about creating order in universe

Ljubljana, 17 May - Mathematician Franc Forstnerič, a professor at the Ljubljana Faculty of Mathematics and Physics, is one of the three Slovenians who won the prestigious ERC Advanced Grant for established researchers this year. Maths is about creating order in the universe, says the recipient of the first ERC project for mathematics in Slovenia.

Forstnerič received the European Research Council (ERC) five-year grant worth nearly EUR 1.5 million for his project titled Holomorphic Partial Differential Relations, which is aimed at coming up with new methods and findings in the area of Oka manifolds and more generally of oriented holomorphic systems.

In 1985, Forstnerič completed his doctoral thesis about holomorphic mappings in several

principle, he told the STA.

After he obtained his PhD, Forstnerič first returned to Ljubljana and then went on several extended research stays abroad. In 1997, he was back in Ljubljana, determined to work intensively on the Oka-Grauert principle.

"In 1989, an important article on the subject was published by the eminent Russian-French mathematician Mikhael Gromov, the recipient of the Abel Prize in 2009. Gromov put the theory on a new footing, introduced new techniques and suggested possible further development, but he did not present detailed proof.

"Gromov is a brilliant mathematician who has contributed key new ideas in a number of mathematical fields, but he often leaves the detailed arguments and further development to others," Forstnerič said.

He involved his PhD student Jasna Prezelj in the research, and together, in a few years, they managed to make a crucial breakthrough in the understanding of Gromov's ideas.

Forstnerič then went on to work on the problem of characterising the class of complex manifolds to which the results of the theory apply. In 2006, he characterised this class by a simple "convex approximation property" and by a number of other properties which were not obviously equivalent to each other.

"This manifold property means that any holomorphic mapping of a convex set in a complex Euclidean space can be approximated by holomorphic mappings of the entire Euclidean space into a given manifold," he explains. This has solved one of the key problems posed by Gromov, and within a few years a complete theory emerged.

Based on this, Forstnerič introduced a new class of complex manifolds into the literature in 2009, which he named Oka manifolds after the theory's originator, the Japanese mathematician Kiyoshi Oka (1901-1978).

Manifolds are geometric objects such as curves and surfaces. "The world we live in is a manifold," notes the Slovenian mathematician, adding: "We live on a sphere; the sphere, galaxies, the universe, these are all manifolds."

Complex manifolds always have an even number of dimensions. "There is an additional structure to them that defines a special class of mappings between these manifolds -

its direction, and this will cause buoyancy.

"This is what keeps the aircraft in the air. But when you want to model how that airflow is going to flow around the wing, you draw a shape and then you have to calculate what is going to happen. It is more straightforward to use conformal mapping to map this wing shape onto a circle. Having mapped it onto a circle, you have explicit solutions of laminar flow that avoids the circle. Then you map these solutions back using conformal mapping. This is one simple application of such mappings," Forstnerič said.

His Oka theory received significant recognition in 2020. "Every 10 years, the American Mathematical Society renews the classification of mathematical fields in cooperation with the German journal Zentralblatt fur Mathematik. There was no suitable field for this theory, so we proposed it and it was accepted.

"They introduced a new field called Oka Theory and Oka Manifolds. This is my contribution to the classification. As far as I know, this is the second such case in mathematics in Slovenia," he noted.

His work is also fascinating in that it has helped to bring the theory of this type of complex manifolds back home to Japan after 80 years. "My main contribution was to conceptualise the theory and therefore make it more widely applicable."

The ERC project awarded to Forstnerič will allow him to expand his research into this field and pave the way for the existence of solutions to a number of problems in complex analysis and geometry as well as other areas of mathematics and beyond.

It will also allow him to build an international team that will include another three or four researchers. The project will be carried out at the Ljubljana Faculty of Mathematics and Physics.

Forstnerič's work has inspired Japanese mathematician Yuta Kusakabe, who managed to make some important breakthroughs in this field in his PhD thesis in 2020.

"I have invited him to Slovenia. He has a young family, so he can't come at the moment, but since the project will last five years, I hope that during that time he will be able to get a sabbatical and come here," Forstnerič said, adding he is pleased he will be joined by another established researcher, Rafael Andrist.

This requires a good knowledge of a specific scientific field, the ability to detect and abstract key features, and a bit of serendipity, he added.

"Mathematics is, in a way, creating order in the universe. It's not just calculations. You have to establish a concept and based on this concept, develop a theory. Once you have the right concept, you can develop it further, but until you get it, it's all a bit foggy," Forstnerič said.

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SI-1000 Ljubljana
Slovenija

+386 (1) 24 10 100
+386 (1) 43 42 970
desk@sta.si

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