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NUCLEAR FUSION RESEARCH IN ARGENTINA

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1.- INTRODUCCION

Following early short lived attempts to fusion research in Argentina, the first continued activity in this field was stablished at the University of Buenos Aires (UBA), approximately in 1968. This group, which belongs to the Physics Department of the Faculty of Exact and Natural Sciences of the UBA, started initially theoretical work in fundamental plasma physics under the direction of Fausto Gratton, who had completed his Ph.D. in Frascatti in the early 60's. Later on, under the scientific tutelage of Winston Bostick, experimental activities were started in plasma focus. The first UBA facility, PF-I, was a 1 kJ plasma focus donated by the Stevens Institute of Technology to the UBA near 1970, and this line of research has continued as the group's main experimental activity up to the present.

In 1975, the Argentine National Atomic Energy Commission (CNEA) started a prospective study on fusion energy, as a result of which it decided to create its own research group in 1976. CNEA's Nuclear Fusion Division belongs to the Commission's Research and Development Management area and its line of work, both theoretically and experimentally, is field reversed configurations (FRC). The FRCs are produced using a field reversed theta pinch, which started operation in 1982.

Finally, in 1983, a part of the UBA group, headed by Roberto Gratton, moved to the newly created National University in Tandil city, some 300 km SW of Buenos Aires. This group also took the plasma focus as their main experimental research line, in which they had experience from their previous work at the UBA. Since 1988, this group extended its activities to the University of Mar del Plata, located 150 km SE of Tandil, where a small z-pinch started operation in 1989 and a repetitive plasma focus is under construction.

All three groups active at the moment in fusion oriented research in Argentina operate independently and no national fusion program is considered at the moment. In all cases, the major source of funding is the Argentine government, complemented by contributions from international funding organizations. In addition, important donations of equipment have been received from the U.S. (UBA - Stevens Institute of Technology) and the F.R.G. (CNEA, Mar del Plata - KFA Jülich).

2.- DESCRIPTION OF RESEARCH ACTIVITIES IN PROGRESS

2.1.- University of Buenos Aires[1]

- Staff: 10 permanent scientific members, Ph.D. level
  3 permanent scientific members, M.S. level
  2 non-permanent scientific collaborators, Ph.D. level
  6 graduate students
  2 technicians

- Typical annual operating budget: U.S. $ 30.000 (excludes salaries)

- Experimental facilities

Type:	Plasma Focus, Mather type	
Name:	PF I (modified version)	PF II
Capacitor bank energy:	0.005 - 1 kJ (variable)	17 kJ
Capacitor bank voltage:	15-30 kV (variable)	50 kV
Peak current:	-	300 kA
Neutron production (D-D):	-	2×10^8
Electron density:	-	10^{18} cm^{-3}
Operating since:	1984 (modified version)	1983
Diagnostics:	framing photography, neutron diagnostics x-ray diagnostics, ion spectrometry, magnetic probes	

- Research activities

  Experimental: - sheath physics during the processes leading to the formation of the plasma focus

  Theoretical:
  - fundamental processes
  - ICF (heavy ion beam) heating models
  - ICF (laser) implosion dynamics models
  - magnetic ion confinement

- International cooperation activities

  - Stevens Institute of Technology, U.S.A. (Vlasov plasmas, plasma focus theory)

  - Technische Universität Graz and Institut für Weltraumforschung of the Austrian Academy of Sciences (dissipative MHD and nuclear fusion physics)

  - Centre de Physique Theorique, Ecole Polytechnique, France (non-linear plasma physics)

  - Universidad de Antioquia, Colombia (statistical mechanics of dense plasmas)

  - Pontificia Universidad Católica de Chile (plasma focus and dense z-pinch experiments)

2.2.- CNEA's Nuclear Fusion Division

- Staff: 4 permanent scientific members, Ph.D. level
  3 permanent scientific members, M.S. level
  2 permanent engineering support members
  3 students
  3 technicians

