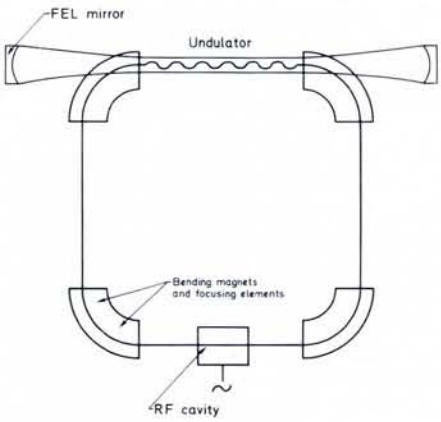

Fig. 4 — Schematic drawing of an FEL on a straight section of a storage ring.

CW power between 10 and 100 W and pulse lengths of about 10 — 30 ps separated by about 100 ns. Such lasers would be extremely useful especially in photo-chemistry. Nevertheless, even if recent experiments have shown good agreement with theory, the feasibility of such devices has still to be proved.

Conclusions

We have briefly summarized the work under way in the field of the Compton type free electron lasers. It is very interesting to note that acceleration of relativistic electrons produces the same phenomena as electronic transitions in atoms, molecules or solids: spontaneous emission and gain. It is also important to note that while FEL theory is quite simple, its development as well as experimental verification have been delayed by a traditional lack of interaction between machine physicists (who were working only on particle physics accelerators) and laser physicists who were busy with their solid or gas amplifiers.

It is quite realistic to expect the field to develop very quickly during the eighties and to foresee FELs working from the millimeter range to the vacuum UV before 1990, with pulsed and electrostatic accelerators in the far infrared and infrared, and with storage rings in the IR, visible and UV.

The possibility of reaching the soft X-ray or X-ray range with an FEL is a common question. We do not believe in such a possibility because the gain drops too quickly with the frequency and optical mirrors become very poor beyond 0.16 μm. With storage rings, one obtains the highest electron density feasible today (higher densities with such machines cannot be reached because of the repulsive interaction between electrons in the bunches) and no one has yet suggested a way to build any other kind of accelerator which could give energies of the order of 1 GeV with much higher electron densities.

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Research on the Structure of Matter in Italy

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20 years Development and the National Group for the Structure of Matter (GNSM) — an overview of basic and applied research on the structure of matter in Italy (covering condensed matter, atomic and molecular physics) and how it has been developed by the GNSM.

The system of organizing research through national groups adopted by the National Research Council (CNR) has been very successful in various fields of physics (and engineering, see panel 1) and for Italy's Finalized Programmes on applied research. (It could even be applied on an international basis in specific circumstances.) The GNSM Group was founded informally in 1962 when most of Italy's research in the field came under the National Research Council after an initial period of funding, through the late 50 s, by the National Institute for Nuclear Physics (INFN). Official acknowledgement dates back to 1967, when it was recognized as a fully titled organisation with a Statute and a Scientific Council.

The Group now consists of 34 Research Units and 5 Laboratories. Research Units including technical and administrative staff range in size from a minimum of five to a maximum of 58 total staff and they operate inside universities and certain other institutions. A single scientific supervisor is responsible but the research covers several (two to six) different fields. The Laboratories which also cover different fields employ between 20 and 35 staff members and are headed by a Director of Research.

The Group's Scientific Council is made up of the Supervisors of the Units and the Directors of the Laboratories together with six elected representatives of the research and technical staff and five coopted scientific experts from industry or research institutions. The executives of the Group are the Chairman of the Scientific Council, and a Board of 10 members elected by the Council. A central office in Rome with a staff of five people is the operating base and is directed by the Group's Director.

Resources

The basic budget, allocated in about equal proportions by the CNR and the Ministry of Public Instruction (see Panel 2) for research expenses of GNSM in 1981 (excluding salaries but including overheads) was approximately 4.85×10^6 US$ of which roughy 3×10^6 US$ went to the Research Units, and 1.25×10^6 US$ to the

Panel 1

Non-nuclear physics in Italy is supported through five research groups under the CNR.

GIFCO (Italian Group for Cosmic Physics) 4 Labs, 2 Res. Units;

GNA (National Group for Astronomy) 2 Labs., 5 Res. Units;

GNCB (National Group for Cybernetic and Biophysics) 3 Labs., 13 Res. Units and Centres;

GNEQP (Nat. Group for Quantum Electronics and Plasms) 2 Labs., 12 Res. Units and Centres;

GNSM (Nat. Group for Structure of Matter) 5 Labs, 34 Res. Units;

Nuclear Physics is supported by an independent institution, the National Institute for Nuclear Physics (INFN).

