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Physics in the German Federal Republic

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Germany has a long tradition of fostering physics research at the universities and, in addition, a tradition of encouraging applied physics and close relations with industry. "Technical physics" was introduced at some universities in the twenties, at a time when theoretical research was at the height of its success which may explain why about one third of all physicists work in industry. Germany's leading position was lost after 1933 through the expulsion of many of the best scientists, the government's neglect or fear of science, and finally through the war. Reconstruction began at first slowly but was greatly accelerated in the fifties and sixties — a little later than in most other countries. The expansion came to a stop in the early seventies. Today, about 3500 physicists hold posts at universities while the number of physics freshmen entering university is about 1300 per year. The corresponding figures for 1955 were about 600 and 300.

The number of physics students has ceased to increase in recent years, so we seem to be approaching an equilibrium in the employment situation. In 1971, the German Physical Society made a survey of physicists in the German Federal Republic excluding high school teachers. It found that about one half of them work in industry, one third at universities and research institutions ; the rest work in Ministries, administration and health services. The total number of physicists in Germany is about 15 000. If conditions remain stationary, we calculate a yearly need of physics graduates of less than 1000 but pessimistic estimates of their number suggest that it will be nearer 3000 in 1990. Unless therefore, the number of students decreases, considerable flexibility will be required of them when it comes to their future employment. In 1976, about 500 physicists were registered as unemployed, that is roughly three percent.

At the universities, about one half of the research is funded from the universities' budgets. Per physics chair (one professor and about four positions for scientists) about DM 150 000 are available per year for equipment and materials. The most important contribution beyond this comes from the Deutsche Forschungsgemeinschaft, for additional personnel, large equipment and smaller cost items. A typical grant is DM 50 000 per year ; one million DM is exceptional. Grants, in what is called "Normalverfahren" are awarded on application to the scientists after refereeing, but without giving priorities to special fields. A scientist may also file an application in a "Schwerpunkt" which has been suggested by a committee of scientists as a field where increased activity is desirable. For an increased local activity, especially in a field where several specialities must cooperate, a "Sonderforschungsbereich" may be created, with a yearly budget of one to several million DM. Tables 1-3 give break-downs of the three funding systems and, at the same time, provide a rather valid description of the distribution of research at universities in the various branches in physics.

Other funding sources for university research include foundations, of which the most important is the Volkswagenstiftung, and the "Bundesministerium für Forschung und Technologie" which makes important contribu-

Table 1
Normal Programme (Normalverfahren)
(1 January 1974 — 30 June 1976)

Physics of Condensed Matter	13	M DM
Physics of Atoms, Molecules, Gases and Plasma	11	M DM
Nuclear and Particle Physics	9	M DM
General Physics	4	M DM
Astronomy and Astrophysics	3	M DM
Geophysics	10	M DM

Table 2 — Priority Research Programmes (Schwerpunktprogramme)
(1 January 1974 — 30 June 1976)

Astrophysics	1	M DM
Electron optics	0,5	M DM
Bimolecular Reactions as elementary process	4	M DM
Physics of Polymers	6	M DM
International Magnetospheric Study	3	M DM
Relativistic Astrophysics	2	M DM
Liquid and Amorphous Semiconductors	1	M DM
Fusion oriented Plasmaphysics	1	M DM
Laser spectroscopy	8	M DM

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Table 3 — Special Research Areas (Sonderforschungsbereiche)

(from 1974 to 1976)

39	Synoptical Meteorology Berlin	5,0 M DM
65	Solid State Spectroscopy, Frankfurt/Darmstadt	4,5 M DM
67	Defect Structures, Stuttgart	6,9 M DM
73	Atmospheric Tracer Substances, Frankfurt/Mainz	4,1 M DM
125	Disorder in Crystals, Aachen/Jülich/Köln	3,7 M DM
126	Solid State Reactions, Göttingen/Clausthal	5,7 M DM
128	Stimulation on Surfaces, München	4,0 M DM
130	Ferro Electrics, Saarbrücken	2,1 M DM
131	Radio Astronomy, Bonn	2,7 M DM
132	Stellar Astronomy, Heidelberg	4,5 M DM
161	Interaction and Hyperfine Structure, Berlin	4,7 M DM
162	Plasmaphysics, Bochum	4,2 M DM

tions within the framework of the "Verbundforschung" or the "Förderungsschwerpunkte". Here, work is funded that is connected with particle accelerators, research reactors, space research, oceanography, and so on, see Table 4. Proposals for research usually come from the scientists and are reviewed by a committee of scientists, but the creation of the programmes reflects the science policy of the Ministry.