- Typical annual operationg budget: U.S.$ 30.000 (excludes salaries)

- Experimental facilities

Type:	Field reversed theta pinch
Peak bias magnetic field:	0.06 T
Peak external magnetic field:	1.0 T (non-crowbarred)
Ionization and preheating:	RF + ringing theta discharge
Coil length:	50 cm
Coil inner diameter:	8.5 cm
Discharge chamber inner radius:	6.7 cm
Diagnostics:	optical spectroscopy, magnetic probes, compensated diamagnetic loops, streak photography

- Research activities

Experimental: - FRC formation physics
Theoretical: - FRC equilibrium, stability and transport
- FRC equilibrium models

- International cooperation activities

- University of Maryland, U.S.A. (transport and microinstabilities)
- University of Washington, U.S.A. (FRC experiments)
- University of Campinas, Brazil (FRC theory and experiments)

2.3.- National University of Central Province of Buenos Aires (Tandil)[2]

- Staff: 2 permanent scientific members, Ph.D. level
2 permanent scientific members, M.S. level
2 students
2 technicians

- Typical annual operating budget: U.S.$ 1.000 (excludes salaries)

- Experimental facilities

Type:	plasma focus, Mather type
Name:	PACO
Capacitor bank energy:	1.9 kJ
Capacitor bank voltage:	31 kV
Neutron production (D-D):	2×10^6
Operating since:	1984
Diagnostics:	Visual diagnostics (framing and schlieren photography

- Research activities

Experimental:- Correlation of sheath dynamics and structure with neutron yield.

Theoretical: - Support studies for experimental work

2.4.- University of Mar del Plata(2)

- Staff: 3 permanent scientific members, Ph.D. level
  9 permanent scientific members, M.S. level
  1 non-permanent scientific associate
  3 students
  3 technicians

(*) 2 scientific members of this group are also listed in the Tandil group

- Typical operating budget: U.S.$ 3.000 (excludes salaries)

- Experimental facilities

Type:	gas-puff dense z-pinch
Name:	NOVA
Capacitor bank energy:	2 kJ
Capacitor bank voltage:	10 kV
Peak current:	250 kA
Operating since:	1989
Diagnostics:	framing photography

Type:	repetitive plasma focus, Mather type
Name:	PULSAR
Capacitor bank energy:	23 kJ
Capacitor bank voltage:	40 kV
Peak current:	600 kA
Repetition rate:	5 PPS
Neutron production (D-D):	10^{10} (expected)
Operation:	1991 (expected)

- Research activities

Experimental:
- edge plasma properties and plasma-wall interaction in a dense z-pinch
- effects of operating conditions of a dense z-pinch on shock wave dynamics and final plasma parameters
- material studies for fusion reactors using a repetitive plasma focus
- plasma focus desing optimization and scaling
- use of a plasma focus as a pellet implosion driver

Theoretical:
- support studies for experimental work

3.- TRENDS AND PROSPECTS

One way of assessing the evolution of fusion research in Argentina is in terms of the number of annual scientific publications in international journals and conferences with well established refereeing standards produced by the groups discussed in the previous section, as illustrated in Fig.1.

Fig.1 Evolution of scientific publications of Argentina's fusion research groups in journals and international conferences with strict refereeing standards

The same analysis in terms of the evolution of permanent scientific personnel and of operating budget, however, does not indicate a significative growth during the past ten years. These facts lead to the general conclusion that in spite of economic limitations, the groups active in fusion oriented research in Argentina have matured and improved considerably their scientific standing during the last decade. This observation is also confirmed by the growth of international cooperation activities established in the same time period. Alternative indicators of recent progress are the addition of four new operating experimental facilities and the creation of two new research groups in this period.

The present level of economic support of fusion research in Argentina ammounts to a small fraction of a percent of the government's total investment in energy research and development. This support is definitely inadequate to allow for the growth of fusion activities much beyond and their present level and, for this reason, the question of establishing a more significative fusion research effort has been under

review at the CNEA lately. Considering that this institution is directly responsable for nuclear policies and activities at a national level, it is clear that it is the natural entity for promoting and funding a meaningful fusion research program in Argentina.

