Global partnerships in scientific research and international mega-science projects*

V. S. Ramamurthy

Pursuit of knowledge has always been a global enterprise. For thousands of years, people have moved across continents, literally on foot, in search of new knowledge. Modern scientific research probing the secrets of the material universe around us is no exception. Meeting of minds through open discussions and joint studies has also been taking place since time immemorial, since it is believed that it enriches all the participating partners. Joint research facilities have also been in vogue for various reasons – locational advantages, scientific, economic and political reasons, etc. While synergizing strengths of the partners, they also reduce the cost burden on them.

Are such open relationships relevant in today's environment? I must qualify 'today's environment'. You will all agree with me that the 20th century has seen major changes in the way scientific research is carried out, and technologies are developed and deployed as products and services for economic benefits. For example, the increasing role of sophisticated instruments is obvious and cannot be ignored. New scientific discoveries lead to new technologies, which lead to new instruments, that in turn lead to new scientific discoveries. There is indeed an effective bootstrap in operation. An immediate consequence of this is the increasing cost of research at the cutting edge and an increasing dependence of the scientists on funding agencies, public or private. The funding agencies in turn look at the research support as investments for the future with consequential expectations on returns-on-investments. There is an increasing perception that the research results are also yet another form of property to be owned, exploited and traded. The close link between scientific and technological strengths, and economic and military strengths has also added yet another dimension to the intellectual property (IP) regime, that of denial, not only of products and technologies but also of knowledge. Are global partnerships relevant? Can they even survive in today's environment, particularly among countries that are highly asymmetric, not only economic and political asymmetries but also scientific, technological and industrial?

While it is true that science has moved away from being a part of the world culture into world commerce, the scientific community has never been fully at ease with today's IP regime. Many of the scientists still believe that the IP regime is fundamentally against the age-old belief that knowledge is a public asset and the driving force for pushing the knowledge frontiers beyond the known limits cannot come from a profit motive. There has also been an increasing disillusionment with the IP protection regime, at least in some sectors such as public health and new drugs for orphan diseases. The new mantra that has caught the attention of scientists is coopetition – cooperate while competing or compete while cooperating. The development of open source software is an example of such coopetition.

Is it important for countries like India to engage in global partnerships in scientific research and is it also important for others to engage us in scientific partnerships? Let us look at some of our strengths. Undoubtedly, India is one of the few countries in the world that not only had a rich scientific tradition, but also chose the path of science and technology for economic and social development soon after coming out of the colonial rule. Thanks to the vision of its leaders, scientific and political, the country can today boast of a chain of R&D laboratories cutting across disciplines, industrial infrastructure for technology-based enterprises, globally competitive infrastructure for education and a large market for new products. Of course, we have limited resources. India has also demonstrated that these strengths can be effectively used to combat some of the challenges facing the country. For example, the green revolution of the 70s led the country from food shortage to self-sufficiency in food. In spite of a rigid technology denial regime, the near self-reliance in nuclear technology is not something that can be ignored. India's capabilities in space technology is universally acknowledged. India is acknowledged as a global player in information technology. The country's potential in some emerging fields like biotechnology, nanotechnology and advance manufacturing have also been acknowledged. Some of our industries are also showing signs of emerging as Indian multinationals. With all these successes, it is not surprising that a large number of Indian students, researchers and professionals have been seen all over the world. Their track records have also been creditable. At the same time these are mostly individual-based and not institution-based.

During the last few decades, there have been some initiatives, a few of which are science-driven and others policy-driven. I would like to describe some of these as illustrative examples.

India's participation in CERN programmes is an outstanding example of science-driven collaboration. As many of you are aware, the European Organization for Nuclear Research, CERN, Geneva was founded in 1954 as a multinational co-operative venture in high energy physics research[1].

