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Conference on
Integrating Science with Society

15-16 December, 2018

Venue: Gandhi Bhavan, Jadavpur University, Kolkata

Announcement

Friend,

Science has impacted our daily life in a myriad different ways. In today's world many of the things which we have taken for granted, like instant light at the press of a button, are gifts from science. However, science is not about just technological development and innovation; science is a world-view; it is a particular way of looking at the material world; it has a distinct methodology of understanding the world around us; it inculcates a particular way of thinking and it has a social commitment. The philosophy of science is distinct from other categories of philosophy, ancient and modern.

Unfortunately, our education system is almost entirely geared towards the technical aspects of science only; its methodology, its philosophy and world-view are given only a cursory treatment if at all. Our education particularly at the school level does not teach the learners to think rationally and act logically. As a result, though our Constitution enjoins the citizens to adopt and promote scientific temperament, virtues like rationality, objectivity and a robust skepticism have not taken a deep root in the psyche of the contemporary Indian society.

Inevitably, there is a disconnect between society and science, which has proved to be detrimental both to the Indian society and the practice of science in India. Vast sections of the people are not able to lift themselves out of their degrading situation and the Indian science is languishing because of the lack of social support.

Breakthrough Science Society, a voluntary organization committed to science, culture and scientific outlook, has taken a small step for addressing this problem by planning to hold a National Conference on "Integrating Science with Society".

Breakthrough Science Society requests you to participate in the Conference and to extend all help to make it a grand success.

Sessions:

Session 1: Philosophy of Science:

After the emergence of modern science, particularly over the last two centuries, there has been intense debate about the correct method of seeking truth. Schools of thought like materialism, idealism, positivism, post-modernism, and spiritualism have waged and are still waging battle for supremacy in the intellectual space. This session will seek the correct path in doing science. It will delve into issues like objectivity, falsifiability, reproducibility, causal-

ity, etc., and will discuss the complexity, uncertainty and humility in the enterprise of knowledge generation.

Session 2: Cultivation of Scientific Temper:

This session will discuss ways of inculcating scientific bent of mind among the common people. Issues like prevalent unscientific beliefs and superstitions, and ways of countering these with science will also be discussed.

Session 3: Ethical Practice in Science:

The cases of scientific misconduct are on the rise today. Unless the scientific community of India addresses this problem squarely, cases of unethical practice in science may tarnish the image of Indian science before the world community. This session will discuss the issues of scientific ethics and research misconduct (fabrication, distortion, plagiarism in proposing, performing, or reviewing research, or in reporting research results).

Session 4: Reforming Science Education:

A persistent problem of the education system in India is that students learn science as a collection of subjects, as a set of information. Most students do not understand the way of thinking that science preaches and do not acquire a scientific temper. As a result, many people who have gone through the education system up to the highest level, still harbour many unscientific beliefs and superstitions. In that sense, our education system is not 'scientific'. This session will discuss what changes should be brought in our education system to make it scientific.

Open Session (for the public):
16 December, 3-5 PM
"Problems facing development of scientific culture in India"

Session 5: Panel Discussion on "The role of scientists in society"

Cultural Programme: There will also be a cultural programme in which a play will be enacted by professional scientists.

Speakers and Session Chairs:

- **Prof. Jayant V Narlikar**, Padma Vibhushan, former Director, Inter-University Centre for Astronomy & Astrophysics (IUCAA), Pune
- **Prof. Ramkrishna Ramaswamy**, President, Indian Academy of Sciences, former VC, Central University Hyderabad, Professor, JNU
- **Prof. S G Dani**, former President, National Board of Higher Mathematics, Professor, Centre for Excellence in Basic Sciences, Mumbai
- **Prof. Dipankar Chatterji**, former President, Indian Academy of Sciences, Honorary Professor, Indian Institute of Science, Bangalore
- **Prof. Dhruba Mukhopadhyay**, former Professor of Geology, Calcutta University and President, Breakthrough Science Society
- **Prof. Dhruv Raina**, Professor, School of Social Sciences, Jawaharlal Nehru University, Delhi
- **Prof. Ajit Srivastava**, Professor, Institute of Physics, Bhubaneswar

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- **Prof. Amitabha Datta**, INSA Senior Professor, Dept. of Physics, Calcutta University
- **Prof. Debabrata Ghosh**, Professor of Physiology, All India Institute of Medical Sciences, Delhi
- **Prof. G Nagarjuna**, TIFR-Homi Bhabha Centre for Science Education, Mumbai
- **Prof. Palash Baran Pal**, former Professor, Saha Institute of Nuclear Physics, Kolkata, and eminent science popularizer
- **Prof. Aniket Sule**, TIFR-Homi Bhabha Centre for Science Education, Mumbai
- **Prof. Debshankar Ray**, Professor and former Director, Indian Association for the Cultivation of Science, Kolkata
- **Prof. Jayshree Sengupta**, former Professor, Dept. of Physiology, All India Institute of Medical Sciences, Delhi
- **Prof. Naba Kumar Mandal**, Former Professor, TIFR, Raja Ramanna Fellow, Saha Institute of Nuclear Physics, Kolkata
- **Prof. Guruprasad Kar**, Dept. of Physics, Indian Statistical Institute, Kolkata
- **Prof. Mayank Vahia**, Professor, Tata Institute of Fundamental Research, Mumbai
- **Prof. M C Arunan**, TIFR-Homi Bhabha Centre for Science Education, Mumbai
- **Prof. Umesh Kadhane**, Indian Institute of Space Science and Technology, Thiruvananthapuram
- **Prof. Abhijit Majumder**, Dept. of Chemical Engineering, IIT Bombay
- **Prof. Arvind**, Professor of Physics, Indian Institute of Science Education & Research, Mohali
- **Prof. Pradipta Bandyopadhyay**, School of Computational and Integrative Sciences, Jawaharlal Nehru University, Delhi
- **Dr. Prabhakar Reddy**, Professor of Cardio-Thoracic and Vascular Surgery, Government Medical College, Kurnool, AP
- **Dr. C M Nautiyal**, Former Scientist at the Birbal Sahni Insitute of Paleosciences, Lucknow, Program Consultant – Science Communication, INSA.
- **Prof. R Ramanujam**, Institute of Mathematical Sciences, Chennai
- **Prof. Soumitro Banerjee**, General Secretary of Breakthrough Science Society and Professor, IISER Kolkata.

Registration information:

Registration fee: Rs. 2000
Concessional rate for bachelor's and master's students: Rs. 1000
Due to limitation of seating capacity in the hall, participation is by invitation. One can express interest in attending this conference by pre-registering at the conference webpage www.breakthrough-india.org/iss2018/
Registration will be completed only after payment of fee at the registration desk at the conference venue.

Distributing Justice in a Digital Society

Nagarjuna G*

Introduction

This article is on the politics of media, covering both digital and non-digital media. The primary purpose is to bring home the point that the current political powers, all around the world, are using the 'new' digital medium to make 'old' governing systems more powerful, rather than empowering citizens, although most of the governments of nations themselves claim to sustain and work towards democracy. We will discuss centralised regulation and decentralised regulation of media, and relate this to the concepts of copyright and copy*left*. A political movement has taken shape to address the issue, which is called *free software movement*, and this has inescapable implications to several aspects of our lives, wherever digitisation of culture impacts and effects.

Historically, as the digital form of information and communication technology (ICT) unfolded, two cultures developed — those who used the new medium and those who abused the new medium, and these have evolved into two incommensurable, indeed, sharply polarised communities. In the light of the emergence of the modern information society, while the policy makers, philosophers, social scientists have been caught napping, power-hungry agencies, an umbrella term that includes governments and mega-corporates, have taken advantage of this lapse.

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This essay attempts to identify the ontological aspects of these new forms of technology, economy, and politics, to explicate both the might and plight of the new digital natives. In the process, the roots of the game and the anatomy of the game are clarified.

The two models of governance

There exist at least two kinds of managing systems. Let us call the first as central-control-model (CCM) and the other as distributed-control-model (DCM) (or decentralised control model), for want of better names.

The CCM is well established, and is commonly considered to be an acceptable form of control in civilised societies, and the latter, DCM, is taking shape in the new digitally and technically mediated social space. Considering that most polities today are democratic, one may wonder, why do we assert that the CCM is the most common? The fact of the matter is DCM is the most talked about political design (or desire), but remained largely on paper, until recently, as we begin to see the design being implemented successfully. Perhaps sufficient conditions for democracy are only just getting satisfied, after the emergence of the 'new media' without the 'mafia.' We will draw the implications of the DCM for policymakers.

CCM is the most common means of managing a social system. However, the reality is that maintaining CCM is expensive and vulnerable, while DCM is economical and

sustainable. One may well question why, if CCM is expensive and vulnerable, how did it come to be recognisably the most common? It is important to note that most of the political or administrative systems, including the modern democracies, remained a CCM despite the professed objectives of democracy. But why?

The answer is, that we learned how to take power from the commons, but did not learn how, in return, to grant power to the commons. As a result, those in power have come to believe that the ignorant and illiterate commons would misuse power. Therefore the 'ignorant', 'uneducated' commons needs to be protected from the wise, educated elite. Although, in theory, democracy developed as a bottom-up model of polity, in practice it remains top-down. The so-called 'democracies' seen in practice seek power through votes from the commons, but power itself is kept under wraps, and centralised. People elected a president or a prime minister, but effectively only through a hierarchy of electoral colleges, and this assures the centralisation of administration. Ironically, the wrapped up power itself requires security and protection, exhibiting the vulnerable state of the centralised batteries of power.

In what follows we will illustrate these contrasting models concerning media politics which, we hope, will offer an insight to formulate our policies.

Copyright versus Copyleft

Soon after the industrial revolution, copyright was established as a social instrument, to protect the power of authors or knowledge creators. (Pollard, 1922) (Cohen & Rosenzweig, 2006). Although copyright was institutionalised as an incentive to authors, it soon transformed itself as an instrument to protect the agents of authors, the publishing houses.

As is required by copyright law, a statement that describes the conditions of copying the creative work is stated following the date and name of the holder of the copyright. While such statements change from publication to publication, in almost all cases the copyright holders assert a variety of ways in which readers are restricted in the use of the published material.

To understand how this works in the modern form, let us look at the copyright page of Mahatma Gandhi's *Hind Swaraj*, republished by Cambridge University Press. Even the most ardent followers or scholars of Gandhi do not know the fact that the book was published initially by Gandhi under the assertion "No Rights Reserved." It should be recalled that he was a lawyer, and was certainly aware of the ramifications of making such an assertion. In practice, the re-publishers of the same book do not respect the original author's claims, which is clear in Figure 1. By inserting editorial inscriptions, a preface or an introduction, the publishers republish the work in a different *avatar* and use this thin excuse to claim copyright of the work. Thus even in cases where the author did not create restrictions, publishers have found ways to prevent the expression from reaching readers without restrictions. This illustrates how blatantly the proprietary media houses have exploited a legal instrument.

The usual restrictions on copying can be illustrated from another example, a book published by MIT Press, titled "Philosophy of Computing Information" has this on the copyright page: "© 2004 by Blackwell Publishing Ltd. All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, except as permitted by the UK Copyright, Designs, and Patents Act 1988, without

First published 1997
Reprinted 1998, 2000, 2001, 2003 (twice)

Printed in the United Kingdom at the University Press, Cambridge

A catalogue record for this book is available from the British Library

Library of Congress Cataloguing in Publication data
Gandhi, Mahatma, 1869–1948

Figure 1: Copyright page of Hind Swaraj republished by Cambrdge University Press. Mahatma Gandhi, the author of the book, asserted "No rights reserved" for the Hind Swaraj.(Achal, 2012)

prior permission of the publisher." Such statements are a norm rather than an exception.

