Conclusion

From the above discussion, one may interpret that Einstein's theory of gravity is more sophisticated and general one whereas Newton's theory of gravity is a particular one valid at low gravity scale. But in schools and colleges, Newton's theory is still taught more than that of Einstein. Even in engineering applications Newton'slaw ofuniversal gravitation is used without any problem. The trajectories of spacecrafts are calculated by applying Newton's law. It is because Newton's law of gravitation works perfectly at these scales. Further it is very simple and easier to calculate.

In spite of the great works done by Newton and Einstein on the theory of gravity, still there is enough mystery to unfold. For example, it is not clear why it is so much weaker than the other fundamental forces. Further, we are still not able to bring it into the quantum fold.

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No doubt our ancestors needed some rational skills to survive, but the human brain evolved more as a religious than a rational organ. Rational science is a minority interest. It is likely therefore that the first human brains evolved to impose symbolic meanings on the external world, and the scientific virus later infected a minority of their descendants, where it now flourishes in nerve circuits that originally evolved to carry other ideas. - ***Nicholas Humphrey***

BRIDGING THE GAP BETWEEN SCIENCE AND SOCIETY

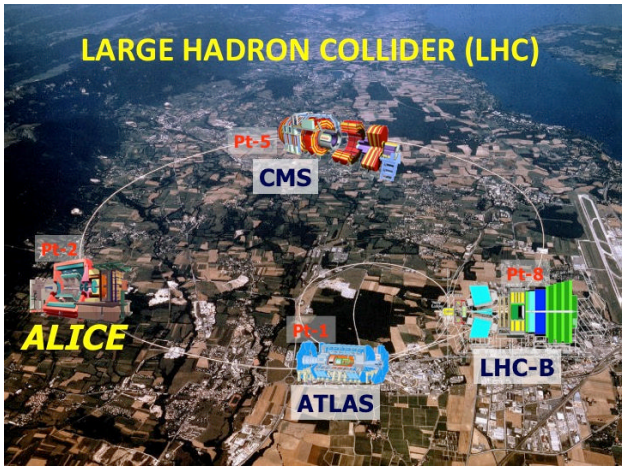
Dr. Raghunath Sahoo

In the words of the famous American author Isaac Asimov, *"The saddest aspect of life right now is that science gathers knowledge faster than society gathers wisdom"*. As a result, there exists always a barrier between science and society. A growing barrier creates misconception, spreads superstition or even sometimes it may result in physical protests either in the form of peaceful demonstration or it may sometimes become violent. Let us proceed by taking examples from three mega science projects: (a) Large Hadron Collider (LHC) at CERN (b) Thirty Meter Telescope at Hawaii and (iii) India-based Neutrino Observatory (INO) at Theni district of Tamil Nadu. While the first one is now a successful ongoing project, the last two are yet to begin. Before we proceed further, let us explain what is a mega science experiment. The LHC at CERN, Geneva, Switzerland, is an epitome of a mega science project.

The LHC at CERN

The Large Hadron Collider (LHC) at the European Laboratory for Nuclear Research (CERN), Geneva, Switzerland is located in the French-Switzerland border spanning almost 27 kilometers in circumference. LHC, the World's most powerful particle accelerator is located underground at around 100-150

