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Inspiration needs new tools

Prof. Maciej Wojtkowski, physicist, head of the Physical Chemistry of Biological Systems Department currently coming into being at the Institute of Physical Chemistry in Warsaw and winner of the prestigious European ERA Chairs grant talks to science journalist Jarek Chrostowski.

JCh: It must surely be every physics student's dream to be the one to unify physical theories. From experience I know this is something one usually grows out of, although exactly when is quite an individual matter. Is it something you have outgrown?

MW: Every now and then research in basic sciences undergoes particularly dynamic phases of development. The twentieth century was just such a period. It saw the birth of new, spectacular ideas, such as the theory of relativity and quantum mechanics. In biology, the discovery of the genetic code was no less revolutionary. But after any basic discovery there should always be a period of its consumption, a transformation of some of the achievements into tools capable of both stimulating further scientific development and of raising human living standards. I believe that today we are forced to work on a certain selection of hitherto achievements, to determine which of them can be forged into new cognitive tools or specific applications. Science involves not only adding new knowledge to the old, but also – and perhaps primarily – on organizing what is already well-known, and making use of it, which is in any case always associated with its further development.

JCh: ...but it's progress in basic research that usually determines the rate of development of science!

MW: That's true. However, I look at our scientific "now" through the prism of rational expectations. Meanwhile, much points to the fact that modern science has grown to an extent that exceeds the mental capabilities of not only individual scientists, but even groups of them. Already, nobody is able to single-handedly fully master higher mathematics and there are many phenomena requiring the use of supercomputers to describe them. Who knows, perhaps we have now reached the stage at which we have to wait until the birth of some sort of new forms of intelligence for the next scientific breakthrough? It's hard to say whether it will be artificial intelligence, created from scratch by man, or perhaps there will be a new quality whereby, thanks to the development of technology, many people's minds will be able to function as one. However, without new processing or data association tools we should rather not expect the quick and brilliant breakthroughs so characteristic of the bygone century. There is a time for discovery and a time to build new tools. The better the tools, the more of the world we can see, the deeper we can understand it and the more questions we can ask.

JCh: Is the obliteration of boundaries between existing branches of science a beneficial process?

MW: I know of a case where one person in the laboratory investigating the tunneling of electrons is treated as a physicist and another, dealing with the tunneling of protons, as a chemist. For me, such a division is completely incomprehensible. When a physicist wants to study the interaction of light with complex systems, such as cells or tissues, whatever he touches is connected with biology or chemistry. Working at the interface of these three areas is, therefore, quite natural and, at the same time, very interesting. In addition, it produces tangible results not only in the better understanding of the mechanisms of interaction of light with complex systems I referred to earlier on, but also in the form of imaging devices, constructed with a view to applications in medicine or biology.

JCh: In 2012 you were awarded the "Polish Nobel" Prize of the Foundation for Polish Science. For, and I quote: "developing and introducing Fourier domain optical coherence tomography into clinical ophthalmology." Hmm. So what was the prize for?

MW: I myself have a problem with the correct naming of what I do. In actual fact, I work on detection methods that use the statistical properties of light. In the case of matter this statistical property is temperature: there is no sense in asking what the temperature of a single electron or proton is – only a system of many atoms or molecules can have a temperature. In the case of light, what interests me in particular is its coherence. It turns out that this property can be used to create forms of description that are very good at characterizing the information carried by light reflected from a biological object, or which has passed through such an object. But all this is not easy. In complex systems often on the way to really interesting structures, there is something that is basically opaque. That's when the fun begins.

JCh: So you're trying to look at what's behind the wall simply by looking at it?

MW: More or less. The Holy Grail here is the possibility of deep penetration of light into the tissue, in order to clearly see all the structures located there under the microscope. However, to achieve this effect one has to understand what happens to the light, how it interacts with the complex system. Describing this gives rise to many problems and seems to be quite unobvious, e.g. it is usual that in one place light should be treated as wave and in another as a collection of photons. For me, these are, in fact, the most interesting topics. In any case, I think that there is still much scope for fascinating discoveries here.

JCh; Why?

MW: In physics, particularly in theoretical physics, the systems that are tested are usually the simplest, that is, idealized ones. Most experiments are conducted in a similar vein. That's all fine, but at some point we come to a situation where, with today's technical possibilities, we have a certain relatively fixed set of such experiments, and each has over the years attracted multitudes of scientists. The scientific potential of these experiments has thus been exploited to a great extent. In my field, fortunately, such a situation has not yet arisen, and there are still many areas in which to be a pioneer. Apart from this there is one more aspect. Often whole decades pass before a discovery that is fundamental in nature is in any way translated into everyday practice. And I like creating something that is useful today. Well, tomorrow at the latest. Optical phenomena in complex systems give me this opportunity. That's the sort of science I like best: practical, close to life, making it possible to create tangible things.

