30 years of Austria's accession to the ILL - Grenoble

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Preliminary remarks: At the end of June 2022, a celebratory event was held in the renovated premises of the Austrian Academy of Sciences (ÖAW) to mark Austria's 30 years of membership in the ILL. This was already planned for 2020, in line with Austria's accession in 1990, but could only be realised two years later after several postponements due to the rampant Covid epidemic. Organisationally, this celebration was combined with an invitation to the ILL to hold the regularly scheduled 114th meeting of the Steering Committee as part of this event, which meant that both the extended ILL Board of Directors and representatives of the founding countries F, D, UK ('Associates') operating the ILL and the various member countries ('Members') that have joined over time were able to attend the festive event in Vienna.

The following overview of the history and scientific significance of Austrian membership was written against this background.

Today, neutron scattering is one of the most universal and at the same time most precise methods for investigating the spatial structure and temporal dynamics of condensed matter, i.e. solids and liquids. It is unrivalled in many respects, both qualitatively and quantitatively. This is primarily due to the electrical neutrality of neutrons, which enables them to penetrate deep into the interior of matter and explore the current position and state of motion of the atoms and molecules there almost non-destructively. The fact that neutrons possess magnetic moments despite their electrical neutrality, contrary to the ideas of classical electrodynamics, also predestines them in a unique way for the investigation of magnetic phenomena with atomic resolution, i.e. directly at the place where these phenomena occur.

The range of applications of neutron scattering is immensely large, and its contributions are indispensable to the application-orientated problems of high technology and materials science, as well as to basic research in physics, chemistry, biology and geosciences. This range extends - to name just a few typical examples - from high-temperature superconductors, magnetic storage, high-performance

ceramics, semiconductors and superalloys to glasses, polymers, metal hydrides, electrolytes, catalysts, biological macromolecules, membranes and foodstuffs as well as fundamental questions of quantum theory and nuclear physics. Moreover, this impressive variety of applications is still growing.

In this role, neutron scattering is certainly indispensable in the long term, despite the enormous progress made in the development of competing methods, and cannot be fully replaced by any of the other existing techniques. Moreover, research with neutrons represents one of the few fields of science and high technology in which Europe can be considered a world leader. Although the focus in the construction of new neutron laboratories worldwide is increasingly shifting from reactor to spallation sources, the high-flux reactor at the Institut Max von Laue - Paul Langevin (ILL) in Grenoble can still be regarded as the world's most powerful centre for research with and on neutrons. Apart from the high neutron flux, this is particularly true in terms of the number of instruments and measurement techniques available and the range of applications. It can be assumed that the ILL will retain this position beyond the completion of the European Spallation Source ESS, at least until the early 2030s.

In addition, the commissioning and continuous expansion of the ESRF (European Synchrotron Radiation Laboratory) since around 1992 and the EMBL (European Molecular Biology Laboratory) since around 2002 have created synergies in Grenoble that are unique in many respects worldwide.

The Institut Laue Langevin (ILL) is the result of an initiative launched by Konrad Adenauer and Charles de Gaulle as a sign of international understanding between France and Germany. The intensive collaboration between Professors Louis Néel and Heinz Maier-Leibnitz made a decisive contribution to its successful realisation, which ultimately made it possible to found the institute in Grenoble in January 1967.

The aim of this partnership was to create the world's most intensive neutron source for basic civilian research and to provide scientists from the participating countries with the associated high-performance instrumentation. In 1971, the European High Flux Reactor, with its then innovative status as a service institute offering world-class conditions and global exclusivity to the scientific community, became critical. In 1973, the UK joined the Institute as an equal partner. Since then, the ILL has been operated by the three founding countries ('Associates')

- **Germany**, represented by the *Research Centre Jülich GmbH (FZJ)*
- **France**, represented by *Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA)* and *Centre National de la Recherche Scientifique (CNRS)*
- **Great Britain**, represented by *United Kingdom Research & Innovation (UKRI)*

The access to research at the ILL has been considerably expanded over the years through co-operation with an increasing number of partner countries ('members') within the framework of multi-year agreements (including Spain in 1987, Switzerland in 1988, Austria in 1990, Italy in 1997, the Czech Republic in 1999, and since then around half a dozen other countries).

The fall of the Iron Curtain inevitably opened up completely new perspectives for cooperation with our eastern neighbours from around 1990. In the Czech Republic in particular, where there had always been a lively scene of highly qualified neutron researchers, with whose leading representatives contacts were quickly established on a private basis after the fall of the Iron Curtain, the Austrian research community gradually found an ideal partner with similar interests. The idea was finally born to form a joint consortium that could act as a single partner vis-à-vis the ILL. The main advantage of this association was that the annual fixed costs to be paid to the ILL by each partner could be borne jointly. For the Czech Republic, which would have found it difficult to cover the fixed costs on its own, this was the only way to gain access to the ILL's high-flux reactor. But Austria, which had officially joined the ILL in 1990, also clearly benefited financially from sharing the costs.

An initial contract between ILL and this MENI consortium (Middle European Neutron Initiative) with the Austrian Academy of Sciences as consortium leader was first concluded in 1999 and extended with slight modifications for a further five years in 2005, with Hungary also joining the consortium as a member for one contractual period, but later withdrawing again. Apart from the financial benefits for both partner countries, the establishment of this consortium also had other positive effects. The regular exchange of information between the representatives of the two countries, which had already been agreed before the Czech Republic joined the EU and had always taken place in an exceptionally friendly atmosphere, subsequently led to

regular scientific contact and close cooperation in joint projects, which stimulated the scientific communities in both countries.

