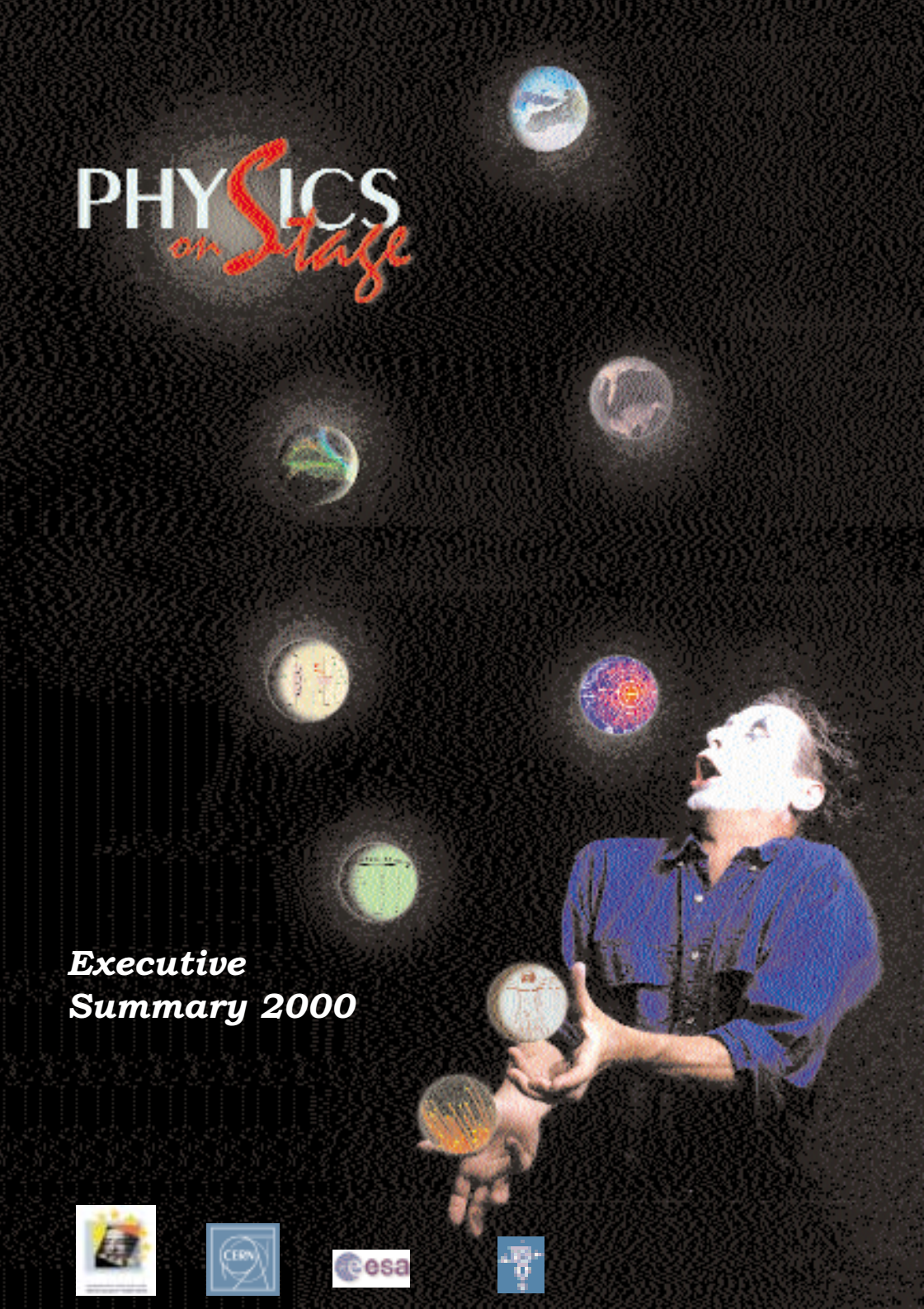
PHYSICS
on Stage
Executive
Summary 2000
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***Physics On Stage was organised by:***


CERN
The European Centre for Nuclear Research
Geneva, Switzerland


ESA
The European Space Agency
Paris, France

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The European Southern Observatory
Garching, Germany

***With the support of:***

The European Commission, Research Directorate
Brussels, Belgium

EPS
The European Physical Society
Mulhouse, France

EAAE
The European Association for Astronomy Education
Esch-sur-Alzette, Luxembourg