JCh: And do you like changes?

MW: Yes, change is something I like very much. Scientists should be dynamic, flexible, they should be able to continually confront their own views with new ones and they should themselves be in constant development. For example, I decided to move to the Institute of Physical Chemistry of the Polish Academy of Sciences not because I was unhappy in my current job, but just the opposite, because I was beginning to feel too comfortable. I didn't want to fall into stagnation and routine. The ability to continuously develop oneself is important in every area of life, but in science it is absolutely critical. For a good scientist mobility should be the norm.

JCh: It should be? Isn't it?

MW: In our country? No. We simply do not have the conditions for mobility. When a scientist from one centre in Poland wants to move to another, generally he has to build everything up from scratch, including the infrastructure. This is a process that takes many years. The result is that moving from one research centre to another means almost certain career death. For the mobility of our scientists to no longer be just fiction, in many centres in the country a certain critical mass of skills, specialties, knowledge, and indeed equipment would have to be exceeded.

JCh: ...and yet you submitted your candidacy to the IPC PAS in the competition for the establishment of a department under the ERA Chairs grant, although it was associated with a move to the capital.

MW: The IPC PAS is a unique research centre, as is the ERA Chairs grant. The Institute itself is not only among the best in its field in the country, but it also conducts research that is often very interdisciplinary in nature. In the context of my interests these are huge advantages. In addition, the IPC PAS is one of only a few centres in Poland to have undergone a thorough reformation of organization in the right direction, that is, focusing on promoting the effectiveness of research. Instead of nurturing the scientific privileges of the top echelons, rather than a hierarchical, rigid structure, there are research groups directed by dynamic leaders, accounted for by concrete results. The ERA Chairs grant itself was also a great incentive. Its financial potential is so great that one can realistically think about the rapid start-up of a new research group and the taking on of new challenges.

JCh: At the IPC PAS you will be creating your own department. Will there be more chemistry, physics or biology?

MW: We will be dealing with methods of controlling light, how to adapt them for it to penetrate into complex structures. There will certainly be biological samples. At the IPC PAS, for example, there is research into the thermodynamic phenomena taking place in the interiors of cells or organelles. This is a great opportunity for our group. But in chemistry itself "there are games to be won." Not infrequently, there is a sample to be examined spectroscopically, and this is not possible by conventional techniques because of the strong scattering of light. And here you have a subject for discussion! Another challenge will be dynamics. At the moment we understand quite well how light interacts with stationary objects. At the IPC PAS there is, however, advanced research being carried out on microfluidic systems where there are dozens, hundreds or even thousands of moving droplets. A different chemical reaction may be taking place or a different bacterial culture can be developing in each of them. We will try to look inside such micro-droplets. Another challenge will certainly be IT issues related to the analysis of large sets of data, that is, big data.

JCh: Will all of this in any way transfer over to the quality of life of the man in the street?

MW: One of the topics we will be dealing with is the search for methods to extract information from light that is useful from the medical point of view. We would like to make our own contribution to the development of personalized medicine. Already in the near future, many devices for medical diagnosis will become portable and will come into everyday use, and the information they collect will be regularly monitored by appropriately specialized IT systems. And it just so happens that most of the sensors in these diagnostic devices uses optics. So we can imagine that, among others, thanks to our work, in the future our smartphones will have a camera and a light source capable of rapidly examining the eye or observing blood vessels.

JCh: We, people, invent many things. We don't manage to transform many into concrete achievements.

MW: Indeed, some scientists are not at all interested in implementation or there is no possibility of carrying it out. The reason lies mainly in the poor organization of work which often doesn't depend on the scientists themselves – research groups are too small and homogeneous to be able to carry out work whose results will find practical applications. In such groups, scientists solve a problem because it is interesting, and when they solve it, they move on to the next one. Science then just becomes a bit like art for art's sake, especially when there are no companies that could develop their own novel technology on the basis of these discoveries. It's a great waste of potential. Another tendency associated with implementations is also dangerous: research in which the results are known from the beginning. I don't understand such research. It's just not science...

JCh: ...it's an application for a grant!

MW: More or less! Seriously, though – I understand the reluctance on the part of some scientists to implement or develop new technologies, these are simply difficult, often thankless tasks and very mundane. With a little good will, however, problems can be overcome. I myself have for a good few years run a company dedicated to the transfer of optical methods to industry. It is not a big company, its core consists of just a few people from the Institute of Physics of the Nicolaus Copernicus University, but we have already completed several interesting projects.

