

Jožef Stefan Institute

Fusion Research in Slovenia

The Announcement of the International Thermonuclear Experimental Reactor (ITER)

By Saša Novak and Milan Čerček

site in south France, which came in June 2005 after long negotiations of the partners, was an event that increased not only interest in fusion research within the European research community, but has also thrown more light on the need for solving the problem of increasing energy demands and decreasing amounts of energy sources for the

future.

Without doubt, the wellbeing of the world's population is closely connected to energy supply, and as a result the development and construction of fusion power plants is becoming a common global interest. It is for this reason that the international scientific and technological community has joined forces in an international fusion research programme, the second largest project after the International Space Station. The experimental fusion

reactor, known as ITER, is going to be built within about the next ten years and will hopefully bring us closer to harnessing the power of a clean, safe and inexhaustible source of energy.

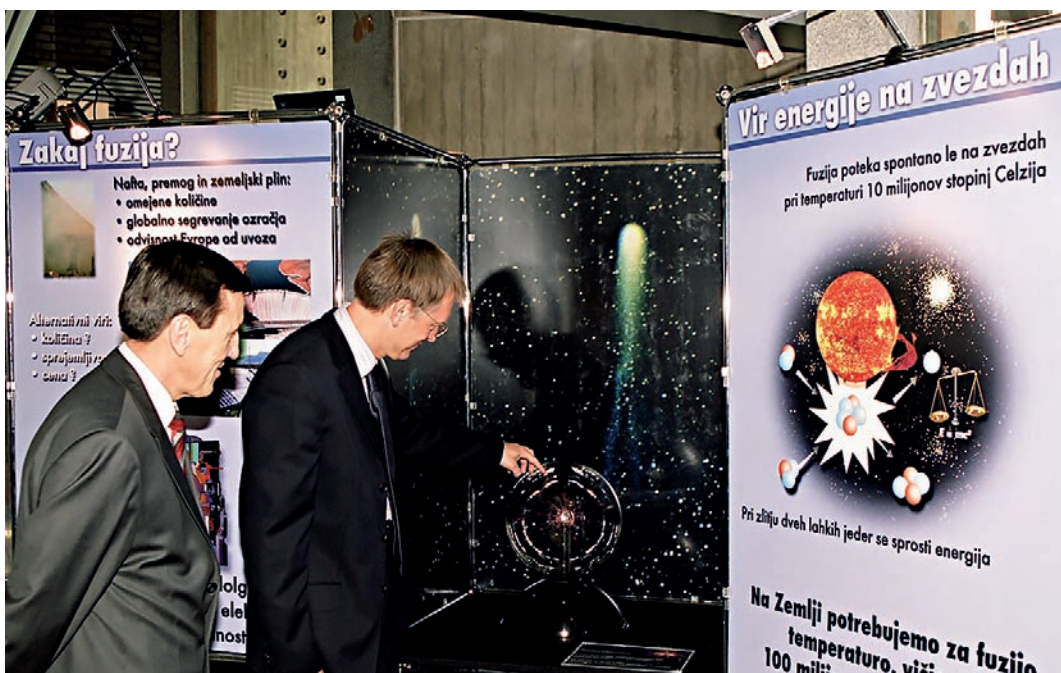
Until recently, fusion research was in the shadows and largely unnoticed, and the progress made over the past 50 years has gone to a large extent unnoticed. It is not, for instance, widely known that ITER is the follow-up to a significant number of tokamaks that have been constructed in a number

of countries, and that it will be the predecessor of the demonstration power-plant DEMO, the last test device before a commercial power plant. With the site for ITER in Europe, there will be great opportunities for research institutions as well as for industry.

