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The merits of ‘useless’ science

Since 1964 the International Centre for Theoretical Physics has been a hothouse for scientific talent from developing countries

The Abdus Salam International Centre for Theoretical Physics, in Trieste (Italy) has a reputation for doing world-class science. And yet most of its research is, deliberately, ‘useless’. At least at first view.

As Erio Tosatti, former acting-director of ICTP and a professor at the nearby International School for Advanced Studies (SISSA) explains, “All of the non-trivial advances are made by very clever inputs that may have been borrowed from theoretical physics and mathematics.” A good example would be the search engines we use to surf the internet. “It’s not just an increase in computing power,” he explains, “there is some very clever maths involved.” And, after all, the World Wide Web itself originated within the physics community not so far away from Trieste, at the European Organization for Nuclear Research (CERN) near Geneva (Switzerland).

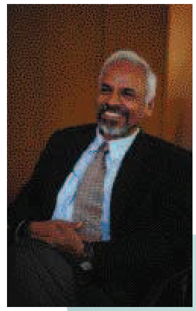
There was a logic, based on experience, that led Abdus Salam to choose theoretical physics and maths as the backbone for a high-level institute dedicated to scientists from developing countries. “Mathematics is the key instrument. It’s crucial,” says Tosatti, “yet it is the cheapest. You can dive right in. In Africa, it’s the main thing we can do that makes a difference. The people who come here from developing countries are like heroes in their own country - though they may not look like heroes!”

“It’s the environment that is missing in developing countries, not just the equipment,” adds Tosatti. And ICTP has none of the glum, nerdy feel its name may conjure to non-scientists. Its modern, beautifully equipped buildings are nestled on a wooded hillside overlooking the Adriatic. It rubs shoulders with the resplendent Miramare Castle and gardens built by Archduke Ferdinand Maximilian, when Trieste was still part of the Austrian empire. “The atmosphere is very informal,” says Iranian-born Seifallah Randjbar-Daemi, head of the ICTP high energy physics group. “We don’t wear ties, we’re all on first name terms, and our office doors are open. I’ve been to many universities and this is one of the unique places open to anyone regardless of race or religion. Yet it is 100 percent tension-free. There are so many people, from so many backgrounds, sitting together in the cafeteria. Everyone is talking about a clash of civilizations. But they're all eating together – Jews, Muslims, Christians." And, after all, the food (and coffee) is Italian, which also helps.

"This indicates to me that education is important," says Randjbar-Daemi. "The more tolerant people are, the less prejudices they have. They may have radically opposed opinions, but they talk in a civilized way. During the Cold War, this was one of the first places that Soviet scientists met colleagues from the West, especially the USA. They used to come with a group of 'watchers'. ICTP is a model of collaboration run with a very small budget, with amazing impact. The Italians have been very generous. Italy is known all over the world through Trieste and ICTP. Ex-students become ministers of science. They think of themselves as part Italian."

But this is no playground, either. ICTP regularly figures in the top 20 for the number of times its research papers are cited by other authors (the main barometer of significant science), which puts it alongside Harvard University.

Peter Coles



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A new director

As Indian-born Katepalli R.Sreenivasan was settling in as the new director of ICTP earlier this year, he made a point of talking to everyone, from senior staff to young diploma students, to find out what was working and what might need to change after 30 years of operation. His first diagnosis was frank: "good but we could do better."

"I would like us to spend some time seeing how we can become more effective," he explained. "ICTP spends a lot of its resources on many things, but it's not clear to me that they're all as effective as they are intended to be." And he singled out the associate scheme (see below) which is at the core of ICTP's efforts to overcome the isolation of scientists from developing countries, as a candidate for improvement.

"Some of them come here and, after a year, they go back to their own country. Quite contrary to what ICTP intended, they may just disappear into the thick of things. We should be encouraging them to somehow form groups around themselves and multiply their effect. This is the only way ICTP can be useful."

"There is a 'string theory' group in Bombay that is really very good," he says." Many of them were and still are associated with ICTP, and they somehow came together. This is like a mother institution and the children have to be let go at some time to do well on their own."

"I'd also like to involve high school teachers in ICTP. If they get excited about some aspect of mathematics for example, they can pass on their enthusiasm to their students. Over a 20-year period, this could change the landscape of Africa, where science education needs a boost."

World-class research

The late Nobel Laureate, Abdus Salam, of Pakistan, founded the International Centre for Theoretical Physics, in Trieste, Italy, in 1964. One of its prime objectives was to provide world-class research facilities for scientists from the developing world, to help stem the brain drain and overcome the isolation that makes it hard for them to work productively in their home countries. About 80,000 scientists from 170 countries have visited the centre in the past four decades.