The participation of Indian scientists started in right earnest as students, postdocs and guest scientists in different programmes in CERN soon after its formation. This matured as participation of one Indian scientific group from the Tata Institute of Fundamental Research (TIFR), Mumbai[2]. It is indeed to the credit of the group that the Indian team leader eventually became the spokesperson of the LEP Upgrade/L3 group. In the late 80s, another group from Variable Energy Cyclotron Centre (VECC), Kolkata joined the SPS/WA80 group to study high-energy heavy-ion collisions. The group was entrusted with the design and fabrication of a photon multiplicity detector (PMD). The PMD has emerged as a major workhorse in all high-energy heavy-ion collision experiments not only in CERN (SPS/WA93, SPS/WA98), but also in BNL/RHIC, USA (STAR). PMD is back in CERN for the Large Hadron Collider (LHC) experiments. A major milestone in India's participation in CERN pro-

*Based on Meghnad Saha Medal Lecture (2009) delivered on 28 December 2010 during the Annual Meeting of the Indian National Science Academy held at the Indian Institute of Science, Bangalore.

grammes was the formal agreement between the Indian Department of Atomic Energy (DAE) and CERN to support India's participation in LHC machine-building, with firm resource commitments (US$ 25 million). DAE also evolved a unique participation model: only in-kind contributions and half the value to be kept aside for supporting Indian scientists participating in CERN activities[3]. India's commitment to the CERN programmes was doubled subsequently and the country was accorded the Observer status in the CERN Council in recognition of its contributions. Indian scientists are actively participating in LHC utilization presently. We are participants in two out of three approved experiments, ALICE and CMS. In addition to PMD, India's contributions include a muon spectrometer to CMS and a fast data acquisition chip, MANAS. The Indian team has also gained considerable expertise in detector design, fabrication, operation, simulation, theory, etc.

How have we gained from this collaboration? The opportunities for Indian scientists to participate in frontier experiments are obvious. When LHC was commissioned, there were two Indian scientists in the control room. Being partners in the collaborations, our scientists had early access to some of the cutting-edge technologies even at the time of development. Parallel processing, BITNET and GRID computing, all entered Indian laboratories long before they entered the commercial markets. The Indian industries also gained new opportunities in terms of access to cutting-edge technologies and new markets. The impact of the collaborations on policy-making and on the work culture cannot be ignored. It is important to note that the entire collaboration was science-driven and formal institutional involvements only followed. I want to recall an extract from an article by Godbole[4], in response to a note on scientific productivity in India.

'In summary, in stark contrast to the overall decline mentioned by Arunachalam, Indian HEP output has increased, and that too at about the same rate as other countries like Japan, France and Israel, though admittedly slower than boom country like South Korea. Further, the citation rate for this increased output has improved as well.'

At a time when science education was finding it difficult to attract young students, high-energy physics research had no problem in attracting good students and India's contributions were actually increasing. The contribution of the international collaborations for this state of affairs cannot be ignored.

Let me now give some examples of policy-driven collaborations. Scientists in India and the US have always had close and friendly relationships. Even today, the US continues to be the preferred destination for Indian students and professionals. However, the relationship between the two countries at the inter-governmental level has always been fragile. Formal scientific collaboration between India and the US has a fairly long history. Starting with the PL480 funds to support scientific and educational cooperation in the 50s, the programme has gone through several initiatives, most of them sub-critical, short-lived and highly susceptible to political weather. A major breakthrough was the establishment of the Indo-US S&T Forum[5] in 2000. The Forum was financially stable with an endowment from the US side and a matching yearly grant from the Indian side. Established as a Registered Society, the Forum has considerable flexibility in its operations. In recent years, the Forum has been able to raise additional resources from corporate sponsors. The present decade has also seen several new initiatives, including a new S&T-related agreement with a US$ 30 million endowment for joint applied research activities and for emphasizing entrepreneurship, innovation and eventual commercialization of the results. A clean energy research and development centre (virtual) has also been announced recently, with firm commitment funds from both the governments.