As the history of its usage suggests, almost everyone in the world has used copyright to restrict the way the resource can be, or, in effect, cannot be used by others. At the time that Gandhi sought to make a difference, the seed did not find fertile soil. However, when Richard M. Stallman (popularly known as RMS) invented copyleft, by turning copyright on itself, the ground was fertile this time. Several other authors, mostly software programmers, employed copyright the way RMS did. The following example illustrates this contrasting use.

The book that contains selected essays of RMS has the following: "© 2002 Free Software Foundation. Permission is granted to make and distribute verbatim copies of this book *provided the copyright notice and this permission notice are preserved on all copies*." (Italics added.) As we notice, this is a creative subversion of the legal copyright instrument. It permitted, not restricted, copying. However, it imposed a condition, that all copies must carry the same copyright notice. This simple act of granting freedom to copy, provided the freedom is not withheld in future by others, is called copyleft (R. M. Stallman, 2002). Though the above copyright statement shows 2002 as the year, RMS invented it around 1983. (R. Stallman, 1985)

Copyleft is a paradigm case of how DCM works. It distributes responsibility, by granting the freedom to copy to everyone. It provides an incentive for the care and responsibility the receivers promise to take. The returns are inbuilt. The recipients get more than what they return. Since they do not have to impose any restriction, no additional energy is required to be spent. Most publishers, on the other hand, control their property by employing lawyers specialising in intellectual property to tailor copyright deeds based on their business models. They need to spend to maintain a constant vigil on potential breaches. Companies that work under CCM spend humongous amounts (of money, but effectively of energy) on intellectual property rights (IPR)

and vigilance related expenditure. If the desired action is of restriction and protection, the care to be taken is expensive. On the other hand, if the desire is to grant freedom and distribute the rights, such expensive managerial and legal infrastructure becomes redundant. Copyleft abuse is minimal and can be safely ignored.

This line of thinking is the beginning of a new era of publishing, moving beyond books, into software, where it has impacted a much more powerful and wealth-creating environment. We will discuss the software specific issues in the next section, of how it helped the creation and sustenance of DCM of free and open source software (FOSS).

During the last three decades, copyleft was used and hardly abused, by thousands of authors worldwide. This has been the single "weapon" used against the CCM of proprietary software companies. Its success is evident in its use by Wikipedia, Creative Commons, and of course free and open source software (FOSS) development.

How to Control Digital Space

Since this section concerns the central concepts of the digital space, media, code, and message, let me begin by establishing the sense in which they are used. The term "medium" refers to the means and the mode of storing and transmission of encoded human actions. I will use the term "code" for the encoded human action. The "new medium" refers to the digitising means, and the mode of storing and transmission of encoded human actions. The interpretation of the code (decoding) is unfolding of the encoded human action, which is inherent in the message of the code.

The computing model used for encoding, decoding and transmitting are known to the experts in information and computer technology (ICT). Since this is an area of the new computer science, it seems logical that we should leave it to them to solve the problems arising out of this digital communication space. However, as we will see, we will be in great trouble if we do so. Most of these experts are not working alone. The agencies for whom they work, and the social and economic motivations of their agencies, demonstrate what they do to this space.

The political operational space of digital society can be best understood if we focus on what happens when we digitise any document — text, audio, video, or any other kind of media. Digitisation uses a computing model to write (encode) the data in any computer memory, and when we try to retrieve the data, the computer reads (decodes) it for us in a human-readable form. We need not go into the technical details of how this is done, but focus on these two operations for a while.

Since any code is by nature arbitrary, each company can invent its model of digitisation, and provide a computing service to its customers. If the arbitrary computing model they use is not published, decoding it becomes a private, or proprietary, process.

Let us now consider two agencies. The first agency, call it D, produces a document using a computing model where the encoding and decoding model is published. The second agency, call it C, creates a document where the encoding and decoding model is held in private custody.

Spread the documents produced by both these agencies all over the world, perhaps by uploading on the World Wide Web (the common standard for machine accessing and/or publishing human-accessible content). If someone wants to decode (read) the documents produced by D, we need an interpreter, often a software program. If the software is not made available, one can create one based on the published computing model. The burden of interpretation

is not on D. The burden of interpretation of decoding a genetic sequence does not lie on those scientists who cracked the genetic code. Since the method of cracking the genetic code is published, anyone who intends to do this can train oneself. Thus publication distributes the power to decode to the commons.

No one can decode the documents produced by C, unless C creates a software interpreter and publishes the interpreter, either gratis or for a fee. Since the computing model is held private, no other agency can create an interpreter for it. C becomes the center of producing interpreters for privately encoded documents. Remember, the documents themselves are not held privately, it is only the interpreter that is kept under wraps. If you have C documents in your hand, you will also need a C interpreter, without which the C documents are like Rosetta stones. You have them in your possession, but you have no way to decipher them. Thus for any practical use of C documents, the users depend on a centrally produced (and controlled) interpreter.

One may think that C is protecting innovation by keeping control of the interpreter. However, digital encoding as mentioned earlier is arbitrary. Arbitrary novelty is not an innovation. The computing community realizes this. Therefore, the useful computing models are published as standards. We have worldwide organizations like ISO, IEEE, Oasis, and W3C that publish standards. These standards can be used by other agencies, either for a fee or gratis. The fact that they are available to any agency is good enough for distributing power to the agencies, instead of holding it in one's custody.

The picture becomes a little more complicated when we bring in the required layers of interpretation. In an operating system, there are multiple layers where interpretation happens.

When programmers write instructions, they do so in one of the programming languages. These instructions can be read only by trained programmers or by the specialized compilers or interpreters. They know how to parse them and decode the meaning of the instructions. However, a compiler is not capable of carrying out the instruction, because it is the processor of the computer that carries out the instruction. It merely acts as a barter, by providing an explicit mapping between the programmer and the computer. Since a computer does not understand the human-readable programming language, the compiler decodes our instructions and then re-encodes (re-writes) in a language the computer can decode (understand). Such a rewritten code is called compiled software, which is written exclusively for machines. Therefore it is often called machine language. This code is humanly impossible to decode (though in principle, of course, it is possible). Since there are several kinds of hardware processors made by different vendors, the compilers have to create different versions of software suitable for each processor. Thus, a program made for an x86 processor is not suitable for a PPC processor.

When software vendors distribute their software, they distribute it for a particular machine, and the code that is distributed is not the code the programmer made for the company, but a compiled version. Added to this complexity is that the program cannot be directly passed onto the processor without an operating system (OS). An operating system is another mediator that helps convey the instructions from the program to the hardware, and vice versa. It is therefore also necessary to keep in mind the OS for which the programs are compiled, apart from which processor they

were compiled. Sometimes, it is possible to use the same bytecode on all the operating systems, provided that there exists a separately compiled interoperable interpreter for each processor and OS. Languages like Java and Python, for example, work this way. This makes the code inter-operable.

Now that we briefly looked at how our instructions before reaching a processor get re-written into a series of 'languages,' we can now see how to convert software into proprietary software. If anyone wants to take control of the software (code) that is made, a proprietary software company can do several things. One way is to provide the source code of a program to everybody, but restrict the interpreter (say a compiler of that language) to only those who pay a license fee. It is also possible to embed the interpreter in hardware, and whoever has the hardware can make use of the software (e.g., iPod). Another way is to provide neither the source code nor the compiler, but only the result of a compiled software (e.g., Microsoft Office), and restrict the operating system to only those who pay a license fee for it (e.g., any of the Microsoft Operating Systems).

It is possible also to restrict the use at all these multiple stages the compiler, the operating system, and the access to the compiled code. The possibility of restriction does not end here. It is possible to create special hardware, which may also contain another layer of an interpreter, and lock the hardware to a single user who enters into a license agreement with the manufacturer (e.g., controlling at the bios layer which software could run on the board). The early Indian language typing solutions use this model, ironically including those produced by government agencies, ignoring or bypassing a 'policy decision' to honour the principles of free and open publishing. It is possible to invent more and more such stages of control by C agencies.

However, in all these stages, mostly the interpreter and sometimes the code is kept under control. Since code per se is of no value, the process that makes it valuable is the interpreter, which decodes the meaning contained in it. By making the interpreter a scarce commodity, it is possible to enhance its value. Since even interpreters are codified instructions to the computer, one copy of an interpreter can be copied to make several copies. That is why a proprietary software vendor searches for technical innovations that prohibit copying, or to find other ways of prohibiting copying. One standard method is to de-couple the interpretation process into two or more layers and embed a part of that into hardware (e.g., Apple). This way an interpreter can be made a scarce commodity, making it available to those who can afford to pay a license for it or buy the hardware and software together.

Another significant way of controlling is to write user's creations (such as digitized text, audio, video, etc.) in a specific language that can be interpreted only by the system that created it. Restricting the user to use only one kind of application all through their life is the most popular way of enhancing the value of software. Microsoft's 'doc' format is an excellent example of this.

The companies that indulge in this kind of practice provide a justification, which is to collect a fee for the interpretation, claiming the ownership of the interpreter. The money users pay therefore called as a license fee, and not the price of the software. This tactic proclaims that it is a service oriented business. They alert us in the fine print that very few of us care to read: the customer is not the owner of the software, and is merely granted a license to use it for a purpose.

Currently, the human effort on the operations involving code is slowly reducing and is increasingly taken care by the artificial agents (computers). Yet, the owners are demanding more, instead of asking lesser compensation. This is not justified, since the precious human effort has come down substantially. Since the new software technology got a fashionable image that it will be creating more value, people began paying fees as per the demands of the software producers. This increased the wealth of the software 'industry' severalfold, virtually minting digital money. In economics, this production of money without a commensurate increase in underlying value is called inflation.

On the other hand, the hardware is also getting embedded with an increasing amount of software. Increasingly, even hardware is entering into a licensing regime. Software and hardware industry are together creating more and more artificial agents. The main problem with this model is, society began to pay for the services of the artificial agents. The manufacturers of these agents are pocketing the money in the name of the service time of these gadgets. In this new economy, it is not the goods and service time of human agents that are on sale, but the service time of the gadgets. Do the manufacturers of the devices deserve to extract the compensation? Yes. However, only if they do not insert additional locks, that is if they do not prevent free dissemination of cultural resources.

Technical innovation should work towards finding out how to preserve cultural resources for a long time, rather than decrease their lifetime. What is the problem with this business model? I think the problem lies in charging for the service of an artificial and copyable agent (interpreter). As long as the interpreters were human beings, we sought to buy their time when we needed an expert. Currently, most human expertise is getting re-written as programmed instructions, and are interpreted by the artificial agents. The scarcity of artificial agents is controlled artificially by the C agencies, so that their demand increases.

It is important to realize that there are two kinds of artificial agents: the hardware and the software. The hardware is a substantial thing, fabricated generically to carry out programmed instructions. It is not possible to make copies of hardware without spending considerable matter and energy. A software, on the other hand, is copyable with minimal effort and with high fidelity. Writing programs is a creative act, just as inventing a formula in mathematics. The compensation should go to the author, and not to the agency that copies the program. Often programs written by several authors is collected and compiled to produce a re-written form of the program, which the author too has lost the freedom to interpret. The author of the program lost this right. The only way to regain it is to keep the entire compilation process accessible. By becoming a custodian of the latter stages of converting the program into machine code, and its interpreter, proprietary software industry invented a technical method of taking away the right to know. This is not required for making the technology work, but only needed to promote business interests. As was described in the previous section, the code is eminently and naturally copyable. Copyability is code's essence. When people indulge in such a natural process, the C agencies call them 'pirates'. However, this aspect of the work of C agencies is inherently inflationary, which, in societal terms, is arbitrary and exploitative.