Slovenia in the European Fusion Programme

Slovenian scientists have long been collaborating in numerous fusion-related projects, so that the establishment of the **Slovenian Fusion Association**, SFA Euratom – MHEST (www.sfa-fusion.si) in March 2005 was very much the official act of joining Slovenia to the European fusion research programme, more than a start of activities. The primary mission of the SFA is to contribute to knowledge supporting the development of the future fusion reactor, but it also aims to improve public awareness of our energy needs, to increase the acceptance of nuclear fusion and to support the involvement of Slovenian industry in the construction of ITER. As its first action, the SFA organised, in collaboration with the European Commission, an exposition, **Fusion EXPO**, at Gallery TR3 in Ljubljana, where more than 2300 people had the opportunity to learn more about fusion – the background and potentials, as well as more about fusion research in Slovenia. After ten days of the exposition in the centre of Ljubljana, the exposition settled at the Reactor Center of the Jožef Stefan Institute in Podgorica. Every year, more than 8000 visitors to the Center, mostly secondary-school pupils, get a lot of information about energy needs and demands, and about the potential for fusion energy, the basics of the technology, and ITER.

The Slovenian Fusion Association, established on the basis of a contract between the European Commission and the Ministry of Higher Education, Science and Technology, is organised as a research group led by **Prof Milan Čerček**, who has been engaged in fusion as a researcher at the **Reactor Physics Department, Jožef Stefan Institute**, for many years. The major part of the research unit is represented by groups at the Jožef Stefan Institute, who are presently engaged in nine projects, strongly linked with the international community. Besides the departments at the Jožef Stefan Institute, the LECAD laboratory at the Mechanical Engineering Faculty,



The Fusion Expo was honoured by a visit from the European Commissioner, Dr Janez Potočnik. He was guided at the exposition by the Head of the Slovenian Fusion Association, Dr Milan Čerček.



The structure and operation of the ITER experimental fusion reactor was first demonstrated in Slovenia as an interactive model at the Fusion Expo in the TR3 Gallery in Ljubljana.

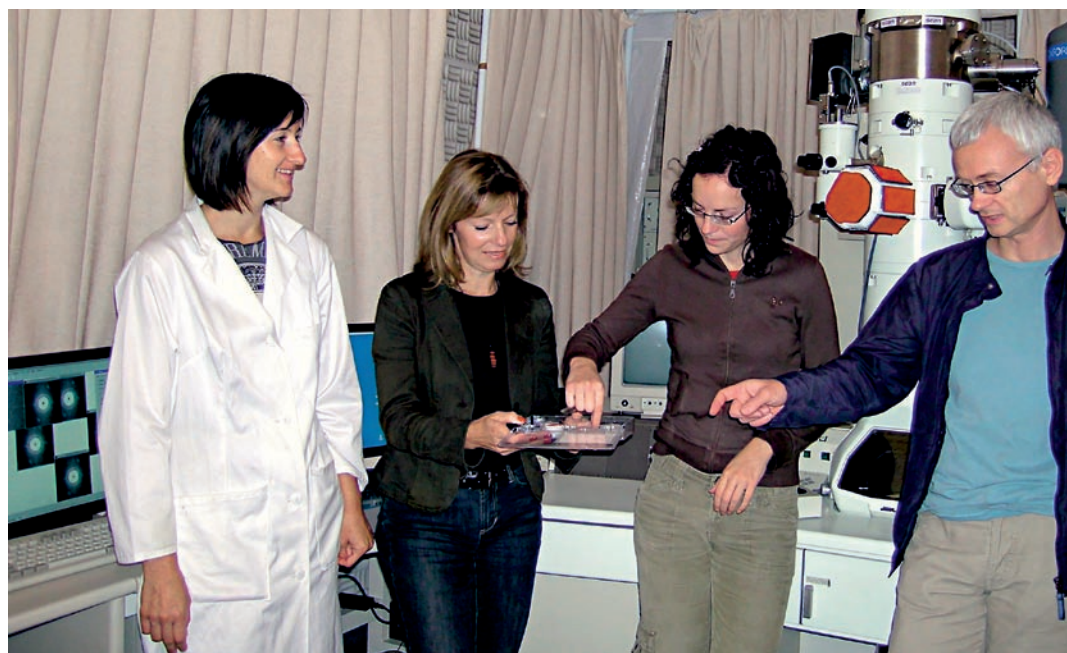
University of Ljubljana, and the associated, University of Nova Gorica, are also participating in the programme.

