Physics research organization, Italian style

Faced with the handicap that research funding in Italy is an order of magnitude lower than in other large countries, the Italian physics community has evolved a system for obtaining as much physics as possible per lira.

Carlo Rizzuto

Most physics research in Italy is organized and conducted through six national research groups. This way of organizing research through national groups has proved very successful and may in part explain how it is that Italian physicists have been able to remain competitive with their international colleagues despite their much lower levels of funding. (For example, in 1981 the total government funding for non-nuclear physics in Italy was about $16 million and $75 million for nuclear physics, of which about $33 million was for CERN.) Our experience has been that the structure provided by the national groups enables the highest productivity possible under difficult financial constraints. The structure has also proved to be valuable in starting and carrying out scientific and technical programs requiring high levels of exchange between many different locations and across geographical, institutional and disciplinary barriers. I suggest that a similar approach could be used to advantage by developing countries and for specific fields in Europe or elsewhere, to counteract the difficult periods connected with funding and student enrollment expected in the near future. It might also be applied on an international basis for specific purposes and programs.

Funding of physics in Italy

As a background to understanding the origin and functioning of the national groups, let us review the structure of the funding for physics research in Italy. Physics research in Italy is mostly state-supported and is conducted mainly through two national research institutions and by the state universities that receive their funding directly from the Ministry of Education.

The two national research institutions are the National Institute for Nuclear Physics (INFN) and the National Research Council (CNR). Both conduct research in their own laboratories and in the universities. But the former is completely committed to basic nuclear and subnuclear physics and the latter, which covers the rest of physics, has the role of supporting and conducting research in all fields, from philosophy and law to medicine and engineering. Physics, then, accounts for only about 10% of CNR activities.

A third national institution, ENEA, the Energy Committee (formerly the Nuclear Energy Committee, CNEN), is now mainly directed towards conducting and supporting industry-oriented research on energy production by nuclear and alternative means.

Apart from the differences in their main commitments, there are other important differences in the policies of INFN and CNR. INFN aims at keeping close ties between its three large (staff

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around 100) national laboratories, the university-based nuclear research and the international programs (for instance, CERN). INFN equips its national laboratories, with large facilities accessible to any groups that submit competitive proposals. The scientific programs of INFN are planned and determined by a single national scientific council, and university research is conducted through funds assigned directly to the local groups.

CNR, on the contrary, conducts its physics research (as well as the activities in other fields), in many small local laboratories (29 for physics, with average staffs well below 50). These laboratories allow only limited (below 20%) external collaboration, and close relationships between the universities and the laboratories is not encouraged. Each laboratory has its own scientific council that reports directly to the CNR main office.

The scientific programs of CNR are, in principle, planned locally by each laboratory or local group and then analyzed by one of eleven refereeing committees (one for each field, including physics). University research is funded by contracts between CNR and the central administration of each university.

A comparison of the planning and conduct of basic nuclear and subnuclear physics research (sponsored and conducted by INFN) and of the rest of physics research shows that, institutionally, the former evolves through well-coordinated national programs and has easy access to international facilities, while the latter is expected, in principle, to evolve through a plurality of small local programs, without any common large facilities or institutional access to foreign collaborations.

These differing management philosophies are made even more unfavorable for physics research funded by CNR by the very tight budget available to the physics committee—well below the subsistence level, if compared with other advanced nations (see table 1), and continuously decreasing in real value. This shortage of funds has resulted in a continuous shift by CNR away from supporting the university-based facilities, in favor of keeping its many laboratories in operation. In 1980 a change occurred in the overall funding picture for university-based non-nuclear physics, which until then had been completely funded by CNR. In that year the university reform allowed the Ministry of Education (MPI) to provide its own resources for the support of university-based research (most Italian universities are state-owned and run on a civil-service basis). The last three years (1980–1982) have seen a planned increase in this source of funding, which has now leveled off.

