesday morning started very early with breakfast although some people had obviously had a late night and did not sleep very well. After a few problems were sorted out, we managed to start making our way to the United Nations building to see what all the fuss was about. From the giant chair, along the way and when we arrived at the United Nations building, everyone turned into tourists and took many photographs. After going through some security measures and some late arrivals from France, we were given a tour where participants learned about how the United Nations worked and viewed some beautifully crafted architecture and art.

After the United Nations, we took a tram to the Geneva train station and another to the CERN reception where a lot of excitement was generated. From the beginning, everyone was able to visit the CERN shop, the Microcosm, read some information leaflets and explore the CERN reception area. At our arrival, we were met by Jason, who escorted us to the CERN restaurant where everyone was able to eat and drink amongst some of the world's most brilliant particle physicists at the location where the Higgs boson would be discovered only a few months later. This included Magdalena Kus, an IAPS member and friend of mine from Krakow, Poland whom I met at the International Conference of Physics Students in Split, Croatia.

The group of 40 were then split into 3 groups where we were able to explore the wonder of the world that is CERN. We started off with an introductory high energy and particle physics lecture in the Microcosm. We were then taken via coach to the LHC visitor centre where we were given explanations about superconductivity, superfluidity, quadrupole magnets, and materials used to reduce the resistance in the wires, how the Large Hadron Collider actually works and how the whole thing was assembled. This was followed by scientific lectures from Agnieszka Leyko about her research, and Jason Tam gave a hilarious presentation about life at CERN. The participants became really intrigued and were able to ask a lot of general and scientific questions.

Once lectures were finished and the participants were tired out of their minds, Mischa Stocklin, also known as the IAPS auditor, arrived with our iaps2cern 2012 tshirts and pens. These items were distributed to the participants who were then free to roam the rest of CERN on their own and fill their hungry bellies with dinner. The geekier part of the group, including myself, decided to have dinner in the CERN restaurant.

The next morning started even earlier as we had to get up to eat breakfast very early and arrive at CERN by 10:00. The first stop for the group was the CERN control room where we were given a scientific lecture from our tour guides. From the upstairs lecture theatre, we were able to see all the scientists hard at work with their multiple computers screens in the CERN control room, which some people have argued is the real heart of CERN.

The real surprise of the trip was when

we were taken to a giant lift and were informed that we should wear our helmets to protect our brains from radiation as there were some beams still on. This was completely unplanned and exciting as everyone was wondering whether we were going underground. We were all amazed when we all got on this lift and found ourselves 80 metres underground, not quite

the 100 m we were hoping for but underground nonetheless.

We then visited more areas of CERN including people's offices and various other computer rooms, which I had not been taken to the previous 4 times I went to CERN. People were working in groups trying to figure out various things, working on computers, laptops and whiteboards.

Later that afternoon, after lunch, we were supposed to have a lecture by my old mathematics lecturer, Professor Jonathan Butterworth. He has been on television frequently and gives lectures at many outreach events on high energy and particle physics. However, instead, we were happy to receive a basic particle physics lecture from Dr Mario Campanelli (UCL) in a lecture room situated just below the office of the CERN general director. Following on from that, Jason Tam gave his second lecture of that week on his lepton-quark research.

After lectures, some participants had enough time to visit the Particles exhibition in the Globe, explore the Microcosm in the basement of the CERN reception and were free to do whatever they wished for the rest of the afternoon. The rest of us decided to go back to the hostel, catch up on some sleep, have some dinner and for dessert, we enjoyed Lidl ice cream together, in one of the rooms.

Everyone was sad to realise that the fourth and final day of the trip had come so quickly. One minute we were meeting each other, touring the United Nations, walking

around CERN and Geneva, enjoying a meal together and the next minute, we were all saying goodbye, ready to go back to life.