To understand that this model of ex-

ploitation does not happen only in digital society, let us take a look at Indian history. There was a time when the traditional wisdom in India, often called Vedas and Upanishads, was available only as spoken (verbal) code, and was part of common knowledge (folklore). Later, this wisdom was rewritten (re-encoded) in an artificial language called Sanskrit. Sanskrit is artificial because of the generative structure of its grammar. There is a sense in which all natural languages are artificial (artificial = made by humans), but Sanskrit is not natural, in the sense that it is a rule-based construction, using the same model as our programming languages. It is not the vocabulary that makes it Sanskrit, but the manner in which it combines the vocabulary to generate more meaning.

After re-writing the traditional wisdom in Sanskrit, it became accessible only to those who spoke or wrote this language. It was the elite section of the society the Brahmins who had this access. They were the 'compilers' of Sanskrit, so to speak! There was a time when the right to learn Sanskrit was prohibited, by promulgating a rule that only the royal caste (kshatriyas) and scholarly caste (Brahman) could decipher what was in there. Even kshatriyas were prohibited from accessing some portions. This restriction to knowledge was accomplished by creating a private language. This is very similar to the way proprietary companies are making private languages to prevent knowledge from flowing freely. Brahmins called a shudra (person belonging to the lower caste) a *papi* (a sinner), just as proprietary world called those who copy software 'pirates'. The powerful people always harbored the 'compilers,' buttressed them, so that the rulers could remain rulers forever. In computer software, this is the same game. Old wine in new bottle! A corporatised multinational version of brahminism!

The question is, are these mechanisms to take ownership of the code or knowledge ethical? Are they even necessary for doing ethical business? Arguably not. In the last ten years or so, a large number of D companies worldwide began distributing software and provided services around it, e.g., Redhat, Debian, Mandrake, Ubuntu, etc. Instead of selling software per se, or claiming ownership of their creations, they sell the services of experts. Indeed, they also harbour a large number of developers in their business houses, to create more software and enhance the efficiency and value, without claiming ownership of what they produce. This proves that ownership of tacit property is not essential for business. The rise in their service business is evidence to its success.

The objection is not to making money, but to the means of control. This is not using technology to enable society to access knowledge freely, it is using technology to curb free access to knowledge. Their inventions are counter to preserving human values.

The story does not end here. There are other aspects to it.

To understand how criminal these intentions are, let us do an activity. Some of you readers may have been using computers for the last 10 to 20 years. Collect all the documents you created during this time. Attempt to open those files today, using your modern OS. Take my word, several of you will find that most of the older documents are unusable. Either the document cannot be opened, because the software that you have on your modern OS does not know how to decode the older documents, or after decoding you see that there is some significant loss of data.

Now the question is, why did this happen? This is because the underlying encod-

ing technology was modified. If our work is inscribed in digital media like this, how can using computers for storing data be justified? Printed books, old audio tapes, etc., can still be used, because they are not encoded in a secret language. We have not lost the ability to decode them. However, our modern operating system lost the ability to decode some of the older computer documents that the same system once produced. Who is responsible for this loss? If the agency which lost this is a public body, like a government, who can be held responsible for this loss of data? Often enough, people have been using, all along, software made by the same company. Yet, this loss took place. Why?

The answer is not technical. True, advancement in technology requires that there be some changes. However, what is the justification for changing the encoding of data, without converting them to a newer form? The computing industry has norms to follow, such as encoding standards, e.g., ASCII, Unicode, XML, HTML, etc. Modern computers did not lose the ability to decode the older encoding standards. The loss took place because the software was proprietary, and the encoding of the data was also proprietary.

If using computers for our work means such loss of data, doesn't this become a sufficient reason to stop using computers? Even our inscriptions in the ancient caves still exist, although deciphering them is often a challenge. This indicates that preserving code is not enough, and we must also preserve how to decode. The only way out of this problem is to make sure that we save our work in a standard format, and record in the museums the process of decoding. Currently, our museums store only the code, often forgetting their meaning. Most users of computers may not be able to understand these subtleties of code dynamics. In such a situation, it is the responsibility of educational institutions, media, and the companies themselves to advice the users to follow the best practices. There must be governing policies to preserve cultural records, and not to preserve knowledge in a proprietary format. Otherwise, they need to, at the very least, include a prominent warning, that there could be a loss of data, if all of it is not regularly, even frequently, recreated and stored anew.

If we collect all the digital documents which cannot be usable in today's operating systems from all the users from merely the last fifteen years, we will realize that this is not an ordinary loss. It is nothing short of wiping away history, since it is the documents that contain what we did in the past. If the documentation cannot persist, we cannot preserve history. It is like walking on quicksand, where we find it difficult to trace the steps we took. Who is going to pay for this loss?

Having seen how the C agencies are controlling the digital space, let us see how the D agencies do it, by employing the copyleft model.

Software Freedom Movement

As we saw in the previous section, several layers of possible exploitation of digital versions of our cultural practices are at stake due to holding interpreters (decoders) as private property. To prevent this, Richard Stallman invented the idea of copy*left* which is an inherent part of the very definition of *free software*.

We realize from the discussion above that software is nothing but a language, though it is invented artificially by a small set of programmers, unlike a natural language. In the computers that we use, several layers of language and different kinds of them are supported, each with their syntax and

semantics. However, once we accept that software is a language, we treat software as a *creative expression.* A legal way of protecting a creative expression of ideas is by applying copyright. Therefore the focus of the discussion turns to who holds the copyright and what are the terms and conditions of the copyright. Richard Stallman did not challenge the legal instrument of copyright, instead asked us to modify the terms and conditions. The inventiveness of his proposal consists in ensuring that we do not curtail the freedom to interpret at any stage of creative expression. *Free software*, thus, is software with liberty to encode and decode.

The first thing we need to know about the term "free software" is that its meaning does not arise from the combination of the terms "free" and "software." The meaning of this term arises from the definition, and not from the terms it contains. The term "free software" is defined by Stallman as that software which gives the user the freedom (1) to use it for any purpose, (2) to know how it works, (3) to improve it by modifying, and (4) to share or propagate or distribute the modified code to others, provided all these freedoms apply recursively to all distributed copies. This is the essence of *General Public License* (GPL).

Any software that meets these four criteria can be called free software. We must notice that there is no mention of the price of software in its definition. This means that there exists a possibility to pay or charge for software. Since free software is intended to give the users the freedoms mentioned above, it is better called "freedom software." In Indian languages there are more options: we may call it "swatantra software" (a preferred term in southern and western India), or call it "azaadi" software (a preferred term in north-eastern India), or else call it "mukta software" (a preferred term in northern India). The last option is nice since we can create a near pun with the word to say: we are talking about mukta, and not mufta (gratis) software. Let us, therefore, bear in mind that free software is not about price, but it is about freedom.

A necessary implication of software freedom is an invitation to shape the technology by anyone who respects the freedom to encode and decode. As a result, the GNU project, founded by Stallman in 1984, unfolded into a full operating system used in almost every computer in some form or the other. Several geeks, often called hackers, collaboratively created several programs and published the code online. Other users, who may not have been that proficient with coding, contributed documentation and user manuals. Others translated them. They made programs 'speak' all the languages of the world. People made several modifications and customisation of the programs, which expanded their diversity, and eventually, natural selection worked on this diversity of programs, to create the best quality programs for any given purpose. Today, GNU/Linux operating system is leading by holding about 80% of the Internet servers, from small systems to supercomputers. It is also spreading fast in mobile and desktop computers.

An exciting development was that the geeks also created software platforms that facilitated collaboration, by publishing information about who contributed what, and when. Transparent auditing of not only the programs, but their process of development, was made possible. This demonstrated the possibility of an alternate form of bureaucracy, or if you like, the elimination of bureaucracy.

This prospect became part of another widely acclaimed project, Wikipedia. Wikipedia used precisely the same model of collaborative development of articles on ev-

ery topic and in every language of the world. Wikipedia uses free software to produce free knowledge by employing a transparent bureaucracy. Nothing is hidden, the entire process of how each article is written is also part of it. For the first time in the human history, the history of each creative expression is also encoded.

Another impact of this movement is open access journals. Many of the traditional research journals bargained to take the ownership of copyright from the scientists and restricted the journals to only subscribers. Open access journals used a derivative of the copyleft model, popularly called *Creative Commons* that modified the terms of the copyright, similar to GPL. Though open access journals are a welcome development, they are far behind in documenting the process (history) of science, since they provide open access only to the generated product and not the process. They have much to learn from Wikipedia and free software projects.

Implications to Distributed Justice

Several areas of our lives are affected by digital technology. Most widely used devices are a result of digital communication technology, in the form of mobile phones. Most mobiles are 'infested' with proprietary software, that extracts information about users without our knowledge. They are Trojan horses living in our homes and pockets. Whether it is set-top boxes or mobile phones, all of them have encroached upon our private as well as public lives. Only recently several countries woke up, and have begun to regulate this space. India is also discussing a draft law for the protection of private data, as we write this article. However, by confining this protective discussion to 'data', meaning in fact digitally stored data, this is a thinly disguised assault on personal freedoms enshrined in the umbrella term 'privacy'. Privacy was, as it happens, reaffirmed as an inherent Constitutional right following the imposition of a digital numbering scheme, branded 'Aadhaar', that, in effect, compromised the societal understanding of identity in India, and which has been subsequently significantly curtailed.

Though we are a professed democracy, the recent use of digital technology by the Governments does not indicate they are interested in distributing power to people. The Aadhaar project, a centralized repository of providing UID to all the residents of India, goes contrary to the idea of freedom. The identity of a human being is socially constructed. Governments are denying the self-regulated identity by increasingly moving towards centrally granted identities using biometry. Linking this to various services amounts to a denial of service. This is a blatant abuse of ICT by the state to create centralized, instead of preserving the existing decentralized and socially constructed identity. All the problems associated with centralised systems discussed above make this system vulnerable and expensive. Free software developers have demonstrated how signing (endorsing) each other's electronic signatures produces greater distributed trust than a centralized trust. Centralized trust can become corrupt very quickly due to single point control. The Aadhaar story so far demonstrated us beyond doubt that the greater the linkage of UID, the greater will be the leakage of personal information. It is unfortunate that the Supreme Court of India does not see this, and a majority of the judges assigned to the Bench adjudicating it, except for the dissenting Justice Chandrachud, have also been caught napping.

Digital technology provides several ways of enhancing transparency which could

minimize corruption in all walks of life. Governments are still using several layers of proprietary software for running the daily functions. Some of the geeks who exposed the vulnerabilities of proprietary software running on Government platforms, voting machines or Aadhaar data leakages were arrested, instead of giving them incentives for protecting the system. This attitude of the government and the policy makers indicates that the so-called democratic governments function like centralised powers. Wikileaks demonstrated how such governments could be found behaving corruptly. They mostly abuse power.

Digitised knowledge is eminently copyable, making it no longer a scarce commodity. Similarly, a deregulated spectrum is necessary for the last mile connectivity of Internet. However, the government sits on this abundant medium, artificially increasing its value by treating it as a scarce commodity. This is the most brutal act of preventing people control of their own media, the remote (or distance) counterpart to speech. Controlling resources that are not abundant, or are not recyclable, such as oil, makes sense. This case of centralized control of spectrum makes governmental behaviour similar to a mafia. In the name of security, the military and State are squatting on this most abundant natural resource. No government anywhere in the world grants a license to the commons, except for the narrow WiFi range of the spectrum. This license model is no different from a mafia holding a *basti*, collecting *hafta* in the name of protecting the small-time vendors doing business (the protection racket), or the British colonial government taxing Indians for producing salt from the natural seawater. In the name of security, spectrum modulation rights are held by the mafia (Government and large Internet Service Providers). Even within the deregulated spectrum of WiFi, people are not allowed to run ad-hoc mesh networks, because Government cannot control them. Do we have to do spectrum *satyagraha* to gain freedom from licensing spectrum?