After the universities, the "Max-Planck-Gesellschaft" is the most important organization for fundamental research. In the field of physics, it operates the following Max-Planck-Institutes :

Aeronomie (upper atmospherics)	: Lindau/Harz
Astronomie (astronomy)	: Heidelberg
Biophysikalische Chemie (biophysical chemistry)	: Göttingen
Festkörperforschung (solid state)	: Stuttgart
Fritz-Haber-Institut (physical chemistry)	: Berlin
Kernphysik (nuclear physics)	: Heidelberg
Medizinische Forschung (medical research)	: Heidelberg
Metallforschung (metallurgy)	: Stuttgart
Physik und Astrophysik (physics and astrophysics)	: München
Plasmaphysik (plasma physics)	: Garching
Radioastronomie (radio astronomy)	: Bonn
Strömungsforschung (fluid dynamics)	: Göttingen

A typical institute has about a hundred scientists, with a budget around DM 20 Million. The Institute of Plasma Physics is larger with 250 scientists and DM 50 million.

The "Bundesministerium für Forschung und Technologie" (together with the respective Land governments) finances mostly industrial projects. In research it finances the "Grossforschungseinrichtungen", namely :

Deutsches Elektronen-Synchrotron (high energy physics) (DESY), Hamburg
Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt e.V. (aeronautics and space) (DFVLR), Köln
Gesellschaft für Kernforschung mbH Karlsruhe (nuclear research) (GfK), Karlsruhe
Gesellschaft für Kernenergieverwertung in Schiffbau und Schifffahrt mbH (nuclear ships) (GKSS), Geesthacht-Tesperhude)
Gesellschaft für Strahlen- und Umweltforschung mbH München (radiation und environment) (GSF), Neuherberg
Gesellschaft für Schwerionenforschung mbH (heavy ions) (GSI), Darmstadt
Hahn-Meitner Institut für Kernforschung Berlin GmbH (nuclear research) (HMI), Berlin
Max-Plank-Institut für Plasmaphysik (plasma physics) (IPP), Garching
Kernforschungsanlage Jülich GmbH (nuclear research (KFA), Jülich

Their total budget is DM 1100 million a year, with more than 4000 scientists, engineers and staff.

The part of physics in all this is difficult to estimate, because many of the programmes are mixed. It may be of the order of 15 percent.

The Ministry also finances the German contribution to international projects like CERN, ESA, the Grenoble High Flux Reactor and the European Southern Observatory. It also finances large new projects, the latest examples of which are the storage ring for electrons and positrons "PETRA" at DESY in Hamburg and the Heavy Ion Accelerator Unilac at GSI, Darmstadt. Such projects are proposed and refereed by scientists, but the decision is taken by the Minister.

Other ministries operate institutions for research in physics, too. The most important is the "Physikalisch-Technische Bundesanstalt" with 300 physicists and a yearly budget of DM 80 million. One other is the "Bundesanstalt für Materialprüfung" in Berlin, which has a strong component of engineering research. A relatively large number of smaller institutions are funded from various sources, often by one of the German "Länder". Examples are the "Institut für Spectroskopie" in Dortmund, financed by Nordrhein-Westfalen or the "Fraunhofer Institut für Sonnenforschung" in Freiburg, Baden-Württemberg. Physicists are of course active in many fields outside physics, for instance chemistry and engineering. An interesting example is research in theoretical medicine, which in Germany, for some reason is not very attractive to students with medical training.

Table 4 — Collective Programmes and Priority Areas of the Federal Ministry for Research and Technology

(1973 and 1974)

Pure and Applied Nuclear Sciences	500 M DM
Energy Programme	2000 M DM
Space Science and Technology, Aviation Technology	900 M DM
New Physical Technology	50 M DM
Oceanography and Marine Technology	120 M DM

We see that physics in the Federal Republic is quite varied in scope and resources, and in its inter-connections with other fields. Planning in research usually originates with the scientists themselves. This has led to a good use of the human resources in the field, and since the scientists are citizens like other members of the community, their plans and wishes do not usually diverge from those of the rest of the population. The scientist wants to be useful, and he himself knows best what he can do and what his limitations are. Therefore, it is probably all to the good that in the German Federal Republic there is no strong central planning authority for research.

For the future, flexibility is the most important aim. Nobody knows what the important fields will be in the lifetime of those who are now students. In the German Federal Republic, physics has not been divided into too many specialized fields and the connections with other disciplines, especially engineering, are still strong and we hope, growing. This again is a good omen for the future.