Explaining the Mysteries of the Universe

By Wael Nabbout

Last November, I wandered the physics department at the American University of Beirut (AUB) searching for a professor to help me script a short video series I was preparing. It was Friday afternoon so the department was virtually empty, save for one office with its door ajar. Little did I know when I walked in and introduced myself that I was meeting a man responsible for a number of theories and models that are aiding humanity unravel the mysteries of the universe.

“As a child I was completely absorbed in mathematics,” explains Ali Chamseddine, who currently serves as a physics professor at AUB. But as chance had it, he ended up enrolling in physics for his undergraduate degree. He humorously attributes it to the fact that his older brother was already studying mathematics and that the family would not allow both siblings to learn the same trade. He chuckles, then tells me that the real reason he opted for physics was because at the time mathematics was taught in French at the Lebanese University.

After completing his degree, he got a scholarship and started working on his PhD on Supersymmetry at London’s Imperial College. There, he was advised by Mohammad Abdus Salam, a Pakistani theoretical physicist and a future recipient of the 1979 Nobel Prize for physics.

What is Supersymmetry?

All matter is made up of fundamental particles, the basic building blocs of everything around us. The Standard Model is a theory of fundamental particles developed in the second half of the 20th century that successfully explains almost all experimental results. The problem is that it explains ‘almost all’, but not everything. There are many phenomena, such as the expansion of the universe, dark matter, and some aspect of the theory of gravitation that the model cannot account for. As such, other models are needed.

Enter Supersymmetry. Elementary particles, as they are alternatively called, are either fermions or bosons. Supersymmetry suggests that for each particle there exists a so-called super partner, and that the super partner would be from the opposite class: fermions would have boson super partners and vice versa. But none of the observed fermions and bosons are partners; in fact, a supersymmetry partner has never been found. This means that if the theory were proven, the number of elementary particles would double.

The Large Hadron Collider, built by the European Organization for Nuclear Research (CERN) and completed in 2008, is the world's largest and most powerful particle collider. "Hopefully with this energy, it will be sufficient to create these particles that have not been seen yet." Just finding one or a couple at first would be sufficient to prove that the model works, and that would mean that "physics as we know it, would completely change."

After completing his thesis, Chamseddine joined CERN as a scientific associate. There he proposed a theory that years later would be used to determine the low energy limit of String Theory. In it, he argued that the space-time continuum is 10 dimensional instead of the four dimensions we are aware of: time and the three dimensions of space. This model was necessary to frame Supersymmetry.

"If you were to look at a sheet of paper, you'll see three dimensions, length, width, and albeit small, a thickness. Now imagine that its thickness is much less, say ten to the power minus thirty-five centimeters. It is there that these dimensions hide. We can't see them, but their implications are around us," says Chamseddine.

Following CERN, he went to Northeastern University in Boston where he proposed a model that predicts where the Supersymmetry particles should be and what are their signatures. With more than 2000 citations, the paper is "very influential" and is still used by experimentals today looking for Supersymmetry. Chamseddine calls it his best work.

The big shift

After 1985, he left the United States and joined the Swiss Federal Institute of Technology in Zurich, known as ETH Zurich, as a research professor where, for 12 years, he concentrated on research around noncommutative geometry.

When Einstein was alive, only two forces were known: gravitational force and electromagnetic force. Since then, it has been discovered that there are two additional forces: the weak force and the strong force. Einstein was able to build a theory that describes the gravitational using a geometry invented by German mathematician Bernhard Riemann but it could not account for the other three forces. You need a new kind of geometry explains Chamseddine, "this is noncommutative geometry."

Noncommutative geometry was initially conceived by French mathematician and a Fields medalist Alain Connes. "It is the frontiers of mathematics," says Chamseddine. Currently, both he and Connes work on building the theory to understand all four forces with this new geometry. He spends summers in France at the Institut des Hautes Études Scientifiques (IHÉS), as a Louis Michel Chair, a post for distinguished long-term visitors.

Coming back to Lebanon

In 1998, officials at AUB lured him back to his home country with the promise to build a research center – the Center for Advanced Mathematical Sciences – and instating him at the helm. A few years later, financial support dwindled so he decided to step down. "They wanted the center to bring money, but research in fundamental science doesn't pay."

Chamseddine was also present at CERN for a roundtable discussion around the Jordan based SESAME project, a cooperative research venture of scientists and governments from all over the region built around a repurposed, "outdated" cyclic particle accelerator. "It's a big mess; I think it will have a rough ride." The operational launch of the center has been pushed back on several occasions.

Puzzle solvers

When asked about the state of scientific research in the Arab world, he runs out of words for a moment, the only time he struggled for an answer, then says “It is really bad, you know. Even before civil unrest swept a number of Arab countries, one barely had any hope; right now, we are going backwards at the speed of light.”

Despite the dire take on the state of science and research in the region, his motivation and ambition to continue on uncovering the universe’s mysteries, is rock hard. He compares himself and researchers like him to puzzle solvers playing a game. “We sit down for days and we try to make sense of it. Where it would take us? We don’t know. But if we knew, it would not be fun anymore.”

Why it matters

Research into mathematics and physics help solve cosmic riddles

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