

## But That Was Then, and This is Now

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The last time I contributed a paper to a scientific meeting was at a joint event: the 1994 International Conference on Plasma Physics and the VI Latin American Workshop on Plasma Physics. The meeting took place at Foz do Iguaçu, from October 31 to November 4, at the time of a solar eclipse. And what constituted on that occasion my discrete disappearance from the plasma scene was of course overshadowed by the disappearance of the Sun in a spectacular total eclipse. Even so, it came as a complete surprise to me when I learned some months ago that I was going to be invited to the present meeting, nine years later, for some kind of acknowledgement of services rendered. Being used to presenting scientific contributions at conferences, I wondered what I would tell you here.

First of all and principally, of course, I would like to thank you for your kindness. This invitation and tribute can be best understood as the result of the friendship and thoughtfulness of my many longtime colleagues and early students in the plasma community. And for that alone I already appreciate it very dearly.

Second, I thought about presenting you a little exercise. Using the circumstance that I was present at the birth and growth of plasma physics in Brazil, and have now been away from it for a decade, it would be interesting to compare then and now. I will show you the result, and I promise you to be very brief.

It seemed to me an important day in 1974 and I registered it carefully in my memory. The Institute of Physics of the Federal University of Rio Grande do Sul (UFRGS), founded 15 years earlier, was doing theoretical research in Nuclear Physics and Quantum Field Theory; experimental research in Perturbed Angular Correlations, Mössbauer Effect and Quantum Optics. Condensed Matter Physics was covered both experimentally and theoretically, and Astronomy was well on its way. After starting from scratch, it had become, in the words of a US visitor at the time, "the nicest little Physics Institute in Latin America". And he was serious, because he traveled around a lot and he had been giving us money! But one of our growing concerns, frequently discussed with my colleagues and good friends Gerhard Jacob and Theodor Maris, was how to broaden this spectrum of research activities in a way that would strengthen the undergraduate and graduate teaching of classical Physics (without  $\hbar$ ), bring us closer to important applications (like fusion) and attract more students interested in beautiful Physics with possible applications. On that day we reached a decision: we would go into Plasma Physics. Theory would start immediately; experiment might follow later (it didn't; our bet for it, then a doctoral student at Ruhr University Bochum, chose to stay in the nuclear engineering area). It was March 19, 1974. We went to the library, pic-

ked up a couple of books that were available and chose one. A group of about 10 theoretical physicists and graduate students working in different fields, started forthwith a series of weekly study seminars to learn Plasma Physics from the beginning. This procedure, introduced by Theodor Maris, the scientific founding father of our Institute, had been used earlier to initiate other theoretical fields and was still a trademark of the Institute at that time. All participants had to prepare the next lecture and one of them was selected for presentation by drawing lots at starting time. Although a participating visitor once remarked this method was a violation of academic freedom, and a graduate student (imagine!) even declared it was a road to sterile erudition, it was very efficient...The fact that both complainers survived their statements in the Institute proves also there was some measure of freedom in the academy, after all...

In this same year of 1974, research groups in Plasma Physics were independently started at the State University of Campinas (UNICAMP) and at the University of São Paulo (USP). They were soon joined in the following years by the National Space Research Institute (INPE), the Technological Institute of Aeronautics (ITA) and the Fluminense Federal University (UFF). Next year will therefore mark the 30<sup>th</sup> anniversary of institutional research in Plasma Physics in Brazil.

The new research area, with support from state and federal agencies, started to grow quickly. Some attempts were soon made to induce these agencies to organize a national plan for development and financing of the plasma physics groups. But without success. We could go on without a national plan, as long as we had the support. And so we did.

But then came the "Status Report on Controlled Thermonuclear Fusion", prepared by the International Fusion Research Council at the request of the International Atomic Energy Agency, and published in 1978. This Report recommended that member countries should support Controlled Nuclear Fusion in their countries as part of an efficient world-wide co-operation and planning in this field.

It is interesting to look at the time scale proposed in the Report of 1978, assuming adequate support:

- 1) demonstration and study of the physics of burning plasmas in ignition experiments: 1984-1986;
- 2) demonstration of a sustained net energy output from a fusion experiment: 1991-1996;
- 3) development and demonstration of the technical practicability, economy and reliability of all necessary components for a fusion reactor plant, including the operation of a full demonstration plant; and
- 4) comparison of the economy and reliability of different reactor types.