A new and very dangerous game by software companies is to provide gratis proprietary software in the name of social networking and communication applications like Google Search. Gmail, Facebook or Whatsapp, which are used by billions of people around the world. These are Trojan horses. Even if the users levy a fee to the company, the business they do is still profitable. They earn revenues by selling our profiles, without paying us for giving our information. All policymakers across the globe are caught napping in this case. Stallman warned about this danger several decades ago.

It is not only the policymakers that were caught napping, the syllabus makers of schools, colleges and universities also were, by introducing proprietary brand names in the syllabus as well as in the examinations. Instead of testing the skills, they test whether the students have rote-learned a specific brand of an application. It is like forcing students to use only pencils of a particular make in an examination. Certificates issued by branded companies like Cisco, IBM, Microsoft, Adobe, etc., are gaining higher value than certificates that display proficiency of generic skills. This trend is not towards freedom of expression.

The danger of using proprietary software in any area of life is treacherous. It is profitable only for big corporations and power hungry governments. If we believe that the direction of democracy is towards distributing power and not accumulating power in the name of governance, we should criminalise their use everywhere.

Computer scientists have demonstrated how economical and efficient will be the

transfer of documents when published and transmitted in P2P networks (torrents). Since this is not in the interest of ISPs, government and ISPs criminalize these networks in the name of 'piracy'. Just as spectrum is controlled in the name of security, the P2P network infrastructure is denied to people in the name of piracy. This is a clear illustration of whose interests the government supports, over the rights of free citizens. Complete denial of democracy is illustrated. In Myanmar, free (unbilled) access to Facebook on mobile phones has led to the spread of hate speech, resulting in the massacre and expulsion of large numbers of Rohingyas, a community in the northwest of the country.

Inter-governmental bodies meet periodically to regulate the space through treaties, expanding and protecting the mafia. The Internet was born as a DCM, but private corporations are seeking Government's sanction to convert the Internet into a CCM. The Internet is governed initially by self-regulating protocols. Frequent demands by various Governments to block social networks, microblogging sites, WikiLeaks, stop the internet in politically dissenting areas, etc., is an indication of how it would work if they regulate the Internet. This is a clear illustration of where governments are heading.

The governments do not control the free software world, or the Wikipedia world. This demonstrates that a transparent protocol based administration is possible without centralised legislation. It is not an accident that only proprietary operating systems harbor computer viruses. Centralised governance, by its very nature, is bound to become corrupt. Power corrupts people.

Information and Communication Technology (ICT) is a genuinely empowering medium and can hasten the process of distribution of power reaching the goals of a democratic polity. Central control of anything, including ICT is expensive, unscientific, and also inefficient.

The story of the free software movement gives us hope that the means of distributed power is not impossible. Commons can make, share and manage small to gigantic scale projects without centralised control. However, this may not be acceptable to power-hungry political parties. They ask for strong and stable government in their election manifestos. What we need are weak, dynamic, transparent, sustainable social systems that are grounded in ethical protocols, rather than strong legislation and executive. A weak government is a blessing for democracy, not a problem to fix.

The Free Software Movement is a political and cultural intervention in an apparent disguise of technical practices. The movement does not become a Trojan horse, because it started with an explicit manifesto. This is already evident in the way it impacted distributed development methods, transparency, collaboration, social networking, the emergence of creative commons, p2p governance, etc. If these episodes are considered primarily geeky by the policymakers, they will be caught napping once again. It is time to study these highly successful methods of self-governance, the true meaning of democracy. Let us conclude at the end that there are multiple lessons to be learned from these episodes, and each of them has policy implications. They deserve to be attended by the policymakers in the Niti Ayog.

To Conclude

Socio-political problems cannot be fixed by technology, however technology can facilitate and expedite the distribution of justice or disruption of social fabric. Copyleft

cannot fix freedom of expression, but it will make it easy and accessible. Copyleft cannot fix abuse of media, such as distribution of indecent content or trolls. However, technology can help detect them through transparent collaborative models, and fix it faster than a centralised model where we appeal for justice through a hierarchical judicial system. Copyleft is a paradigm case of how justice can be made *inherent* as a protocol. Technology cannot grant RTI (right to information), but it can make RTI redundant by making information always accessible. Who will need to file an RTI on Wikipedia? Technology cannot inform us that freedom to whisper is a political necessity and so must be protected. However, technology can help us create means of efficient whispering. The idea that personal data should be protected by the state does not come from technology, but mismanagement of technology can make the personal data leak without notice is a technical lesson.

Technology that we use not only determines but also expands the range of actions of human beings, individually or collectively. And so, it can transform the existing fabric of society, and often this transformation could be disruptive. Whether the action is ethical or not, is part of continuing social mediation and negotiation. Though we cannot fix this through technology, if the technology we use is proprietary, we cannot know what is being done to us in our own action space. That is why, we should never allow opaque technology to enter our lives. Public audit of all technology used in public space for a public goal must be made as a mandatory protocol by the state. Computer Hardware without open drivers should be treated as Trojan horses.

Technology grants an extended action space, which become power to those who have access to technology. In turn, this power could be used by forcing a person or even a country to become subservient or fight. Negotiating this space is the story of human history!

Human actions facilitated by technology can create resources that have exchange value. Multiple forms of currencies/coins are emerging, several of them digital, e.g. Bitcoin. The technology to mint or participate in an exchange of those coins does not seem to be accessible to commons. All of our enthusiasm to distribute justice could collapse, when a new form of currency gets into our life, while we are caught napping, which could take over all our negotiation space. On the one hand, we may feel good that corrupt governments do not have a hold of this space, but on the other hand neither do the commons. This does not seem to be a game for equity. These are also serious issues that we need to negotiate in the space of media politics.

The bottomline is: the human action space, without technology, is unimaginable. We are what we are because of our ability to create and use technology. Politics without technology, digital or not, is non-negotiable. What is negotiable is which actions are justifiable.

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Flood in Kerala: Natural Disaster or Price for 'Development'?

Srikumar Chattopadhyay *

Recent flood in Kerala has drawn national and international attention for more than one reasons. The state apparently insulated from large scale natural disaster is suddenly exposed to an unprecedented flood havoc claiming 488 lives and affecting 56 lakhs people across the state. Ten out of 14 districts experienced flood fury. More than 60 thousand houses were devastated. Fourteen lakhs people have to be moved to temporary relief camps. There were heavy losses of infrastructure like roads, bridges, schools, colleges etc apart from loss of agriculture. Total loss is pegged at 31 thousand crores of rupees. This amount has not accounted for the ecosystem damage like loss of top soil of large tracts of land, unsorted sediment deposit over productive agricultural land, sediment wash out due to strong surface runoff and biodiversity loss to indicate a few.

Apart from assessment of loss, rehabilitation and reconstruction activities the question often raised during deliberations on flood in various parlances and debated widely is about the underlying reasons causing such a devastation. Does this rainfall signify recurrence of rainfall event of 100 year return period? The rainfall departure curve since 1871 (the year when rainfall recording started) and occurrence of comparable rainfall in the year 1924 indicate such a possibility as monsoon rainfall follow simple harmonic motion. The high intensity rainfall, occurrence of peak rainfall during the month of August instead of July as was recorded in 1924 and subsequent years, prevalence of dry period following the extreme wetness and declining trend of rainfall as evident from time series analysis of annual and monsoon rainfall data since 1871 perhaps manifest impact of human induced climate change on rainfall pattern.

Besides these two possibilities of cyclicity of monsoon rainfall and change in rainfall pattern due to climate change, one of the most challenging question raised widely is human contribution in this flood devastation. A largely prevailing view often referred to suggests that had Gadgil committee report on the Western Ghats been implemented this devastation could have been averted. Another point often raised is about opening of dam shutters of almost all major and medium reservoirs in the state without prior and proper warning. Another question which has deeply disturbed a large section of society both within and outside the state is that how come in a state like Kerala that had accomplished so much in human development, successfully led several environmental conservation movements like that of Silent Valley and Plachimada and can boast of a strong and vibrant civil society movement, land use planning, adaptation and execution of environmental regulations

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are so weak? While taking cognizance of all the issues associated with these questions, it is important to analyse cause-effect relationship objectively and contextualise this flood incidence with larger issue of environment-development relationship, so that proper lessons can be drawn and acted upon during the process of planning for reconstruction and building a new Kerala.

Incidence of 2018 flood

Heavy rainfall and flood are intertwined. Average annual rainfall in Kerala is around 3000mm. Around 70% of this rainfall precipitates during south-west monsoon spreading from June to September. Like all previous years this year also monsoon broke on 1st June, 2018. Rainfall crossed normal rainfall by 2nd week of June itself. Heavy rainfall continued for more than two and half months except 1st week of July. Rainfall received in Kerala from 1st June to 18th August was 42% more than the normal rainfall. In a span of six days from 9th to 15th August, Kerala received 35 cm rainfall, whereas normal rainfall for the entire month of August is 32 cm. Idukki district, source of several major rivers in Kerala, received 568% more rainfall than the normal between 13th and 19th August. Volume of river discharge was 12300 million m^3 in just three days from 15th to 17th August. This was around 16% of total annual volume of water received by the state. Kerala was completely rain soaked by first week of August. Soil was saturated, wetlands were flooded and reservoirs were full to the brink. Shutters of 24 reservoirs were opened by 10th August and during next two or three days shutters of several other reservoirs were also opened. Flood and landslides that intensified since 8th August turned into deluge during subsequent days.

This is not the first time that Kerala was flooded. There were historical records of flood in 1345, when one distributary of the river Periyar changed its course and the present Kochi mouth was opened up. It is also said that flash flood of Periyar in 1789-90 stopped Tipu Sultan's march to invade kingdom of Travancore. The devastating flood of 1924 is often remembered in connection with this year's flood. Analysing rainfall and flood data from 1961 to 2003 an earlier study by the present author brought out that there were floods of various magnitudes in 1961, 1968, 1975, 1981, 1985, 1986, 1989, 1992 and 1994. Besides, limited flood incidences were also reported in the years of 1964, 1971, 1978, 1996, 1998, and 2001. In terms of human lives lost and property damage, the floods of 1961 and 1992 were significant after 1924. The 1992 flood caused death of 60 persons and affected 988 revenue villages. Incidentally it may be noted that this year's flood affected 774 revenue villages. Both 1961 and 1992 flood years were the years of heavy rainfall. However, the 1989 flood was noteworthy as the annual rainfall was below average. This apparently anomalous situation is indicative, proper understanding of which may provide important insight in flood management.

Land use change and loss of flood moderating capacity

Land in Kerala is intensively used. The state is densely populated with 860 persons / km^2 against an all India average of 382 persons / km^2. Settlements are dispersed, linear, continuous and corridor type long roads, railways and water courses. Most of the settlements are concentrated in the coastal plain and adjoining low lands and parts of mid lands. Kerala is experiencing widespread land use change across the topographic boundaries. Population growth, economic development, intrastate migra-

Picture of a flood-affected village in Kerala.

tion, foreign remittance, government policy, globalisation and economic liberalisation since 1990s, and urge of young generation for cosmopolitan modern way of life – all have contributed in this change.

