Amalendu Krishna

Mathematician Amalendu Krishna of the Tata Institute of Fundamental Research (TIFR), Mumbai has been awarded the Ramanujan Prize for the year 2015 for his outstanding contributions in the area of algebraic cycles, algebraic K-theory and the theory of motives.

The ICTP Ramanujan Prize for Young Mathematicians from Developing Countries is awarded annually by the International Centre for Theoretical Physics, Trieste, Italy and named after the famous mathematician Srinivasa Ramanujan. It was founded in 2004 and was first awarded in 2005. The Prize is awarded to a researcher less than 45 years of age, who has conducted outstanding research in a developing country. The Prize is supported by the Ministry of Science and Technology (India) and Norwegian Academy of Science and Letters through the Abel Fund, with the cooperation of the International Mathematical Union. The first Indian receipient of the award was Sujatha Ramadorai in 2006.

Krishna hails from Patna, Bihar, where he did his schooling and early college education. He dropped out of IIT Kanpur, after getting disillusioned by the job-oriented focus of engineering students there. He then shelved the option of being a bureaucrat as he realized that bureaucracy was not to his liking. His love for academics led him to join Vasudevan Srinivas at TIFR, where he completed his Ph D in 2001. According to Krishna, it is his tenure as a doctoral student at TIFR which fuelled his interest in the field of mathematics. He believes that working with Srinivas was a enriching experience for him and it was during this period that he learned the values of doing research with honesty and dedication. He then joined University of California, Los Angeles as a researcher and returned to his parent organization TIFR, where he realized that this was the place where he could work peacefully without interference.

The pure and challenging nature of mathematics keeps Krishna hooked on to it. He has over 25 publications in high-impact journals and is currently guiding a few students for doctoral research. In an interview with *Current Science*, Krishna spoke about his research interests, his love for mathematics and shared his thoughts on how students can be attarcted to the field of pure sciences and the importance of quality addition in Ph D courses.

Congratulations on winning the 2015 Ramanujan Prize. Can you please tell us about the current research work you are engaged in?

Thank you very much. At present, I am engaged in research work which aims to solve certain problems in the area of algebraic K-theory, a branch of pure mathematics. More specifically, I am trying to develop some explicit cohomology theory using geometric objects, like algebraic cycles, which can be used as a tool to describe the algebraic K-theory of spaces which have singularities.

Can you describe your research in general terms? Does it have applications in other areas?

As I said above, I work in the area of algebraic K-theory and algebraic geometry. Algebraic geometry is a subject which teaches us how to study and understand a geometric structure which is constructed out of a family of finite sets of polynomial equations in several variables over a field, say, rational, real or complex numbers. I study certain aspects of these geometric structures which use inputs from algebraic K-theory. To compute this K-theory in turn, we need to have some simpler and more explicit models. My focus is to check if a theory of 'the algebraic cycles', which is defined explicitly, could be used as one such model for K-theory of algebro-geometric objects. Algebraic K-theory has applications in almost every area of mathematics.

What is K-theory and why does it have an aura of inapproachability and how to make this area explicit?

K-theory is a subject of mathematics, invented in its original form by Alexander Grothendieck. Arguably, one of the greatest mathematicians of the 20th century, Grothendieck gave a partial construction of algebraic K-theory, which was enough for him to solve the famous Riemann–Roch problem. The construction of Grothendieck was greatly expanded by Daniel Quillen on the algebraic side and Michael Atiyah on the topological side. Since then, both the algebraic and topological K-theories have had enormous applications in mathematics. However, one issue with algebraic K-theory is the significantly high degree of abstraction in its construction. At times, in many potential applications, this becomes an impediment in using K-theory. So one needs to construct explicit models from it in order to make the huge potential of K-theory more realizable in practice. Ever since K-theory came into being, mathematicians have been engaged in this task and have achieved a lot of success.

What would be your advice to young researchers aiming to work in the area of K-theory?

As I mentioned above, K-theory in general and algebraic K-theory in particular, have enormous potential of applications in almost every branch of mathematics. It is not surprising that a theory with such potential would be difficult to comprehend and compute. On the other hand, what a scientist does is to see the potential of a theory and then work towards realizing it. In this sense, the subject of K-theory provides a lot of research opportunities which young people can get involved in and achieve enough success in it.

