ESF/PESC Exploratory Workshop on p-Process Nucleosynthesis

Vravron, Attika, Greece, April 18-21, 2002

Scientific Report

by Dr. Sotirios V. Harissopulos,
Convenor of the Workshop

Nuclear Astro*Group, Institute of Nuclear Physics,
National Centre for Scientific Research "Demokritos"
15310 Aghia Paraskevi, Athens, Greece
E-mail: shariop@inp.demokritos.gr

Executive Summary

The ESF Exploratory Workshop on p-Process Nucleosynthesis took place at the "Mare Nostrum" Club Med Hotel located on the coast of Vravron in Attika, Greece, from the 18th to the 21st April 2002. It was attended by 30 scientists, including the ESF representative, from 9 different European countries and 1 scientist from Japan. Of the 29 european attendants 25 received support from ESF funds. The total amount granted by ESF was 14.000 €. The Workshop's expenditures amounted to 13.975 €, 31% of which covered the travel expenses of mainly young researchers, 54% went towards the cost of full-board accommodation, and the remaining 15% covered the cost of renting of the conference room as well as the necessary coffee breaks. The Workshop's costs per participant amounted to 559 €. 1/3 of the ESF Member Countries were represented in the Workshop. 40% of the participants, i.e. 12 scientists, were young researchers (age<38 with no permanent position). 50% of the young researchers were below 30 years old. Furthermore, 40% of the participants were from less favoured regions of the EU and former East-European countries. The participants arrived in the afternoon of Thursday, 18th of April, and departed in the morning of Sunday, 21st April. 22 talks were given on Friday (4 sessions) and Saturday (3 sessions). Each talk was on average 30 minutes long. 55% of the talks were given by young researchers. The Workshop closed with a 2-hour round-table discussion.

The Workshop was the first of its kind. It focussed on a topic that had been, until then, only inadequately covered by some international nuclear physics conferences. This is largerly due to time limitations imposed in such conferences and also to the poor knowledge that both nuclear physicists and astrophysicists have of the *p process*. The Workshop was in concordance with the increasing interest of the nuclear astrophysicists in the topic covered: It brought together, for the first time, scientists from different disciplines, who are enganged in research activities on p-process nucleosynthesis. Experimentalists and theoreticians from the communities of nuclear physics, meteoritics, astronomy and astrophysics interacted intensively during the Workshop in order to understand the new results presented by the speakers and define the most interesting and crucial checkpoints of p-process modelling.

The programme included talks on a) astrophysical models of p-process nucleosynthesis, b) studies of p-process related isotope anomalies in meteorites, c) results for key nuclear reactions in stellar nucleosynthesis and d) theoretical and experimental nuclear physics aspects of the *p process*.

Among the most important tasks carried out during the Workshop was the evaluation of the extent to which nuclear physics uncertainties can affect the predictive power of the astrophysics models of p-process nucleosynthesis, especially with regards to the predictions of the solar system abundances of the *p nuclei*. The role of these uncertainties was presented by many speakers and discussed intensively by the participants. Abundance calculations based on recent data for the rates of the key reactions $^{22}Ne(\alpha,n)^{25}Mg$ and $^{12}C(\alpha,\gamma)^{16}O$ were shown and proved that the discrepancies between observed and predicted p-nuclei abundances cannot be explained by the experimental uncertainties associated with these reactions only. From the results of various experimental studies of capture reactions at energies relevant to the *p process* that were presented during the Workshop, it was concluded that the Hauser-Feshbach theory of nuclear reactions provides reliable predictions of the proton capture reaction cross sections that are involved in the p-process nucleosynthesis calculations. However, this is not the case for the α-particle capture reactions. Therefore, it is of paramount importance to study experimentally such reactions in the future. In addition to these data needs, the importance of having data for photon-induced reactions at energies relevant to the *p process* was also emphasized. These reactions have a dominant role in the nucleosynthesis process and their investigation can contribute decisively to the understanding of p-process nucleosynthesis. Hence, future European installations that will provide proper photon beams are very welcomed by the nuclear astrophysics community.

A very important ingredient of the Workshop was the discussion on the astrophysical conditions that have to be fulfilled in a stellar environment in order to have p-process nucleosynthesis. The satisfactory description of the composition of such an environment and its evolution with time, has by far not yet been achieved by the existing astrophysics models. From these discussions it became clear that more sophisticated, extended 3D models are necessary to provide a more realistic description of the stellar site and hence solve the puzzle of the origin of the so-called *p nuclei*.

