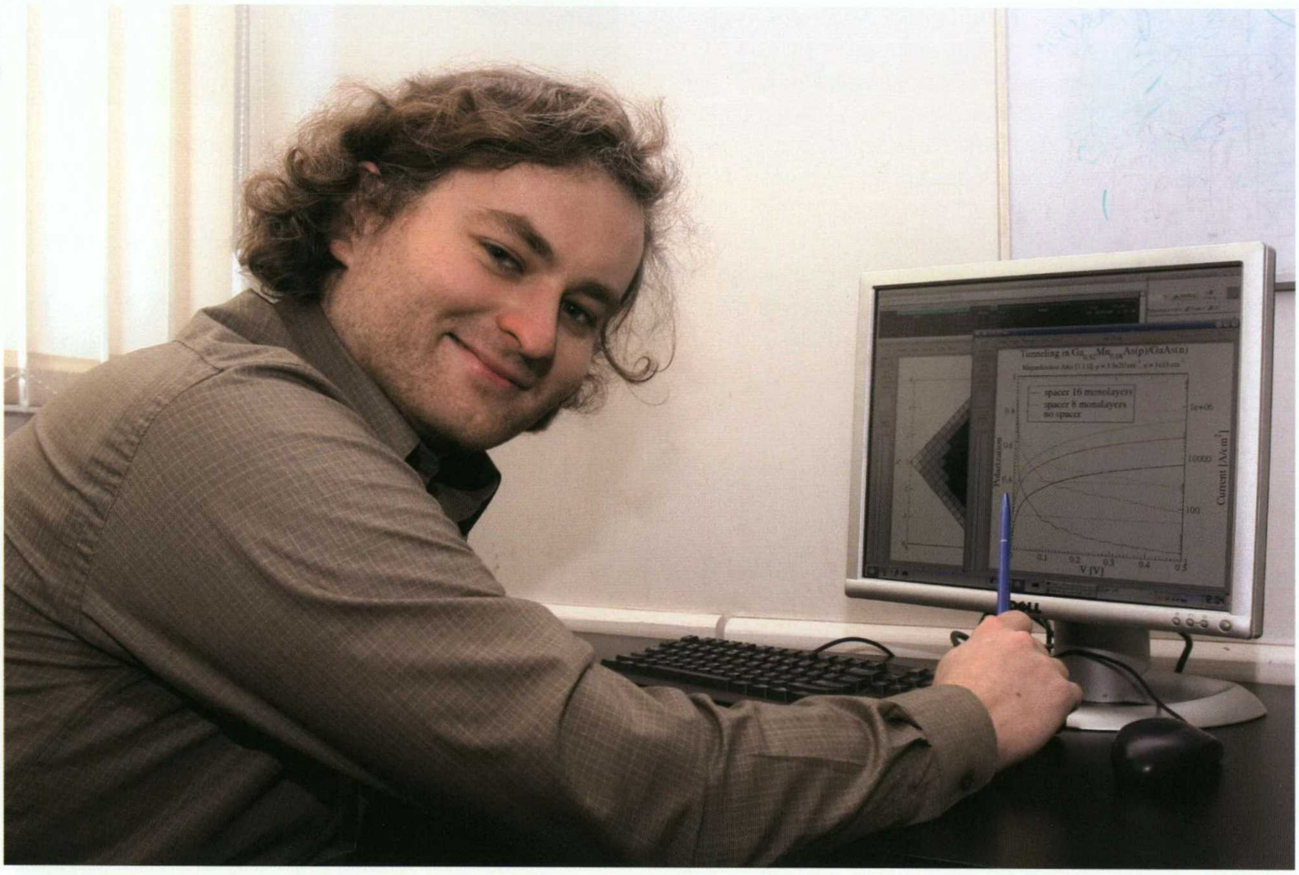
Interview with Piotr Sankowski

Spintronics and Algorithms

Krzysztof Kaliński



"I have always been interested in both computers and physics. When I was taking the university entrance exams, I decided to choose both majors - I was simply unable to give up either of them"

Academia: For someone your age, you have quite an impressive CV. When did you first take an interest in computers? What was it that persuaded you to major in computer science and physics at the same time - and then to do doctorates in both fields at the same time?

Piotr Sankowski: *You might say that I have always been interested in both computers and physics. Ever since I got my first Timex computer and soldered my first circuit. Both fields were my hobbies throughout grade school and high school. When I was taking the university entrance exams, I decided to choose both majors, so as to follow through with my interests. I was simply unable to give up either of them. Once I got my master's degree in computer science I started doctorate studies in the field, while at the same time continuing work on my master's in physics. Then when I defended my master's thesis in physics, my advisor proposed that we might continue working together, and so the natural next step was to start doctorate studies in physics as well.*

Does anyone in your family share your scientific interests?

