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EDITORIAL

Quo vadis nuclear science?

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The symposium "Nuclear Science in the XXI Century", organized to honour the 50th anniversary of the Institute of Nuclear Research and reported in this issue of "Nukleonika", could have bear the subtitle borrowed from the Polish political life of some years ago: "Experience and Future".

The 50 years of the Institute of Nuclear Research coincides with the Einstein year and with more than 100 years of nuclear science. This anniversary symposium is programmed to look into the future rather than into the past. The experience will help to make knowledge and/or intuition based forecasts.

We shall try to show that we are working in a fascinating field of the highest discovery potential, of the highest intelectual challenge, but at the same time in the field of a very high economic potential, the field which continues to surprise everybody, ourselves included, by continually finding new applications in new domains of human activity.

Quo vadis nuclear science in general? Quo vadis nuclear science in Poland? How do we define nuclear science? Where do we stand, where do we go? How far can we predict? What are our extrapolations and predictions worth?

Any general definition of the nuclear science would be controversial and probably wrong, so I shall resort to enumerating. Thus, I include here:

– all of the subatomic physics (nuclear physics, particle physics, but also the fundamental issues of quantum-electrodynamics as well as the new fields of science based on subatomic physics, such as astrophysics);
– nuclear chemistry with all its complexity and challenges;
– hot plasma physics with its close links to nuclear processes and with the great promise of using those links to the benefit of the mankind;
– the subfields of other sciences which use the nuclear techniques, notably the materials science studied with methods of nuclear physics (diagnostic techniques as well as the methods of modification of materials) or the accelerator based high energy atomic physics;
– the applications of subatomic physics in various other walks of life (nuclear medicine, industrial applications, environmental studies, food production and storing, safety problems etc.);
– last but not least the crown application of subatomic physics: the nuclear engineering, presently fission based, eventually, we firmly believe, the fusion based one.

The list may be continued to anybody's taste. I feel the above is sufficient for the present purpose. For non-scientific reasons I keep out of my list the military.

Where do we stand? I start in the reverse order of my list.

– The world economy gives us a clear message: the energy needs of the world call for a rapid employment of nuclear power. The urgency is particularly strongly felt in the developing countries. We shall hear about this in one of the main talks of this conference. In the developed countries there is a strong political opposition to nuclear power led by, of all the people, those who call themselves ecology minded. This opposition has had one beneficial, even if costly, result: the technology has gone to the extremes of the safety regulations; it is now reliable and well tested.
– The bad name, given to nuclear science because of its military use or of some accidents with nuclear power stations, is often extrapolated for other uses, however beneficial they might be. The results are sometimes ridiculous. Thus, e.g., it is now "politically incorrect" to talk about the "nuclear magnetic resonance", one of the forefront medical diagnostic techniques, and we are taught to replace the name with the neutral euphemism the "magnetic resonance". Medicine is probably the most note-worthy customer of our techniques and methods, and the closest to our hearts, too. But important applications of the nuclear techniques can be found nearly everywhere, often in most unexpected places. In this respect, the ingenuity of people is endless. This could be largely increased if the knowledge of the methods and underlying principles were better among the potential inventors. The applications are widely, even if sometimes thinly spread. This is a strength and a weakness of our field. The strength, because we know we are very useful, we know our value. The weakness, because it seems that this knowledge is alien to our funding agencies. By the very nature

and the diversification of our applications we have no mighty sponsors.