Finally, throughout the Workshop the different European teams had the opportunity not only to discuss common problems but also to identify joint projects for the future. The possibility of setting up soon a large European network aiming at contributing to the investigation of modern scientific problems and theories in the field of Nuclear Astrophysics was further discussed and recognized by all participants to be the next common goal.

Scientific content of the event

Nuclear astrophysicists have made an impressive progress in improving our understanding of the solar system nuclidic composition. However, there remain many puzzles that challenge the basis of theoretical modelling, as well as of experimental approaches. Among these puzzles, the origin of the so-called *p nuclei* is a major one. The ESF Exploratory Workshop on "p-process nucleosynthesis" was dedicated to the discussion of the various aspects of and recent developments in the field of the nucleosynthetic *p process* that leads to the production of these *p nuclei*.

The term *p nuclei* refers to the 35 stable neutron-deficient nuclides lying on the "northwest" side of the stability valley on the chart or nuclides, between ^{74}Se and ^{196}Hg. In the development of the theory of nucleosynthesis, it was realized very early that the production of the p nuclei requires a special mechanism named *p process*, that can be described by various nucleosynthesis scenaria. These nucleosynthetic scenaria involve more or less complicated sequences of (p,γ) and (α,γ) reactions as well as of the relevant photodisintegrations (γ,n), (γ,p) and (γ,α) which dominate the p-process nuclear flow. One of the most important goals of all models of p-process nucleosynthesis is the description of the abundances of the *p nuclei*. In this direction various p-process calculations have been successful, however, there are still many cases where discrepancies between predicted and observed abundances remain unresolved. These discrepancies could be attributed to uncertainties in the astrophysical modelling of the p process, as well as to uncertainties in the nuclear physics data entering the calculations. Hence, the main scientific questions addressed and discussed by the participants of the Workshop were:

a) Are the astrophysical p-process models realistic enough to describe properly the conditions and the dynamics of the stellar environments where p-process nucleosynthesis is believed to occur?

b) To what extent nuclear physics uncertainties can affect the predictive power of the astrophysics models of p-process nucleosynthesis?

c) What are the needs for reliable nuclear physics data both experimental and theoretical?

An overview of the existing p-process models and their deficiencies was given by M. Arnould (IAA, ULB) in the opening session. In the following talks given by T. Rauscher (Univ. of Basel) and V. Costa (Observatory of Catania), p-process abundance

calculations in type II supernovae were presented. The dependence of these calculations on the initial stellar conditions and the subsequent stellar evolution in which modern aspects of stellar physics like, e.g. mass loss due to stellar winds, are taken into account, were addressed. The question of the advantages and disadvantages of the present models further captured the interest of the participants during the final round-table discussion. The current status of the p-process modelling can be summarized as follows: to date, single as well as binary stars can be thought as suitable astrophysical sites where p-process nucleosynthesis can occur. In the former case (type II supernovae, or pair-creation supernovae) the relevant burning phase is the Oxygen-burning (explosive as well as non-explosive), whereas in the latter case (type I and type Ia supernovae) deflagration (explosive Carbon-burning) or detonation (explosive Helium-burning) are the dominant burning mechanisms. In any case, the astrophysics requirements for the development of the *p process* in a stellar environment are I) high enough temperatures ($T>>10^9$ K) during short enough periods and II) pre-existing "seed" nuclei already produced by either the so-called *s* or *r process*. *P nuclei* can be then produced via incomplete photo-erosion of such heavy *s* and *r* nuclides down to Iron. All p-process models that have been developed so far have focussed on the case of type II supernovae. The calculations performed using the different models have succeeded to reproduce the abundances of the *p nuclei* above mass A=100 within a factor of three. All models however fail to reproduce those of the lighter *p nuclei* below mass A=100. For the understanding of this deficiency various aspects of the modelling of the *p process* have been discussed by the participants. These seem to be related to i) the correct description of the stellar dynamics just before or during the explosion of a supernova as well as to ii) the correct modelling of the preceding *s process* and the reproduction of the corresponding s-nuclide seed distribution. With respect to i) one can conclude that improved models are required, in which the impact of various effects, like rotation or deviations from the spherical symmetry, on the p-nuclei producing "zones" before and during the supernova explosion will be investigated. For the description of such effects multi-dimensional models are necessary. The conclusion with respect to ii) is that although the *s process* is thought to be well understood, there are still a lot of open questions related to possible interferences with the *p* and *r processes*. This interference was addressed by F. Käppeler (FZ-Karlsruhe) who showed that although the *p* components in the observed solar abundances of elements between Iron and the Actinides are usually small, they can account for a non-negligible fraction of some s-only isotopes. From the results presented in this talk, one can conclude that the now available *s* abundances are good enough to determine p-process residuals with meaningful