Land use change has a long history. However, large scale change began with introduction of plantation crops and settlement of indentured migrant labours in the Western Ghats during 19th century. Since then, the Western Ghats, provenance of all rivers in Kerala and covering 48% of total geographical area of the state has undergone considerable change. Forest cover has come down from 44% in 1905 to 14% in 1983. Plantation, forest plantation, and various other projects claimed sizable area. There were streams of internal migration from lowlands to highlands. It has been reported that in a span of 80 years (1911-1991) population growth in the highland region was 1342% whereas it was only 306% in the coastal plain. Besides land-use change, there had been severe landscape alteration in the form of terracing, slope modification, rock quarrying, construction of roads cutting across all types of slopes and impoundment of reservoirs. Catchment characteristics of all rivers have been altered. This has resulted in breaking down of natural landscape matrix evolved through weathering and formation of soil under natural vegetation condition. Consequently, natural water absorbing capacity is lost, thereby contributing to increasing instantaneous flow and reduction in infiltration and dry season flow/ base flow. There are 57 large and medium reservoirs dotting the Western Ghats of Kerala. These reservoirs have water storage capacity of 5.8 billion m^3, 7.4% of total average annual discharge. These reservoirs have increased water storage capacity within the Western Ghats, however, they have also created potential danger as was experienced during this year. It has been globally accepted that reservoirs, although useful for irrigation and production of hydro-electricity, can serve the purpose for flood moderation in a limited way, as during high rainfall water

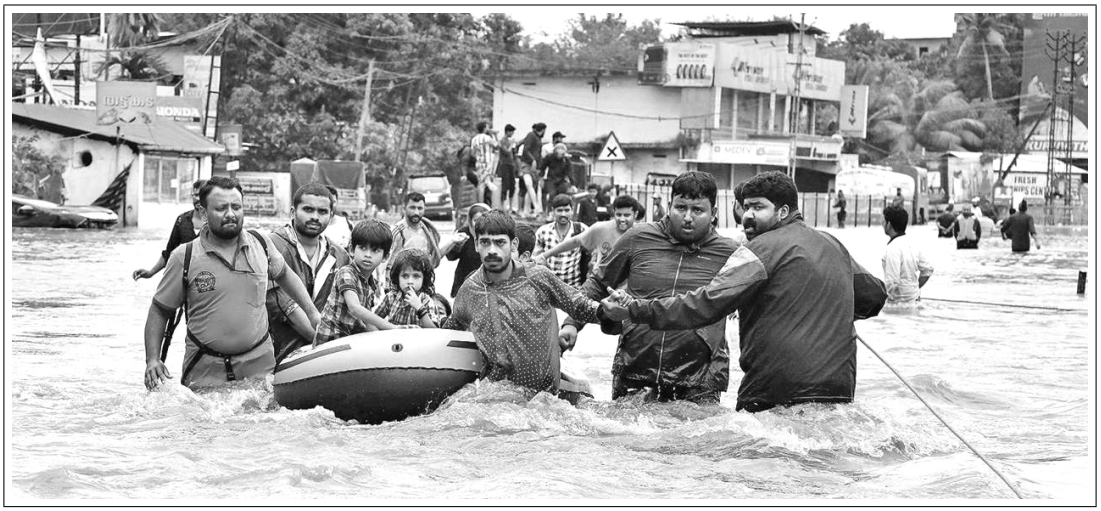
from the reservoirs have to be released to prevent dam burst.

Similarly, floodplains along middle course and downstream and coastal lowlands are under tremendous pressure. Land use is diverse, dynamic and intensive. All major urban centres are located in the coastal plain and lowlands. Urban population in Kerala was more than 48% in 2011. Population density in some parts of coastal plain is well over 2000 persons / km^2. Due to urbanisation and growth of population built-up areas are increasing at the expanse of agricultural lands. Settlements from traditional sites spilled over the adjoining lowlands and flood plains are heavily occupied. All low lands surrounding urban centres are being reclaimed to build urban sprawls and to accommodate new generation settlements and high rise buildings. With increase in built-up area, infiltration reduces and surface run off increases, thereby contributing to flood flow. Area under non agricultural use in Kerala has increased by 215% since 1960. Gross area under paddy had declined by 75% since 1974-75. Wetlands are being reclaimed all around its periphery. Even a lake like the Vembanad, which plays a very important role in Kerala's socio-economy has lost 75% of its water holding capacity, thereby increasing flood risk of the adjoining areas. It has been reported by James Wilson in an article in Frontline, dated 28 September, 2018, that in three days from 15th to 17th August, 2018 when the rivers of Meenachil, Pamba, Manimala and Achankovil generated 1.63 billion m^3 of surface run off the Vembanad lake, which originally had the capacity to hold 2.4 billion m^3 of water could hold only 0.6 billion m^3 of water. About 1 billion m^3 of water raised the water level in the lake, flooding all low lands around and also pushing flood water upstream. Overall, the state has lost a sizable area, which traditionally served as flood cushioning area / spill area, thereby increasing flood risk of the truncated spill area and movement of flood water upstream.

In one hand water holding capacity of river provenance is declining, causing high instantaneous flow and on the other hand there is high reduction of flood cushioning area. Both these activities in synergy contribute to increasing flood susceptibility. These changes are impacting hydrological dynamics. Even in a year of below average rainfall like 1989, precipitation in consecutive days created flood problem. Heavy economic loss in this year's flood is partly due to unprecedented rainfall and largely due to higher investment in flood plains and gradual reduction of flood cushioning areas. Several flood affected countries report that as more and more investments are being made in flood plains, economic loss and risk of damage increase proportionately. Therefore, flood plain management, more specifically the land use management is a key to flood management.

Future challenges in development perspectives

Future challenges call for appropriate action to increase water holding capacity of the catchment to moderate flood flow, and at the same time to take necessary measures to minimise/ regulate human activities, particularly non-agricultural activities in the vulnerable areas and spill areas / flood prone areas so that human artefacts are not unduly exposed to flood vagaries and excess river discharges are adequately accommodated and drained out. Restoration of ecosystem services, flood plain zonation, vulnerability assessment and adaptation of nature based flood management practices are necessary steps to address flood related disasters. In re-



Rescue operation in Kerala.

cent years there is stress on implementing nature-based flood protection measures or a hybrid of nature based and structural measures for flood management across the world as pure structural measures are found inadequate. The nature based measures stress on system scale perspectives – spatial scale and time scale, integration with ecosystem conservation and restoration, adaptive management and people's participation. Land use management has pivotal role in this process.

All human activities take place on land, which is multi-functional and has multiple uses. Devising appropriate use of land is always a challenge. Land use evolves to cater to the development need of the society and reflects the philosophy of development. The present mode of development has been questioned and there is global urge to transit to sustainable development. In 2009, Johan Rockstorm and a group of 28 scientists across the world working in Stockholm Resilience Centre published a paper in 'Nature' magazine in which they proposed the concept of planetary boundary and necessity of identifying 'Safe Operating Space' for human activities to transit to sustainable development. According to this group, human activities since 1950 induced changes beyond resilience limit in seven sectors and land system change is one of them.

Changes in land system impact water flow, biodiversity and biogeochemical cycle. Land system change begins with local action, which through aggregation leads to large scale change with global manifestation including climate change. There are also several ex-situ factors that determine the land use. Kerala is no exception to this trend. Flood management and planning for reconstruction in Kerala should rest on three pillars: 'Place', 'Policy' and 'People'. While place indicates the biophysical set up, policy and people are part of governance, management and participatory initiatives. The problem of flood management might have to be approached holistically from the larger perspective of sustainability science. Perhaps, this disaster provides an opportunity to reorient Kerala's development process to be resilient and sustainable. □

Where is the evidence?

Sangeetha Balakrishnan*

0.

I was recently browsing through the website of a top-ranked university abroad. The webpage of one of their much sought-after undergraduate programmes stated that it aimed at strengthening their students' analytical and quantitative reasoning, and that it further endeavoured to instil in the young minds the ability to ask the right questions. The programme's goal resonated with me. We educators in India too strive to achieve this very end, but perhaps our efforts are not sustained and not supported by an adequate curriculum in most cases. Tangential efforts wherever possible spur us on, for our explicit end point seems to be different.

1.

December 2016 saw Chennai battered by cyclone Vardah. Even as the winds howled and the rains pummeled, Chennaiites dealt with not just fallen trees and downed electric poles, but a vicious social menace. The menace in point was a WhatsApp message imploring the city's residents to evacuate Chennai right then. The message claimed that the forthcoming 72 hours would bring very heavy rain to the city, and that cyclone Vardah was in fact an El Nino cyclone as reported by NASA. The bleeding-heart-of-a-message further urged Chennai residents to get to the Arakonam Air Base to be air lifted to safety. Well, what about the trees blocking our gates and roads, you might have asked. Perspective! That must have been the tacit answer.

This message—I only found out much later—did the rounds during the 2015 Chennai floods as well. Strangely enough, I never received it then. This year though, someone sent me the message. Having read it, I saw it for what it really was: an ignominious display of intellectual cowardice.

2.

Imagine you see something out in the natural world that you do not understand. Let's say, you see plants around you, and do not understand how is it that they grow. Let's call this thing that you do not understand: a phenomenon. So the phenomenon here is: plant growth. Also imagine that you are curious to understand this particular phenomenon. And let's say we phrase this curiosity in the form of a research question, which here reads: how does a plant grow?

Now, here's a sensible thing you can do in your bid to go forth with the research question: you can come up with a guess that seems a plausible answer to it. Let's call your guess: the hypothesis. And let's say, your hypothesis in this case is: a plant grows in the presence of sunlight.

Now the next intelligent thing would be to design an experiment to test your hypothesis. Your experimental result here can do two things. One, it can verify the hypothesis, or two, it can falsify it. In

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the latter case, you'd need an alternate hypothesis and do your experiment all over again. But let's hold our horses for now.

Let's say the following is your experimental design.

You have two potted plants A and B of the same kind. You place A in sunlight. And you place B in a closed, darkened box. As the next step, you observe the plants after, let's say, three days. You might then see that B would have begun to wilt, while A would have been thriving.

Now let's say you take two more potted plants of the same kind as before. Let's call these plants C and D. You keep C in a closed, darkened box as before, and you keep D in a darkened box which has an opening on one of its sides to let sunlight in.

When you observe the plants after three days as before, you'll see that plant D has now started leaning towards the opening and is 'growing', while plant C has wilted.

What has happened here is that the experiment has verified your hypothesis. You now have evidence to say that a plant grows in sunlight.

This of course is a very simple experiment where we haven't controlled for other variables like water and minerals that affect plant growth. But the take away from this experiment is this: science is based on evidence; it is empirical. Evidence drawn on the basis of observation and experimentation is the hallmark of science.

And also this: scientific results are repeatable. This means that anyone who repeats the experiment under the same experimental conditions should get the same result.

3.

Back to the WhatsApp message. The thing that it glaringly lacked was evidence. The message claimed heavy rains for 72 hours and Vardah being El Nino cyclone.

To those who mindlessly forwarded the message: why did it not occur to you to check the veracity of its claims? Also, do you know what is an El Nino cyclone? Again, since you were online on your mobile phone whastapping, what stopped you from checking NASA's website to ascertain the claim?

Why did you send those messages? Was it mere titillation? Did you merely want to instill fear in an already disturbed mind? And to the one who started the whole thing: What did you get out of this? Did you do it just because you could?

4.

Science doesn't belong exclusively to lab coat-clad scientists in laboratories. Every one of us is a scientist as long as we are objective and look for evidence in what we believe.

When we are ruled by emotions, peer pressure, authority etc., and believe things because that's what we are taught to believe, we are being spectacularly irrational. This is when we are said to lack scientific temper. Not just in science but in everyday life too, it is essential that we ask ourselves: where is the evidence?

The next time a well meaning relative asks you to take a different route because a black cat crossed your path, thank the person for his concern, but make sure to let it be known loud and clear that your day being affected by a black cat crossing your path does not rest on evidence. To get the required evidence, you'd have to do an experiment that'd involve a black cat deliberately made to cross your path for n days (where n is a significantly large number), and having all of those n days turn out bad. You'd further require the 7.2 billion people on Earth participate in the same experiment under the same con-

ditions, and have all their days turn out bad. At least a statistical correlation has to be established. Unless you do this, the black cat causing you a bad day is never a fact; it is a superstition. The hallmark of superstition is lack of evidence.

The next time someone advices you to consider homeopathic treatment, tell them politely that it does not have a scientific underpinning and that it lacks scientific evidence of cure. Homeopathy is pseudo-science, not science.