meters with an elevation, housing the gigantic experiments like the CMS, ATLAS, ALICE, LHCb etc. While the aims of CMS and ATLAS experiments are to look for the Higgs boson, popularly known as the God Particle, which is responsible for the generation of masses of subatomic particles, in addition to physics beyond standard model- SUSY particles, dark matter candidates etc.; the ALICE experiment aims to recreate the Big Bang, a theory that explains the creation of the Universe. Science is driven by the human curiosity. The "Why and How" of things have driven us to understand the beauty of nature and its underlying dynamics. Successful scientific discoveries lead to technological applications, which work like a boon for the human civilization. Since the discovery of the atomic model through the famous -scattering experiment by Sir Ernest Rutherford, the curious mind has always tried to probe deeper in length scale following the famous de Broglie relation, $\lambda = h/p$. This famous wave - particle duality relation of de Broglie for which he got Nobel Prize, tells us that we need higher energy to probe lower in length scale. For example we need more energy to see/ probe the nucleus and further nucleons and quarks compared to seeing the atoms and molecules. At the LHC, we probe a length scale of few femtometers (10-15 meters), which translates to collision energies of few GeV to TeV. GeV is the unit of energy- one Giga electron Volt, i.e. 10^9 eV and one eV is the energy one electron gets if allowed to be accelerated in a potential difference of one Volt. To achieve this, there is a need of huge particle accelerator with detectors of dimensions of few storey buildings to track the high momentum particles in the magnetic field for their identification as pions, kaons, protons etc. The high wealth of particle multiplicity makes the environment very complex. Because of the need of huge manpower, financial budgets, each of the experiments at the LHC, involves multinational participation. For example, the CMS experiment has about 42 countries participating with nearly 4300 scientists and engineers involved for detector making, data taking, software development and physics analysis. The scientific endeavors of this magnitude are therefore named as mega science projects. India has a sizable participation in CMS and the ALICE experiments with about 30 institutes and universities involving more than 300 scientists and engineers.



(Schematics of the LHC showing its experiments at the France-Switzerland border of 27 kms: Picture source: CERN)

Society is a complex heterogeneous system, the time evolution of which has made scientific discoveries mostly need based. The 1st half of 20th century physics was driven by the war based applications, namely the nuclear physics research, which was funded by the then governments in Europe and USA. CERN established in 1954, just after World War-II, when people thought of uniting nations for peaceful utilization of nuclear energy for sustainable research was an initiative of the leading European scientists. CERN thus signifies unity in diversity beyond demographic dividends, bringing peace, harmony between nations and standing like a pillar of success for Science. When the LHC at CERN was conceptualized in early 1980s and was built between 1998-2008 by almost 10,000 scientists and engineers from 100 countries, it was not free from the social agitations/obstructions. Initially it was thought that stategically a good communication with the localities is necessary to convey the importance and the long term implications of the project. At the sametime it was also argued by a section of the CERN management that it would be a hopeless attempt to explain the intricacies of the complicated research and technological developments CERN plans to undertake [1]. The common people misunderstood the word "nuclear" in "CERN" and thought it would be an advanced nuclear power station. Lack of appropriate information and hence a communication gap between the scientific management and the general public with several other misunderstandings, created a number of protests against the CERN LEP/ LHC project. As discussed in Ref.[1], about 173 meetings were organized in the French territory, which houses major part of the LEP/ LHC project. The Large Electron Positron Collider (LEP) is the precursor of the LHC. Several public conferences and discussions were organized at the University of Geneva, along with individual discussion meetings with the local authorities like the mayors, delegates from various localities, regional committees and the local influential people. This resulted in very less number of opponents with no meaningful arguments but having some political visibility only, which is the case that might happen everywhere. Like it is for all major long-term projects, a proper study on the environmental effect etc. was done for CERN and a public awareness was thus made in order to convince the public. In an advanced and civilized society, the common interest always takes the priority over party issues and personal interests. Unless people understand the importance and objective of major scientific projects, the public agitation can hinder the scientific and hence the technological growth of the civilization. Sometimes, projects may be lost under legal problems, the solution of which should be fast tracked by special means. Think of LEP/LHC being an underground tunnel of almost 27 kms going under several villages in the country