# *A message from European Commissioner:*

## Philippe Busquin

*Commissioner for Research in the European Commission*

***Philippe Busquin speaks to journalists after his tour of the Physics On Stage fair.***

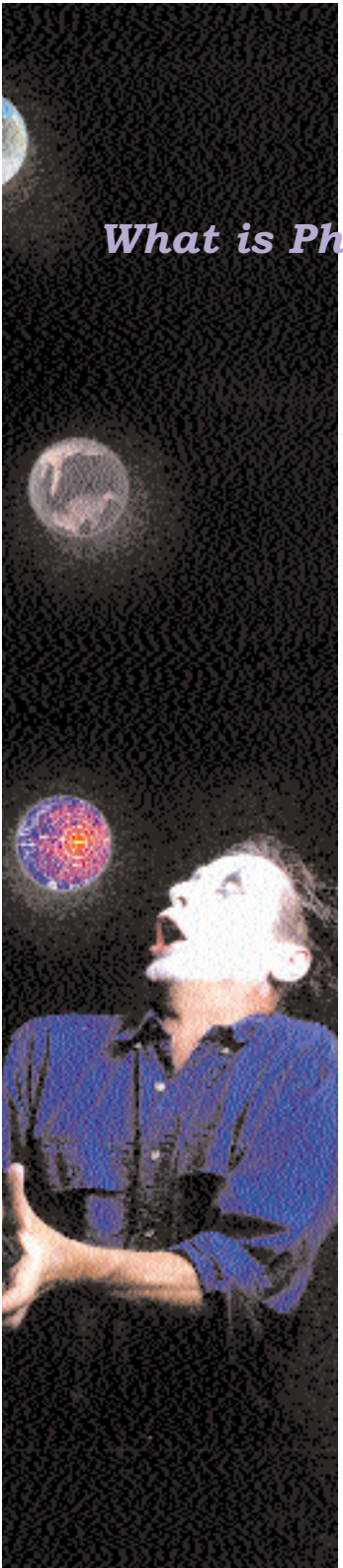
Perhaps the greatest challenge facing the physics teaching profession today is to be constantly on the lookout for new ways of conveying the excitement and wonder of physics to youngsters.

But this is not just a problem for the teaching profession. Society itself depends on a constant flow of young people wishing to take up careers in science and in this respect physics has been particularly badly affected by falling numbers of students - and teachers - in recent years. Against this gloomy background "Physics on Stage" stands out as a shining example of positive action aimed at reversing the decline of interest in science.

I witnessed at first hand the contagious enthusiasm of over 500 teachers and young people from 25 European countries who came together for five days to share experiences, debate the issues and enjoy the demonstrations and performances. It was interesting to see how participants had interpreted the objective of the meeting in completely different ways.

We all know that science is not entertainment per se but that's no reason why science teaching should not be both instructive and entertaining! It is also vital for teaching not just to convey facts but rather to arouse curiosity as well.

Clearly interesting more youngsters in science is a necessary condition for increasing the number of future science professionals - but it is not the only factor. "Physics on Stage" is one of a number of initiatives contributing to this year's European Science and Technology Week. The Week is itself part of a wider Commission initiative aimed at promoting the role of science in society. This is an important element for achieving a European Research Area.



# What is Physics On Stage?

*Physics is everywhere, but how much do people in Europe really know about physics?*

Physics On Stage is a unique European-wide programme for physics teachers and those in fields related to physics to assess the current situation in physics education and raise the public awareness of physics and related sciences.

The project was initiated by the three major European research organisations: the European Organization for Nuclear Research (CERN), the European Space Agency (ESA) and the European Southern Observatory (ESO), with support from the European Union. Other partners in the project are the European Physical Society (EPS) and the European Association for Astronomy Education (EAAE).

The objectives of Physics On Stage are:

- to draw attention to the low level of scientific (and particularly physics) literacy among European citizens
- to propose innovative and practical solutions to this problem
- to establish a network of experts on physics teaching and popularisation from all over Europe
- to produce and distribute materials that highlight the opinions and recommendations of these experts.

National Steering Committees were set up in 22 European countries*, with the support of the EPS and EAAE networks. During the course of the year 2000, a wide variety of national activities took place to identify outstanding projects and individuals in the field of physics teaching and popularisation.

***In CERN's main auditorium***

The highlight of the Physics On Stage project was a unique, five-day festival held at CERN in Geneva between 6 – 10 November 2000. More than 500 people from the participating countries met to exchange ideas and discuss how to improve the current situation and motivate the youth of today to become the scientists and engineers of the future. Approximately 300 of these were secondary school teachers, with the potential to amplify the ideas presented at Physics On Stage to over 40000 students.