JCh: For instance?

MW: People who use contact lenses are sure to be familiar with the company Bausch & Lomb. We have constructed a device for them to examine lenses immersed in liquid. Now, without having to open the package you can check if a lens is deformed and how long it maintains its optical performance. It sounds simple, but this was no trivial task. Contact lenses are very thin structures, with a high degree of curvature and extremely low contrast, and the material they are made of has properties almost identical to the liquid surrounding them. In a liquid it is really difficult to see the edges of such a lens. For another client we developed a method for non-invasive, optical differentiation of blood cells designed for applications in microfluidic sensors. We have been involved in more such projects. We are also starting the implementation of a few new ones, which as a scientist I would gladly tell you about, but as president of a company collaborating with industry, at this stage, I simply cannot.

JCh: How many people will there be in your department?

MW: I hope that in 4 years we will be able to organize 2-3 groups. Past experience has convinced me that the optimal group size is about 15 people. Above this number, there are problems with management. On the other hand, there is no sense in smaller groups, because if we want to be competitive on a worldwide scale, we need to have the right rate of work. If we do not keep it up, in competition with other groups in the world, our success will be more or less like that of drivers of the old “Syrenka” cars in the Paris-Dakar race.

JCh: Are all the positions in the groups already allocated?

MW: We now have our core personnel, which guarantees transfer to the IPC PAS of competence with regard to methods of optical imaging of complex structures. However, we are still looking for well-educated and even better motivated staff. It is mainly a matter of doctoral students in physics, interested in new ways of studying biological processes, or chemists, who look at complex systems and biology in a non-standard way. A valuable asset would be an electronics engineer, an engineer or a biotechnologist. We are very open to new experiences and ideas, provided that they are accompanied by competence.

JCh: Do you intend to expand cooperation with other research groups in the country?

MW: I will certainly keep in contact with my current group at the Institute of Physics of the Nicolaus Copernicus University, at least until the end of the period of the ongoing grants, and I hope that for a lot longer. I hope that I will manage to develop several projects that we have already started to implement with the Warsaw centres: the Institute of Experimental Biology of the Polish Academy of Sciences and the Faculty of Biology of the University of Warsaw. It also seems quite natural to strengthen our ties with the Laser Center of the IPC PAS and the Faculty of Physics of the University of Warsaw. We also cooperate extensively with foreign groups in different fields.

JCh: Is it possible to carry out research in Poland on a really decent level – and in addition to have fun?

MW: I don't know about the others, but I have fun. As to the potential of our science... Do I have to answer?

JCh: You know, all our previous governments financed Polish science on a level typical for Latin American countries and did not seem to be embarrassed. And I'm just asking for an evaluation...

MW: In our country we have research groups that function very well, but there are not many of them and they are scattered. There are also no mechanisms to ensure their long-term existence and development, even if the quality of the research is at a high international level. The equipment of our laboratories today is comparable with – If not better than – what the leading research groups in the world have. What is really a sticking point is work organization and group management – and the education of our youth. The current level of secondary and higher education is, to put it mildly, highly mismatched to the intellectual requirements set by any good research group.

JCh: Are we lacking in idealists or practitioners?

MW: Science has to pose open questions, sometimes even crazy ones. That is what is most beautiful in it. But let me repeat myself: today in science it is not so easy to indicate any new, really deep and truly promising ideas. I think that we will not make any real breakthroughs unless we first create new tools. Today, it is not observable nature, but new tools that have the potential to become our main source of inspiration. That is why I put my money on practitioners. Especially those who are competent and who have a remarkable imagination.

JCh: Thank you for your time.

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http://www.ichf.edu.pl/
The website of the Institute of Physical Chemistry of the Polish Academy of Sciences.

http://www.ichf.edu.pl/press/
Press releases of the Institute of Physical Chemistry of the Polish Academy of Sciences.

IMAGES:

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Prof. Maciej Wojtkowski, winner of the Award of the Foundation for Polish Science, creates a new Department of Physical Chemistry of Biological Systems at the Institute of Physical Chemistry of the Polish Academy of Sciences in Warsaw. (Source: IPC PAS, Grzegorz Krzyżewski)

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Advanced optical imaging techniques will be developed at the Department of Physical Chemistry of Biological Systems at the Institute of Physical Chemistry of the Polish Academy of Sciences in Warsaw. (Source: IPC PAS, Grzegorz Krzyżewski)