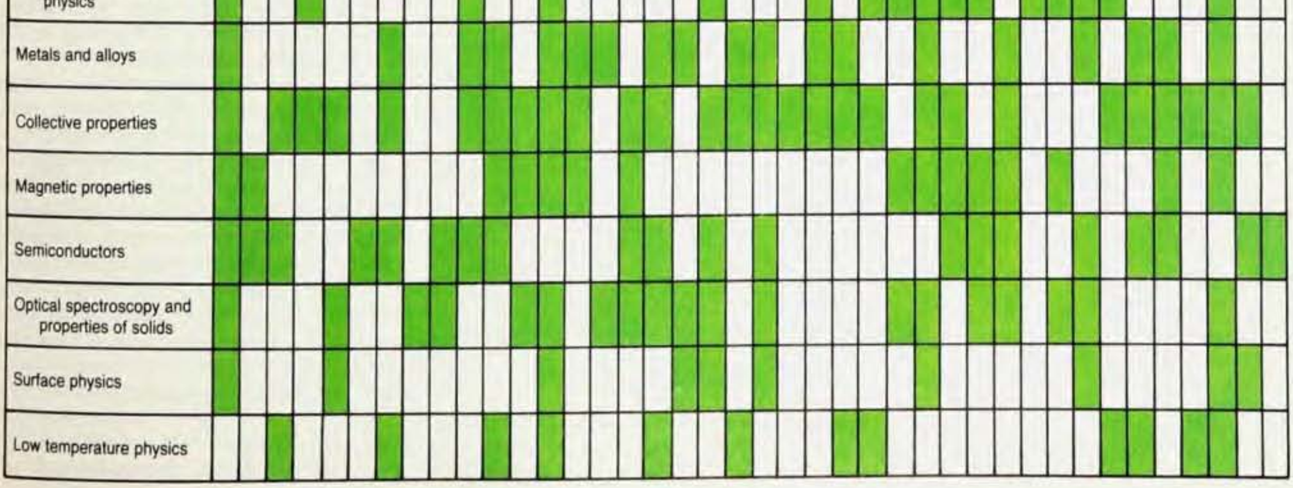
Funds from MPI are given in part (60%) to the universities, which then decide internally the funding between different areas and programs, and in part (40%) directly to proposals submitted to a central office, where they are reviewed by 14 national consulting committees (one for physics). At present about 12% of the direct budget is allocated to physics research, while the physics part of the 60% university-managed budget varies widely from place to place.

Table 1 shows the overall level of spending for physics and the relative contributions of the three governmental sources for the years 1975, 1980 and 1982.

Direct funding to physics, either through national programs of CNR for applied physics or from industry is difficult to assess and varies considerably with time. In 1982 it contributed an estimated 10% extra to the budgets of research programs.

A final difference in the funding

Geographic distribution of the laboratories and research units that make up GNSM (the national group involved in research on the structure of matter). In addition, five university groups are associated with the GNSM programs. Research groups are identified in the chart, which also shows the research interests of groups in eight subdivisions of physics. Figure 1



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patterns of the three sources is the delay between the decision to fund and the time that money is actually available to pay invoices at the university. This time delay is very short for INFN (one or two months), but very long for CNR (over one year); MPI has a delay of about six months. With high inflation rates, long time delays significantly lower the actual values of the funds.

Research staff

In Italy, staff compensation must be analyzed separately from research funding. In our country it is not permitted to pay staff directly from contract money, and everybody is normally on tenure in a civil-service job, at both the technical and professional levels.

The research and technical staff working in physics under funding by INFN, CNR and MPI have, therefore, job positions with one of these three institutions. The total staffs employed by the institutions are summarized in table 2. The CNR and INFN laboratories are mainly operated by their own staffs, while the university departments are staffed by variable mixes of their own faculty and CNR staff. The exception is nuclear-physics research, which is mainly staffed by INFN.