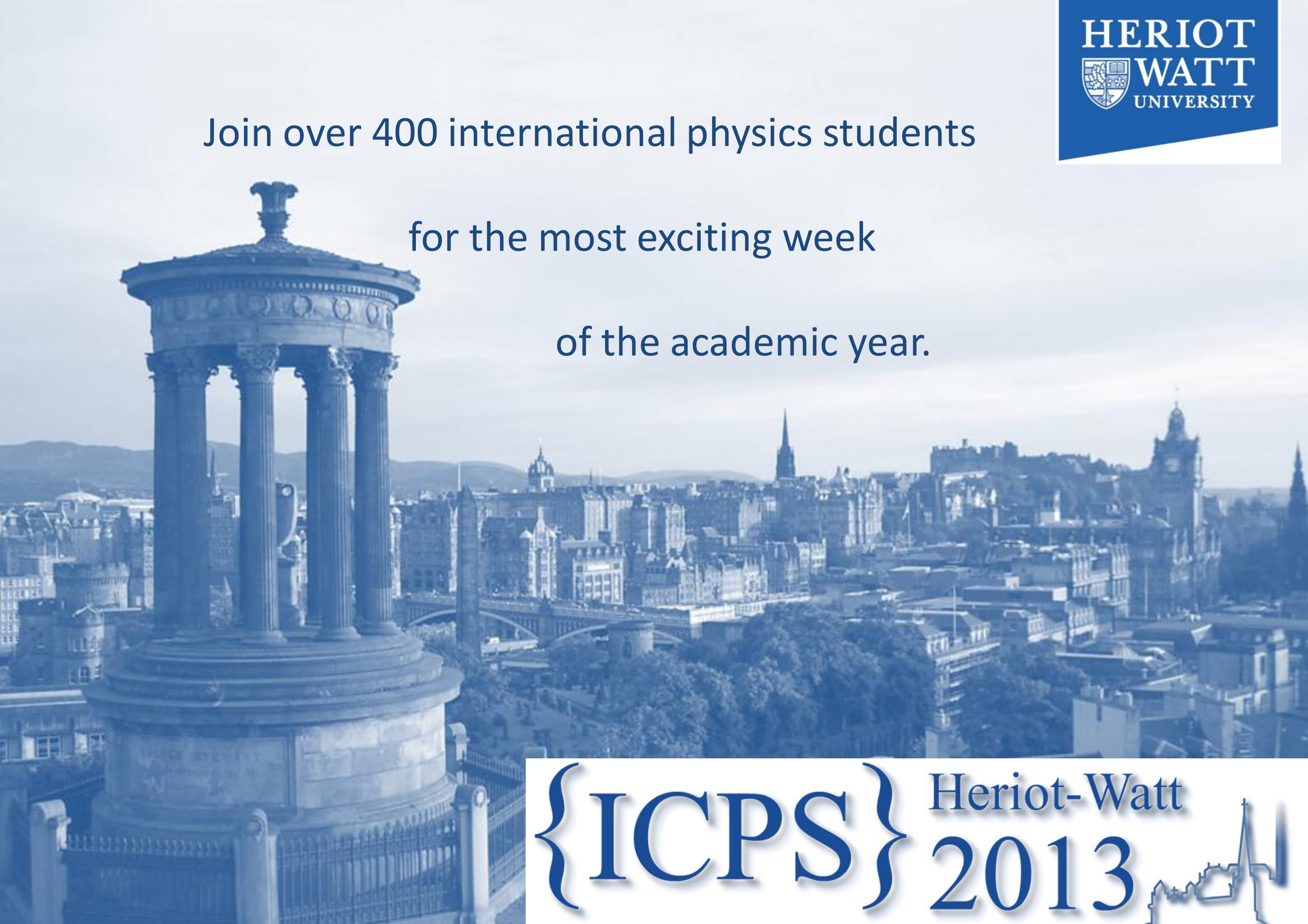
However, this was not before a certificate ceremony on a traditional Mouette for all those who had participated.

The majority of people left that afternoon and evening of the last day, though a significant number of people stayed for an extra one or two days. With the group who stayed for a few extra days, we visited the Jet d'Eau, the Geneva flower Clock, the Giant Chess set, the cathedral in the old town, and various

monuments around the Lake Geneva area.

For anyone who is interested, I am organising the iaps2cern trip 2013 for the preliminary dates of Monday 25 to Thursday 28 March 2013. The LHC is being switched off in December 2012 so that it can be prepared for higher energy beams. This means that we are certain that we will be going underground again. Participants will be coming from all over the world and please keep checking the IAPS website on www.iaps.info as registration should open by November. See you there or see you somewhere in the world sometime soon!

By Sahra Haji, IAPS EC Vice-President 2011-2012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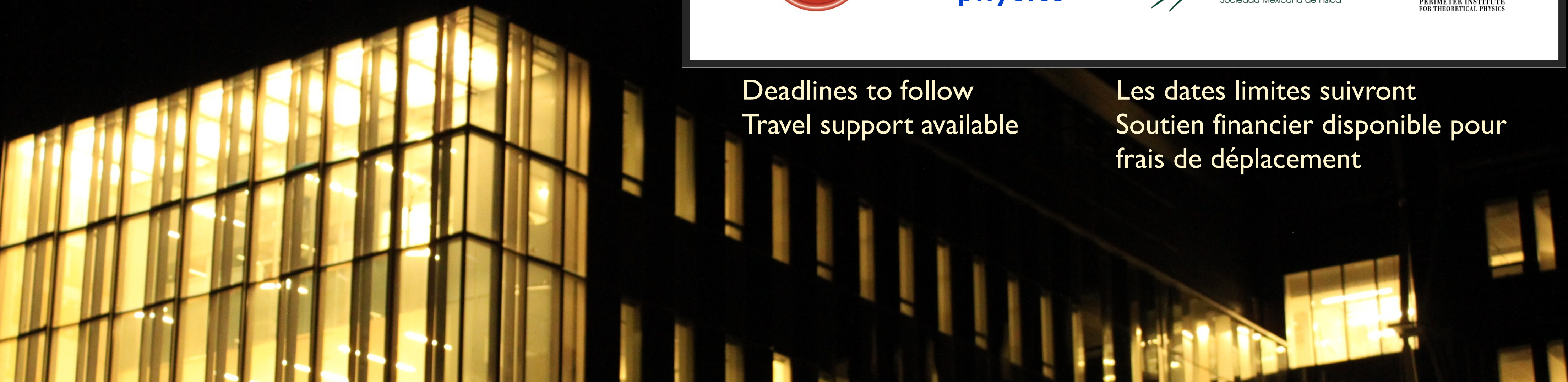

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