Lab Character: Who We Are

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He's as versed in physics as in language studies and can program any computer made in a day...

The patterns dotted on the punch cards catch Tanmoy Bhattacharya's eye.

Scattered across the paper, the clusters of tiny holes represent answers. The computer has all the knowledge. He just has to ask the right questions with the cards to get it — "talk nicely to the machine," as he likes to say.

Working in a laboratory in 1980s Kharagpur, near Calcutta, India, Tanmoy's mind begins to see the broader picture of how an IBM 1620 — a very early computer; loud, large and cumbersome with flashing lights and dials — thinks and works.

Head down, he clicks away, perforating his cards on a typewriter-like machine that bulges from the IBM like a gear box on a Royal Enfield motorcycle.

> Click here to see how punch cards were made

The original IBM 1620 in all its glory. (Photo: IBM.com)

All these little notches are made to create programming and data sequences for the computer.

This work is tedious, but it helps him understand the machine's logic and how it functions from the hardware to the operating system. It will ultimately propel his career toward the pursuit of some of the most advanced science ever known.

"Once you know the difficulties of designing a language, the rules of the computer language are no longer arbitrary; rather they become ingrained," Tanmoy says, thinking back on those years.

Punch cards (also referred to as "punched cards") from an old IBM computer. The perforations represent programming and data sequences. (Photo: IBM.com)

Over time, he finds more opportunities to work on microprocessors and multi-terminal mainframe computers — not easy in a developing country. He masters them all.

"Computers don't create problems for me, they like me," he says. "I ask them nicely for information and they give it to me. I can program on any computer made in a day."

'Intellectual stamp collecting' — From punch cards to solving the HIV crisis

Decades later, Tanmoy (Nuclear and Particle Physics, Astrophysics and Cosmology, T-2) helps maintain and program computers at Los Alamos that crunch complex data in order to design computational models for vaccines that can predict and possibly prevent HIV — one of the most enduring, complicated and devastating bloodborne diseases on the planet.

The work eventually contributes to the development of the world's first computationally-generated vaccine sequences — including the HIV "mosaic" vaccine, which is one of only a handful of potential preventive measures to ever reach human efficacy trials.

> Click here to find out more

The principal architect of the mosaic vaccine, Bette Korber (Theoretical Biology and Biophysics, T-6), a Lab Fellow and Richard Feynman Award winner who was recently named R&D Magazine's "Scientist of the Year," says Tanmoy is "really good to have on a project, as he is very clear thinking, fast on his feet and spectacular at a whiteboard." She also lauds his "substantial contributions" to determining viral evolution and transmission and phenotype/genotype relations of HIV.

Creating and administering programming data for vaccine sequences is a far cry from shuffling through decks of punch cards in Kharagpur. But the tenets of the old analog systems — that "ingrained" language Tanmoy absorbed early in his career — still deliver critical knowledge.

"My cordial relationships with computers stems from this complete picture, so often I can intuit why the computer did not give me the 'logically' correct answer," he says. "I just place myself in the shoes of the designer/compiler writer/language specifier/etc. and ask myself to debug what I might have messed up in that role."

It's determining these scales of error — stepping back to see the big picture and then taking details out of it to solve the larger problem — that have helped drive Tanmoy's career. And not just in HIV research, but in the wide variety of science he's involved in at the Lab and beyond.

Paul Dotson, associate Laboratory director for Simulation and Computation (ALDSC), calls Tanmoy's gyrating scientific prowess "amazing."

"The more I've worked with Tanmoy, the more I realize the breadth of his talents and interests," Dotson says. "I've yet to find a topic where he didn't have an informed opinion."

Just a few of Tanmoy's specialties:

> Particle physics and physics of complex systems
> Phylogenetics and emergence in evolutionary systems
> Quantitative studies of linguistics and human behavior
> Computer security and machine learning in the health sciences

He's also an aspiring historian.

Specifically, Tanmoy wants to know about India's past, but not in the Encyclopedia Britannica sense of historical knowing. Instead, he plans to use his skills to examine his homeland from a scientific perspective; to “disentangle” the history of thought regarding its origins and development as one of the world’s cultural and spiritual epicenters.

