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ACTINET: a European Network for Actinide Sciences

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ABSTRACT: Because of its strategic importance for the development of a dynamic and sustainable science-based nuclear industry, the European research in actinide sciences deserves to be revitalized. ACTINET is a consortium of more than twenty five European research organisations, supported by the European Commission. Its objective is to take some steps in order to bring both research infrastructures and human expertise in Europe at an adequate performance level in the fields of physics and chemistry of actinides. This paper describes the main features of the network.

KEYWORDS: *Actinides, Network, Europe*

I. INTRODUCTION

The European Union currently produces 35% of its electricity from nuclear fission. Furthermore, it should maintain a diversity of its sources of energy supply [1]. Nuclear fission is therefore likely to contribute substantially to the European energetic mix in the future, as an option to reduce the energy dependency of the European Union, while avoiding greenhouse gas emission. In this context, research and technological development will play an important role.

Although the nuclear industry has now come to maturity and operates nuclear plants with a high level of safety and efficiency, some issues in the field of the back-end cycle and resource management remain open. Research and Development are needed to explore new concepts for nuclear energy generation that make better use of fissile material and generate less waste. One other major issue requiring intensive Research and Development programs remains a broadly agreed approach to waste management. All these issues require expertise and improved knowledge of the processes involved in the behaviour of fuels in reactors or transmutation targets, spent fuel treatment, as well as a comprehensive understanding of the processes governing the behaviour of high level waste in storage and disposal systems.

Advanced research in actinide sciences is therefore recognized as one essential endeavour for further development of a dynamic, competitive and sustainable knowledge-based nuclear industry.

As a general trend of nuclear science and technology, assessment of the behaviour of nuclear systems rely more and more on basic scientific understanding of each component, down to the nanometre and atomic scales. This requires further development of basic knowledge, which in turn needs to be supported by state-of-art experimental capabilities. Maintaining high-performance research infrastructures and expertise are therefore necessary to allow science-based decision-making on issues of great relevance for the industry, and for the public.

However, during the past decades, safety requirements have gradually made researches on actinides very costly, many radiochemistry laboratories in Europe have restricted their activities on actinides, and the actinide sciences have become less attractive for young scientists. At present, only few European national research institutions are able to maintain the necessary infrastructure to perform research at the relevant scale, and to support education in actinide sciences.

Because of its strategic importance, the research in actinide sciences must therefore be revitalized. Reinforcing links between national nuclear research institutes, the Joint Research Centre of the European Commission, and radiochemistry laboratories of academic research organisations, is necessary to maintain in Europe the threshold level of excellence and research in actinide sciences. This networking will not only facilitate the coordination and utilization of the available facilities, but also consolidate and optimise research programming and training capacities in Europe.

The objective of the ACTINET network is to take some steps in order to bring both research infrastructures and human expertise in Europe at an adequate performance level in the fields of physics and chemistry of actinides.
More specifically, ACTINET has a three-fold objective, related to i) research infrastructures, ii) research programmes, and iii) education and training:
i) A global European infrastructure policy is necessary, in a context where the available tools are scarce resources, scattered among several institutes. Some facilities are redundant, while others are either missing or difficult to gain

access to by academic researchers. It has been chosen to proceed step-by-step, starting by improving the accessibility of the major facilities to the scientific community, then optimising their utilisation at the European scale, and finally coordinating the future deployment of new facilities and instruments (see section III below);
ii) Offering the access to up-to-date major experimental tools must be accompanied by the definition of shared ambitious research programmes, and by improved mobility between the involved institutions, in particular between academic institutions and national laboratories, in order to reduce the fragmentation of the European community of actinide sciences. The objective of the network is to stimulate and support joint research projects proposed by member organisations. The support essentially consists in access to pooled facilities and funding for the mobility of researchers and radioactive samples (see section IV below).
iii) Enhanced mobility and enhanced availability of the infrastructures for joint research programmes will allow the next generation of actinide scientists and engineers to gain hands-on experience as part of their training. The objective is to coordinate and increase the attractiveness of actinide sciences among European students. The network also supports a stronger participation of national laboratories in training at the universities, as well as a stronger use of facilities for teaching and training (see section V below).

II. ORGANISATION OF THE NETWORK

ACTINET is a consortium gathering more than twenty five European research institutions. It was established in March 2004. The consortium is supported by the European Commission under a four year contract within the sixth Framework Programme for Research and Technological Development. However the network is designed as a long lasting structure, and intends to operate beyond this four year period.
The members of the network range from large national laboratories to smaller university departments, thus bringing at the same time major experimental facilities, training experience, academic and applied research capacities, within the broad area of actinide sciences.
Four member organisations form a “core group” of the network: the Commissariat à l’Energie Atomique (CEA, France), the Institute for TransUranium elements (ITU, Joint Research Centre of the European Commission, in Karlsruhe, Germany), the Forschungszentrum Karlsruhe (FZK, Germany), and the Centre d’Etudes Nucléaires (SCK-CEN, Belgium).