Everyone in my family has always been very interested in what I do. Although I have to say that each of them does something completely different.

Back in your school days, you once won the Computer Science Olympiad competition, and now you sit on the jury. How do you feel contests of this sort further the development of young scientists like you?

In my view, they play a very great role, although it is hard to sum it up in a single sentence. Above all, school-age contests stimulate young people's interest in a given field. It also gives them *a chance to become familiar with interesting problems, which motivate them to expand their knowledge. The most important contribution made by such contests is that they spark a certain "curiosity" that can be later guided and developed at university.*

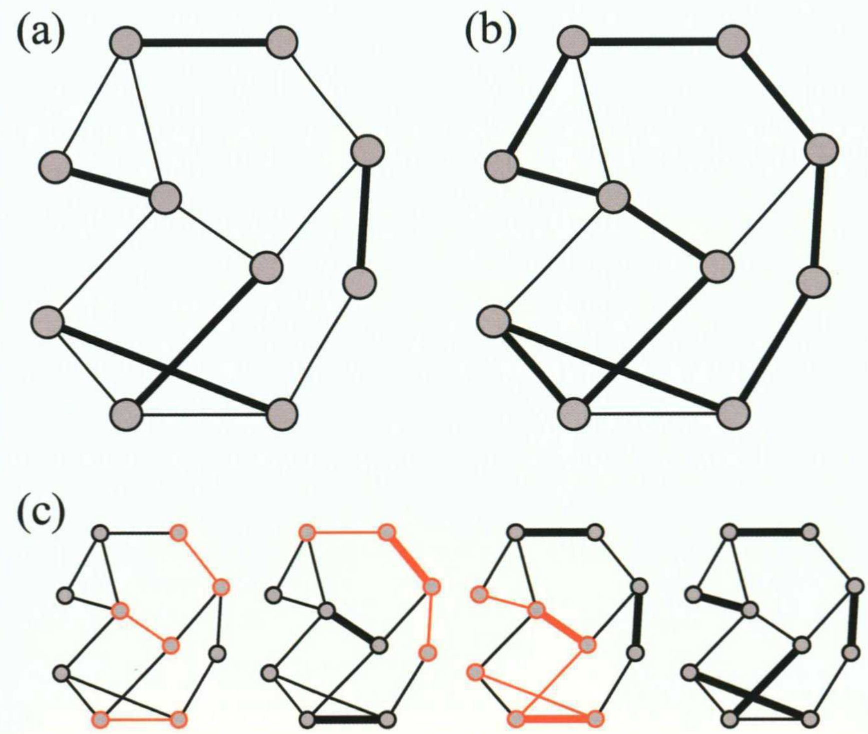
Can you give us some sort of "recipe" about how to compose problems for young people involved in Olympiad contests, so as to stimulate their curiosity as much as possible?

The problems that we prepare for the computer science contest are always prepared in the form of an interesting and frequently amusing little story. But although the form of the questions and the topics chosen are important, I feel this is still a secondary issue. What is much more important is for there to be a good atmosphere during the competition itself, for there to be good communication between the organizers and the participants. If that is achieved, such contests become much more pleasant for both groups, and students are eager to compete in them just for the sake of participating.

Do you manage to somehow combine your experience in physics and computer science?

The problems that I deal with in the two fields are very loosely related to each other, and I only sometimes draw inspiration to investigate a certain issue from my other specialization. But an awareness of both fields frequently gives me a broader perspective on the problems that are set exclusively in one of them. This broader perspective frequently proves very useful in finding solutions.
I'll give you a very concrete example: in one of my computer science papers, I obtained a result using things I learned from courses at the physics department. Good differentiation skills proved to be useful in solving the problem at hand, even though at first they didn't really seem to be related. Still, knowing certain particular things is not as important as grasping the different ways the two fields work. In physics, one is forced to describe reality, which confronts us with very difficult problems that are sometimes impossible to solve. However, we just have to come deal with this, since there's is no way to change reality. Computer science, on the other hand, is guided by a completely different philosophy: if we cannot solve a problem in a realistic model, then we create a simpler model and seek a solution there. That's a completely orthogonal, completely opposite approach. A knowledge of physics encourages me not to give up when confronted with tough algorithm problems, and a good knowledge of computer science helps me to better simplify problems in physics.