The support of graduate studies, introduced by the 1979 reform, may alleviate the rigidity of the staff system at the junior research level, but this beneficial effect will take a few more years to be felt.

The mobility of people in Italy is very small. First there is the residual tradition of family ties. But the most important factor is the very difficult housing situation, which tends to discourage people from moving elsewhere.

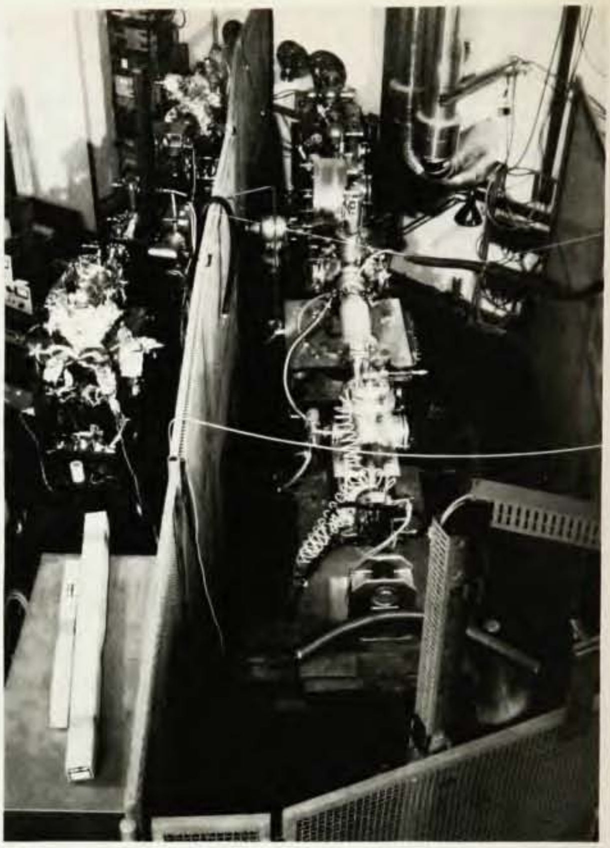
The difficulty of mobility has caused major problems in some of the larger research laboratories that were funded and rapidly staffed in the "golden" fifties and early sixties. These staffs have since become quasimonochromatic in their age spectra, with practically no new members added and no turnover. The universities have experienced the same lack of turnover since 1974.

The lack of growth and turnover are partly due to the job ridigity and low mobility described above but also have strong historical links to two major external events: In the early sixties a strong political attack against modern research management in (applied) nuclear research caused a setback in all research institutions as well as a sudden increase of onerous red tape—which has kept increasing since that time with double or triple formal checks now required for both fund allocations and final accounts. The second event, in the early seventies, was that the government became overcautious with universities and research institutions in reaction to student unrest. This change in attitude brought a halt to funding for fellowships in all disciplines (in philosophy, social sciences and physics as well) starting from around 1974.

In summary, the boundary conditions for physics research (and research in general) in Italy are, with the exception of nuclear and subnuclear research, scarce and with rigid financial and staff resources and a strong tendency to allocate these resources in uncorrelated and therefore dispersive ways; this tends to decrease even further their effectiveness.

Some parts of this scenario—especially the problems of low turnover and scarcity of resources—may be duplicated, in the near future, in other large countries. This same overall situation has long been detrimental to the growth of good physics research in many emerging or small nations.