With 9 research centres the CEA has at his disposal a set of unique facilities and operates in the fields of nuclear energy (support for nuclear power stations, design of future reactors and fuels, safety, waste management…), defence, technologies, and fundamental research in physics and life sciences.
The ITU is one of the few European centres dedicated to Actinide research with appropriate operating facilities. It is one of the Institutes of the Joint Research Centre of the European Commission.
The Forschungszentrum Karlsruhe GmbH (FZK) is a research institution working in the area of technology and the environment. The Institut für Nukleare Entsorgung (INE) is part of the FZK and works in safety research for nuclear waste disposal.
The Belgian Nuclear Research Centre (SCK-CEN) plays in Belgium a major part in radioactive waste management and site restoration, in nuclear reactor safety and radiation protection.

The network is coordinated by the CEA. A Governing Board formed of representatives of each member organisation, is responsible for the general policy and strategic orientations of the network. It provides budget guidelines and takes decisions regarding inclusion, exclusion, or withdrawal of a member organisation, etc. The Governing Board appoints an Executive Committee and a Scientific Advisory Committee. The Executive Committee is responsible for the day to day management of the network, while the Scientific Advisory Committee provides general scientific guidance and acts as referee for the selection of internal research projects (see section IV below).

III. POOLED FACILITIES

A first priority objective within ACTINET is to pool selected parts of the major facilities of some large European institutes (CEA, ITU, INE, SCK-CEN, Forschungszentrum Rossendorf (FZR), and Paul Scherrer Institut (PSI)), and to operate this pool as a multi-site user facility, in order to make it accessible to all members through a competitive selection of joint research projects.

The pooled facilities are laboratories that allow handling radioactive material at various levels of activity (from dilute solutions to high concentrations of actinides and spent nuclear fuel) and under specific conditions (inert gas boxes), with access to analytical techniques and specific characterization methods (elementary and isotopic analysis, laser spectroscopy, synchrotron radiation etc.). The main ACTINET pooled facilities are listed below and more details can be found at http://www.actinet-network.org.

The CEA provides the LN1 Laboratory in Marcoule, the LECA laboratory in Cadarache, and the DPC analytical platform in Saclay.
The LN1 is a part of the ATALANTE facility. It has been commissioned in April 2005, and it is dedicated to molecular chemistry of all actinides in solution, solid state and at interfaces. It brings together selected techniques to obtain structural information, speciation and thermodynamic properties.
The LECA has a set of shielded analytical equipment able to characterize highly irradiated fuels and materials, including electron probe micro-analysis, scanning electron microscope, and secondary ion mass spectroscopy.
Finally the Analytical Platform of the Department of Physics and Chemistry provides a large set of analytical tools, and the instruments for characterisation of the chemical retention of inactive tracers or radionuclides on natural and industrial

solid phases.

The ITU provide instruments for the study of solid-state properties of actinides compounds with particular emphasis on metals and alloys, instruments for the study of the thermodynamics, the thermophysics and radiation damage with particular emphasis on oxides, and instruments for solid-liquid interface chemistry.

The FZK-INE provides an analytical platform with radio-analytical methods, trace and isotope analysis, surface and solid-state analysis, and a wide spectrum of speciation methods. INE also provides an access to the FZK synchrotron radiation source ANKA dedicated for the study of actinides.

The SCK-CEN provides access to the LHMA hot cell facility (shielded cells for the post irradiation examination of fuel rods and core components), solid state research tools for nuclear samples, chemical and radiochemical analysis tools.

FZR provides access to the Rossendorf beam-line, at the European Synchrotron Research Facility in Grenoble (France), and to a pool of laser spectroscopic tools at the Rossendorf Laser Laboratory.

Finally PSI will provide the microXAS beam-line at the Swiss Light Source (SLS), which will be operational later in 2005.

A number of issues have to be dealt with in order to reach operation as a multi-site user facility. Among them are:
- implementing improved regulations and procedures to allow or ease access to and use of some facilities, including mutual acceptance of safety certificates already obtained by researchers at their home institutions or at other ACTINET institutions,
- preserving compatibility between users, in particular between academic ACTINET users and industrial users, including potential issues as confidentiality and planning,
- facilitating accommodation for ACTINET users,
- implementing or adapting the necessary trainings for ACTINET researchers, and last but not least,
- implementing a viable economic model for the operation of the multi-site user facility in the long term.