The fusion research programme in Slovenia

The contribution of the institutions in the Slovenian Fusion Association to several areas of the fusion programme are based on the R&D experience of the researchers in the fields of nuclear, atomic and plasma physics, materials science, mechanical engineering and computer-aided design. The major equipment available in the institutions includes an ion-beam accelerator with material diagnostics installations, the TRIGA reactor, high-temperature furnaces, an advanced, dedicated fully-integrated high-resolution microscope facility for investigations of nanostructured materials, computer systems for simulations, structural mechanical analysis and CAD, and much more.

Structural materials have been established as the key factor in realising the economic viability of fusion power, full operational safety and low environmental impact. Hence, one of the primary goals of the fusion research programme is to develop suitable materials. For the economic exploitation of the fusion reaction, a severe temperature regime will be encountered, and hence only materials with specific compositions and behaviour will be suitable. The development of a material that will

meet all the demanding requirements for the structural application in the first-wall blanket (gas-tightness, highly reliable high-temperature mechanical properties, etc.) is a challenging task for scientists. There is a very short list of candidate materials, among which the most promising is a composite of a SiC-fibre textile infiltrated with a low-activation SiC-based matrix material, SiCf/SiC. A group of materials scientists at the **Department for Nanostructured Materials** (Dr Saša Novak, Dr Goran Dražič) is focused on ceramic processing for the production of low-activation SiC-based composites.



A group of researchers from the Department for Nanostructured Materials, engaged in the development of ceramic composites for the first wall in a fusion reactor: Dr Saša Novak, Dr Goran Dražič and young scientists Katja Mejak and Tea Toplišek by the transmission electron microscope.

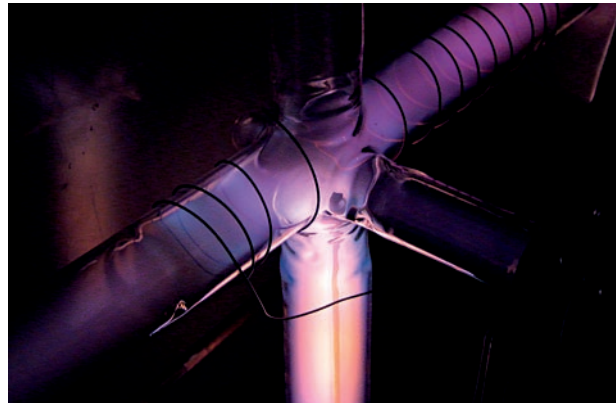
The researchers at the **Department for Low and Medium Energy Physics** study the processes that occur on plasma facing materials and in the edge plasma of tokamak reactors and involve neutral hydrogen/deuterium molecules. These molecules are typically vibrationally excited, which influences the respective reaction cross-sections. The group, led by **Dr Iztok Čadež**, has developed a special experimental technique for the vibrational spectroscopy of molecules and also uses the ion-beam analytical technique ERDA to characterize the hydrogen content on and beneath a material's surface. The investigations are performed in neutral test atmospheres with vibrationally excited molecules as well as in a plasma environment in the linear magnetized plasma machine in the **Plasma Physics Laboratory** (Dr Milan Čerček) of the **Reactor Physics Department**. Another study in the department (**Dr Primož Pelicon**) focuses on ion-beam analytical methods for studies of plasma-wall interaction processes, such as erosion, deposition, fuel retention and material migration in fusion reactors. The relevant specimens from the experimental fusion reactor TEXTOR in Germany, including probes, tiles, co-deposited flakes, microbalance crystals and limiters are analyzed.

