SASP 2000

XII Symposium on Atomic and Surface Physics and related topics

Folgaria (Trento) Italy
January 30 – February 5

Contributions

Editors: Davide Bassi and Paolo Tosi

SASP 2000

From Fundamental Research to Industry: A personal View

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Abstract: The transition from the world of fundamental research to that of industry and business is an undertaking rather common in some countries, but relatively exceptional in others. There is, in my opinion, no unique recipe to modify this state of affairs, and I will not attempt to propose one. But I will try and illustrate, on the basis of my personal experience, that the "real world" out there is a very exciting one, with daily challenges and opportunities that alter at rapid pace. The training and experience that characterize scientists can be an excellent starting point for a career in which non-adiabatic transitions are common. Provide he or she wants to try.

1. Ortho-para transitions do have industrial implications :

Behind the performance of our PC's, the flight of Ariane 5, the 300 km/hour speed of the TGV, exploring the wreck of the Titanic, the marvels of modern medicine… stands of course a lot of inventiveness from a lot of clever people who worked very hard to finish their projects in time. This was my first realization after having "temporarily" left the labs at Orsay for the rather research center of Air Liquide, just a few kilometers away: many of the challenges facing industry are technically and scientifically extremely interesting, and often complex. And to my own surprise having been trained to try and understand things I did not understand before came in rather handily when I was asked to help guide the company's efforts in meeting the future requirements of the Semiconductor Industry: chips are made from silicon and gas.

The first job with commercial context that I was given concerned building up the sales of liquid hydrogen for industrial applications on the European market. Why me? Because I had asked to do something else than research; because, as a scientist, I was used to working in an international context. And because I was very good at explaining to our customers that our liquid hydrogen was better than that of our competitor because it was 100% pure para-hydrogen. That it because I did some work on hydrogen-atom recombination with Giacinto Scoles at the University of Waterloo [1] and on the translational spectroscopy of excited triplet states of H2 with Joop Los' group at the FOM Institute in Amsterdam [2]. Maybe some of you wish to wonder what the industrial relevance is of liquid hydrogen being pure para, and how you go about measuring this. I will try and explain this at the Conference.

There is one thing that I was not quite used to, even when it came to submitting a paper for a Conference: in the real world you have to be on time, preferably all the time. Getting there late means getting there after the competition, and that is just not good at all. And getting there too early, which may mean that no one wants to buy your marvelous invention, is no good either. Because in the real world, if no one buys your product, you need a very rich uncle to survive. Darwin's principle strictly applies.

2. Non-adiabatic transitions :

The transition from the fundamental research world to that of industry and business reminds me of surface hopping trajectories between potential energy surfaces. Once you get onto the excited industrial surface, the trajectories may become very intricate, you may encounter many other crossing seams or –funnels, and the probability to cross back to the fundamental surface becomes very small. My own average residence time in these various industrial surfaces has been three years.

My fourth job with Air Liquide concerned the market for oxygen, hydrogen peroxide and ozone used for the bleaching of paper pulp. Countries that are among the most active in this area are the USA, Canada, Sweden, Finland, Japan, Brazil, and South Africa.

Again a timing issue. A strong push from "Green" movements towards abandoning traditional chlorine-based bleaching, a "threat" (that only partly materialized) for stringent US legislation, technological progress allowing large-scale, economically competitive production of ozone that represents an environmental-friendly alternative: seven years ago the time was judged right to launch a world-wide "offensive" to promote oxygen-ozone-hydrogen peroxide based pulp bleaching. I was charged with creating a de-localized task force with correspondents in all of the above countries, became an active member of several frequent-flyer programs, and quickly became an "expert" on pulp bleaching. Reference [3], with as title: " The Cost of Ozone-based ECF and TCF Bleaching" was not refereed, but is quite a good paper nevertheless. It demonstrated that what we propose is not only environmental-friendly, but also economically very attractive.

The usefulness of my scientific background? Being able, in a few months' time, to learn sufficiently about pulp bleaching to understand our customers' problems and contribute to solving them. Getting an international team to work together on a common project. Knowing how to write a paper and give an invited talk in front of an international audience.

3. People :

"Science is public knowledge". I do not remember whose quote this is. The "public" to me means that "science" only deserves that name when you have "sold" it to someone, to some public. Your colleagues, your students, the general public perhaps. But you have to succeed in convincing other people at least of the fact that what you do is interesting, or useful. Not necessarily useful, but necessarily interesting. "Public" also means that you share your knowledge, and also your questions. With other people.

The "people" issue is of course equally fundamental the world of industry and commerce. Because what you do has to be "sold": to you colleagues, to your boss, to those who report to you. And, ultimately, to a real customer, who is willing to pay for what you propose. A lot of convincing, a lot of listening, a lot of willingness to be taught and to teach.

The difference between scientific and industrial surfaces is, from that point of view, not so large.

If you get to a non-adiabatic crossing, at least take the time to consider crossing over. The probability of remaining on the other surface is p*(1-p). Preferably, some trajectories should come back to the original surface, probability p**2. Because, after all, not all of your students can become University Professors, or Senior Scientist with the Institute for XYZ. In fact, most of them will end up doing something else than fundamental research. Should those who teach them not have at least some experience about what those other surfaces look like?

4. **Acknowledgements :**

My very sincere thanks to Davide Bassi, Paolo Tossi and their colleagues who organized this meeting, for inviting me to SASP 2000. One thing sets fundamental research apart from any activity I know: scientists are at the same time each other's suppliers, customers, competitors and friends.

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