To overcome these difficulties and to foster the growth of the various subfields of physics, the physics communi-



Synchrotron radiation facility developed in the PULS program in Frascati (ISM). On the left is the 100 eV–1 keV channel equipped with a "grasshopper" monochromator. On the right is the 1 keV–12 keV channel with a crystal "channel cut" monochromator. INFN has installed a wiggler section, which is now available for further instrumentation. Figure 2

Table 1. Funding of physics research in Italy

	1975	1980	1982
	(millions of US dollars)		
INFN			
Staff	9.50	24.52	19.15
National labs & expenses*	1.23	14.01	14.73
Universities	9.50	12.84	11.05
CERN (directly)	27.12	43.86	39.17
CNR			
CNR laboratories†	6.17	8.39	8.59
Universities	2.11	3.40	1.84
MPI			
Direct funding (40%)	0	6.07	6.22
University funding (60%)	0	0	6.26
Total (excluding staff and CERN)	19.01	44.71	48.69
Yearly average inflation**	17%	21%	17%

*Includes new buildings
†CNR physics labs numbered 16 in 1975 and 29 in 1982
**The devaluation rate as well as inflation increases the price in US dollars, so that the budget erosion for purchasing instruments abroad is greater than inflation. The dollar/lira ratio used is the yearly average which varied from 650 in 1975 to 1360 in 1982

ty in Italy made the decision to organize and conduct physics research through a number of national "research groups." These groups were formed, beginning in the early sixties, by the few local research groups working in the various subfields and were later recognized by CNR.

Today the national groups covering non-nuclear physics are:

GNSM—Structure of matter (5 labs, 34 research units)

GIFCO—Cosmic physics (4 labs, 2 research units)

GNA—Astronomy (2 labs, 5 research units)

GNCB—Cybernetics and biophysics (3 labs, 12 research units)

GNEQP—Quantum electronics and plasmas (2 labs, 12 research units)

GNTS—Earth physics (11 labs, 13 research units)

GNAO—Atmosphere and ocean physics (11 research units)

Recently physics teaching (GNDF) and physics history (GNSF) have also been organized as national groups. The chairmen of the physics groups meet on a regular basis to assess common trends and policies towards the financing bodies. The only other discipline to organize in this manner is mathematics, which is completely covered by five national groups. In the other fields of research only a few branches of engineering have organized along these lines.

Table 2. Physics research manpower in Italy (1982)

	Research	Technical	Adminstrative	Total
INFN				
National labs	62	200	60	322
Universities	130	425	116	671
CNR				
CNR labs*	387	381	67	835
Universities	65	54	2	121
Universities	2000	500	(unknown)	2500

*Does not include vacancies in 280 research and technical positions unfilled because of budget cuts and delays in refilling positions.

National Group for Structure of Matter

To provide an understanding of the national group approach, I propose to describe in some detail the genesis and operating experience of the first national research group to be formed in Italy—the National Group for the Structure of Matter (GNSM). This group proved so successful that it became the model for national programs of CNR for applied research.

GNSM was founded informally in 1962, when most of Italy's research in this field became supported by CNR, after an initial period of funding, through the late 1950s by INFN.

The fields of research covered by GNSM are condensed-matter and atomic and molecular physics. Work in these areas is carried out by a number of research units and laboratories that function under the auspices of the GNSM.

The official acknowledgement of GNSM by CNR dates back to 1967, when it was recognized as a fully titled organization with a statute and a Scientific Council. GNSM acts as a consultant to the National Physics Committees. Its proposals determine the budget allocations for the research units, but not for the laboratories.

GNSM now consists of the 34 research units and 5 CNR-type laboratories (Instituti del CNR) shown in figure 1. Each research unit consists of a group of research, technical and administrative staff (from a minimum of 5 to a maximum of 58) operating in universities or in other institutions, such as Ispra-EEC Laboratory, CISE in Milano, ENEA (the National Energy Commission) in Rome and IENGF (the Galileo Ferraris Electrical Standards Laboratory) in Torino.

In each unit the research activity is carried out under a single scientific supervisor (*responsabile di unità*), but covers several (two to six) different fields (*indirizzi di ricerca*).

Each of the GNSM (CNR) laboratories have between 21 and 47 staff members (two of them are now just being formed), are headed by a director of research and also cover different fields of research (*reparti*). The director reports informally to GNSM for the general planning and to the Scientific Council and CNR for detailed planning.