In the **Department for Surface Engineering and Optoelectronics** researchers are engaged in two fusion-relevant projects. The first, led by **Dr Miran Mozetič**, deals with an investigation of the surface recombination of hydrogen



Dr Igor Lengar, Luka Snoj, Dr Matjaž Ravnik and Dr Andrej Trkov examining the results of the calculations of neutron attenuation for a new gamma-ray camera at JET.

atoms on fusion-relevant materials, with the aim to create a reliable database of recombination coefficients. A precise determination of the coefficients is not possible without knowing the atom density, and for this purpose a new probe has been constructed. It makes use of a catalytic recombination process on the probe-tip surface. The objective of the second project (Dr Vincenc Nemanič) is to study and quantitatively characterize the kinetics of the deuterium interaction with the reactor wall material. Precise pressure-gauge measurements and quadrupole mass spectrometry of the up-taken and

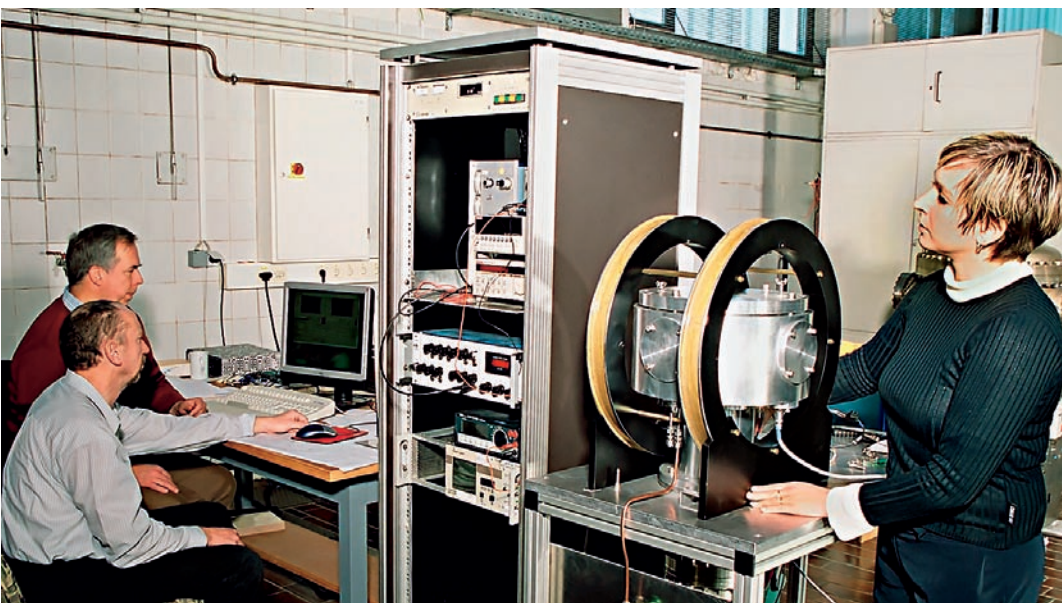


Plasma device for studying the atomic hydrogen interaction with materials.



Dr Tomaž Žagar introducing a ceramic sample into the irradiation channel in the TRIGA Mark II.

released gases are utilized in the study. A better understanding of the deuterium interaction will also help to predict tritium retention and the decommissioning kinetics more accurately. The world's largest experimental fusion reactor at present, JET, is equipped with a great deal of diagnostic instrumentation, including gamma-ray spectrometry and imaging. The present systems have components that are quite old and difficult to support. A number of upgrades are required to preserve JET's diagnostic capability and to improve the quality of the measurements. In particular, by using appropriately chosen neutron-attenuating materials to reduce both the neutron background and the neutron-induced gamma-ray background, the measurements of fast ions and α -particles could be performed in JET's discharges. A group of researchers at the Reactor Physics Department under the leadership of **Dr Igor Lengar** is responsible for neutron-photon transport calculations, the evaluation of attenuation factors and neutron in-scattering effects within this JET-diagnostics upgrade project. Several types of blanket modules for ITER are being developed within the European fusion programme. A specific project, the sensitivity/uncertainty pre-analysis of a mock up of the test-blanket module based on the HCLL concept is performed in the same department in order to assess the uncertainty about the tritium production ratio resulting from the uncertainty in the basic nuclear data. The researchers, including **Dr Andrej Trkov**, use deterministic transport codes, a special sensitivity/uncertainty code package and libraries during their work. Sensi-