side of the French and Swiss territory. To avoid legal procedings by any localities, which might have delayed the project for years in view of compensation, with proper study of the environmental impacts of LEP a "declaration of public interest" was to be issued by the highest administrative authorities. This needed public hearings and taking the public into confidence with very high will power of the people's representatives, any major scientific adventures like the LEP/LHC at CERN could be achieved. Now with many countries beyond European territories taking up membership and associate membership roles (India is going to get an Associate Member status soon), CERN has become truly an international platform for scientific research. People have got a common goal: doing science and understanding the working secrets of nature. If one looks at the scientific discoveries afterwards, CERN has been instrumental in the discovery of the mediating particles of weak interaction i.e. the *W* and *Z* bosons, the Higgs particle in 2012, along with the *World Wide Web (WWW)* or the modern day internet. The particle detectors have got immense applications in biomedical imaging, proton therapy for cancer treatment etc. The LHC at CERN has been credited for creating a soup of quark-gluon plasma that might have existed a few microseconds after the Big Bang by creating a condition, which pertains to a temperature of 10^5 times the same at the core of the Sun. The LHC superconducting magnets used for particle acceleration and bending, use cryogenic technology that operates at a temperature of 1.9 Kelvin, which is colder than the Cosmic Microwave Background (CMB) radiation average temperature, i.e. the average temperature of the Universe (2.73 Kelvin). These are a few to name. There are many such miracles created at CERN. The detailed discussions on technological implications are huge and beyond the scope of this article. Further down the line, during the operation of LHC during 2008, it was thought of and also media made a propaganda that the LHC will create a black hole which will engulf the whole universe, thereby destroying the Universe. This was later explained to people that a small lifetime and spatial dimension of a possible mini black hole, if created in the particle collisions at the LHC, would not do any harm to the civilization. A public awareness on scientific issues is therefore a must, as science is meant for the civilization.

The TMT in Hawai, USA

It is needless to mention here that scientific projects of international repute bring the site under the map of science, while someway boosting the economy of the country directly or indirectly. The Thirty Meter Telescope (TMT) is one of the world's largest telescopes proposed to be built in Mauna Kea in the Hawaii Island of USA. It was conceptualized by University of California

(A sketch of the proposed TMT for Mauna Kea Observatory, Hawaii, USA. Picture source: www.tmt.org)

and Caltech, USA and was designed to be a joint scientific venture of the USA, Japan, India, China and Canada to start with. The TMT, based on segmented mirror telescope technology, is designed for astronomical observations from near-ultraviolet to mid-infrared (0.31 to 28 m wavelengths) with its adoptive optics system to help in the correction of the image blurring caused by Earth's atmosphere.

Usually the site selection for mega science projects is based on scientific, financial, and political criteria. Out of 7-proposed potential sites (Hanle, JK, India was one of them), in 2009, Mauna Kea was selected as the preferred site because of its unique location that includes high altitude and different hemisphere as another next generation telescope is planned to be in Chile (European Southern Observatory is building the E-ELT: European Extra Large Telescope), so that both the telescopes together, would enhance the observational capabilities. The TMT got approval from the Board of Land and Natural Resources. However, several protests started by the habitat of several species owing to potential disruption to the fragile alpine environment of Mauna Kea due to construction, traffic and noise. In addition, this was associated with a mixed feeling of religious sentiment and fear of damage to age-old heritage. Mauna Kea is believed to be a sacred mountain of Hawaii created out of Volcano and is the son of Wakea, the sky father, and of Papahanaumoku, the Earth mother. After local agitations and legal procedures in the State Supreme Court, the project has been invaildated for construction and an alternative site is being looked for.

The India-based Neutrino Observatory (INO)

The multicrore indigenous mega science multi-institutional project, INO was initially proposed in a cavern in Singara Hills around 5.5 km from Masinagudi town in Nilgiri district of Tamil Nadu. INO aims to study the atmospheric neutrinos for the precise measurement of neutrino mass heirarchy, physics beyond the Standard Model. Once completed, this will have the glory of having World's largest magnetised Ion Calorimeter (ICAL), almost four times higher than the 12,500-tonne magnet used in the CMS experiment at the LHC. Conceptualized in early 2000, INO makes a synergetic collaboration of both Indian high energy theorists and experimentalists, who are engaged in stydying the physics aims, detector technology, electronics, physics simulation and site survey.