uncertainties that can be used not only for a sensitive test of s-process models but also for the comparison with p-process abundance calculations. The interplay between the *s* and the *p process* was further pointed out in the talk of U. Ott (MPI-Chemie, Mainz) in terms of isotope "anomalies" in meteorites. According to the results shown by the speaker and in contrast to what was believed until now, no clear-cut isotope abundance anomalies that can clearly be related to p-process nucleosynthesis can be justified by the studies conducted so far in meteorites. Instead, the observed overabundances of *p* isotopes are more likely to be due to s-process deficits.

The rest of the talks given in the Workshop were focussed on the nuclear physics uncertainties that can affect the p-nuclei abundance calculations. This problem was extensively reviewed by S. Goriely (IAA, ULB). It has to be emphasized that the reproduction of the p-nuclei abundances requires extended network calculations involving more than 20.000 nuclear reactions with about 2000 nuclei in the mass region $12 \leq A \leq 210$. Obviously, experimental data on the cross sections of all these reactions could hardly be available. Consequently, all the relevant calculations have to rely almost completely on the predictions of the Hauser-Feshbach (HF) theory. Hence, in addition to the importance of the astrophysical modelling, the reliability of the statistical model calculations has also to be tested. One should of course note that the uncertainties involved in any HF calculation are not related to the HF theory itself, but rather to those associated with the evaluation of the nuclear properties entering the calculations. Among these properties, the nuclear level densities (NLDs), the nucleon-nucleus and α-particle-nucleus optical model potentials (OMPs) have shown to have the strongest contribution to the uncertainties in the HF calculations. In this direction, a new combinatorial method of calculating microscopic NLDs was presented by Stephane Hilaire (CEA, Bruyères-le-Chatel). The advantage of these microscopic NLDs is that they are based on the ground-state properties of the nucleon obtained from sound microscopic theories and are therefore, more reliable than phenomenological approaches for extrapolations to nuclei in the drip-line where no experimental information exists. The sensitivity of α-particle reaction cross sections to the α-particle OMPs was displayed by P. Demetriou ("Demokritos", Athens) who emphasized the need for additional experimental data on α-particle reactions at low energies in order to constrain the parameters of the global α-particle OMPs. From the experimental point of view, the Oslo University group (M. Guttormsen and S. Siem) presented a new experimental method for measuring level densities and γ-ray strength functions, to be used as a sensitive check of the theory. New experimental data on the cross sections of proton-capture reactions at energies relevant

to the *p process*, necessary for testing the reliability of the HF theory were presented by G. Gyürky (ATOMKI, Debrecen) and the group of "Demokritos", Athens (S. Galanopoulos, G. Kriembardis and P. Tsagari). The existing experimental information on proton-capture reaction cross sections was further reviewed by E. Somorjai (ATOMKI, Debrecen), who discussed the advantages and disadvantages of the two main experimental techniques used, the activation technique and the in-beam method, and S. Harissopulos ("Demokritos", Athens). The latter speaker also presented a systematic comparison of all existing data with the statistical model calculations carried out using various combinations of NLDs and OMPs. From the latter two talks it became clear that the amount of available data on proton-capture reaction cross sections has considerably increased during the last three years. This allows for a thorough check of the global character of various nucleon-nucleus optical model potentials and of different models of nuclear level densities proposed for astrophysical applications. At the same time it was stressed that in the mass region of interest, there is scarce experimental information on α-capture reaction cross sections and that on top of that, the existing data exhibit large uncertainties. In all cases of α-reactions and α-scattering considered, the HF predictions were found to be very sensitive to the chosen α-nucleus OMP potential. Detailed contributions to this problem were made by W. Rapp (FZ-Karlsruhe) and P. Mohr (TU Darmstadt).