Motivated by this Report, the Brazilian plasma physics

groups decided to go back to the idea of drafting a national plan by themselves, in order to

- 1) organize and coordinate their activities at a national level;
- 2) call the attention of government agencies to the scope and importance of this field; and
- 3) facilitate international exchange.

Work on the plan started in February, 1978, on the occasion of a Summer School on Plasma Physics at the UFF (where 15 physicists and 40 students met) and its first edition was concluded in July. The Nuclear Energy Commission took notice of the plan while it was still being formulated and got interested in it.

The objectives of the proposed Brazilian plan of 1978 were:

- 1) pursue ongoing work on Theta Pinch, Low-beta Tokamak, Basic Experiments, Theory and Diagnostics up to 1981-82 at least; and
- 2) discuss in the meantime the possibility of creating a National Center of Plasma Physics to support a "large-scale" made-in-Brazil experiment (US\$ 2 - 3 million) to be defined later.

The National Center idea was discussed, with ups and downs, for almost a decade, and finally seemed to get off the ground in 1988. The plan, as it was developed from its initial form by the community, considered four sites for the National Center of Plasma Physics: Cachoeira Paulista, Guaratiba, São José dos Campos and Xerém; it chose the construction of the Advanced Toroidal Experiment (ETA) as the main activity of the Center in the area of fusion; and it proposed the INPE laboratory as the transitional site of the Center until the choice of the definitive one. But this plan suffered a transmutation in the Ministry of Science and Technology, which decided to install the Center in Xerém; build a heavy particle accelerator of at least 500 MeV to work on Muon-Catalysed Fusion, and use the Centro Brasileiro de Pesquisas Físicas (CBPF) as the transitional site of the National Center. The Ministry had been clearly co-opted by a Nuclear Physics lobby. And that was the end of the National Center of Plasma Physics; and of the accelerator, of course.

#### **But that was then...**

How did the International Fusion Research Council's and Brazil's proposals of 1978 work out if you look 25 years later? For an international update I used the report of the U.S. National Research Council titled "Burning Plasma - Bringing a Star to Earth", released as unedited prepublication copy two months ago; as well as yesterday's presentations here, by Varandas, Navratil and Bombarda, on

burning plasma and connected experiments represented by FIRE, IGNITOR and ITER. For a national update, I used the Abstracts of papers submitted to this Conference.

The USNRC study concludes that there is high confidence in the readiness to proceed with the burning plasma step; that the tokamak is the only fusion concept ready for implementing such an experiment; and that the US should become a partner in ITER, which is the best choice for a burning plasma experiment because its design is the most mature and flexible of all alternatives. ITER had to decide among four proposals for its site: Cadarache (France), Vandellòs (Spain), Clarington (Canada) and Rokkasho (Japan). Cadarache seems at this time to be the choice.

As can be seen from this meeting's session on Thermo-nuclear Fusion, there are now three machines operating in Brazil:

- 1) TCABR (Tokamak Chauffage Alfvén)/ USP;
- 2) ETE (Spherical Toroidal Experiment)/ INPE; and
- 3) Nova Tokamak/ UNICAMP.

which shows a clear commitment to the tokamak option.

#### **And so this is now...**

Only this year have preliminary contacts been started again with the Ministry of Science and Technology on the possibility of creating a Plasma Physics Program for Brazil, with strong emphasis on Fusion. The Program should include four items:

- 1) The ongoing efforts in radiofrequency heating and spherical tokamak development, possibly in connections with a National Fusion Center;
- 2) A link to the ITER program through partnership with Portugal;
- 3) The nuclear engineering capabilities of Brazil in activities relevant to future fusion reactors;
- 4) The activities in Basic Plasma Physics, Space and Astrophysical Plasmas, and Technological Applications of Plasmas at the Universities and Research Institutes.

If these discussions prosper, they should be quickly extended to the plasma physics community in Brazil and Latin America. Let us all get together, first, to do it, and then again, to check the progress in our next meeting.

May I express my thanks once more to the Organizing Committee for the honor bestowed upon me, and to all of you for your attention.

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