The GNSM's Scientific Council consists of the research units' supervisors and the laboratories' directors, together with six elected representatives of the research and technical staff and five coopted scientific experts from industry or research institutions.

The executive officers of the group are the chairman of the Scientific Council and a board of 12 members, some elected by the Council and the others by the laboratory directors. A central office in Rome with a staff of four operates under the group's director.

The basic budgets, allocated by the CNR and the MPI for the research expenses of GNSM in 1975, 1980 and 1982 are given in table 3.

The total staff working directly in the laboratories and research units is about 1000 (including researchers, technicians and graduate students), while some 200 other outside people collaborate in GNSM's scientific exchanges. For the 1982 budget each researcher received an average of \$6800 in financial support or \$5300 per researcher in the universities and \$17 500 per researcher in the laboratories (the total research staff is 576 in the universities and 90 in the seven laboratories). The higher expenses for the laboratories are due in part to their isolated settings.

Increases in staff between 1975 and 1982 mainly involved the addition of

Surface physics facility at the Modena research unit provides various surface measurements (AES, XPS, ELS). It is part of a surface-physics project involving six research units at different universities. Figure 3 groups operating at other universities and of researchers who had changed their fields; the number of young people joining the staff during this period is estimated to be less than 10%. The present average age of the research staff is, therefore, above 42.

The budget to support arrangements for or participation in scientific exchanges, meetings, schools and travel to a few selected overseas meetings was, in 1982, $0.17 million. This budget, disbursed from the central office in Rome, is consistent with our experience that the funds needed for these various actitivies should be about 5% of the total budget to be effective.

Policies, programs, effectiveness

In the fields of condensed-matter and atomic physics—or structure of matter, as we call the combination of the two—developing research of international stature and accomplishing anything of practical interest both require in-house theoretical and experimental know-how and laboratory facilities covering a wide range of capabilities.

On the other hand, the distribution and size of both the local groups and laboratories and the financial and staff resources clearly indicate that there are no centers large enough in Italy to provide cross-fertilization for research in the structure of matter or related fields. In the other European nations, for example, this kind of environment is provided by the large laboratories at Grenoble and Orsay, at Harwell and at Eindhoven, by the Max Planck Institutes, the Rutherford laboratory, and so on. Hence we felt it imperative to find ways to encourage cross-exchange and joint efforts on a nonlocal basis to counterbalance the negative effects of low mobility and limitations on laboratory size.

The National Group's approach has been successful in connecting the activities of the various local groups and laboratories and has helped develop a joint scientific program which is very nearly producing the results one would expect from large laboratories. This development, which has been achieved after only ten years of operation, was made possible by closely adhering to the following main policies:

▶ The budget allocated each year for university research is distributed after withholding a part (10–20%) to be dedicated to larger experimental facilities located in the various local units, but which are of general interest also for other groups (some of them are referred to in figures 2–6).

▶ The examination of the scientific programs takes into account mainly the productivity of each group at an international level, but also responds to the need to develop fields of potential interest now absent in Italy.

Array of superconducting Josephson junctions built by R. D. Parmentier and collaborators[2] in the research unit at the University of Salerno. Low-temperature physics in the Napoli–Salerno area is aided by common liquefier facilities purchased by the local groups with GNSM funds. Figure 4

▶ Starting from about 1967, a number of applied-physics programs have been funded and encouraged.