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Renamed in 1996, after its founder's death, the Abdus Salam International Centre for Theoretical Physics has three main research groups: in condensed matter physics, high energy and astroparticle physics, and mathematics. These groups have 16 permanent staff scientists, six long-term senior visitors and 27 post-doctoral fellows. Each year these groups host about 500 visitors from all over the world for training and collaboration. They also organize some 20 workshops and conferences for about 700 participants. Other smaller groups include: a microprocessor laboratory, a physics of weather and climate group, and synchrotron radiation related physics.

Each year the centre selects between 50 and 150 associates from a pool of 1,000 candidates. Those selected may come to ICTP three times in a six-year period.

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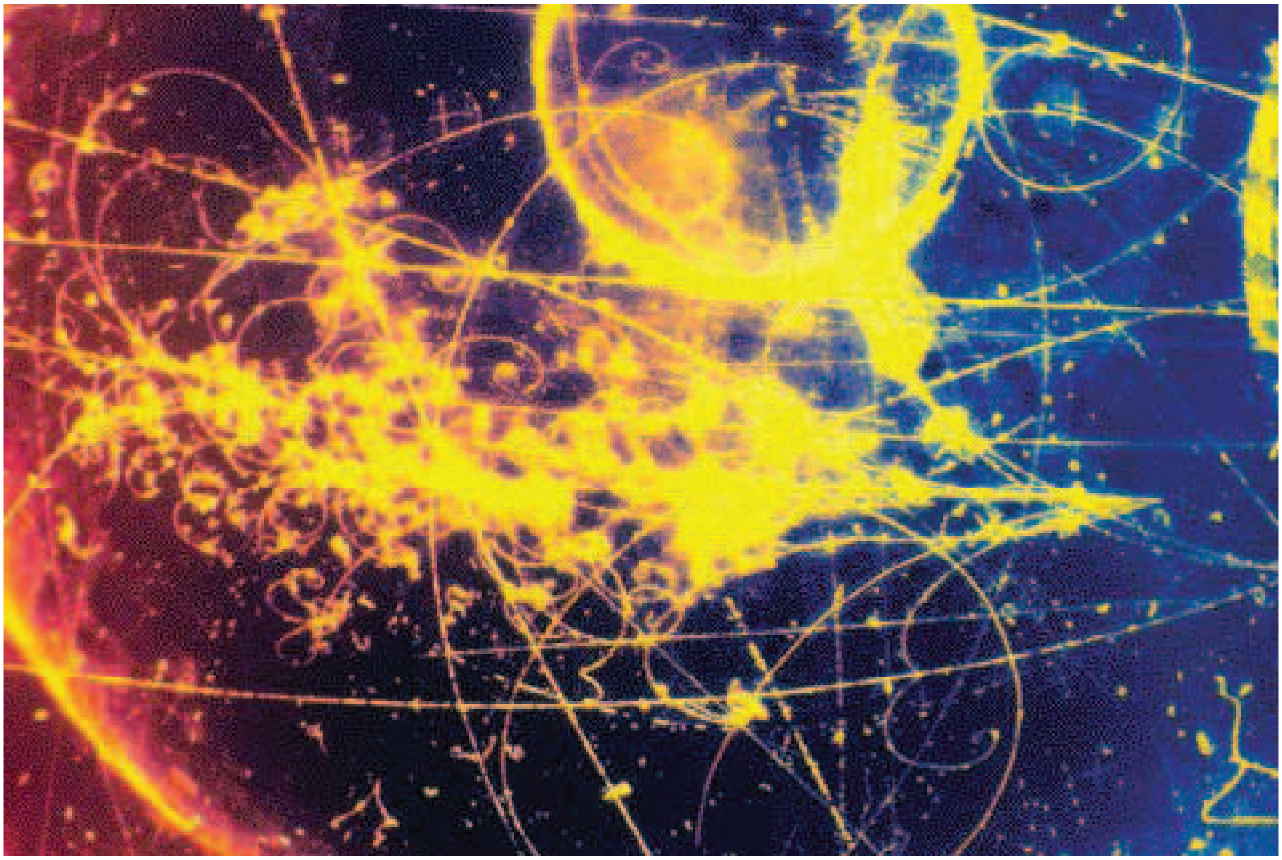
ICTP is administered through a tri-partite agreement between UNESCO, the International Atomic Energy Agency (IAEA) and the Italian government. In 1996 UNESCO took over as lead administrator from IAEA, although 85 percent of the annual budget comes from the Italian government – about $18 million a year.



Language of the universe?

Mathematics knows no borders, even if cultures can put their stamp on it

Talking about high-level mathematics with Lê Dung Tráng is a bit like trying to improvise with jazzman, John Coltrane. If you've got the language and the skills, you can fly very high. If not, you can feel on the outside of something you only think you understand.

