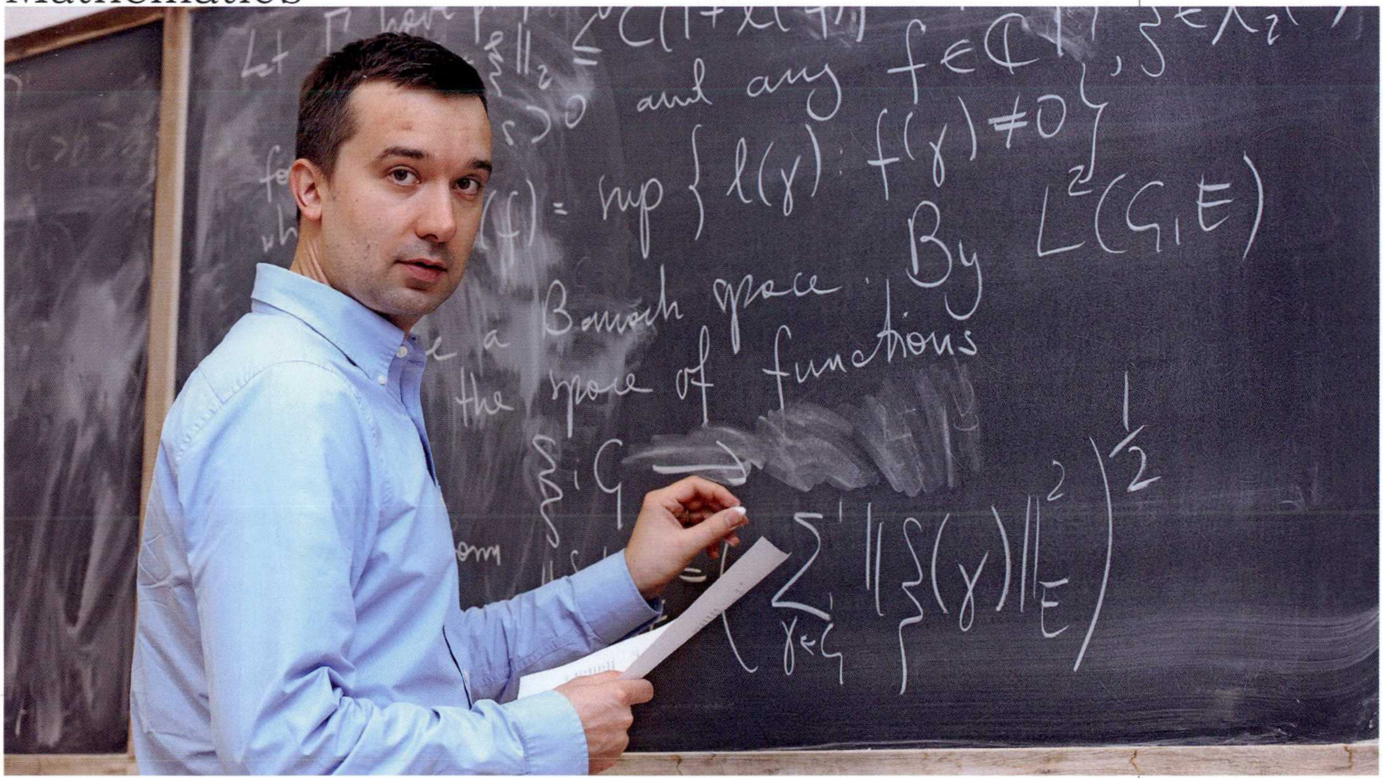

Movement and Mystery

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We talk about mobility and index theory with **Dr. Piotr Nowak**, who received a Starting Grant from the European Research Council for a project entitled "Rigidity of groups and higher index theory."

ACADEMIA: **You are the first Polish mathematician to receive a grant from the European Research Council. This is all the more sensational in that Poles in general have not won many ERC grants, compared to other Europeans. The amount is also impressive: 880,000 euro. Is that a lot?**

PIOTR NOWAK: That depends on one's field of research. For me it is a lot, because one does not have to have a laboratory to do mathematics. That money will be used to organize research meetings, conferences, to visit foreign institutions and to host foreign guests in Poland. In other words, to facilitate discussion and the exchange of views. But above all, it will be used to build a team.