In addition to the above mentioned reactions, the "influence" of the large uncertainties in the rates of certain "key" reactions, such as the $^{12}C(\alpha,\gamma)^{16}O$ and the $^{22}Ne(\alpha,n)^{25}Mg$ reaction, that play a very important role in the network calculations, was also discussed during the Workshop. W. Hammer (Univ. of Stuttgart) presented new results on both of these reactions and reviewed all experimental works done so far. This presentation combined with the earlier one of V. Costa (Observatory of Catania) on the abundance calculations based on the recent data for the key reaction $^{22}Ne(\alpha,n)^{25}Mg$, sparked a round of intensive discussions. The discrepancies between observed solar system abundances and theoretical predictions seem to persist and cannot be explained by the experimental uncertainties associated with these key reactions only.

The importance of having data from photon-induced reaction cross sections was emphasized by many participants during the workshop. Although the production mechanism for the heavy *p nuclei* is photodisintegration by successive (γ,n), (γ,p) and (γ,α) reactions, there are hardly any experimental data on the rates of these reactions. The need for such data has motivated new projects in this direction. H. Utsunomiya (Konan University, Kobe, Japan) reported on the results of an indirect method of

measuring the production cross section of ^{180}Ta, a long-lived p-process isomer, and also discussed his future research plans with quasi-monochromatic γ beams produced by inverse Compton scattering of laser photons from relativistic electrons. A. Zilges (TU Darmstadt) and P. Mohr (TU Darmstadt) reported on the results of their first (γ,n) measurements using an intense bremsstrahlung beam at the Darmstadt S-DALINAC accelerator combined with the photoactivation technique. They presented two methods of extracting reaction rates, the conventional one based on an assumption on the threshold behaviour of the E1 cross section and a new one based on the superposition of various bremsstrahlung spectra where no assumptions whatsoever are required.

In the last talk of the Workshop, C. Rolfs reviewed the phenomenon of electron screening that plays a crucial role in nuclear astrophysics studies. He additionally reported on the status of the ERNA project, in which the key reaction $^{12}C(\alpha,\gamma)^{16}O$ is planned to be investigated –for the first time- in inverse kinematics and at very low energies, in order to achieve the desired accuracy in the determination of the astrophysical *S* factor in the Gamow window.

Assessment of the results

The Workshop gave the opportunity to European scientists working in the field of heavy element nucleosynthesis to obtain a deeper insight into the problem of p-process nucleosynthesis. An intensive interaction between the participants took place during the discussions at the end of specialized talks. Review talks contributed to obtaining a global view of the problems associated with p-process studies. The round-table discussion carried out at the end of the Workshop was very useful in defining and further documenting the current status of the research work relevant to p-process nucleosynthesis. This status can be described as follows:

- The existing nucleosynthesis models have all been worked out satisfactorily in various astrophysical conditions (Supernovae of type II and Ia, pair creation supernovae, He-detonation in Sub-Chandrasekhar mass white dwarfs etc.). They all however exhibit large uncertainties in the description of the initial seed abundances for the p-process nucleosynthesis. Moreover, large uncertainties are encountered in the modelling of phenomena like convection, rotation, explosion with no spherical symmetry etc. Finally the role of neutrino effects in the p-nuclei producing processes is still an open question.
- Nuclear physics uncertainties can indeed affect the predictive power of the astrophysics models of p-process nucleosynthesis. However, the discrepancies between the predicted and the observed p-nuclei abundances can not be “removed” by simply eliminating the nuclear physics uncertainties. On the other hand accurate nuclear physics data are crucial for obtaining global parameters for the description of nuclear properties that enter in the abundance calculations, especially for nuclei near the drip-line.

Based on these facts, the future needs identified for p-process studies are as follows.
From the astrophysics side:

- More sophisticated, extended 3D models are necessary to provide a more realistic description of the stellar sites suitable for p-process nucleosynthesis.
- The role of the s-process abundances in the initial conditions of the p-nuclei producing sites has to be further investigated.

From the experimental nuclear physics side:

- Cross section data with reasonable uncertainties are still necessary. The rates of certain key reactions like $^{12}C(\alpha,\gamma)^{16}O$, $^{12}C+ {}^{12}C$ still exhibit uncertainties that do not allow us to draw any definite conclusions on the astrophysics aspects. In addition, cross section data of radiative α and proton captures in the medium mass region and of photodisintegrations in the heavy mass region are needed to enable us to develop global models of nucleon- and α-particle-nucleus potentials, Nuclear Level Densities and γ-ray strength functions. Experimental information on Nuclear Level Densities and γ-ray strength functions are also desired.

From the theoretical nuclear physics side:

- Further work is required in the development of microscopic models for practical applications and in the parametrization of global models on large data sets. All in all, a consistency between the different global models is a pre-requisite in order to arrive at reliable predictions particularily in the experimentally unexplored mass region.