"Mathematicians can still communicate from one speciality to another, which is rare in other fields," explains Tráng, head of mathematics at the ICTP, "but it's hard to explain anything to an outsider. If I wanted you to see a problem I am working on, I would have to explain it to you for a long time, reduce it to concepts you could grasp. Each step might be very easy, but the whole process needs years of training."

This idea of "understanding the code" crops up often for Tráng. And not only regarding maths. Yet, like Molière's Monsieur Jourdain, who is delighted to learn he has been speaking prose most of his life, Tráng believes that, with training, we are all capable of a kind of mathematical competence. "The structure of language, for example, is already mathematically very complex. And even the most retarded person can express himself in a logical way." And if we can already produce something that is mathematically complex (like language) we should, in principle, be capable of learning the code that expresses this complexity (mathematics). He therefore feels we may have the same kind of propensity to learn mathematics as we do for language. "People are stronger than they know," he says.

Tráng is also convinced that a grounding in mathematics is essential for everyone, providing not just basic numeracy, but tools for thought. "In developing countries the need for mathematics is so great that the idea of asking what's the use of it is stupid. We're not at the level of having too many mathematicians. We won't be there for 50 to 100 years. But a country without mathematics has no soul. There is no science or technology without mathematics. And training in mathematics is comparatively cheap. A mathematician can be trained to become a biologist or another type of scientist, yet it's not so easy to do the converse," he says. But, he adds, not just any kind of mathematics will do. "There are mathematicians in Vietnam, for example," he explains, "but they have been trained in a fairly backward way, like 19th century French mathematics for engineers. It doesn't fit any more for a lot of purposes."

Particle tracks in a bubble chamber at the Fermilan accelerator laboratory near Chicago (USA)

Since 1972 Tráng has been returning every year to his native Vietnam to teach mathematics. But, he says "as time goes on, I feel they need me less as an individual." In France, where he has spent most of his academic life, he says, an individual "can give a lecture and then a group of young people get excited and may even create a new school of thought. This happened to me." But in a country like Vietnam, the needs are more fundamental. "You need to enlarge the base. At the beginning there were very few students I could train to become teachers or researchers. Now they have all made their careers and most are more important than I am."

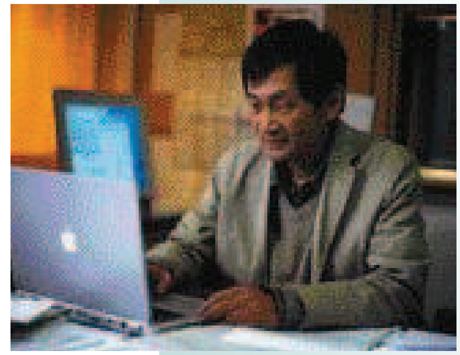
A DELICATE ALCHEMY

And for Tráng, there is something noble about being a teacher. "As a student, in my group, we were very keen on seeing the merit of the one who shows the way." And he is proud to be able to trace his own lineage directly back to the late Renaissance mathematicians Galileo and Descartes, via great contemporary mathematicians, like Thom, Grothendieck and Hironaka, who taught him at the Sorbonne in Paris in the 1960's. "It's a very delicate alchemy," he says. "To begin with, you need interesting teachers, and that is not easy in developing countries. But one is enough. And then you need the student to meet the teacher. This teacher doesn't have to be a famous mathematician, but one who likes maths."

But if mathematics may be a universal language for science, Tráng believes it is nevertheless influenced by culture."Different countries have different ways of doing mathematics," he says. "The Vietnamese, for example, have a keenness for abstraction, like the Romanians. The French have a very different way of understanding abstraction compared to the British. Mexico is strong in analytic geometry, India in the theory of numbers, China in differential geometry. Every country also has a different way of seeing the relationship between mathematics and the rest of their culture. Most people think mathematics is something absolute. But that's basically wrong."

"Myself, I grew up in two different cultures. And as a kid I couldn't understand that it made any difference. When I was older I realized that a lot of people couldn't understand what I could. I thought there was something wrong with me. Little by little I realized it was a matter of understanding the cultural code. Later on, when I went to Vietnam with people who knew nothing about developing countries, I was surprised by their reaction. Even if a developing country looks poor and powerless, it still has its own power. But without the cultural code, they just can't see it. They only see the kind of power they are used to, like the power of machines."