In conclusion, the development of fusion research in Argentina has shown a definite progress in the last decade in terms of new experimental facilities, of the creation of new research groups and, particularly, in terms of the scientific maturity and consolidation of the existing groups. Further progress beyond the present situation will depend strongly on fusion policy decisions by government nuclear authorities.

REFERENCES

1. J. GRATTON, private communication
2. J. POUZO, private communication

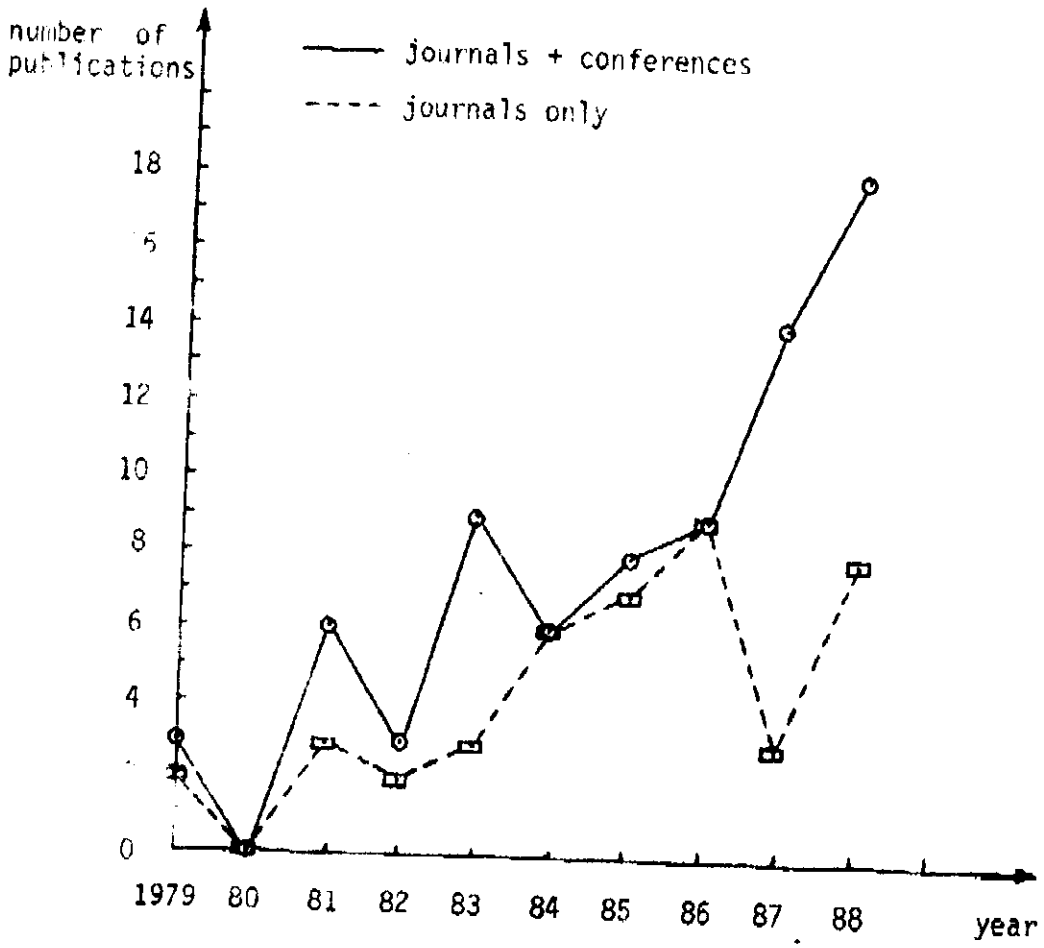

FIG. 1 - Number of publications in journals and international conferences with strict refereeing standards