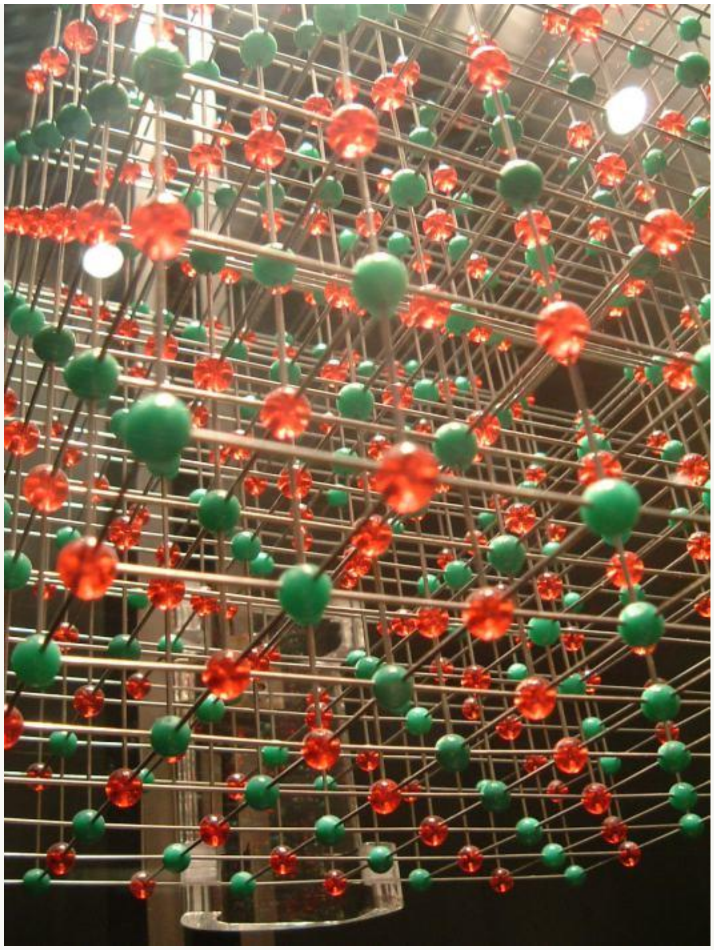
THE TWO SIDES OF PROMOTING MATERIALS SCIENCE

The study of materials is one of the major areas of science, with legions of researchers in physics, chemistry and materials science working on this topic. Condensed matter physics is one of the largest research areas in physics. Yet, it makes me often uneasy how the benefits of materials science are promoted. It is all too often about applications, and not about fundamental physics. How materials such as graphene might revolutionize electronics. And how new physical concepts could be used to develop materials for energy applications: solar cells, batteries and so on. In classical materials science it's often about tougher materials, such as enhanced steels, and less about the fundamental insights they are based on. Of course, applications are an important aspect in the study of materials. But does this mean that too often fundamental insights are neglected in favour of a material's commercial potential?

Last week I visited the European Spallation Source (ESS) in Lund, Sweden, which is currently under construction. From 2019 onwards the ESS will use neutron beams to study various properties of materials. And I've discussed with ESS's science directorDimitry Argyriou how to promote such a facility. Of course, the materials research done at the ESS will hugely benefit all the important applications that I mentioned above, and more. And for this reason alone the costs of the ESS (1.5 billion Euro, if not a little more) seem justified.



Model of a crystal lattice. Photo by Kaptain Kobold via flickr.

At the same time, there is plenty of fundamental physics to be learned from neutron research facilities, whether it is the ESS, the ILL in Grenoble, the SNS and HFIR at Oak Ridge National Laboratory in the United States, or others. The fundamentals of high-temperature superconductivity. Or the properties of magnets, which we don't really understand at all. And for new yet also very complex materials such as topological insulators, which could revolutionize computing, well, either there are hardly any news reports, or if there are, they're often wrong or distorted. Writing about some of the complicated topics in condensed matter physics is not easy. But this is not an insurmountable obstacle. As long as the science is perceived to be interesting journalists will write about it. The issue is more how to excite people about the fundamental science in condensed matter physics.

And here we might simply be looking at the problem from the wrong end of the stick. For example, what is it that distinguishes materials from particle physics, which so efficiently captures people's imagination? I think in materials science it's sheer numbers. A couple of grams of any material contain about 10^{23} atoms. That's 100 billion times a trillion atoms. To put this in comparison, 10^{23} metres correspond to a distance of about 10 million light-years, which is about four times the distance to our neighbour galaxy Andromeda.

Many of the magnificent properties of materials, whether it is crystals or glasses, arise from the large number of atoms involved. Here, the sum is certainly greater than the parts. At the same time, it's already almost impossible to solve the precise physics governing moderately-sized molecules, let alone that of large crystals. Describing the collective properties of so many particles means that scientists fall back to the use of abstract concepts to handle this complicated physics. That's where all these exotic so-called quasi particles come in that scientists use to attack the problem – plasmons, polaritons, polarons, magnons, excitons and so on.

The level of abstract thinking such quasi-particles enable is often crucial to the analytical penetration of the scientific problem at hand. At the same time, in my view too often such abstract concepts distract from the real beauty of materials science: understanding the interplay of trillions of atoms, the intricate dance of electrons and ions in such materials. A deeper fundamental understanding in this area is where large research facilities such as the ESS will make major contributions. Whether these future scientific findings will then lead to more efficient solar cells, or enable faster computers and smartphones, well, this will be the secondary outcome.

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