And the next time someone tells you climate change is all hogwash, get a little irate and point them to all the evidence in support of rising temperatures on earth. (And that is just one manifestation of climate change.) Recent finding: the North Pole is 36 degrees warmer than what it should be now.

5.

Following Jawaharlal Nehru's use of the phrase scientific temper in his *Discovery of India*, referring to it as a way of life, a process of thinking, a method of acting and associating with our fellow men, the Indian Government, included in its Constitution the development of scientific temper, humanism and the spirit of enquiry and reform as a fundamental duty of all citizens of the country [Article 51-A(h)].

Scientific temper is an attitude. It is a commitment to reason and objectivity. It is a promise made to self to have an intellectually open mind and a healthy dose of scepticism. It is that in-built baloney detector that prevents us from falling prey to hoaxes. Most of all, it is a call to rely on evidence.

Scientific temper is the standpoint that enables one to break free from hanging on to the coattails of blind faith. Scientific temper empowers; it eggs one to look beyond sensational news like idols of Ganesha drinking milk, or cow urine containing gold to dig for the truth in it. Scientific temper gives one the determination to vow that the deaths of Dr. N Dhabholkar, Govind Pansare, M M Kalburgi and other rationalists fighting obscurantism shall not be in vain. It gives one the direction which points at building a narrative of scientific temper and to work towards including in its fold, the young and the old alike. Simply put, scientific temper aims to build an inclusive and progressive society. And this can be made manifest by enquiry, not by faith.

Ask: where is the evidence? □

The Classical Determinism and the Quantum Theory

Satyendra Nath Bose *

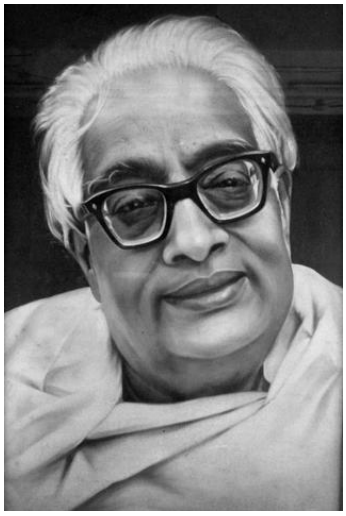
I wish to express sincere thanks for the great honour you have done me. The presidentship of the Science Congress is a great distinction, and I confess, I have my own misgivings about the wisdom of your choice. Your first decision had raised high hopes. Many of us expected that a deliberate programme of the future scientific activities of the country would probably be a feature of the opening speech of this Congress. Pandit Jawaharlal had studied the needs of the country. Many of our front-rank scientists and industrialists had met under his leadership, not long ago, and given to questions of future reconstruction much time and anxious thought. The result of this deliberation would have been invaluable at the present moment. My regret is that chance has deprived us of the benefits of a sustained and careful study of the problems of the day. I would have liked to present here the results, if they were available. Unfortunately they are not, as most of the reports are inaccessible to me.

One of your former presidents had remarked that "a scientist is apt to become a man that knows more and more about less and less, so that his opinion upon subjects outside his field of special study is not necessarily of special value." I realise the wisdom of this warning and hope to have your indulgence, if I seem to be more at home with doubts and criticism than with useful knowledge.

I would like to present before you certain aspects of modern physics and draw your attention to the profound changes in the principle of scientific explanation of natural phenomena brought about by the quantum theory. The last fifty years record remarkable discoveries. I need only mention the electron and the neutron, X-rays and radioactivity to remind you of the increase of our knowledge. Our equipment has gained in power, range and accuracy. We possess powerful telescopes to scan the farthest corners of the universe, also precise and delicate instruments to probe into the interior of the atoms and molecules. The alchemist's dream of transmutation has become a reality. Atoms are now disintegrated and synthesised. X-rays reveal invisible worlds and wireless links upon the furthest ends of the earth with possibility of immediate intercommunication. These discoveries have their repercussions in the realm of ideas.

Fifty years ago the belief in causality and determination was absolute. Today physicists have gained knowledge but lost their faith. To understand properly the significance of such a profound change it will be necessary to discuss briefly how it all came about. Classical physics had begun with the study of astronomy. With his laws of gravitation and his dynamics, Newton had explained planetary motion.

*Presidential Address to the Thirty-first Indian Science Congress, Delhi, delivered on January 3, 1944



Prof. Satyendra Nath Bose
(1 January 1894 – 4 February 1974)

Subsequent study has shown astronomical prediction to be possible and sure. Physicists had taken the equations of celestial mechanics as their model of a universal law. The atomic theory had in the meantime gained universal acceptance; since matter had resolved into a conglomeration of particles, the ideal scheme was to explain all phenomena in terms of their motions and interactions. It was only necessary to set up a proper set of equations, and to take account of all possible mutual interactions. If the mass, position, and velocity of all the particles were known at any instant, these equations would theoretically enable the physicist to predict the position and motion of every particle at any other subsequent moment.

The phenomena of light did not at first fit into this simple scheme. To regard it as a stream of particles was impossible due to the discovery of interference. Accordingly the wave theory of light was originated by Huygens and perfected by Maxwell. With the discovery of the electron as a universal constituent of matter, the electromagnetic theory of Maxwell was converted into an electronic theory by Lorentz. To the dynamical laws were added the electromagnetic equations and the two together apparently gave an exact and ideal formulation of the laws of causality. In the forces of interaction henceforth, were to be included not only the gravitational forces but also those interactions which depended on the charge and the motion of the particles. These interactions were brought about by influences which spread out as waves with the velocity of light. They superimposed, interfered and constituted the field of force in the neighbourhood of the particles, modified their motion and were in turn modified by them. The motions of all particles throughout the universe were thus interlocked. These out-going influences also constituted light, invisible radiation, X-rays and wireless waves. Thus a set of universal laws was supposed to have been discovered and we had only to apply them suitably to find explanations of all conceivable natural phenomena.

In physical science we do not however always proceed in the above way and turn to the 'microscopic' equations whenever we have to explain events. We often study materials en masse, consisting of an enormous number of corpuscles, and we use either the principle of the conservation of energy or the laws of thermodynamics to explain their behaviour. These laws were however regarded either as simple consequences of the fundamental equations or as statistical laws derivable from them by a suitable averaging. Though in the latter cases we talk about probabilities and fluctuations, it was more or less a matter of faith to maintain that if it were possible for us to obtain all the necessary data by delicate observations, universal laws would enable us to follow each individual molecule in this intricate labyrinth and we should find

in each case an exact fulfilment of the laws and agreement with observation. The above in brief form an expression of faith of a classical physicist. We see that it involves as necessary consequences, belief in continuity, in the possibility of space-time description of all changes and in the existence of universal laws independent of observers which inexorably determine the course of future events and the fate of the material world for all times.

A few remarks about the general equations will perhaps enable us to follow better the criticisms that have been levelled against the system. The structure of the mechanical equations of particles is different from the field equations of Maxwell and Lorentz. The principles of conservation of energy and momentum were first discovered as consequences of the mechanical equations. Mass and velocity of the corpuscle furnish means to measure its momentum, and its energy, if we leave aside the potential energy which resides in the field. To maintain the integrity of the principle of conservation, the field must also be considered capable of possessing energy and momentum, which, however, being associated with wave-motion, must spread out in all directions with the waves. The transfer of energy from the field to the particles must thus be a continuous process, whereby a finite change should come about only in a finite interval and the process should theoretically be capable of an exact description in space and time.

Physics being essentially concerned with relations between quantities, these should all be capable of exact measurement. We measure always intervals of time or inter-distance between points; hence the specification of the reference frame is just as important as the units of measure. Newton had not analysed closely the conception of mass and time. This vagueness persisted in the dynamical equations for the particles. The field-equations which form the basis of the wave theory of light have a different origin. With the discovery of the principle of the least action, a common derivation of both has been attempted. But a difference in the choice of reference frame in the two apparently subsisted. The wave-equations assumed fixed ether whereas the material laws contemplated a Galilean inertial-frame. An immediate deduction from this distinction was the possibility of measuring the relative velocity of the observer with reference to ether. The experiment of Michelson and Morley showed it to be unrealisable in practice and formed the starting point of the celebrated relativity theory. Einstein had subjected the conception of time-measurement to a searching examination and showed the impossibility of conceiving a time independent of an observer, or an absolute simultaneity of events happening at two different places. The same space-lime reference should be chosen for dynamical equations as well as the equations of the field, this being supplied by the observer. In spite of this apparent limitation, Einstein demonstrated the possibility of formulation of natural laws independent of all axes of reference and pointed out that the necessary auxiliaries existed already in the invariant theory and the tensor calculus of mathematicians. In spite of its apparently revolutionary character, the theory of relativity upheld the ideal of causality and determinism. Einstein himself has continued to seek with great earnestness a unifying field theory which will combine gravitation and electromagnetism and render unnecessary a separate formulation of the dynamical equations. No such theory as yet exists.

II

The development of the quantum theory has raised fundamental issues. Facts

have been discovered which demonstrate the breakdown of the fundamental equations which justified our belief in determinism. A critical examination of the way in which physical measurements are made has shown the impossibility of measuring accurately all the quantities necessary for a space-time description of the motion of the corpuscles.

Experiments reveal either the corpuscular or the wave nature for the photon or the electron according to the circumstances of the case, and present us with an apparently impossible task of fusing two contradictory characters into one sensible image. The only solution suggested has been a renunciation of space-time representation of atomic phenomenon and with it our belief in causality and determinism.

Let me briefly recapitulate the facts. In 1900 Planck discovered the quantum of action while studying the conditions of equilibrium between matter and the radiation field. Apparently interchange of energy took place in discrete units whose magnitude depended on 'h' and the frequency of the radiation emitted or absorbed by matter. Photo-electric emission had similar disquieting features. Einstein therefore suggested a discrete structure of the radiation field in which energy existed in quanta instead of being continuously distributed in space as required by the wave theory. The light-quantum however is not the old light-corpuscle of Newton. The rich experimental materials supporting the wave theory preclude that possibility altogether. Moreover the fundamental relation, $E = h\nu$, and $p = hk$, connecting energy and momentum of the photon with the frequency ν and the vector wave number k, makes a direct reference to idealised plane wave so foreign to the old idea of a corpuscle.

Soon afterwards, Bohr postulated the existence of radiation-less stationary states of atoms and showed how it led to a simple explanation of the atomic spectra. The extreme simplicity of the proposed structure and its striking success in correlating a multitude of experimental facts at once revealed the inadequacy of the ordinary laws of mechanics and electro-dynamics in explaining the remarkable stability of the atoms.

The new ideas found application in different branches of physics. Discontinuous quantum processes furnished solutions to many puzzles. Suitably modified, the theory furnished a reasonable explanation of the periodic classification of elements and thermal behaviour of substances at low temperature. There was however one striking feature. It was apparently impossible to characterise the details of the actual transition processes from one stationary state to another, that is, to visualise it as a continuous sequence of changes determined by any law as yet undiscovered. It became clear that the dynamical laws as well as the laws of electromagnetism failed to account for atomic processes. New laws had to be sought out, compatible with the quantum theory, capable at the same time of explaining the rich experimental materials of classical physics.

Bohr and his pupils utilised for a time a correspondence principle, guessing correct laws for atomic processes from analogy with the results of the classical theory. In every case these appeared as statistical laws concerned with the probabilities of transition between the various atomic states. Einstein tackled the problem of the equilibrium of matter and radiation on the basis of certain hypotheses regarding the probabilities of transition between the various states by absorption and emission. A derivation of the Planck Law was obtained by Bose by a suitable modification of the methods of classical statistics. Heisenberg

finally arrived at a satisfactory solution and discovered his matrix-mechanics and a general method for all atomic problems. Dirac and Schroedinger also published simultaneously their independent solutions. Though clothed in apparently dissimilar mathematical symbols, the three theories gave identical results and have now come to be looked upon as different formalisms expressing the same statistical laws.