A major outcome of the discussions held during the Workshop is the ascertainment that in order to pursue the research goals outlined above, a coordinated effort within the framework of a European Network is necessary. The joining of forces of different expert groups in Europe under a specific protocol of collaboration would facilitate the mobility of researchers, the exchange of ideas and experience, the efficient circulation of information on developments and would thus lead to the desirable progress in the field.

The physics case that emerged from the discussions is highly promising but it's realization requires dedicated facilities in Europe that would provide the infrastructure and easy access necessary to carry out the proposed experimental investigations. In this respect, the operation of facilities capable of producing real photon beams is strongly recommended.

At the end of the round–table discussion the participants concluded that although the European teams working in the scientific domain of heavy element nucleosynthesis are recognized by the international Nuclear Astrophysics community to have the leading role in this field, the support given so far by the European Community to the European nuclear astrophysics community is in comparison with other scientific communities negligible. It has to be emphasized that this highly respected scientific status of the European Nuclear Astrophysics community has been achieved by the close interaction between a few theoreticians from the discipline of astrophysics and nuclear physics and

the experimentalists of small nuclear physics laboratories with very low national or european funding. In most of these labs, experimental work has been carried out by using "small" accelerators amongst which however, very few remain in operation nowadays, and even these are spread throughout Europe with bleak perspectives. This situation needs to be significantly improved in order to ensure that Europe remains at the forefront of the developments in the field of Nuclear Astrophysics. Specific measures have to be taken by the authorities of the European Community in this direction, such as the set up and financial support of a European Network of small accelerator laboratories dedicated to the study of topics related to Nuclear Astrophysics.

Final programme

18-04-2002 THURSDAY

Late afternoon Registration and welcome cocktail

19-04-2002 FRIDAY

09.00–09.30 Welcome addresses
Prof. E. Biémont, ESF Representative - Dr. S. Harissopulos, Workshop's Convenor

09.30– 11.15 SESSION I — p nuclei (1) : abundances, production processes
(Chair: Nikos Prantzos, IAP, Paris, France)

- 09.30-10.15 Marcel Arnould (IAA, ULB, Bruxelles, Belgium)
  The p-process : an overview
- 10.15 - 10.45 Thomas Rauscher (Dept. Physik, Uni Basel, Basel, Switzerland)
  p-process in type II supernovae
- 10.45 - 11.15 Vincenzo Costa (Osservatorio Astrofisico di Catania, Catania, Italy)
  The p-process in type II supernovae: current status

11.15 – 11.45 Coffee break

11.45 – 13.15 SESSION II — p nuclei (2) : abundances, key reactions
(Chair: Marc Rayet, IAA, ULB, Brussels, Belgium)

- 11.45 – 12.15 J. Wolfgang Hammer (IfS, Uni Stuttgart, Stuttgart, Germany)
  New Reaction rates of the key reactions of stellar nucleosynthesis
- 12.15 - 12.45 Franz Kaeppeler (IK, FZK, Karlsruhe, Germany)
  Interferences between s- and p-process abundances
- 12.45 - 13.15 Ulrich Ott (MPI-Chemie, Mainz, Germany)
  On p-process and related "anomalies" in meteorites

13.15 – 15.00 Lunch

15.00 – 16.30 SESSION III — Nuclear physics aspects of p process (1)
(Chair: F.-K. Thielemann, Uni Basel, Basel, Switzerland)

- 15.00 - 15.30 Stephane Goriely (IAA, ULB, Bruxelles, Belgium)
  Impact of nuclear uncertainties on the p-process nucleosynthesis
- 15.30 - 16.00 Magne Guttormsen (Dept. of Physics, Univ. Oslo, Oslo, Norway)
  Extraction of level densities from primary γ-spectra
- 16.00 – 16.30 Sunniva Siem (Dept. of Physics, Univ. Oslo, Oslo, Norway)
  Level densities and γ-strength functions: important quantities in nucleosynthesis

16.30 – 17.00 Coffee break

17.00 – 18.00 SESSION IV — Nuclear physics aspects of p-process (2)
(Chair: Claudio Spitaleri, LNS-INFN, Catania, Italy)

- 17.00 – 17.30 Stephane Hilaire (CEA/DAM, Bruyères-le-Chatel, France)
  Level densities far from the valley of stability
- 17.30 - 18.00 Paraskevi Demetriou (INP, NCSR "Demokritos", Athens, Greece)
  Improved global α-optical model potentials for astrophysical applications