For most, skimming Wikipedia might be enough. Not in his case.

“For as long as I can remember, I had an interest in intellectual 'stamp collecting' — gathering facts that are practically unimportant but interesting,” he says. “Of course, they are interesting because of their explanatory power: they tell us something about how things are organized, how things come about."

To Tanmoy, science and other disciplines present a puzzle of patterns that must simply be processed like punch cards on an IBM 1620 to understand.

“Science is all about patterns — I try to arrange it by section so I can make connections, and physics has been doing this exact same thing for a long time,” he says. “Aristotle has a quote that says, ‘Should we study animals individually, or look at similarities of all animals first?’ So, don’t think of HIV alone — think about viruses.”

Explaining the impossible

Tanmoy reduces challenges in science and other disciplines to a puzzle of patterns.

Physics is Tanmoy's favorite subject of all.

In 2000, he and colleagues started to examine the emergence of classical physics from quantum mechanics, asking why — contrary to all the expected quantum fuzziness — everyday objects seem to have concrete attributes like position.

Using the supercomputers of the day, their work showed that when measurements are neither unbelievably strong nor weak, there is no way to tell the difference between the classical and quantum models.

“In other words, under ordinary conditions, the world looks both classical and quantum, but since the classical description needs less mental resources to work with, we have learned to think of it as classical,” Tanmoy says. “This body of work naturally led to the really interesting case when measurement is basically absent, so that quantum mechanics in its pure form flourishes.”

Not surprisingly, computation runs through many of Tanmoy's physics pursuits.

Today, he is calculating the low-energy properties of neutrons from the current regnant Standard Model of particle physics, which can’t account for things like dark matter or that the universe has matter in it, not just light.

“The standard model, for all its remarkable successes, cannot be complete: it does not explain the observed dark energy or dark matter, but even more importantly, it declares our universe, that we know exists, an impossibility,” he explains.

Tanmoy and others hope large scale computation can bridge these yawning gaps.

“These are difficult calculations since the absence of a simple small parameter makes approximations hard to come by, and it really needs large scale computation to make progress,” he says.

If that's not enough, Tanmoy also co-leads a Lab cohort looking for and interpreting a possible electric dipole moment of the neutron — the separation of the positive and negative charges inside the neutral neutron by an imperceptibly small distance — through experiments, hard computer calculations and machine learning.

“This experiment, along with the associated calculation to interpret it, is hugely exciting in particle physics,” he says.

Such diversified experience in both quantum mechanics and calculations in high-energy physics recently landed Tanmoy’s team a grant from the Department of Energy to develop methods for using quantum computers to do high-energy physics.

Collaboration = innovation

Tanmoy finds deep appreciation for the Lab’s openness to new ideas, collaborative spirit and innovation, owing to it much of his personal scientific growth and development.

Looking east from his office window in the Theoretical Division building, Tanmoy can see the mountains. Although he's not here much — often in motion, as one might imagine — it's a good place to pause and reflect; to let those "ephemeral surface trappings" go and think about the next big thing.

In these moments, Tanmoy finds deep appreciation for the Lab’s openness to new ideas, collaborative spirit and innovation. The Los Alamos culture helps him to flourish as a scientist.

“LANL doesn’t give you boundaries — it’s a unique place. It’s very difficult to find that kind of freedom in most places,” he says. “Having a talent pool like this that wants to work together — it’s very unique. Collaborations are rampant.”

More about Tanmoy Bhattacharya

Tanmoy Bhattacharya received his doctorate in physics from the Tata Institute of Fundamental Research. He then joined the Brookhaven National Laboratory as a postdoctoral fellow. After two years at Brookhaven, Tanmoy moved to France to work at Service de Physique Theorique. In 1992, he joined the high-energy particle theory group at Los Alamos National Laboratory as a postdoc and in 1999 became a regular staff member. Tanmoy also joined the Santa Fe Institute as a part-time resident faculty member in 2005.