I have mentioned that the photon gave a simple explanation of many of the properties of radiation and thereby presented its corpuscular aspect while the well-known properties of interference and super possibility brought out its wave character. That the same dual nature may exist in all material corpuscles was first imagined by de Broglie. His phasewaves found quick experimental verification, and raised a similar problem of the real nature of the corpuscle. The formulation wave-mechanics by Schroedinger, once raised a hope that by a radical modification of our usual ideas about the corpuscle, it might be possible to re-establish the law of causality and classical determinism. Subsequent developments have shown such hopes to be illusory. His waves are mathematical fictions utilising the multidimensional representation of a phase-space and are just as incapable of explaining the individuality of the electron, as the photon is incapable of explaining the super possibility of the field. The true meaning of his equations appears in their statistical interpretation.

III

The adherents of the quantum theory interpret the equations in a peculiar way. They maintain that these equations make statements about the behaviour of a simple atom and nothing more than a calculation of the probabilities of transition between its different states is ever possible. There is nothing incomprehensible about such a statistical law even if it relates to the behaviour of a single particle. But a follower of determinism will interpret such statements as betraying imperfect knowledge, either of the attendant circumstances or of the elementary laws. We may record the throws when a certain die is cast large number of times and arrive at a statistical law which will tell us how many times out of a thousand it will fall on a certain side. But if we can take into account the exact location of its centre of gravity, all the circumstances of the throw, the initial velocity, the resistance of the table and the air and every other peculiarity that may affect it, there can be no question of chance because each time we can reckon where the die will stop and know in what position it will rest. It is the assertion of the impossibility of even conceiving such elementary determining laws for the atomic system that is disconcerting to the classical physicist.

Von Neumann has analysed the statistical interpretation of the quantum mechanical laws and claims to have demonstrated that the results of the quantum theory cannot be regarded as obtainable from exact causal laws by a process of averaging. He asserts definitely that a causal explanation of quantum mechanics is not possible without an essential modification or sacrifice of some parts of the existing theory.

Bohr has recently analysed the situation and asserted that we cannot hope any future development of the theory will ever allow a return to a description of the atomic phenomena more conformable to the ideal of causality. He points out the importance of the searching analysis of the theory of observation made by Heisenberg, whereby he has arrived at his famous principle of indeterminacy. According to it, it is never possible for us to determine the simultaneous values of momentum, and positional

co-ordinates of any system with an accuracy greater than what is compatible with the inequality

$$\Delta p \Delta q \geq \frac{h}{4\pi}$$

This natural limitation does not affect the physics of bodies of finite size but makes space-time descriptions of corpuscles and photons impossible. When we proceed to study the behaviour of the elementary particles, our instruments of measurement have an essential influence on the final results. We have also to concede that the contributions of the instrument and the object are not separately computable from the results as they are interpreted in a classical way with the usual ideas of co-ordinate and momentum, accepting thereby a lack of control of all action and reaction of object and instrument due to quantum effects.

It is in this imperative necessity of describing all our knowledge with the usual classical ideas, that Bohr seeks an explanation of the apparently irreconcilable behaviour of corpuscles and radiation in different experiments. For example, if we set our experiments in such a fashion as to determine accurately the space-time co-ordinates, the same arrangement cannot be simultaneously used to calculate the energy momentum relations accurately; when our arrangements have pushed the accuracy of determining the positional coordinates to its utmost limit, the results evidently will be capable only of a corpuscular representation. If, on the other hand, our aim is to determine momentum and energy with the utmost accuracy, the necessary apparatus will not allow us any determination of positional co-ordinates and the results we obtain can be understood only in terms of the imagery of wave-motion. The apparently contradictory nature of our conclusions is to be explained by the fact that every measurement has an individual character of its own. The quantum theory does not allow us to separate rigorously the contribution of the object and the instrument and as such the sum total of our knowledge gained in individual cases cannot be synthesised to give a consistent picture of the object of our study which enables us to predict with certainty its behaviour in any particular situation. We are thus doomed to have only statistical laws for these elementary particles and any further development is not likely to affect these general conclusions.

It is clear that a complete acceptance of all the above conclusions would mean a complete break with the ancient accepted principles of scientific explanation. Causality and the universal laws are to be thrown simultaneously overboard. These assertions are so revolutionary that, no wonder; they have forced physicists to opposing camps. There are some who look upon causality as an indispensable postulate for all scientific activities. The inability to apply it consistently because of the limitations of the present state of human knowledge would not justify a total denial of its existence. Granted that physics has outgrown the stage of a mechanistic formulation of the principle, they assert that it is now the task of the scientists to seek for a better formulation. Others of the opposing camp look upon the old determinism as an inhuman conception, not only because it sets up an impossible ideal, but also as it forces man to a fatalistic attitude which regards humanity as inanimate automation in the hands of an iron law of causation. For them the new theory has humanised physics. The quantum statistical conception of determinism nestles closer to reality and substitutes a graspable truth for an inaccessible ideal. The theory has brought hope and inspired

activity. It constitutes a tremendous step towards the understanding of nature. The features of the present theory may not at all be familiar but use will remove the initial prejudice. We are not to impose our reason and philosophy on nature. Our philosophy and our logic evolve and adjust themselves more and more to reality.

In spite of the striking successes of the new theory, its provisional character is often frankly admitted. The field theory is as yet in an unsatisfactory state. In spite of strong optimism, difficulties do not gradually dissolve and disappear. They are relegated to a lumber room, whence the menace of an ultimate divergence of all solutions neutralises much of the convincing force of imposing mathematical symbols. Nor is the problem of matter and radiation solved by the theory of complementary characters. Also we hear already of the limitations of the new theory encountered in its application to nuclear problems.

The quantum theory is frankly utilitarian in its outlook; but is the ideal of a universal theory completely overthrown by the penetrating criticism of the nature of physical measurements?

Bohr has stressed the unique character of all physical measurements. We try to synthesise their results and we get probabilities to reckon with instead of certainties. But how does the formalism

$$\frac{ih}{2\pi}\frac{\partial\Psi}{\partial t} = H\Psi$$

emerges as a certain law? The wider the generalisation, the less becomes the content. A universal law would be totally devoid of it. It may nevertheless unfold unsuspected harmonies in the realm of concept. More than ever now, physics does need such a generalisation to bring order in its domain of ideas. □

An aerial view of a flooded region in Kerala

Organizational News

Flood Relief Work in Kerala

In the month of August, Kerala witnessed a devastating flood, the worst ever in the last 100 years. All the 14 districts of Kerala were affected and 8 districts were severely affected. Lakhs of people had to flee their homes leaving behind all their belongings and life-long savings and took refuge in relief shelters. It is reported that more than 500 people lost their lives and around 10 lakh people had to take shelter in relief centres. It is estimated that more than 30,000 houses were either partly or fully damaged. The floods caused enormous loss of crops and damage to roads and other infrastructures. The total loss is estimated to be around 35000 crores of rupees.

Common people and youths jumped into a rescue operation. Fishermen in thousands rushed with fishing boats and, braving all odds, saved the lives of tens of thousands of people stranded in the midst of several feet of water.

Responding to the call of humanity, members of Breakthrough Science Society plunged into relief and rescue work from the very beginning. Collection of fund, relief materials and medicines were undertaken by the BSS units in different states and the collected money and materials were sent to the BSS Kerala Chapter.

In the first few days following the flood, volunteers were engaged in clearing the debris and cleaning the houses and undertook sanitization works. In association with Medical service Centre (MSC), BSS volunteers helped to set up medical camps in different districts from August 19. Doctors, nurses and paramedical staff from West Bengal, Karnataka, Tamilnadu, Andhra Pradesh, Madhya Pradesh and Maharastra joined the team of medical staff from Kerala to conduct the medical camps. The majority of medical camps were set up in the worst affected areas of Kottayam, Alleppey, Pathanamthitta, Ernakulam and Trichur districts.

A team of volunteers also undertook the repair of motors and other electrical appliances in Kuttanad area which was under water for nearly a month.

Another work undertaken by the BSS volunteers is the repair of damaged cots. Since cots were immersed in water for several days, the plywood sheets were damaged. BSS, with support of other organizations like Karmodaya supplied 100 plywood sheets. The work is still continuing with the support of philanthropic people.

Many of the wells in the flood affected areas were contaminated by the flood water. BSS volunteers took up the job of cleaning the wells in Ramankary, Neerattutupuram, Thiruvanchoor, Komenkary and Poovam. The testing of water with the support of the School of Environment, M G University is going on.

In Kuttanad, the potable water is always a problem. Flood accentuated the water problem. BSS is now working on the issue. With the School of Environment, M G University and other agenencies, BSS is trying to develop low-cost water filters for providing to the people.

There was tremendous support from the

View of the medical camp at Alleppey, Kerala, run by BSS and Medical Service centre

people of the state and the entire country for the relief works.

Seminar on 'Kerala Flood – A Scientific Inquiry'

Breakthrough Science Society, Trivandrum chapter, in association with Kerala State Science and Technology Museum, organised a seminar titled 'Kerala Flood – A Scientific Inquiry' on October 6, 2018, at the seminar hall, Priyadarsini Planetarium, Thiruvananthapuram. Dr. M. Govindan Kutty, Associate Professor, Department of Earth and Space Sciences, IIST, Trivandrum spoke on the topic 'Understanding Climate and Climate Change'. Dr. Sreekumar Chattopadhyaya, former scientist, Centre for Earth Science Studies, Trivandrum made a presentation on 'Flood Disaster Management'. Prof. T P Kunhikkannan, former president, Kerala Sasthra Sahithya Parishath spoke on 'Eco-friendly Reconstruction of Kerala'. In a felicitation function held after the seminar, certificates of appreciation was presented to the members of Breakthrough Science Society and the students of Government Engineering College, Barton Hill, Trivandrum and Government Women's College, Trivandrum who actively participated in the flood relief activities.

National 'Scientific Temper Day' observed on 20 August

Along with many other science organizations, the BSS gave a call to observe 20th August as the National Scientific Temper Day in memory of Dr Narendra Dabholkar. The day was observed throughout the country through various programmes.

West Bengal: The day was observed through anti-superstition programmes, and campaign in demand of an Anti-Black-Magic Act. More than 50 science clubs affiliated to BSS undertook such programmes in their respective localities.

Bengaluru: BSS along with other science organizations organized the National Scientific Temper Day at National College Bengaluru. The organizers marched from Vivekananda Statue to National College. The speakers included Prof Sarbari Bhattacharya (Bangalore University), Prof Balachandra Rao (Honarary Professor, Bharatiya Vidya Bhavan), Prof S Chatterjee (President, All India People's Science Network-AIPSN), Mr Basavaraju (State Secretary, Karnataka Jnana Vignana Samithi–KJVS), Ms Prabha (Secretary, Bharitya Gnana Vignana Samithi), Mr Abdul Rehman Pasha (Popular Science Writer and President, Karnataka Vignanika Manovrithi Andolana), Mr Ananth Nayak (Manavabandhu Vedike, Member), Mr Ma-

Dr. Sarbari Bhattacharya speaking at the programme on National Scientific Temper Day at Bengaluru.

havadevapa (KJVS, President, Bangalore), Ms Rajani K S (Secretary, BSS Karnataka), and Mr Satish Kumar G (President, BSS Karnataka). About 200 students participated in the march and attended the programme.

Kurnool: National Scientific Temper Day – 20 August: BSS and JVV(AIPSN) jointly organized a rally of students and teachers numbering more than 300 at Raj Vihar centre, Kurnool town. Mr. Viswanatha Reddy (BSS Incharge) and Mr. Satyanarayana Reddy (Jana Vignana Vedika Incharge) addressed the gathering.