After Slovakia also joined the consortium in 2009, it was jointly decided to rename it the Central European Neutron Initiative (CENI) to reflect the geographical location of the three partner countries following the recent EU enlargement. In the long term, CENI could also have become the nucleus of a larger Central European research network with more weight at the ILL, similar to existing research collaborations in the Scandinavian countries, where the responsible ministries, funding organisations and universities work together intensively for the common benefit. However, changes in the framework conditions, both with regard to the design of the contracts by the ILL and with regard to the research policy conditions in Austria's neighbouring countries, have once again led to a regulation of membership via individual contracts of the respective countries for the contract period from 2023.

The ILL in Grenoble can justifiably be described as a model of success on a global scale. Currently (as of 2024), around 1,000 experiments are conducted annually by approximately 1,500 researchers from more than 40 countries in a wide range of disciplines. Due to the large number of proposals submitted, the requested measurement time on the ILL instruments always significantly exceeds the actual time available. Scientific life at the ILL is organised in around ten 'colleges', within the framework of which international review committees select the best experimental proposals twice a year, thus ensuring that the ILL's scientific programme meets the highest standards. By constantly adapting its instrumentation to the latest technology, it also offers the research community unrivalled opportunities to realise their projects.

In the years since around 2010, due to the scientific quality of the proposed experiments and the resulting publications, the use of the ILL by Austrian scientists has regularly and in some cases considerably exceeded the measurement times to which Austria is entitled in accordance with the membership fee paid, which was benevolently tolerated by the ILL for a short time, but could not be accepted in the long term without adjustment. The founding of the NESY (Research on Neutron and Synchrotron Sources) expert committee of the Austrian Physical Society in 1996, whose members and representatives are available at any time to provide advice and assistance to potential neutron users in exploring the possibilities of neutron scattering

and its actual experimental implementation, as well as the organisation of regular winter schools, has undoubtedly contributed to this.

In the latest available statistics, which cover the contract period from 2019 to 2023, almost 90 experiments were carried out on 33 different instruments, involving a total of around 100 Austrian scientists. The performance of the Austrian scientific community in the field of research with neutrons is also impressively demonstrated by the number of approximately 140 peer-reviewed publications in international scientific journals (including numerous 'highlights'), which a literature search for the above-mentioned period from 2019 to 2023 reveals. In addition, there are numerous other publications not directly resulting from experiments at ILL that use neutrons at other research institutions, in whatever field, as a central tool: without the scientific environment created by access to ILL, all of this work would hardly have come about, or only to a much lesser extent.

In order to meet this ever-growing interest and success of the Austrian user community, it was possible, with the support of the Ministry of Research, to increase the Austrian beam time share in the ILL to 2.5 percent on the occasion of the last contract extension. Together with an extension of the contract term from five to seven years, this has created an excellent basis for the period 2024 - 2030.

Finally, a historical peculiarity that sheds light on Austria's participation in the ILL from a different perspective should be pointed out at this point: Helmut Rauch (†2019), for many years head of the Atomic Institute at TU Wien, has operated the "S18" instrument at ILL since the mid-1970s - 15 years before Austria joined ILL in 1990 - as part of a collaboration between his research group and the Dortmund group led by Ulrich Bonse (†2022), which was originally designed as a pure neutron interferometry measuring station, but has since also become the "gold standard" for ultra-small angle scattering experiments with neutrons (USANS). Finally, neutron interferometry with perfect crystals, first realised by Rauch et al. in the early 1970s, is still the only way to coherently split and successfully recombine matter waves over macroscopic distances of several centimetres - a powerful tool for investigating and verifying fundamental quantum mechanical phenomena, which has led to numerous spectacular and groundbreaking results and their publication in the most renowned scientific journals (Physical Review Letters, Nature, etc.).

The S18 device was specially designed for interferometry experiments, which is undoubtedly one of the most experimentally demanding techniques that neutron research has to offer. Due to its complexity and the extraordinary requirements in terms of sensitivity and stability, it could therefore not be operated in the usual ILL user mode, which meant that for a long time it did not appear at all in the statistics on the utilisation of the ILL by Austrian scientists. It is obvious that the operation of S18 by two groups with very different research orientations, especially due to the laborious conversion of the experimental set-up, sometimes led to considerable friction losses. This unsatisfactory situation changed when Austria officially joined the ILL in 1990, as S18 was now operated as a so-called "CRG-C" (Collaborating Research Group) instrument financed exclusively by Austria. "C" means that it is not used for the normal ILL user programme, but that it is at the sole discretion of the Austrian operators who may carry out experiments on it. The "normal" ILL user would have no chance of mastering this complex instrument without extensive training.

With effect from 1 January 2014, a contract between the ILL-Grenoble, the Federal Ministry of Science and Research and the Atomic Institute of TU Vienna stipulates that the S18 instrument will in future be operated as a CRG-B, with 70% of the measurement time allocated to the Atomic Institute and 30% to ILL, i.e. external users. In return, however, the infrastructural support from the ILL will be increased accordingly. However, as already mentioned, the co-operation of the scientific staff seconded by the Atomic Institute or permanently working on site anyway is absolutely essential for the successful execution of experiments. Finally, it is very pleasing to note that, after almost 50 years of operation, it has finally been possible to completely modernise the experimental set-up of S18 and its electronic equipment and bring it up to the latest state of the art thanks to generous financial support from the Ministry and FFG funding. No less pleasing is the fact that TU Wien has included the operation of S18 in its current performance agreement as part of Austria's participation in ILL.