– The materials science has always been very quick to implement nuclear physics discoveries. The Mössbauer effect, neutron diffraction, ion implantation and recently synchrotron radiation as well as various diagnostic techniques are but a few examples.
– The nuclear chemistry is now a large and diversified field, ranging from such obvious branches as the chemical separation of radioactive species (*obvious* does not mean *easy*) through using refined nuclear physics techniques to, e.g., study on the fastest possible chemical reactions. The field has on the one hand close links to practical life, on the other it maintains a high discovery potential. We shall witness examples of both during this symposium.
– Subatomic physics encompasses by definition the micro-world. It is also at the roots of our understanding of the large scale macro-world as well. The traditional subdivision into nuclear and high energy (meaning: particle) physics is now increasingly blurred. Thus, e.g., the two frontiers in the to-day subatomic physics, which we shall have samples of during this meeting the neutrino physics and astrophysics (with nucleosynthesis and cosmology) can be claimed with equal rights by the low and high energy subatomic physics. Some former frontiers are closing down, however. The discovery potential of the traditional nuclear structure and low energy nuclear reaction physics is gradually being replaced by the large applied potential of these subjects. The risk is, among other things, that this may bring to a halt the development of new techniques and even create a "reborn illiteracy"' in using the traditional ones, since it is the active basic research which is necessary to keep this art alive. "There is no applied science without the science to be applied" as one Nobel laureate has remarked.

Where do we go?

– In power production, we go nuclear whether we want it or not. Hopefully, the second half of the century will belong to the controlled fusion reactors.
– They say as soon as a new physical phenomenon is discovered, there is a physicist who wants to use it to develop new detectors. Paraphrasing this, as soon as there is a new detection or analysis method worked out in basic research, there is a medical practitioner who wants to use it and there could-and-should be an inventor who would make a patented gadget utilizing this novelty. This will never stop and should be encouraged. Hopefully, with an improved level of education there will be a fast development of these practices. The "bad name" syndrom ought to be eliminated, however, here as well as in the nuclear power sector.
– The materials scientist will acquire yet novel techniques of subatomic physics. There is now a very popular and promising new subfield the "nano-science" which for rather obvious reasons is looking to nuclear methods, mainly the accelerators based ones. Quantum dots are next door. A similar statement can presumably be made about the branches of nuclear chemistry with the highest discovery potential.
– The trend of ever going higher with energies of the accelerated particles to shift the frontiers of our understanding of the subatomic world will be difficult to maintain beyond the LHC at CERN. The expectations for LHC run high now: we might learn about the supersymmetric particles, find the connection between lepto- and baryo-genesis and discover a number of expected and unexpected phenomena. The innovative ideas how to go further with accelerator energies will presumably be very difficult to implement. Instead, there is a growing interest in non-accelerator subatomic physics (including the astro-particle physics), in building huge detectors to detect rare events from space, be it low energy neutrinos or highest energy cosmic showers, detectors of mind-boggling sizes (e.g. one kilometer cube piece of ice as a detector) and sensitivities. Let us hope that we join this race in Poland by building a modern low background underground laboratory utilizing favorable conditions in one of the Polish copper mines.
– There is a new and increasing appreciation of plasma physics all over the world. One of the reasons is the priority number one assigned in Europe, the US and Japan to the thermonuclear power research. This is good news for us with our strong plasma physics group.

The nuclear science in Poland?

The state is certainly miserable now, but some light in the tunnel is seen. Thus:

– The postulate: "The economy of the XXI century is the knowledge" based economy seems to be gaining recognition. The Polish government declares to adhere to the Lisbon declaration (3% of gnp for science in not too distant future).
– The European Union is changing its policy from sponsoring only the so-called applied programmes to emphatically sponsoring the basic science. This is good news for us because our curiosity driven basic science is well established in international collaborations and it thus should be able to exploit the possibilities offered by the EU far better than our applied teams. It also ought to be able to provide a good transmission belt for the applied programs.
– The Polish economy is becoming, albeit slowly, innovation hungry.
– Poland will return to nuclear power within 15–20 years, according to the recent governmental plan. This seems late, but even so, the preparations should start now.
– Our main worry that too few candidates for Nobel prizes in physics or chemistry are entering our fields remains for the time being unchanged, but if the tunnel is better lit then may be the situation will improve also in this respect.

Let me finish the article with this optimistic note.