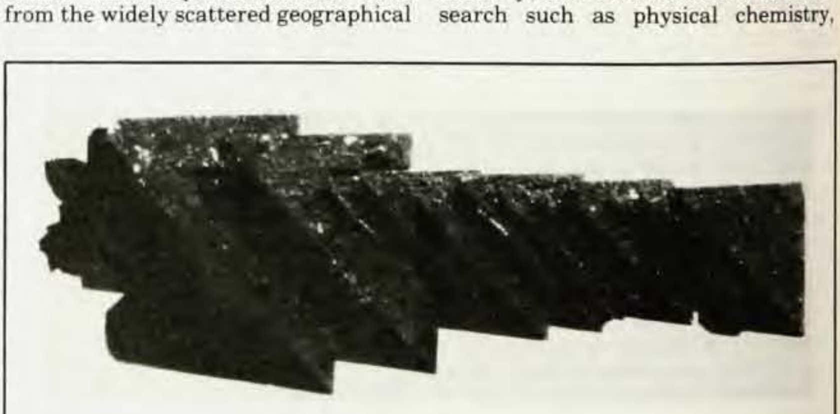
▶ Each year a national research school is held for the younger researchers working in GNSM as well as in other institutions; this program has fostered a number of collaborations among researchers attending the school. The school has also provided a substitute for nonexistent graduate courses. The national school program has recently been extended to include a school on experimental techniques (open both to young graduates and expert technicians). This step has enabled staffs from the widely scattered geographical locations to become personally acquainted to the level of technicians and has enhanced the effectiveness of joint experimental programs. An important asset to the program has been the participation of good foreign lecturers, who remain in contact afterwards.

▶ A central fund (approximately 5% of the total budget) is reserved to supplement the local group's funds for travel money spent on collaborations either in Italy or abroad, and to fund scientific meetings and other exchanges, including foreign visitors who spend time on joint programs between units.

By enforcing these simple rules, the quality and size of research has steadily grown from the initial situation in 1962 when the number of local groups was six and the number of related scientists was well below one hundred, to the present situation with 39 groups and 700 scientists. Where originally there was very little overlap between the scientific programs of the local groups, now over 20% of the papers published are produced by collaborations between different local groups.

This marked improvement was achieved in spite of periods of tight budgets and campus unrest. In fact, collaborations accelerated as a response to local problems during the period of students unrest in the early seventies.

The growth of GNSM and the overlap of interests have made it useful to go to a more complex structure. Initially the structure was vertical, with the National Scientific Council overseeing the work of the local groups. We have now added a "horizontal" structure that consists at present of eight sections (*settori*) (see figure 1), very informal and dedicated only to scientific concerns. Researchers outside of GNSM are invited to participate in these section from both the universities and industry, and from other fields of research such as physical chemistry,



Stacked tetrahedra of $CnZn_6GaTe_8$ (β-region of the $CuGaTe_2$–ZnTe phase diagram) grown from $ZnCl_2$ flux by L. Garbato, F. Ledda and P. Manca at Cagliari.[3] Search for new complex semiconducting materials, such as one shown, takes place in conjunction with work on standard materials such as silicon and GaAs. GNSM is planning a joint university–industry program for solid-state materials and devices. Figure 5 engineering and biology and so on. "Outsiders" account for more than half of the participation in some sections (for example, semiconductors and atomic physics). These exchanges have been very beneficial in developing scientific programs and activities better suited to our national situation and have been very appreciated by those in the fields of chemistry, and engineering where the funding and activities are still quite dispersed.

Consider now briefly the major unsolved problems that face Italian physics:

▶ Low funding and financial erosion are expected to become worse from 1983 onwards. (Normally Italy follows international trends with a delay of three to four years.)

▶ High age of the research staff and lack of turnover.

▶ The decrease of staff that is taking place in those groups that have been most successful in their interaction with industry.

▶ The lack of major facilities.

The financial situation prevents us from starting new activities in fields still largely unrepresented (for example, metal physics and physical metallurgy) or enlarging existing activities to the point where they could become sources of know-how for industries (amorphous silicon or ceramic materials, for example). The decrease in applied-physics staff is due to the greatly increased job market for physicists in industry—the need of industrial laboratories and production plants for the flexibility of laboratory-experienced physicists. Physicists were, before the early seventies, never considered an asset to industrial production; while the industrial job market has improved since then, physicists, compared to engineers and chemists, are still fairly rare in this environment.