Panel 2

Starting from 1980, university research has been funded on a regular basis also from the Min. of Public Instruction. The Overall funding for all non-nuclear physics in university and CNR was, for 1981, approximately 3.75×10^6 US$ from MPI and 12.25×10^6 US$ from CNR, the allocation of the funds to the various subfields of physics being made by two consulting committees (one for each) elected by all physicists. Nuclear physics is funded directly by the government and received in 1981, including the international programmes, approximately 75×10^6 US$ of which approximately 33.3×10^6 US$ was for CERN.

Panel 3

Basic Research:

- Atomic and molecular physics, collision physics and non-linear 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
- Semi-conductors and insulators
- Physics and technology of surfaces and interfaces
- Energy conversion and storage
- Superconductivity and cryogenic techniques
- Failure physics
- Advanced technology with the use of lasers

Laboratories, some 0.6 × 10^6 US$ having been obtained on special finalized programmes.

The total staff working directly in the Laboratories and Units is about 800 (including researchers and technicians), while some 200 additional people are collaborating and participating in GNSM's scientific exchanges. Averaged over all the people directly involved, this makes approximately 6 × 10^3 US$ per person (5 × 10^3 US$ in the universities and 12.5 × 10^3 US$ in the Laboratories).

The added budget for direct interventions in support of scientific exchanges, meetings, training, schools and a little selected travelling to overseas meetings totalled in 1981, 0.19 × 10^6 US$.

Why a National Group

Now that the background has been established, let me come to the main part of the information which I should like to convey: Why a National Group is necessary, and how it operates.

A detailed presentation of the scientific activity would be out of place in this paper, but a feeling of it can be obtained from the summary given in Panel 3 of the areas for development recommended in 1978 by the Group to the CNR.

It is not generally appreciated that in Italy, for various (and not always understandable) reasons, it has not, until now, been possible to build and maintain laboratories of a size which could act as a cross fertilizing environment or "think tank". The maximum staff in each of the Units and Laboratories referred to previously is below 60. The few government laboratories and industry centres of greater size established in the "golden age" of the late 50 s or early 60 s have undergone a long and disabling crisis. Italy has nothing comparable to Grenoble, Orsay, the Max-Planck institutes, Harwell, Rutherford, Eindhoven, Budapest, etc.

Sections \ Research Units and Labs.	ISM (PULS + LISONE)	MASPEC	IESS	IFAM	ITS	Bari	Bologna	Cagliari 1	Cagliari 2	Catania	Ferrara	Firenze	Genova	CNEN Casaccie	EURATOM Ispra	Aquila	Messina	Milano 1	Milano 2	Milano-CISE	Modena	Napoli 1	Napoli 2	Padova	Palermo 1	Palermo 2	Parma 1	Parma 2	Parma 3	Pavia	Pisa 1	Pisa 2	Roma 1	Roma 2	Roma 3	Torino	Salerno	Trento	Trieste	Lecce	Camerino	Cosenza	External participants
Atomic and molecular physics										●			●						●				●		●	●	●	●	●		●	●	●	●				●					G.N.E.Q.P. (see note 1)
Metals and alloys	●			●						●	●		●	●	●		●	●		●	●		●	●			●			●			●		●	●		●					Metallurgy National Program
Collective properties			●		●		●			●	●	●	●	●		●	●		●	●	●	●	●	●			●	●		●				●	●	●	●	●	●				Superconductivity National Program and Industry
Magnetic properties		●	●	●			●				●	●	●	●		●										●	●	●	●	●		●				●	●					Metallurgy National Program
Semiconductors	●	●	●			●	●			●	●	●				●	●		●		●							●	●	●			●		●	●			●	●	●		Electron Mat. Nat. Prog. Energy Nat. Prog.
Optical spectroscopy and prop. of solids	●			●	●			●	●			●	●		●	●	●	●	●		●	●				●	●		●	●	●	●	●			●						
Surface physics	●				●							●	●					●	●		●						●						●				●	●		●			Industries

On the other hand, physics in the field of the structure of matter requires the prompt availability of theoretical and experimental know-how and a broad range of measuring facilities. Cross-exchange and joint efforts are the rule if anything competitive on an international level, or of practical interest, is to be done.