How you envision that team?

I want to invite four post-docs to get involved (each for 2 years), two doctoral students (each for 4 years), and three visiting professors (each for 4 months). I will be sending out invitations around the world, and I hope that some good candidates will respond. And since it is hard to employ people right away, we will start implementing the grant during the summer vacation period, so that the timing is synchronized with the academic calendar.

The topic of your project has intrigued us. You want to find counterexamples to the well-known hypothesis of index theory. In other words...?

Index theory began back in the 1960s, when Michael Atiyah and Isadore Singer proved what we now call the Atiyah and Singer index theorem. It links together two fields of mathematics: analysis and topology. Mathematical analysis describes functions, continuity and differentiation, it provides estimates, something can be larger or smaller. Topology, in turn, is a science of objects in which we are interested only in certain shape-related characteristics. In topology, if we stretch or deform a sphere or a torus, for instance, as if they were made of modelling clay, they essentially remain unchanged. There's a popular joke among mathematicians in the United States, which says that to topologists a donut is basically the same thing as a coffee mug: they both have a single hole, and so the shape of the mug can be smoothly deformed into a donut shape, or torus.

Atiyah and Singer demonstrated that the number of solutions of a certain category of equations does not depend on their analytical properties, but on their significantly weaker topological properties, in other words on "soft" structures. Let's imagine that we have an equation that describes something about the Earth, and we want to know how many solutions it has. It turns out that even if we stretched the Earth out and somehow tied knots in it, the number of solutions will still not change, even though everything might seem to indicate that it might change. For this assertion, Atiyah won a Fields Medal – the most well-known prize for mathematicians. The theorem is considered one of the most important theorems of the 20th century. And so, researchers started working on generalizing it.

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That is why today's index theory is significantly more abstract. The idea is the same, but the way it is formulated is much broader. Doing things right takes a lot of mathematical apparatus and even mathematicians need to specialize in this. So that is what we want to work on: the current formulation of index theory. More concretely: we will study the conjecture formulated by two mathematicians, Paul Baum and Alain Connes, which if true would be a very broad generalization of the Atiyah and Singer index theorem. But for the time being, we do not know if it is true. In certain situations it holds, but we will be looking for counterexamples, in order to test it.

To put it even more precisely, we will be trying to find certain algebraic objects known as groups (sets functioning "properly" under multiplication) that have quite exotic properties. For instance, their geometry would be incompatible with the geometry of most of the natural linear spaces known to us. A key assumption of the project is that such exotic properties are also inconsistent with the Baum-Connes hypothesis. To show this, we will have to bring together techniques from several fields of mathematics: geometric group theory, harmonic analysis, noncommutative geometry, and topology.

Getting back to the ERC grant... how does a researcher go about winning one?

You have to come up with a concept, write an application, and fill out the forms. But there are fewer formalities than, say, when applying to Poland's National Science Centre. You just have to have a "big," persuasive idea on a European scale, and be able to present it well.

Who evaluates the application, and how?

There are two stages. In the first, it is evaluated by a panel of 10–15 experts, in my case mathematicians from different fields. The application contains a five-page description and also a full, 15-page one. The panel analyzes the short description and the CV and decides whether the application will be admitted to the second stage. If so, it gets sent out to specialist reviewers. Then there is an invitation to a meeting in Brussels, with 10 minutes to present a slideshow and 20 minutes for answering questions.

Not much time.

To be able to sum up an application in 10 minutes, one really has to have a clear vision. You have to convince the audience that the project is important and that you are capable of carrying it out. A certain effort needs to go into this.

And later? You get an e-mail?

A very short one: "The evaluation has been completed and the grant has qualified for funding."

That's an exciting moment, isn't it?