Dr Iztok Čadež, Zdravko Rupnik, MSc, and young scientist Sabina Markelj during measurements at the spectrometer for vibrationally excited hydrogen molecules.

tivity profiles and nuclear data uncertainties, which will be determined for the neutron responses, will be used to guide and optimise the design of the benchmark experiment.

Besides the research aimed at supporting the development of JET and the ITER, the Jožef Stefan Institute also takes part in the design of more "distant" fusion power-plant reactors. **Dr Matjaž Ravnik** from the **Reactor Physics Department** is a member of the DEMO Working Group. The main objective of his collaboration and participation is contributing to topics related to conventional nuclear power-plant technology, in particular to topics related to nuclear safety and nuclear-waste treatment. One of them, a review of the report on the categorization of activated material, prepared as the basis for various power-plant conceptual design alternatives, has already been investigated.

The LECAD laboratory at the University of Ljubljana (Prof Dr Jože Duhovnik), has been chosen as a partner to provide an insight into the design problems of stellarator Wendelstein W7-X, another type of toroidal fusion device. The results of the analysis pointed to potential problems by providing an insight into zones of excessive plasticity, which might lead to fractions or collapse of the structure. LECAD currently continues to provide engineering solutions for Wendelstein W7-X by performing additional parametric analyses of the supports in new projects. LECAD also designed and manufactured new tools for the manufacturing of the vacuum vessel sectors of ITER.

The areas of the fusion programme of the SFA:

- plasma-surface interaction in ITER-relevant conditions
- integrated tokamak modelling
- development of nuclear diagnostics for JET
- development and irradiation testing of new ceramic materials for fusion reactors
- analysis of TBM neutronics experiments and validation of EFF nuclear cross-section data
- development of special tools for the construction and production of ITER parts
- structural mechanical analyses and evaluations to support the ITER and Wendelstein 7X projects
- collaboration in the DEMO Working Group
- fusion-related experimental methods at the TRIGA Reactor

20 Years of the Science Supplement in the Newspaper DELO

Credibility is the Key for Us

By Boris Čerin

It is generally the case that leading national newspapers build their image on correct reporting, which in view of the complexity of the various events in the majority of today's societies is demanding and responsible work. You have to be up to the task, or in terms of individual journalists, they must be capable of analysing comprehensively the issue they are presenting to the reader. Nor can we forget the reader's trust. This trust is conditioned to a great extent by the overall image of the individual newspaper and how readers sense the individual newspaper. And this brings us to the entirety. An overly narrow orientation puts off the more demanding reader. For this reason leading newspapers like to show that no subject is too difficult for them and that they can delve into all fields – including science, which readers take to be the most difficult of all.

Of course a point such as this is just one aspect of the whole. Science delves into so many areas that affect us, that is, each individual, that there most certainly exist a whole range of topics that might draw our attention. It offers much fascination. Yet we quickly face a dilemma of what form of reporting and writing about scientific achievements is most suitable for the individual newspaper. And this is the area covered by the individual editor.

At the most eminent Slovenian daily paper, *Delo*, responsibility for this lies with Gregor Pucelj, editor of the weekly supplement *Science [Znanost]*. He talked to us for this article.

QUARK: We might say that over the years the Science supplement has been formulating its appearance. What was going on in the initial thinking? The readers, most probably. And a sufficiently wide circle of correspondents?



Gregor Pucelj, editor of the weekly supplement *Science [Znanost]*.

PUCELJ: Our supplement, which was then called Znanje za razvoj [Knowledge for Development], first came out precisely two decades ago, on 30 September 1986. There was simply a growing awareness and need at that