It is clear that the entire programme is top-down. It is also sub-critical considering the size of the two countries. Mostly, the activities have not gone beyond scientific exchanges and collaborations of individual scientists. Notwithstanding all the above, it needs to be emphasized that the scientific communities from both the countries have gained as a result of these initiatives[6].

A more recent development in Indo-US scientific relations is the Indian Institutions and the Fermilab Collaboration[6]. Physicists from Indian institutions have been collaborating at the Fermi National Laboratory (FNL) for more than two decades. In the D0 experiment that led to the discovery of the Top Quark, there were collaborators from Delhi University and TIFR. The investments were small and more importantly, there were many pin-pricks like visa denials, etc. By the beginning of this century, CERN/LHC was a reality and India was fully committed to it. Not surprisingly, the Indian high-energy physics community was seriously thinking of packing its bag from Fermilab and migrating to CERN/LHC. In 2002, a group of scientists from FNL and their Indian collaborators met me and the then Secretary DAE, Anil Kakodkar, to explore possibilities of India participating in the FNL programmes, in particular the International Linear Collider (ILC) that was then in air. We sent out a clear message: 'Get our scientists excited about the science and show that there are mutual benefits to both sides.' The first candidate for collaboration was the ILC. Following several rounds of discussions, today we have one Indian Institution – Fermi Laboratory MOU and four Addendums in accelerator and neutrino science[6]. Unlike the programmes under the Inter-Governmental agreement, the FNL agreement is science-driven and has good potential for growth.

Like the Indo-US relations in science collaboration, science and technology cooperation between India and Russia also has a long history. Starting from a formal Science and Technology Cooperation Agreement and the Integrated Long-Term Programme of Cooperation (ILTP) between India and the erstwhile USSR, the ILTP was transformed in 1992 as an Indo-Russian programme and the programme was extended with additional mandate of technology transfer to industry[7]. While the strategic sector and through them the Indian industries have been the major beneficiary of this programme, some of the successful initiatives in the non-strategic sectors include the creation of Polio Vaccine Production Centre, Advanced Research Centre International, Centre for Bio-Medical Instruments Research, Super Computing Research Centre in Moscow, etc.

Science and technology cooperation between India and France is one of the early inter-Governmental initiatives in S&T cooperation. The idea of setting up a joint centre for promoting collaboration between Indian and French scientists came up first during a discussion between the then Indian Prime Minister, Indira Gandhi and the then French President Valery Giscard d'Estaing[8]. The formal decision to set up the centre was taken in 1985. The centre was registered as a Society under the Indian Societies Registration Act in April 1986; the Governing Body of the centre first met in May 1987; and the centre became functional on 9 September 1987, when the first Director took up his post. As of date nearly 400 research projects, including industry-related projects and nearly 100 Indo-French seminars have been supported by the centre. Over 1800 articles have been published and more than 2000 exchange visits of Indian and French scientists have been supported. Unfortunately, while being cited as a successful initiative, budget constraints and changing priorities of the Governments have seriously limited the growth of this programme.

Another international accelerator facility (Facility for Antiproton and Ion Research, FAIR) is coming up in Darmstadt, Germany, to study the fundamental building-blocks of matter and the evolution of the universe, involving nearly 50 institutions in 15 countries[9]. India has joined this effort with financial commitments (in-kind) for both facility creation and facility utilization[10].

I have given several examples of India's participation in international mega science projects, all centred around nuclear accelerators. Obviously, the accelerator community has discovered the advantages of international collaborations before others. Are there no opportunities beyond accelerators? I can think of at least three programmes where India can gain by international collaborations.

(i) India-based neutrino observatory (INO)[11]. It is clearly a mega science project. There are scopes for international collaborations.

(ii) The open source drug discovery of CSIR is a major effort in global partnership in addressing diseases of the poor and can grow into a mega science project[12].

(iii) The Indian Institute of Science, Bangalore is discussing a 3 GeV synchrotron facility in its new campus in Chitradurga. Considering that there already more than a dozen synchrotrons of a similar kind across the world and it will take us at least five years to build a new one, it does not make sense to build one more of the same kind. On the other hand, can we build in unique features in the Chitradurga synchrotron through an international effort? I would like to suggest the following strategy.

