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Volume 57 **Strong and Ultrastrong Magnetic Fields and Their Applications**
Editor: F. Herlach

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Strong and Ultrastrong Magnetic Fields

and Their Applications

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Preface

In one way or another, magnetic fields have been involved in most of the important discoveries in modern physics. As new effects are often discovered after the extension of the range of a basic experimental parameter, continued efforts are made to design and build stronger magnets. For generating fields above 10–15 T, extraordinary technical efforts are required. The necessary resources are available only at a few large magnet laboratories which have been established for this purpose.

This volume gives a comprehensive review of experiments with such strong magnetic fields. The introduction includes a survey of magnet laboratories where strong magnetic fields are available for general experimentation; most of these facilities are open to guest experiments on rather generous terms.

At the present time, most applications are in solid-state physics. In particular, very strong fields are needed to affect quantum phenomena in semiconductors. In the extreme quantum limit, when all conduction electrons are condensed into the lowest Landau level, basic scattering mechanisms can be studied and theoretically analyzed with relative ease. Research on two-dimensional semiconducting systems has recently resulted in the discovery of another macroscopic quantum effect that occurs at very high magnetic fields. This is reflected in the chapter on *magnetotransport phenomena* which includes an extensive treatment of the theoretical background and an up-to-date discussion of two-dimensional systems and the quantum Hall effect.

Research in *magnetism* has evolved from the more practical applications into a testing ground for advanced statistical physics. As the interactions in a cooperative magnetic system are well defined, these are amenable to rigorous theoretical analysis. This can be checked against experimental results from samples with special characteristics that have been synthesized for this purpose. Very high fields are needed to compete with strong exchange interactions and to detect resonances which are broadened to the extent that they cannot be observed in lower fields.

Strong magnetic fields are well suited for studying large *biomolecules* in vivo. In research on this and related topics, great progress has been made in recent years. This chapter is the first comprehensive review of this new field of research. It includes research on polymers and polymerization reactions, liquid crystals, biological membranes and artificial multilayers, the separation of macromolecules in strong magnetic field gradients, and the influence of magnetic fields on living organisms.

At the present time, advanced electromagnets are designed mostly for plasma physics and *nuclear fusion research*. Here the general emphasis is more on large scale and special geometries than on the highest field strength. In this chapter the relative merits and trade-off considerations regarding an increase of the magnetic field strength are discussed, primarily with the example of the Alcator high-field tokamak. This gives a good view on the technical problems involved in modern high-field magnet design.

The final chapter points to the future. Techniques for experimentation with *pulsed magnetic fields* are now well developed but many researchers have been reluctant to adopt them for their experiments. Right now there is an increasing trend for switching to this method which is efficient, economical and nearly open-ended regarding the field strength. The revival of this trend initiated mainly in Japan and is now gradually spreading to Europe and to the USA. We describe methods for generating the fields as well as many experiments in the field range from 20 T to several megagauss. The megagauss (=100 T) is the limit above which the magnetic field violently destroys the field coil, thus requiring drastically different one-shot experimental methods.

This volume is intended to provide inspiration and guidance for making good use of the excellent magnet laboratory facilities that are now available worldwide.

Leuven, January 1985 *Fritz Herlach*

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