An optimal use of the pooled facilities furthermore requires exchanging scientific and engineering expertise to improve the experimental set-ups to meet common ACTINET user requirements, and improving compatibility and convergence of reference databases, software tools, and data processing methods, to be jointly used to allow a better comparison and interpretation of experimental results within the network.

In the same spirit as the pooling of experimental facilities, the model will be extended to theoretical expertise for the modelling of systems containing actinides. The objective is to bring together in a long lasting structure (the Theoretical User Laboratory) the tools and expertise available in European actinide modelling and simulation, and to make these available to the whole European community of actinide scientists, in order to create an environment that will enable each research worker to come to grips with the problems of modelling systems of interest. The needed resources include both tools (access to local and national computing equipments and software) and human expertise. The concentration or networking of these resources should enable interested workers to make rapid progress in their research, thus contributing to spread expertise within the Network, increase the attractiveness of the field for students and young researchers.

IV. JOINT RESEARCH

ACTINET supports joint research projects proposed by teams from the member organisations. These research projects potentially address all the major fields of basic actinide sciences, keeping in mind the potential applications for the production of nuclear fission energy:
- The safety assessment of waste management strategies is a major issue, including geological disposal of radioactive wastes, and partitioning and transmutation of long-lived radionuclides on an industrial scale, which has to be established through demonstrations on weighable quantities of radionuclides. This requires an adequate understanding of the behaviour of materials containing actinides (fuels, waste matrices, transmutation targets), and of the chemistry of actinides in geochemical environments and in partitioning processes.
- Furthermore, in-depth technical assessments are and will remain required to support operation of existing nuclear plants and improve their performance in terms of safety, economy and flexibility. This covers issues such as increased fuel burn-up, longer fuel cycles, extension of plant life, power up-rating, and therefore requires a better understanding of the fuel behaviour under reactor conditions and after irradiation.
- Finally, the potential of innovative concepts for better use of fissile resources must be investigated and evaluated in terms of safety, economy, reliability, environmental impact, resistance against proliferation, and diversity of application. The assessment of these new concepts also requires considerable amount of experimental and modelling work on systems involving actinides.

Three calls for collaborative research projects have already been published within the network. Thirty-five research projects have been selected by the Executive Committee after evaluation by the Scientific Advisory Committee. For these projects, ranging from instrumentation to quantum chemistry, from solution chemistry to the physics of irradiated actinide materials, access is given to the requested pooled facilities, and support is given for mobility, accommodation, sample transports.
These projects (see the list at http://www.actinet-network.org) have been undertaken by the end of 2004 or early 2005 and are now in progress, while the next call has a deadline in December 2005.

V. EDUCATION AND TRAINING

Today some European academic centres still have a teaching

activity and research programs in actinide sciences, although they usually lack support for renewing equipment, for increasing their staff and sometimes for keeping courses in nuclear sciences. In addition some scientific events, such as summer schools, workshops and symposia on actinides are regularly organised or have been proposed for the near future, and ACTINET members are organisers or actors in these meetings, e.g. ACTINIDES'05 organised in July 2005 in Manchester (UK), or the "Jounées des Actinides" scheduled in March 2006 in Oxford (UK).

Some of these education and training activities and resources are put in common within the network. In particular, a stronger participation of the ACTINET core members in training at the universities is planned, as well as a stronger use of the pooled facilities.

Calls for education and training projects are published jointly with calls for joint research. Six schools or workshops have been selected up to now and have been or are being organised with the support of the network;

Furthermore, an ACTINET Summer School (AnSS) has been established, and is organised alternately by ITU and CEA. The AnSS consists in lectures, visits of laboratories, and laboratory demonstrations during which the participants can learn and experience the challenges of working with actinides.
The ITU ACTINET Summer Schools cover basic actinide chemistry, physics and material science, while the CEA ACTINET Summer Schools focus each time on a different field of actinide sciences: the first AnSS was organised in June 2004 in Avignon (France), and dealt with "Thermodynamics and Kinetics of Liquid-Liquid Extraction", the third AnSS will take place in Saclay (France) in 2006 and will deal with "Geochemistry and Migration of Actinides".

Finally, a winter school "theory for experimentalists" is scheduled early 2006 in the framework of the Theoretical User Lab, with the objective of stimulating the interactions between experimental investigations and modelling efforts.

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REFERENCES

1. Green Paper "Toward a European strategy for the security of energy supply" published by the European Commission in 2000.