(a) Invite competitive proposals (concepts only) from across the world. (b) Have a workshop and discuss in detail short-listed concepts. (c) Choose the most appropriate to prepare the final project proposal to the funding agency. (d) Invite international collaborators for machine-building and machine utilization.

What is the need and relevance of global partnerships in technology? Technologies, defined as the application of scientific knowledge to solve specific human needs, are inherently 'local'. Proven technologies are generally transferred through commercial contracts. Industries and Governments generally adopt a wait-and-watch policy for new technologies at the pre-commercial phase. It is at this stage that technology demonstration projects result in more confidence among the decision-makers on the viability of the technologies and enable fine-tuning of the technologies to local requirements. They also open up new business opportunities.

An illustrative example of a technology demonstration project is the Sattellite Instructional Television Experiment (SITE) in collaboration with the US in the early 70s, long before India emerged as a major space technology player[13]. Under this programme supported by US-AID, the NASA Applications Technology Satellite F (ATS F) was relocated over India for the duration of the experiment to study the application of satellites for rural education. The experiment and the experience enabled policy options for India long before the country entered the satellite era.

India's participation in the International Thermonuclear Experimental Reactor (ITER)[14] is one of the recent initiatives in technology cooperation. ITER is an ambitious programme to demonstrate the scientific and technological feasibility of fusion energy for peaceful purposes. India had expressed interest in participating in the project as a full partner on the basis of its advanced scientific and technological base, its established record of R&D in fusion research as well as from the perspective of a country with enormous energy needs. India has been accepted as full partner in the ITER project (other partners are China, Japan, EU, Republic of Korea, Russia and the US). India's acceptance as a full partner is an acknowledgement of the country as a responsible nuclear state with advanced nuclear technology, including in the field of fusion research. It also recognizes that India can significantly contribute to such endeavours. As a full partner, Indian contribution to the ITER project shall be on the same basis as that of other partners. One should not forget that Institute for Plasma Research was a small project under DST just two decades ago.

Many more opportunities in technology cooperation in sectors such as agriculture, healthcare, renewable energy, etc. exist and are under discussion at various platforms. However, none seems to be on the anvil. As mentioned earlier, mature technologies offer little scope for open collaborations. On the other hand, technologies in the premature phase, while offering ideal candidates for international collaborations, are too risky for corporates to go on their own. They require active support by Governments both by way of policies and resources. At the same time, Governments need convincing by someone on the viability of the technologies. Who else, but the scientific community can offer such convincing?

In summary, it has been demonstrated that India has the capability to contribute effectively to international collaborations in mega science and technology projects. Such collaborations have something to offer to everyone. However, the collaborations must be driven by overlapping scientific interests. While sustained institutional support is a necessity, such a support can only come when there is a national commitment.

1. http://public.web.cern.ch/public
2. http://international-relations.web.cern.ch/International-Relations/obs/india.html
3. Sahni, V. C., *Curr. Sci.*, 2004, **87**, 441–446.
4. Godbole, R. M., *Curr. Sci.*, 2002, **83**, 1179–1180.
5. http://www.indousstf.org/
6. http://iifc.fnal.gov/
7. http://www.dst.gov.in/inter-russia.pdf
8. http://www.cefipra.org/aboutcentre.htm
9. http://www.gside/portrait/fair_e.htm/
10. FAIR, Special section, *Curr. Sci.*, 2011, **100**, 671–696.
11. http://www.ino.tifr.res.in/ino/#
12. http://www.osdd.net
13. http://en.wikipedia.org/wiki/Satellite-Instructional-Television-Experiment
14. http://www.iter.org/proj

V. S. Ramamurthy is in the National Institute of Advanced Studies, Bangalore 560 012, India.
e-mail: vsramamurthy@nias.iisc.ernet.in