20-04-2002 SATURDAY

09.00– 11.00 SESSION V Experimental aspects of p-process (1) :
(Chair: Filippo Terrasi, II Univ. Napoli,/INFN, Napoli, Italy)

09.00 -09.30 Hiroaki Utsunomiya (Dept. Physics, Konan Univ., Kobe, Japan)
Photoneutron cross sections for the p process

09.30 -10.00 Andreas Zilges (IKP, TU Darmstadt, Darmstadt, Germany)
Investigation of photon induced reactions during nucleosynthesis

10.00 - 10.30 Peter Mohr (IKP, TU Darmstadt, Darmstadt, Germany)
(γ,α)-reactions and α-nucleus potentials

10.30 - 11.00 Endre Somorjai (ATOMKI, Debrecen, Hungary)
Experimental aspects of p-process studies using p- and α-beams

11.00 – 11.30 Coffee break

11.30– 13.00 SESSION VI Experimental aspects of p-process (2) :
(Chair: Adelaide Pedro de Jesus, CFN, Univ. Lisboa, Portugal)

11.30 – 11.50 Wolfgang Rapp (IK, FZ Karlsruhe, Karlsruhe, Germany)
Alpha and neutron induced reactions on Ruthenium Isotopes

11.50 - 12.10 Gyorgy Gyürky (ATOMKI, Debrecen, Hungary)
(p,γ) and (p,n) cross sections in Se isotopes

12.10 - 12.25 George Kriembardis (INP, NCSR "Demokritos", Athens, Greece)
Cross section measurements of ^{78}Se(p, γ) and ^{80}Se(p,γ) reactions

12.25 - 12.40 Stratos Galanopoulos (INP, NCSR "Demokritos", Athens, Greece)
(p,γ) cross sections of Sr isotopes

12.40 - 13.00 Panagiota Tsagari (INP, NCSR "Demokritos", Athens, Greece)
(p,γ) cross sections of ^{89}Y relevant to p process

13.00 – 15.00 Lunch

15.00 – 16.00 SESSION VII (Chair: Stathis Kossionides, NCSR "Demokritos", Athens)

15.00 – 15.30 Sotiris Harissopulos (INP, NCSR "Demokritos", Athens, Greece)
Capture reactions relevant to p-process : present status and future needs

15.30 - 16.00 Claus Rolfs (EP3, Ruhr-Uni-Bochum, Bochum, Germany)
Electron-screening effects on fusion reactions

16.00 – 16.30 Coffee break

16.30 – ..... ROUND-TABLE DISCUSSION: How to proceed ?
(Coordinator : S. Harissopulos, Workshop's convenor)

21-04-2002 SUNDAY

Departure

List of participants

Convenor

Dr. Sotirios HARISSOPULOS (sharisop@inp.demokritos.gr)
National Centre for Scientific Research "Demokritos", Institute of Nuclear Physics
POB 60228, 153 10 Aghia Paraskevi , Athens, Greece. Tel: +30 1 650 34 93, Fax: +30 1 651 12 15

Organising Committee

Dr. Paraskevi DEMETRIOU (vivian@inp.demokritos.gr)
National Centre for Scientific Research "Demokritos", Institute of Nuclear Physics
POB 60228, 153 10 Aghia Paraskevi , Athens, Greece. Tel: +30 1 650 3514, Fax: +30 1 651 1215

Dr. Michael KOKKORIS (kokkoris@inp.demokritos.gr)
National Centre for Scientific Research "Demokritos", Institute of Nuclear Physics
POB 60228, 153 10 Aghia Paraskevi , Athens, Greece. Tel: +30 1 650 3495, Fax: +30 1 651 1215

ESF/PESC Representative

Professor Emile BIEMONT (E.Biemont@ulg.ac.be)
Université de Liège, Institut de Physique Nucléaire, Atomique et de Spectroscopie (IPNAS)
Bât. B15, Sart Tilman, 4000 Liège 1, Belgium. Tel: +32 4 366 36 92, Fax: +32 4 366 28 84

Professor Marcel ARNOULD (marnould@astro.ulb.ac.be)
Université Libre de Bruxelles, Institut d'Astronomie et d'Astrophysique,
Campus de la Plaine, CP 226, 1050 Bruxelles, Belgium. Tel: +32 2 650 2864, Fax: +32 2 650 4226