Peter Coles



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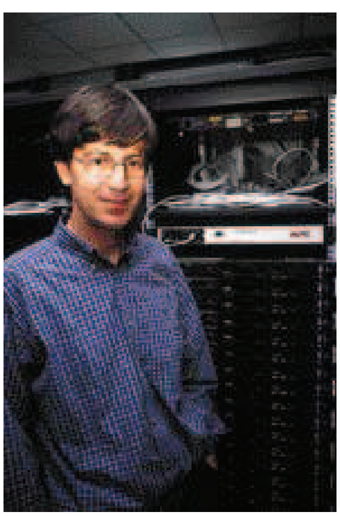
For Lê Dung Tráng a country without mathematics has no soul



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Crunchy numbers

Sandro Scandolo has proven the adage that "time is money". By leading the effort to connect 80 Pentium PCs running at 2 GHz in a high speed network, he has helped ICTP develop a parallel computer that is as fast as the fastest supercomputer was two years ago. And for about a tenth of the price. According to Moore's Law, computing capacity doubles every 18-24 months. "And two years is nothing on the scale of scientific research," says Scandolo. On the staff of ICTP's condensed matter group, Scandolo is using the new computer facility to carry out simulations of the conditions inside planets, including Earth. With pressures running at a million atmospheres and temperatures of 5,000°C near the Earth's core, scientists were using nuclear explosions, earthquakes and firing bullets at targets to try to replicate these conditions before fast computer simulations became feasible. Colleagues at ICTP will be using the parallel computer to study climate change, while others, like postgraduate student, Van Wellington Elloh, from Ghana, are predicting the behaviour of materials that don't even exist yet, like intelligent fibres that could put computing power into our clothes.

What flavour neutrinos?

ICTP's Alexei Smirnov is a happy man. Last year, after some 20 years of efforts, independent experiments proved that his contribution to the theory of neutrinos was right, earning Raymond Davis and Masatoshi Koshiba the Nobel Prize for physics.

Neutrinos are sub-atomic particles with almost no mass. The Sun's core produces countless billions of them, all the time, through nuclear fusion. It takes about eight minutes for one to fly the 150 million kilometres from the Sun's core to earth, where some 60 billion neutrinos hit every square centimetre every second. But when they get here, they just pass right through, which makes them exceptionally hard to detect. In the 1960's Davis built a massive pool containing 615 tons of dry-cleaning fluid, 1.5 km underground in a disused gold mine, to spot their passage. And over a 30-year period, he found evidence of just six or so a month. A triumph, given how elusive these little particles are – except that this was about a third the number that theory predicted. Which is where Smirnov and his colleagues stepped in.

In 1985, Stanislav Mikheyev and Alexei Smirnov added to an existing theory developed by Lincoln Wolfenstein that there are three different kinds ("flavours") of neutrino, corresponding to the three kinds of charged "lepton" particles (electrons, muons and tau) that were already known to exist. The researchers suggested that, in their passage from the sun, the neutrinos were converting (oscillating) from one "flavour" to another. This, they said, would explain the "deficit" between observation and theory, because the detectors were set up mainly to detect electron neutrinos.

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"Twas a sweet marriage, and we prosper well..."

(Shakespeare, The Tempest)

ICTP's sister organization in Trieste, the Third World Academy of Sciences (TWAS) is 20 years old, and celebrated last October in Beijing (China).

For Executive Director Mohammed H.A. Hassan, the objectives of TWAS haven't changed since a group of eminent scientists from developing countries, under the leadership of Abdus Salam, set it up in 1983: to encourage excellence in science, support young scientists, promote South/South and North/South cooperation in science, and to use science and technology to solve practical problems in developing countries.

But if the objectives haven't changed, the means have evolved. "Now we're concentrating on the least developed countries," explains Hassan. "We were finding that we were giving little support to the very poor. So we've turned it round. We're using the strength of the more successful (developing) countries to open up their labs. We've created a list of 600 centres of excellence in over 100 countries. We sign agreements with them so that they receive scientists from the very poor countries and pay for them. It's a joint UNESCO/TWAS project, with UNESCO paying for travel and subsistence. It's just like the ICTP associate programme but it all takes place in developing countries."

With a $750,000 grant from the Global Environment Facility, a new project is concentrating on 20 least developed countries, via the Third World Network of Science Organizations (TWNSO), an NGO set up by TWAS to unite research councils, science ministries and heads of science academies in developing countries around the theme of sustainable economic development. Under the rubric "sharing innovative experiences", TWNSO commissions case studies on practical development themes, like managing water resources, conservation and use of indigenous and medicinal plants, and the biodiversity of dry lands. "We challenged the scientific community in the South," explains Hassan. "We drew up a list of areas in which we were looking for excellence and picked a few. It's one of our major tasks and it will continue."

TWAS also hosts the Third World Organization for Women in Science, that provides some 60 women Ph.D. students from developing countries with grants to complete their studies. "They can go anywhere in the South," explains Hassan. "Half are in South Africa, but others are in India, Brazil, Malaysia and China, usually through a 'sandwich' system, whereby they register at a university in their home country, go away for six months at a time, then return home. The number of applicants is huge. Many are excellent. It's one of our most rewarding programmes."

Peter Coles