Moreover, at the beginning of the Group's activities, the total number of Units and related scientists working in this field, in Italy, was so small (below six and less than one hundred respectively), the possibility of interaction within Italy was almost non-existent. It was, therefore, necessary to make a special effort to enhance the interactions between researchers in Italy and abroad, and to buy equipment and start new research lines able to bridge the existing research fields in order to allow this interaction to start. This is done by ear-marking each year a part of each Unit's allowance for selected common actions and holding specialized meetings and schools on research and on experimental techniques where the researchers, especially the youngest, can interact and learn to work together, independent of their home base. Foreign scientists of special capability and enthusiastic about teaching and establishing multiple contacts are most often invited.

This way of proceeding by joining forces, which was decided by the physicists working in the field in the early sixties, has resulted in the growth of a common national programme which allows us to make use in a very effective way of the very limited financial and human resources available in Italy. The efficency is achieved by sharing these resources, and by planning complementary funding in various localities, promoting the continuous exchange of experience and joint activities between different Units and Laboratories. (Compared with France, the appropriations for staff and money for basic plus applied government funded research in Italy are about a factor of ten lower.)

The Scientific Council of GNSM continues its efforts towards increasing the capability of its National Programme on the Structure of Matter, despite continuous difficulties generated by the central bureaucracy, which seems to appreciate very little the value of collaborative action between people working in different cities and institutions. Instead it makes continuous attempts to break down the coherence of the various activities, in order to have separate control of each Unit's (even each person's) activities.

The greatest difficulty in the management of a large Group with differentiated programmes may lie in its growth: It is evident, for example, that it can become inefficient to circulate scientific information among the present approximately 40 different locations, if this is done only through the members of the Scientific Council. Also, whereas at the beginning when the membership was below 20, the Council was a very good exchange medium, it is now too big to take detailed decisions. For these reasons, starting in 1976, to the "vertical" structure which relates the Scientific Council to the Units and the Laboratories, a "horizontal" structure has been added, which is very informal and free of management problems. This currently comprises seven research area sectors listed in the Table above to which both GNSM and non-GNSM people can contribute on an informal basis, by organizing topical scientific meetings, and by direct interaction. In some of these sectors (e.g. semiconductors or atomic and molecular physics) the participation is about 50% from outside GNSM (university and industry people, physical chemists, biologists, engineers, etc.). The creation of such sectorial exchanges has proved to be very useful; the "matrix" has not turned out to be a "cage", but an efficient way of maximising the scientific exchange.

In the past few years we have also embarked on the building of much needed national facilities, and have started more organized collaborations with relevant foreign laboratories. The synchrotron radiation facility (PULS) in Frascati has been funded by the CNR on an extra 1981 budget (10^6 US$), while the pulsed neutron facility (LISONE) is now in a state of advanced planning with a funding appropriation for its main equipment of again an extra 10^6 US$ in 1981. The pulsed neutron source will be complemented by agreements with other nations with neutron facilities to allows reciprocal access.

Both facilities will be managed through the newly founded Istituto di Struttura della Materia (in Frascati), which will be built while keeping in mind the need to allow other joint activities by researchers throughout Italy. We hope that this will open up the prospect of finally building a centre for the cross breeding of this area of physical research in Italy.

There are some major problems which have not been solved by the Group's present structure:

a) The total budget is definitely below the minimum limit for initiating new activities or covering fields still with a very low activity in Italy (e.g. metallurgy and physical metallurgy etc.);
b) Applied research on a continuing basis is very difficult because of the size limitations;
c) Most of the Units lack technical staff and local facilities;
d) It is not possible to plan the research and technical staff as this part of the budget is not under the scientists' control;
e) The increase in industry positions for physicists, to which GNSM has greatly contributed, has depleted the Units in the more industrialized towns;
f) Student enrolment is stable in physics, but graduate students tend to prefer other types of physics or to go directly into industry.

To try to overcome this, GNSM has proposed a five-year plan which indicates ways out of the present situation, but... the bureaucratic viscosity makes it difficult to get a firm position out of the Government.

However, we now have enough experience of the GNSM to conclude that such a structure is well adapted to start and support scientific and technical programmes requiring a very strong exchange between different locations, institutions and disciplines. It is also successful in attaining very high productivities even in very difficult conditions. I suggest that a similar type of approach could be tried by developing countries, and could be programmed for specific fields in Europe, to counteract the problem periods associated with the funding and student enrolment crises expected in the near future.