After getting a positive signal from the Department of Atomic Energy, Govt. of India, the site couldn't get the environmental clearance, as the proposed area comes under the buffer zone of Mudumalai Tiger Reserve (MTR) and is in the close proximity of the tiger habitats in Bandipur and MTR. It is also an elephant corridor for the Western Ghats to the Eastern Ghats. Although highway passes though the area and there are human settlements and resorts nearby, it was assumed that such a big scientific project would disturb the habitat and hence the environment through the transport of construction materials, human traffic etc. The site has been changed because of the protests from environmental groups. The environmental clearance has been obtained in 2010 for the new site in Theni, Bodi West Hills, Tamil Nadu. The project was further delayed because of environmental and radiological issues raised by political bodies. Legal issues also contributed to the obstruction and hence delays, when the National Green Tribunal issued notices on the environmental clearance obtained for the construction of INO. Further clearance was sought from the Pollution Control Board before commencing the work and the major scientific project of India has been delayed till date to start the construction work. To do frontier science an equal cooperation is required from all fronts. If a project conceptualized in early 2000, gets delayed so much, people won't stop doing science in the international arena and the result will be that we shall lose international visibility of doing frontier science. Note that the Nobel Prizes in Physics for the year 2002 and 2015 have been awarded for atmospheric neutrinos and the neutrino oscillations, respectively.

The Solution

Before looking into the possible solutions to bridge the gap between science and society, let's discuss a few more examples, which are not related to the mega science projects but seriously affected due to some scientific the gap between science and society. Let's recall the story of the architect of the first Indian test tube baby (Durga), Dr. Subhas Mukhopadhyay, a physician from Kolkata, who invented IVF (In Vitro Fertilization) technology. This happened just after 67 days of the invention of IVF in Oldham General Hospital in UK during July 1978, for which Robert G. Edwards got the Nobel Prize in medicine in 2010. Although his name appears in the "Dictionary of Medical Biography", published by World Foundation, in the list of famous medical scientists who did path-breaking discoveries, Dr. Mukhopadhyay couldn't get his due acclaim in his lifetime. This was because of the ignorance and jealousy of his peers and the bureaucratic procedures; he had to go through an uphill struggle for proving the new technology. The higher authorities denounced Dr. Mukhopadhyay's achievements and as an act of humiliation, he was denied to leave for preparing a detailed

report on his findings. He was not allowed to leave the country to present his works in international conferences [4,5]. Unsurprisingly, this has also happened to many scientific discoveries in the past. Galileo supported the theory of Copernicus that the Earth revolves around the Sun, which went against the prevailing wisdom of the Church at that time. This barrier of religious origin was finally removed through the famous Galileo's telescope experiment, which has given birth to observational science.

In conclusion, the solution is very complex. Issues creating barriers against the progress of science and technology are related to economy, ecology, environment, religion, culture, heritage and politics of the region. All issues need to be addressed. Science has been a boon to the society. Both Science and Society should co-exist, as they need each other. However, people need to be convinced through scientific awareness and rational thinking. The scientists and engineers should take a pro-active role in bringing the complex message of science and technology to the level of common-man by speaking to them in simple popular terms with physical demonstration, where ever possible. This could be done through massive science outreach programs and educating the next generation from the school level. Therefore, it is the need of the hour that we produce as many social scientists as scientists and engineers, if not more.

If science is for society, we have to bring the benefit of science to common people. What reaches the society today are the technology-driven profit-making products of the industry. What do not reach every one are the scientific knowledge and the excitements of the scientific discoveries. There is a gap between science and society. It needs to be filled with the help of social scientists.

Being a large population in diversity, India needs a boost in the education sector with long term vision plans to bring synergy between science, technology, industries and the societal needs. We need to emphasize on agriculture, defense, space research, environment, health, food safety etc. by making proper industry-academia correlation and the society in large.

Acknowledgement

I am grateful to Prof. Ajit K. Mohanty, Director, SINP, Kolkata and my teacher Prof. Niranjan Barik for the inspiration and encouragements for writing this article.

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