Nellore: BSS, PSV (Praja Science Vedika), JVV (AIPSN) jointly organised a demonstration at Gandhi statue, Nellore. Ms. Ameena (BSS Incharge) and Ms. Mobeene (BSS member) spoke about the life struggle of Dr. Narendra Dabholkar.

Chennai: A programme was organized jointly by Tamilnadu Science Forum (TNSF), Breakthrough Science Society (BSS) and some other organizations. A rally was held at Elliots beach, Besant Nagar, Chennai from 4.30 pm to 6.30pm. At the end of the rally Prof R Ramanujam (IMSc), Dr T R Govindarajan (CMI), Dr Mohana (TNSF) and Dr S H Thilagar (BSS) addressed the gathering.

A talk was organized at the Dept of Visual Communication, Loyola College, Chennai on 21 August. Dr Suresh Paul, HoD, and Dr R Venkatesan, Advisor to BSS Tamilnadu Chapter spoke on the struggle of Dr. Narendra Dhabolkar. A documentary on Dhabolkar was also shown.

Madurai: A public meeting was organized at Pazhanganatham, Madurai. Prof Rajamanickam from TNSF and Ms Selvi from BSS addressed the gathering.

Other programmes

Andhra Pradesh and Telangana

Hyderabad: Engineer's day celebration: BSS and Stanley College of Engineering Technology jointly organised a convention on the 'Role of engineers in development of society' at Stanley college on 15 Sept 2018. Dr Satyaprasadlanka (Principal), Dr. V Anuradha (Director) and Mr. R Gangadhara (convener BSS) spoke in the convention.

Hyderabad district committee organised seminars on the contributions of Madam Curie for high school students at Mahabubia Junior College on 6 July and at Raj Bhavan Govt High School on 18 July. Mr. R Gangadhara and Mr. D Gangaji were the speakers in the two programmes.

Hyderabad district committee organised a seminar on the life of Ishwar Chandra Vidyasagar in G. Pullareddy Degree and PG College on 26 Sept 2018. Mr. R Gangadhara (Convener BSS) spoke about role of Vidyasagar in developing scientific thinking in India.

Anantapur: Vidyasagar birth anniversary program was observed on 26 Sept at Viswabharathi High school, Anantapur. Mr.Tabrez Khan presided over the meeting. Mr. Karunakar, Principal of the school, spoke about life of Vidyasagar. Mr. T Narendra, Lecturer in physics spoke on the importance of scientific thinking.

BSS and JVV (AIPSN) Kurnool committees jointly organized an awareness program on the Lunar eclipse day on 27 Sept. near the Collector office.

Karnataka

Bengaluru: A workshop on science experiments was organized at Lal Bahadur Shastri College, RT Nagar on 27 September. The workshop, aimed at building simple science models, was conducted by Ms Dipti. About 60 students actively participated by individually constructing science models.

Mysore: Flood relief work: In the month of August, Kodagu district was severely hit by torrential rains that caused flooding. Members of BSS Mysore unit were actively involved in the flood relief activities in Kodagu as well as in Kerala. Dr G Sudha (Mysore district Convener) along with the volunteers of BSS collected necessary relief materials from nearby districts. The team along with Medical Service Center set up a relief camp at Kodagu. They also mobilized clothes, food grains, drinking water bottles, medicines and other requirements to serve the affected people.

Two talks were organized at the Ideal Jawa Rotary School on 29 Sept. Ms Nileena (BSS member) talked on 'Time management' and Ms. Harika talked on 'Scientific Temper'.

A program on scientific temper was organized at Maharani High School on 3rd Oct. Mr B Ravi (Advisor, BSS Mysore) was the main speaker. Mr Sunil (BSS Activist) performed a Miracle Busting show. An interactive session followed.

A miracle busting program was organized at Government High School, Lakshmipuram on October 5. Ms Ranjitha (BSS Activist) performed the show.

Chickaballapur: A discussion on Scientific Temper was organized on 28 August, for a group of lecturers and science enthusiasts. BSS Chickaballapur district unit was formed.

Gulbarga: A group of students from the Central University of Karnataka along with BSS members undertook flood relief collection and collected money, medicine and other materials for the flood hit Kerala.

A discussion on 'Philosophy of Science' was organized at a public garden. Ms Rajani K S (Secretary, BSS Karnataka) addressed the gathering.

Kerala

Kottayam

Oct 5: Sky Watch at CMS LPS Kadamury, Changanacherry. Mr K Thankaapan conducted the program.

Oct 10: Sky watch and astronomy exhibition at Belmont School, Kottayam in connection with world space week. Mr K Thankappan led the sky watch.

Oct 13: Astronomy club monthly program on everyday chemistry. Prof Devan P R of Govt. College, Nattakom delivered a talk.

Trivandrum

On the occasion of the 49th anniversary of Moon landing, a public lecture titled 'Earth to Moon: How to Reach and Land?' by Dr. R V Ramanan, Adjunct Professor, Department of Aerospace Engineering, Indian Institute of Space Science and Technology (IIST), was organized at the Kerala State Science and Technology Museum, Trivandrum on July 21.

BSS, Trivandrum chapter in association with Kerala State Science and Technology Museum and Aastro Kerala organized two public lectures at the Priyadarsini planetarium, Trivandrum:

July 31: Talk by Dr. Pushkar Kopparla of California Institute of Technology on 'The Blind Men and the Elephant: What does an Exoplanet look like?' Dr. Krishna Warier of Aastro Kerala, Dr. Rajeevan and Dr. Anand Narayanan also spoke at the function.

September 12: Talk by Dr. Ravikumar Hosamani, University of Agricultural Sciences, Dharwad, (formerly with NASA Ames

Research Center, USA) on 'Fruit flies in space: Relevance to Astronaut's Health'.

BSS, Thiruvananthapuram Chapter is conducting a 45-hour free course on 'Introduction to Quantum Mechanics' by Dr. Umesh R Kadhane, Associate Professor, Department of Physics, Indian Institute of Space Science and Technology (IIST), Thiruvananthapuram. 50 candidates are selected from more than 200 applicants.

A Madam Curie memorial program was organized at Government Women's college, Thiruvananthapuram on July 4, 2018. Mr. P S Gopakumar was the main speaker.

BSS, Trivandrum chapter in association with the International Society for Optics and Photonics organized a lecture on 'Computational imaging using random amplitude/phase modulation' by Prof. Takanori Nomura (Department of Opto-Mechatronics, Faculty of Systems Engineering, Wakayama University, Japan) at Government Engineering College, Barton Hill on September 18, 2018.

Uttar Pradesh

The UP State Chapter of BSS held its second State Conference at Indian Medical Association Hall, Lucknow on 29 Sept 2018. Prof Soumitro Banerjee, General Secretary of BSS, was the main speaker on the topic 'Integrating Science with Society'. A brief message from Dr. Chandra Mohan Nautiyal, member of the advisory board of the state chapter was read out. Er. Jai Prakash Maurya, State Secretary and member of the National Executive Committee, Prof Smarjit Sensarma, Dept of Geology, Lucknow University and Dr. Brajesh Katiyar, Associate Professor, Harcourt Buttler Technical University, Kanpur also addressed the delegates. Mr. Dinesh Mohanta, member of the National Executive Committee, placed a panel of 23 members for the State Co-ordination Committee with Er. Jai Prakash Maurya as the Co-ordinator. He also proposed a 13-member Advisory Board, with Padmashree Dr. Nitya Anand, Ex-Director, CDRI-Lucknow as Advisor In-Chief. Both the proposals were approved unanimously by the house. 250 delegates participated in the conference.

Gujrat

Universe Science Forum (USF) and Shalin Vidyalay jointly celebrated the 99th birth anniversary of Dr. Vikram Sarabhai on 14 August. Mr Uttam Surapati discussed about the lives of Dr Vikram Sarabhai and Dr. C V Raman. Mr Mahendra Parmar talked about the objectives and activities of USF.

A program on science and scientific temper was organized in Adarsh B.Sc. College, Botad district on 3rd October, 2018. Mr Uttam Surapati and Mr Dilip Satashiya discussed the topic.

A photo exhibition on the life of Dr. C V Raman was arranged on both the occasions.

Chhattisgarh

BSS Durg chapter organised a program of learning science through experiments on 8 Oct 2018 at GRD School, Durg. Students enthusiastically participated in the program and learned to perform experiments with a questioning mind.

Tamilnadu

Madam Curie Day was observed at American College Higher Secondary School, Madurai, on July 4 and at the Othakadai Girls Higher Secondary school, Madurai, on July 11. Dr. Malarvizhi (Retired scientist from ISRO) spoke on the life of Madam Curie on both occasions.

West Bengal

125th birth anniversary of Saha, Bose, and Mahalanobis

BSS observed the 125th Birth anniversary of legendary scientists Meghnad Saha, Satyendra Nath Bose and Prashanta Chandra Mahalanobis. As part of the year-long observance, on 15 July a subdivision-level science workshop was held at Kakdweep Sishu Sikshayatan High School. On 21-22 July, the 'Light of Science' club of Jalpaiguri organised a science competition and seminar. On 22 July, Kanthi and Egra units of East Midnapore district organised a local Science Camp. A science workshop was organised at Krishnachandrapur High School of South 24 Parganas on 26 August. On 9 September, a science camp was organised at Panskura. On 22 September, a science competition and workshop were organised at Uluberia (Howrah), and the Uluberia Science Club was formed. A seminar and prize distribution program was organised by BSS Jadavpur University Chapter on 27 September.

Other programmes in WB

2 August: 158th Birth anniversary of Acharya Prafulla Chandra Ray was organised in Panskura Banamali College and Ranigunj Shershole Raj High School.

9 August: Contai Science Society organised a March and a protest meeting against proposed Nuclear Power Station at Haripur.

22 August: A Science Camp was organised at Vidyasagar Smriti Bhavan, Mecheda. Dr Anindita Bhadra and Dr Ayan Banerjee (both from IISER, Kolkata) delivered lectures on "Darwinian Evolution and Scientific Evidences". Shri Debasish Roy (Vice-President, All India Committee) discussed on "Science, Philosophy and Ethics".

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2 September: A Science Competition was held at Tarakeswar. BSS unit formed.

7 September: A P C Ray Science Society organised a seminar in memory of Prof. Stephen Hawking at Durgapur Government College, with Prof Partha Sarathy Majumder as speaker.

12 September: Boson Science Centre and Patha Bhavan Biswa Bharati University organised a workshop. Prof Dhrubajyoti Mukhopadhyay (President, Breakthrough Science Society) was the main speaker.

29 September: CV Raman Science Club, Jadavpur, organised a seminar and a demonstration of learning science through experiments. Prof Atish Dipankar Jana spoke on "Birth, Evolution and Death of Stars".

2 October: Madame Curie Science and Cultural Society, Bashirhat organised a seminar on 'Relativity'. Shri Subhas Kundu and Dr Nirmal Duari were the speakers.

7 October: Science festival the SCIENTILA was organised by Young Scientist Forum at Taki Govt. High School.

7 October: Annual Science program of Acharya Prafulla Chandra Ray Science Society was held at Bidhannagar Govt. Sponsored Boys' High School.

8 October: A discussion on life and work of Megnad Saha and a slide show on Solar System was organised by BSS North 24 Parganas unit.

9 October: BSS Nadia District in association with INYAS, INSA and IISER Kolkata organised a seminar at Debgram S A Vidyalaya. Dr Moulinath Acharya (NIBMG, Kalyani), Dr Anindita Bhadra (IISER, Kolkata), Shri Girija Shankar Roy (Head Master) and Shri Asish Samanta were the speakers. The topics discussed were 'Modern Medical Science and Genomics' and 'Wherefrom we came'.