To compensate for the lack of larger facilities, especially for neutron spectroscopy and synchrotron radiation, a number of agreements have been and are being worked out with other institutions in Italy or abroad.

One of the newly founded laboratories (ISM, in Frascati) should develop as the main center for these facilities. A major and well-instrumented source of synchrotron radiation is being developed at Frascati, in collaboration with INFN, using the Adone 1-GeV storage ring (PULS program). The construction of a pulsed-neutron source using a microtron accelerator is expected to start by 1983 in collaboration with ENEA. The neutron program will supplement the existing medium-power reactor of ENEA, and will be completed by an international agreement with a major European laboratory.

The evolution of these major facilities and the stimulation of a reasonable turnover (or better, a planned gradual introduction of young researchers and experienced technicians) are very difficult problems to solve. They must go through the decision process of CNR, and they are in conflict with the dispersive approach that still dominates government-funded research. (The *divide et impera* approach is an old Italian tradition, dating back to the Roman Empire, when even weak central governments could stay in power because of the divisiveness of the subjected areas.)

Table 3. Budget for GNSM in 1982

	Research budget (millions of US dollars)		Staff*	
	CNR	**MPI**	**CNR**	**MPI**
CNR Laboratories†	1.58		70(72)	20(0)
University units	1.01	1.89	44(66)	532(84)
Others (ENEA, CISE, EEC, and so on)**	0.04		25**	
Central GNSM office	0.17		0(4)	
Totals	2.80	1.89	139(142)	552(84)

Total funding in universities: US$3.07 million including central funds; local, university-managed funding is approximately $1.5 million.
*Numbers in parentheses are technician plus adminstrative staff
†Includes funds for synchrotron radiation program
**Numbers shown are GNSM(CNR) contribution for money and internal research staff.

To overcome, at least in part, these problems, GNSM recommended in 1978 to CNR (and to the various governments that have since been in power) a five-year program to increase efforts in those research areas that are, by now, well established. These are the areas:

Basic research

▶ Atomic and molecular physics, collision physics and nonlinear optics

▶ Electronic and vibrational properties of perfect and disordered solids

▶ Properties of amorphous solids and of liquids and biological molecules

▶ Transport phenomena in solids and liquids

▶ Instability phenomena and phase transitions

▶ Magnetism and magnetic resonances

▶ Defects and mechanical properties

▶ Physics of surfaces and interfaces in solids and liquids.

Applied research

▶ Physics and technology of materials

▶ Semiconductors and insulators

▶ Physics and technology of surfaces and interfaces

▶ Energy conversion and accumulation

▶ Superconductivity and cryogenic techniques

▶ Failure physics

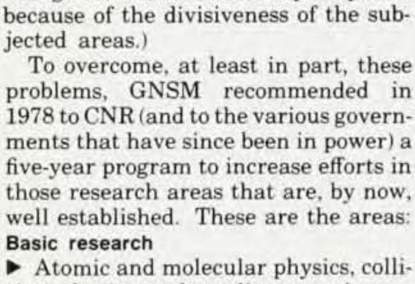
▶ Advanced technology using lasers.

(See figure 1 for the specific areas of the local groups.)

In all of these fields good levels of activity already exist, but increases in staff and funding are needed to make it possible for them to contribute at an international level.

Although there has not yet been an operative official response to this proposal, GNSM has been able to interest more local groups in the idea of developing a joint effort and has received strong support from the National Committees in physics in CNR and MPI.

The growing overlap of scientific interest between various areas of physics and of chemistry and engineering may serve to dramatize the usefulness of a coherent planning of research and the resultant benefit to society, eventually allowing a more rational decision at the political level.



Copper specimen modified by ion implantation in the central region exhibits different surface oxidation rates in the two regions.[4] Other properties of metals and alloys are controlled by implantation, such as bearing wear. The ion-implantation programs are based on the main facilities of INFN in Legnaro (Padova) and the GNSM groups in Trento and Catania. Figure 6

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