Can you help us understand the concept of conjectures and give an example?

In mathematics, the word conjecture means a definite mathematical statement which is believed (often strongly) to be true, but is not formally known to be true, when the statement is made. In modern mathematics, conjecture is often used as a kind of status given to an unresolved mathematical statement which has been made on the basis of strong evidences and whose resolution is likely to have significant impact on a certain area of mathematics. One of the oldest and easiest conjectures in mathematics, and yet unresolved, is the famous Goldbach conjecture (AD 1742), which states that every even integer greater than two can be expressed as a sum of two primes.

Can you help us understand the role of standard conjectures in the field of algebraic cycles?

The 'standard conjectures' in the theory of algebraic cycles were proposed by Grothendieck. Every algebraically defined geometric object with reasonably nice properties has associated to it many cohomology theories. These cohomology theories are meant to detect information about the given geometric object using purely algebraic tools. The standard conjectures essentially state that certain important operators on these (Weil) cohomology theories are actually given in terms of algebraic cycles. Furthermore, many of these operators coming from algebraic cycles act on the cohomology theories in a non-degenerate (in terms of matrices, definite) way. These conjectures are still unresolved, but are supposed to have enormous consequences in the study of algebro-geometric objects. In particular, it is supposed to say that these geometric objects are equipped with a kind of universal cohomology theory, famously called 'motives'. Incidentally, the standard conjectures were announced by Grothendieck during his visit to TIFR in 1968 in one of the most prestigious international colloquia, held every four years. The next one will be held in January 2016 and the theme is again K-theory.

In your space as a mathematician what do you find most rewarding or productive?

The most rewarding thing for me as a mathematician is the recognition and appreciation of my work by the experts around the world in my area of research.

Please elaborate on the role of mathematics in the real world.

It is a common knowledge that at the basic level, mathematics surrounds us everywhere and almost every task we do. Every type of work or career requires a certain level of mathematics.

What are the factors that groomed you to become a mathematician?

I do not know if there were specific factors that groomed me as a mathematician. Like many others, I found during my school days that I liked science and mathematics. I was very fortunate to have studied in good schools like in Indian Statistical Institute, where my teachers were very supportive and always encouraged me to pursue mathematics. That played a role.

According to you what is the Holy Grail of the field of mathematics?

It is difficult for me to say what could be called the Holy Grail of mathematics? There are many mathematicians around the world with better expertise who can say what it is. But there are some outstanding open problems in mathematics whose solutions will have profound impact on further development of various areas of mathematics, and we should work toward making contribution in solving these problems.

As a professor, what would be your advice to students who fear the subject?

I usually do not like to give advice. But to young students looking to make a career in mathematics, I would say that mathematics undoubtedly is not an easy subject to pursue. But every subject is hard, if one wants to truely excel in it. And, we need to put in equally hard work to reach the level of excellence, no matter what subject we choose.

Your thoughts on the best incentives that can be given to young researchers to attract them to the field of pure sciences?

I have been asked this question in many interviews, and this may be the evidence that there is a perception of lack of incentives for research in India. I think that various agencies have written reports on this issue and our Government is in possession of them. I am not sure what the priorities of the Government are and if it has some definite plans to improve high-quality research activities in India. I will only say that any country that wishes to become truely developed, be counted as a superpower and respected in the world must necessarily have its science of very top quality. A country like China has made serious efforts in this direction.

Do you think India is producing sufficient Ph Ds in the area of pure sciences and what is your take on quality vs quantity with respect to churning out Ph Ds from Indian academia?

I do not have clear data to say if India produces enough number of Ph Ds every year. But the issue of quality vs quantity is more relevant. In the field of mathematics, the country has minimum representation among the top universities across the globe and much can be learnt and imbibed from the West in terms of imparting quality education at the doctoral level. The scenario is now changing with rapid expansion of premier research institutions which contribute to high-quality education and research. With respect to Indian universities catering to higher education, largely the performance is sub-optimal, though the situation is now improving.

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