You have won numerous prizes and distinctions awarded to young scientists – including last year's Witold Lipski award and the "Zostań z nami" stipend



The problem that interest us in the field of algorithms include the problem of finding perfect matchings, where we need to pair all the vertices of the graph (a), and the traveling salesman problem, where all the vertices of a graph need to be arranged in a cycle (b). Both of these problems have many practical applications. Matchings can be used to solve the problem of how to allocate employess to various tasks, while the traveling salesman problem is involved when we want to identify the best order in which to perform certain tasks, such as planning a trip to visit all the cities on a map. These two problems in fact have much in common. If we have a solution to the salesman problem, we can obtain a solution for the matching problem – by taking away every other edge included in the salesman's route. The matching shown in (a) was in fact generated in this fashion from the cycle in (b). Of course, the salesman's route represents the sum of two perfect matchings. Despite these interrelationships, however, only the problem of finding perfect matchings is simple – e.g. we know an effective algorithm for solving it. Shown in (c), this algorithm involves finding paths that begin and end on vertices that have not yet been matched, which pass alternatively through unmatched and matched edges. Next, we can replace the unmatched edges on the path with matched ones, thus increasing the number of matches. For the traveling salesman problem, however, no such algorithm is known.

awarded by the weekly magazine *Polityka* to encourage young researchers to stay in Poland. Three of your articles have been commended at international symposia as the best student papers. Do you feel that your work in the field of algorithms is blazing a new path in science?

No, actually I don't get that feeling. My papers have been commended at conferences because they deal with classical algorithmic problems. I think that if I had written about something else, my papers would not have made such a mark. Somewhat in jest, you might say that my recipe for succes was to find a classic research domain that had been completely neglected in the last years. Algebraic graph algorithms were very intensively researched in the 1970s and 80s, but since then very little has happened in the field. There has been lots of development in related areas in the meantime, and so revisiting the field is much easier nowadays.

What are the practical applications of your research?

My research on algorithms is motivated by practical problems. The basic problem I can mention is that of finding a path, such as how to get from home to work. We would like to find out whether a path exists from point A to point B on a given map. When formulated in this general way, such a problem forces us, in the worst case, to search the entire map. A natural question to ask is if we can tell whether a path still exists after a certain change is made in the map. For instance, one section of the road we usually take to work might be shut down for construction work. My papers showed that in such a case it is not necessary to search the entire map from scratch. If we partially remember the outcome of previous searches, a new path can be found much more quickly.
My research in physics concentrates on spintronics, a field that aims to create electronics technology based on electron spin. I make calculations aimed at describing the spin effects present in semiconductors made of magnetic materials. My research aims to interpret the experimental results and attempts to predict what impact various experimental parameters might exert on them.

Does science leave you any room for a hobby or interests?

Yes. I might even say that choosing a scientific career helps me to pursue my hobby, which is traveling. Conference trips frequently give me a chance go visit interesting places. I always make the most of such opportunities and try to see as many interesting things as possible. This year, a conference in Kunming gave me a chance to visit several interesting places in China.

Is it hard to be an "up-and-coming" Polish doctorate student? How do you

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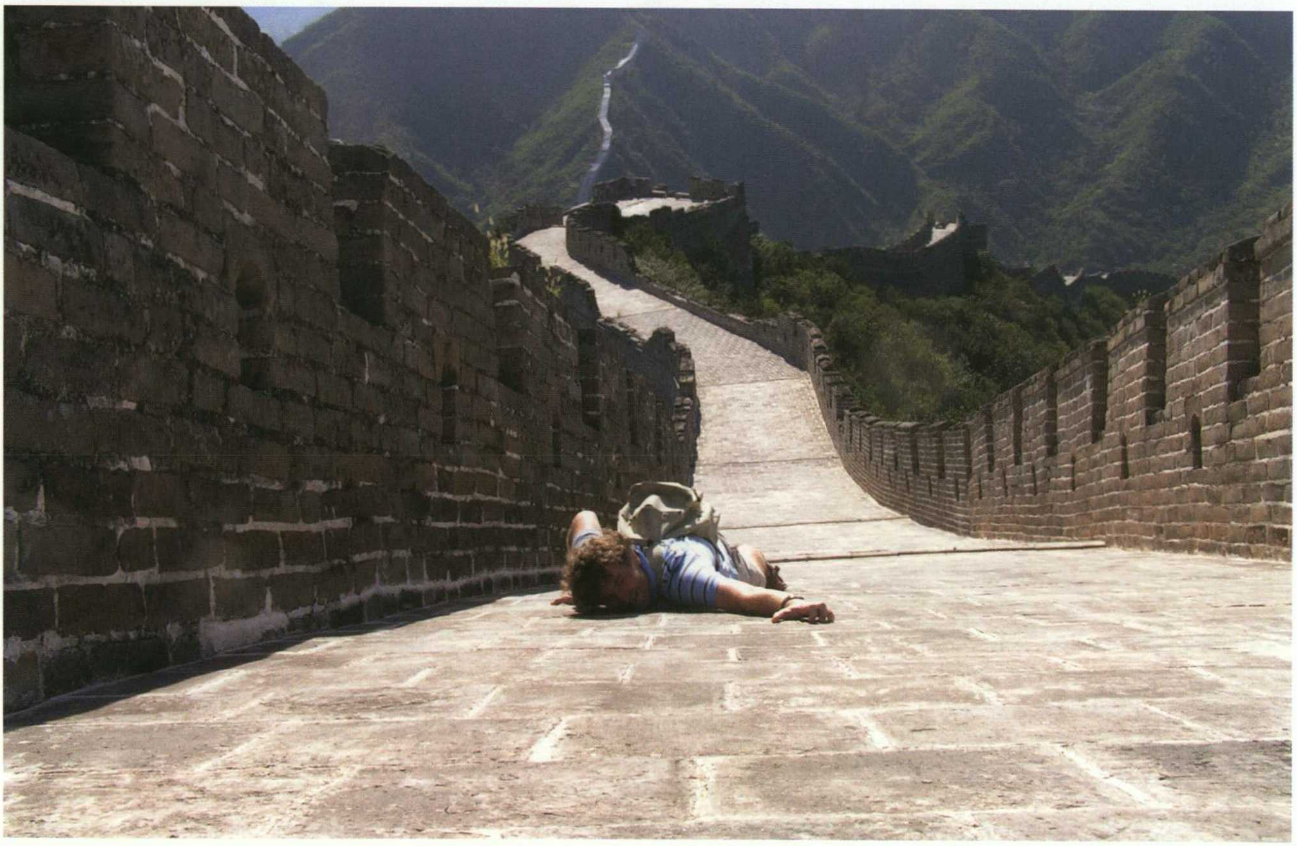