Yes. Especially since the previous year I had received an email that my project did not fit into the budget. My application qualified for funding, but it was not ranked high enough on the list. An additional difficulty is that at the end of the review process, the application is evaluated with an A, B, or C after the first stage, or an A or B after the second stage. Anyone who gets a C has to wait two years before applying for another grant, or one year for a B. Because I had received an A in the second stage in 2014, I was able to use the reviews to strengthen the application. And this time it was successful.

It may sound simple, but Poles are not winning many such grants. So far, there have been

a dozen or so. What recommendations should be given to those thinking about applying?
It is absolutely crucial to boost researcher mobility. People in Poland generally do not travel away far or for long, and that is very important in science. It opens up perspectives, enabling one to see what kind of problems others are working on, to become familiar with other styles of work, to absorb the things that are standard elsewhere. The most important thing is getting to know the people in one's field. Thanks to that, when reviewers look at an application, they know who wrote it. Such grounding in the Western research community is very important.

How mobile have you managed to be?
It was quite late that I made the decision to focus on mathematics, having spent a long time trying to do something different from my father [Prof. Sławomir Nowak – eds.]. But in the end I became convinced that doing mathematics could be quite a good idea. I went to the United States to do my doctorate, and spent nine years there. Thanks to that, I think I know all the specialists working in my field. That helps a lot, enabling one to operate on a greater scale. In the case of a grant application, it gives you credibility that you will in fact be able to utilize the money properly.

Does mobility also give one courage?
I think so. The stage of overcoming psychological complexes and barriers in interacting with other people is limited to the first year. After that, one finds it easier to make new contacts and stops being afraid of the wider world out there.

You came back to Poland in 2012. Why?
My wife and I considered various options. There were several reasons, but mainly I knew that mathematics in Poland is on a high level, a lot is happening, there are some excellent people, so coming back here was not like going into exile, quite the contrary. So I ended up turning down the offers I had in the States. I also had a sense that there is something excellent in Warsaw that is nevertheless weak in the States: the level of the students. Students who have master's degrees in mathematics in our country are very well prepared. That was one reason why it was clear to me that something successful could be built here.

University lecturers teaching science complain that incoming students have gaps in their knowledge of mathematics.
Because mathematics was removed from the high-school leaving exam (matura). That was a mistake. Now it has been reinstated. Of course, the students who choose to major in mathematics are good at it. But there are problems in other majors – this is confirmed by my friends who teach other subjects. The stories they tell about what lengths they have to go to, to bring their students up to even a decent level, are disheartening.

Did you have the problem of being under-taught?
No, but after all I could always turn to my father, who explained every problem to me the way mathematics should be explained – so that I would understand, not just memorize things. What high-school students should be learning is how to attack a problem, how to think it through and work out a solution. In a certain sense, how to apply the scientific method – to know what to do and why.

Is it good to be a researcher in Poland?
Very much so. There is a lot to do here, one of the reasons being because Polish science has a kind of split personality between generations, due to the sharp changes in the scientific environment following the collapse of communism and the subsequent reforms. Previously we were quite isolated.

Is that also because today's young people have somewhat different customs, different ways of communicating?
Yes. I think the main example is the higher doctorate degree in Poland, the "habilitation" or DSc, which is celebrated by the older generation but the younger ones do not really see any sense in it.

What is it about mathematics that enchants you?
Probably the fact that I can immerse myself in a problem that I cannot tear myself away from. Finding a solution is a tremendous feeling. Unfortunately, in 90% of cases one does not find such a solution, and so the success rate here is not high.

Still, 10% is not a bad rate! But how do you know when a solution is definitely correct?
It needs to be discussed with other specialists, by sending them preliminary versions of articles. Sometimes one of them will find an error, of greater or smaller significance. Sometimes it can be patched up, sometimes not, and then one has to start back at square one. I think every mathematician has such a story. It is hard to spot the errors in one's own deductions, because the human mind lapses into schematic ways of thinking about things. Perhaps a certain assertion might hold in general, but one can easily forget about a single case when it does not, and so a problem arises.

Another mystery to discover?
Yes. Without mystery, mathematics would not be so intriguing.

Interview by
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