Dr. Vincenzo COSTA (vco@sunct.ct.astro.it)
Osservatorio Astrofisico di Catania, Via S. Sofia 78, 95123 Catania, Italy.
Tel: +39 095 17332325, Fax: +39 095 330592

Stratos GALANOPOULOS (galano@inp.demokritos.gr)
National Centre for Scientific Research "Demokritos", Institute of Nuclear Physics
POB 60228, 153 10 Aghia Paraskevi , Athens, Greece. Tel: +30 1 650 3495, Fax: +30 1 651 1215

Dr. Stéphane GORIELY (sgoriely@astro.ulb.ac.be)
Université Libre de Bruxelles, Institut d'Astronomie et d'Astrophysique,
Campus de la Plaine, CP 226, 1050 Bruxelles, Belgium. Tel: +32 2 650 2843, Fax: +32 2 650 4226

Professor Magne GUTTORMSEN (magne.guttormsen@fys.uio.no)
University of Oslo, Department of Physics, PO Box 1048, Blindern, 0316 Oslo, Norway
Tel: +47 2285 6460, Fax: +472285 6422

Dr. Gyorgy GYÜRKY (gyurky@atomki.hu)
Hungarian Academy of Sciences – ATOMKI, Institut of Nuclear Research,
PO Box 51, 4001 Debrecen, Hungary. Tel: +36 52 417266, Fax: +36 52 416181

Dr. J. Wolfgang HAMMER (hammer@ifs.physik.uni-stuttgart.de)
Universität Stuttgart, Institut für Stahlenphysik, Allmandring 3, 70569 Stuttgart, Germany
Tel: +49 711 685 3888, Fax: +49 711 685 3868

Dr. Stéphane HILAIRE (Stephane.Hilaire@cea.fr)
CEA/DAM Ile de France, DPTA/SPN, BP 12, 91680 Bruyères-le-Châtel, France
Tel: +33 1 69 26 43 03, Fax: +33 1 69 21 70 63

Dr. Franz KAEPPELER (kaepp@ik3.fzk.de)
Forschungszentrum Karlsruhe (FZK), Institut für Kernphysik (IK),
Bau 425, Postfach 3640, 76021 Karlsruhe, Germany. Tel: +49 7247 823991, Fax: +49 7247 824075

Dr. Stathis KOSSIONIDES (kosion@inp.demokritos.gr)
National Centre for Scientific Research "Demokritos", Institute of Nuclear Physics
POB 60228, 153 10 Aghia Paraskevi , Athens, Greece. Tel: +30 1 650 3495, Fax: +30 1 651 1215

Georgios KRIEMBARDIS (gkrieb@inp.demokritos.gr)
National Centre for Scientific Research "Demokritos", Institute of Nuclear Physics
POB 60228, 153 10 Aghia Paraskevi , Athens, Greece. Tel: +30 1 650 3495, Fax: +30 1 651 1215

Dr. Peter MOHR (mohr@ikp.tu-darmstadt.de)
Technische Universität Darmstadt, Institut für Kernphysik,
Schlossgartenstr. 9, 64289 Darmstadt, Germany. Tel: +49 6151 163221, Fax: +49 6151 164321

Professor Ulrich OTT (ott@mpch-mainz.mpg.de)
Max-Planck-Institut für Chemie, Joh.-J.-Becher-Weg 27, Universitätscampus, 55128 Mainz, Germany
Tel: +49 6131 305 366, Fax: +49 6131 305 575

Professor Adelaide PEDRO DE JESUS (apjesus@cii.fc.ul.pt)
Universidade de Lisboa, Centro de Fisica Nuclear, Av. Gama Pinto 2, 1649 003 Lisboa, Portugal
Tel: +351 21 790497, Fax: +351 21 7954288

Dr. Nikolas PRANTZOS (prantzos@iap.fr)
Institut d'Astrophysique de Paris, 98bis Boulevard d'Arago, 75014 Paris, France
Tel: +33 1 44 32 81 88, Fax: +33 1 44 32 80 01

Ass. Prof. Thomas RAUSCHER (tommy@quasar.physik.unibas.ch)
Universität Basel, Department für Physik und Astronomie, Klingelbergstr. 82, 4056 Basel, Switzerland
Tel: +41 61 267 3754, Fax: +41 61 267 1349

Dr. Wolfgang RAPP (rapp@ik3.fzk.de)
Forschungszentrum Karlsruhe (FZK), Institut für Kernphysik (IK)
Bau 425, Postfach 3640, 76021 Karlsruhe, Germany. Tel: +49 4247 823991, Fax: +49 7247 824075