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view your professional situation, compared to colleagues from Poland and other countries? Do you regret having opted for a career of this sort?

I definite do not regret my choice of career. It gives me an extraordinary opportunity to do what I love. The fact that I have such good conditions for doing research I owe entirely to my two advisors: Perła Kacman and Krzysztof Diks. Comparing my situation to those of my colleagues, I can say that mine is exceptional.

What do you have to thank for ending up in this exceptional situation?

My answer will be quite standard, because I owe it to both hard work, and a bit of fate. Hard work because I was always determined in studying these two fields, and that definitely played a large part. And fate - I won't say good fortune - because a big part was also played by many events that I didn't have any influence over, although they were not always fortunate ones.

How do you envision the rest of your career? After finishing your doctorate (or rather doctorates), do you intend to "stay in science"? Do you plan to do a post-doctorate internship abroad?

Yes, I plan on working at the university and continuing research in the fields of computer science and physics. After finishing my doctorate in physics, I would like to work with research topics that will enable me to harness my knowledge in both fields. I also love to teach and giving lectures is for me an inseparable part of research work. In my opinion, doing research without sharing the results makes no sense. That is why I take a lot of satisfaction in both researching and teaching. After finishing my doctorates I do in fact plan to do a post-doc abroad. Unfortunately I don't yet know where.

What is your view, do young scientists have the ability to form their own research groups in Poland? Are grants very available for this?

It is hard for me to assess this ability everywhere in Poland, but I know that there are very good conditions for this in Warsaw. Things are much easier in computer science, which is cheaper than physics because all you need is essentially a computer, and the field is much younger. Unfortunately there are too few grants for young people. Still, that isn't caused by a "bad system," but simply a lack of money for research.

Have you already got an idea about what to concentrate your research on?

You might say so. Non-classical physical effects are likely to be of increasing importance for the way computers work. I don't want to talk about quantum computers per se, because their implementation seems unlikely. But I am thinking about classical computers that will operate in a quantum regime, where quantum effects will be important.

Interviewd by
Weronika Śliwa
Warszawa, March 2006

Piotr Sankowski (born 1978) is a doctorate student at the Warsaw University Institute of Informatics as well as at the Institute of Physics, Polish Academy of Sciences. He works with algorithms (especially those solving basic graph problems), and at the same time does research in solid-state physics related to spintronics (using the spin of electrons to construct new electronic devices). He is preparing doctorate theses in both disciplines, algorithmics and spintronics. He has won the Witold Lipski Award for young Polish scientists for his achievements in the field of computer science and its applications. As the contest's website reports: "His most important results include new algorithms, more effective than those previously known, for solving such problems as finding and enumerating graph matchings and tracing shortest paths. These results combine tools from several fields and apply them in novel fashion to tackle classical, widely-studied problems with numerous practical applications. They evidence the author's great inventiveness, capacity for independent thinking, and craftsmanship as a researcher." Sankowski is the author of numerous research papers that have earned distinction at international conferences.