PRESENTATION OF LLB

The Laboratoire Léon Brillouin (LLB) is a facility that depends on both the Commissariat à l'Energie Atomique (CEA) and the Centre National de la Recherche Scientifique (CNRS). Its aim is to carry out fundamental and applied research in the field of condensed matter using neutron beams supplied by the reactor Orphée.
As a national laboratory, the LLB facility is opened to external users (via a written proposal and Selection Panel procedure), coming in priority from french laboratories, but also to some extent from foreign countries (mainly of European Union and Central and Eastern Europe).
The LLB both carries its own scientific research programme covering different fields of condensed matter physics, and collaborates closely with many scientists of the french and foreign communities, coming mainly from fundamental research laboratories, but also from applied research and industry. The synthesis of activities and the highlights presented in this Report, as well as the list of publications (more than 250 per year), show that the ensemble of research performed at LLB encompasses a very large scientific domain, in physics, chemistry, biology, materials science and geosciences.

The reactor Orphée and the LLB instruments

Orphée (which operates since december 1980) is the most recent and the highest flux medium size reactor, especially designed to produce thermal neutron beams for fundamental research. It is managed by the Direction of Nuclear Reactors of CEA.
Orphée has a very compact highly enriched ^{235}U - 34% Al core, a heavy water reflector and a light water swimming pool.
The variety of problems studied by neutron scattering requires a neutron wavelength (and energy) distribution as broad as possible : small wavelength to explore a large volume of the reciprocal space for atomic structure resolution, large wavelength (and therefore low energy) to study large scale structures up to a fraction of µm and to perform high resolution energy spectroscopy (neV to meV scale). This is solved by local thermalization of 3 neutron beams by a hot source (heated graphite, 1400 K), of 8 others by two cold sources (liquid hydrogen, 20 K), the 6 remaining ("thermal" beams) being thermalized at the temperature of the D_2O moderator (300 K). This makes available incident neutrons of any wavelength ranging from 0.5 to 15 Å. 6 cold neutron beams are distributed in a guide hall via neutron guides. The design of the 9 horizontal neutron beam tubes (which point tangentially towards the core) and of the 6 curved neutron guides, has allowed to considerably reduce the background due to fast neutrons and γ-rays coming from the reactor, and to optimize the signal-to-background ratio measured on the spectrometers.
The Orphée reactor is maintained at the best possible working order and safety requirements : in 1997, the zircaloy housing core has been replaced; the safety authority undertook a detailed examination of the reactor, and declared itself quite satisfied with it.
A layout of the reactor hall and the neutron guide hall instrumentation is shown in the joined figure. The characteristics of the 24 neutron scattering instruments opened to external users are given in Table 1. Two other new instruments (a small-angle diffractometer with polarized neutrons "PAPOL", and a neutron resonance spin-echo spectrometer in G1bis, see below) will be partly opened to users at the next Selection Panel.
In addition to neutron scattering, a part of Orphée reactor activity is devoted to other utilizations : non-destructive testing by neutron radiography, chemical analysis by neutron activation, irradiation of silicon for the industry and elaboration of isotopes for medical use. These activities are not described in the present Report.

Collaborations

Several collaborations with other countries, particularly European, have been developed, and the international character of the laboratory appears clearly in the large number of publications where, for example, several researchers (worldwide) appear as co-authors. The LLB is consequently an ideal place for the exchange of scientific ideas and for the establishment of collaborations.
Among the international collaborations, it is worth mentionning some particularly intense and fruitful ones.

1) Germany. An agreement exists since 1979 with the Kernforschungszentrum of Karlsruhe, following the CRG principle. It concerns two spectrometers : the triple-axis 2T and the 4-circles 5C2. The latter is supervised by the University of Aachen (prof. G. Heger). Two german physicists and one technician work on a permanent basis at LLB.

The Technical University of Munich has built between 1995 and 1998 a spectrometer of the resonant spin-echo type; one physicist is supported by this University.

2) Austria. Since 1980, a 3-axis spectrometer works also in the conditions of a CRG. This collaboration was initiated by Prof. O. Blaschko, unfortunately deceased in 1997. The responsibility of the scientific programme is now assumed by Prof. P. Fratzl (University of Leoben) and Dr. G. Krexner (University of Wien), and one physicist is permanently at LLB.

3) Italy. One of the largest users, Italy established an agreement with LLB that corresponds to a financial participation. Another agreement concerns the renewal and the utilisation of the diffractometer DIANE (G5.2), that studies residual stresses in the field of materials science.

4) Russia. Three agreements of scientific collaboration have been signed in 1994 by the CNRS and the CEA with the Petersburg Nuclear Physics Institute of the Russian Academy of Sciences, the Kurchatov Institute at Moscow, and the Joint Institute of Nuclear Research at Dubna.

A new diffractometer for the study of the structure of powders at high resolution, built at Gatchina, is now at LLB (in G4.2 in the guide hall), where it has been inaugurated in 1997 (see photographs).

5) Hungary. A collaboration has been established with the Neutron Physics Department of the Research Institute for Solid State Physics at Budapest (Prof. L. Rosta).

6) Other international operations concern Morocco, Korea and China.

The LLB continues also a very fruitful collaboration with the Institute Laue-Langevin (ILL), namely in the domain of instrumentation, in particular on the elaboration of polarizing Heusler single crystals.

It participates also (since july 1998) in the pool that uses as a CRG the backscattering spectrometer IN13 at ILL, mostly used for biological studies.

Finally, in the international domain, the LLB benefits since 1993 from the funds of the "Large Scale Facilities" access programmes ("Human Capital and Mobility" (1993-96) and "Training and Mobility of Researchers" (1997-2000)) for the countries of the European Union and associated states, extended in the case of HCM to PECO countries. Within this frame, the LLB participates in the network XENNI (The 10-Member European Network for Neutron Instrumentation).

Undertaking an important role in the training of young scientists, the LLB participates in the european course HERCULES, organises and participates in many workshops, schools, educational meetings, and organises visits of its installations. Some of the visits, during specific days, are adressed to a more general public.

The tables and statistics shown at the end of this Introduction (list of LLB staff, of long-term visitors and post-docs, and of PhD students) and in the chapter "Experimental Programme and User Activities" give a numerical idea of the ensemble of the activities. Even non exhaustive, they show how much the LLB is a tool used by several hundreds of researchers and students coming from many different places and disciplines. More than the numbers, the scientific production, as mirrored by the list of publications, shows the richness of the research activity, and the devotion of all the staff : permanent researchers, engineers and technicians of LLB and Orphée, administrative staff, associated researchers, post-docs and PhD's. It is due to their work and competence that the LLB can be considered among the most recognised places for neutron scattering research.