Dr. Marc RAYET (mrayet@astro.ulb.ac.be)
Université Libre de Bruxelles, Institut d'Astronomie et d'Astrophysique,
Campus de la Plaine, CP 226, 1050 Bruxelles, Belgium. Tel: +32 2 650 3572, Fax: +32 2 650 4226

Professor Claus ROLFS (rolfs@ep3.ruhr-uni-bochum.de)
Ruhr-Universität Bochum, Institut für Experimentalphysik III
Universitätsstrasse 150, 44801 Bochum, Germany. Tel: +49 234 32 23596, Fax: +49 234 32 14744

Dr. Sunniva SIEM (sunniva.siem@fys.uio.no)
University of Oslo, Department of Physics, PO Box 1048, Blindern, 0316 Oslo, Norway
Tel: +47 2285 6406, Fax: +47 2285 6422

Dr. Endre SOMORJAI (somorjai@atomki.hu)
Hungarian Academy of Sciences – ATOMKI, Institute of Nuclear Research,
PO Box 51, 4001 Debrecen, Hungary. Tel: +36 52 417266, Fax: +36 52 416181

Professor Claudio SPITALERI (spitaleri@lns.infn.it)
Instituto Nazionale di Fisica Nucleare, Laboratori Nazionali del Sud
Via S. Sofia 44, 95123 Catania, Italy. Tel: +39 095 542335, Fax: +39 095 7141815

Professor Filippo TERRASI (Filippo.Terrasi@unina2.it)
II Università di Napoli / INFN-Napoli, Dipartimento di Scienze Ambientali
Via Vivaldi 43, 81100 Caserta, Italy. Tel: +39 0823 274 412, Fax: +39 0823 274 605

Professor Friedrich-Karl THIELEMANN (fkt@quasar.physik.unibas.ch)
Universität Basel, Department für Physik und Astronomie, Klingelbergstr. 82, 4056 Basel, Switzerland
Tel: +41 61 267 3750, Fax: +41 61 267 1349

Panagiota TSAGARI (nuastro@inp.demokritos.gr)
National Centre for Scientific Research "Demokritos", Institute of Nuclear Physics
POB 60228, 153 10 Aghia Paraskevi , Athens, Greece. Tel: +30 1 650 3495, Fax: +30 1 651 1215

Professor Hiroaki UTSUNOMIYA (hiro@konan-u.ac.jp)
Department of Physics, Konan University, Okamoto 8-9-1, Higashinada, Kobe 658-8501, Japan
Tel: +81 78 435 2471, Fax: +81 78 435 2539

Professor Andreas ZILGES (zilges@ikp.physik.tu-darmstadt.de)
Technische Universität Darmstadt, Institut für Kernphysik,
Schlossgartenstr. 9, 64289 Darmstadt, Germany. Tel: +49 6151 162925, Fax: +49 6151 164321

Statistical information on participants

The Workshop was attended by 30 scientists, including the ESF representative, from 9 different European countries and 1 scientist from Japan. Of the 29 european attendants 25 received support from ESF funds. The total amount granted by ESF was 14.000 €. The Workshop's expenditures amounted to 13.975 €, 31% of which covered the travel expenses of mainly young researchers, 54% went towards the cost of full-board accommodation, and the remaining 15% covered the cost of renting of the conference room as well as the necessary coffee breaks. The Workshop's costs per participant amounted to 559 €. 1/3 of the ESF Member Countries were represented in the Workshop. 40% of the participants, i.e. 12 scientists, were young researchers (age<38 with no permanent position). 50% of the young researchers were below 30 years old. Furthermore, 40% of the participants were from less favoured regions of the EU and former East-European countries. The participants arrived in the afternoon of Thursday, 18th of April, and departed in the morning of Sunday, 21st April. 22 talks were given on Friday (4 sessions) and Saturday (3 sessions). Each talk was on average 30 minutes long. 55% of the talks were given by young researchers.

Statistics

Young Scientists (Y. Sci.) = 12 (40%)

Participipants from less favoured regions of EU and
former East-European countries = 12 (40%)

Participating ESF countries = 9 (33% of the ESF Member Countries)

Country	Partici-pants	Country	Partici-pants	Country	Partici-pants
Belgium	3	Greece	7	Norway	2
France	2	Hungary	2	Portugal	1
Germany	7	Japan	1	Switzerland	2
		Italy	3		