***Many bright people at Physics on Stage...***

The festival revolved around a lively physics teaching fair, where all countries had the opportunity to present their methods, ideas, experiments, books, projects, etc... Participants met in workshop groups, focussing on a wide range of issues, to identify problems in physics teaching and understanding. They formulated recommendations for future improvements, which are summarised in this booklet. Throughout the week, inspiration was provided by a series of presentations, suggesting different ways in which physics might be taught, and a number of entertaining performances, which literally put physics on stage.

* Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, The Netherlands, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, United Kingdom.

# *Some words from the Directors General*

### *DIRECTOR GENERAL OF CERN*

*Luciano Maiani*

Physics on Stage is an exciting experiment. Never before, have so many physics teachers from so many countries come together to share experiences, present new ideas and initiate progress in physics teaching, a subject which has the uttermost relevance for the cultural and economic future of Europe.

Young peoples' desire for knowledge, their enthusiasm to continue in science, is almost always generated at an early age by the energy and motivation of their teachers. Europe's future scientific and technical strength lies in the hands of those teachers.

### *DIRECTOR GENERAL OF ESA*

*Antonio Rodota*

The current, high quality of life enjoyed in European countries is, to a large extent, a direct result of the progressive mastering of new sciences and technologies. The immense technological development would not have been possible without a sound basis of physics literacy.

Youngsters will need to obtain the necessary skills to develop and shape the future. A prime reason for the Physics on Stage project is the recognition that literacy in Physics amongst many young Europeans is insufficient. As the European economical and cultural strength has been and will be greatly dependent on its technical and scientific basis, such recognition must lead to action. Physics on Stage is therefore a very important and timely action!

### *DIRECTOR GENERAL OF ESO*

*Catherine Césarsky*

I think it is very important that we find ways to attract young people to science, and teachers have the main role in doing this - especially teachers in high schools.

At ESO, we find that astronomy is a marvellous road to attract young people to physics. All children and a lot of adults want to understand where they live and how the Universe works.

Events like this one are very useful. I liked Physics on Stage particularly and hope that there will be opportunities to do this kind of activity on an even greater scale in the future.

# *The welcome to the participants*

**RICHARD WEST**

*Chairman of the International Steering Committee*

It is my great pleasure to welcome you to this truly unique event, organised by CERN, ESA and ESO with their partners EAAE and EPS. It represents the high point of the European Union's Science and Technology Week 2000.

Our theme is physics. The goal is education. The audience is all of Europe. The message is one of excitement. The means are those we shall jointly explore together during the next few days, within a programme that is densely packed with useful opportunities for everybody.

We are meeting in a state of genuine concern. The gap between the European public's increasing dependence on technology and its knowledge about that technology is rapidly widening. In parallel, or as a result, there is an apparent lack of qualified young people in basic science such as physics.

But what is it that makes physics less attractive? Why this widespread public attitude of blissful ignorance? Why do gifted young people hesitate to enter the world of physics? Those are some of the questions for which we hope jointly to formulate answers. Even more important, we want to propose realistic measures that will contribute to changing this unfortunate state of affairs.

Now, it is up to all of us to take the best advantage of this unique opportunity. We have a great time ahead of us in these highly inspiring surroundings.

# The performances

*The Circus of Physics (The Netherlands)*

*The Name of Fame (Germany)*

*A Top, a Buoy and a Ping-Pong Ball (Germany)*

*WWW - What a Wonderful World (France)*

*Oracle de Delphi (Switzerland)*

*Movers and Shakers (Ireland)*

*The Physics of Ping-Pong (Poland)*

*Cera Una Volta (Belgium)*

*Walking Robots (Austria)*

*Musical Squares (United Kingdom)*

# The presentations

*Recreational Physics (Miguel Cabrerizo, Spain)*

*Revitalising Physics Education (Jon Ogborn, United Kingdom)*

*We Live on Earth - the Rotating System (Jersy Jarosz, Poland)*

*The Wonders of Speed (Tim Scholten & Tonny Hofstetter, The Netherlands)*

*The Magic of Chemistry and Physics (Guido Pegna, Italy)*


*The Life and Death of a Particle (Amelia Maio, Portugal)*

*The Physics of Flying (Wolfgang Send, Germany)*

*Perpetual Motion (Gernot Born, Germany)*

*Schola Ludus Science Toys (Katarina Teplanova, Slovak Republic)*

*Acoustic Lenses (Beat Schaeren, Switzerland)*

**In addition to those pictured, the following presentations were given:**

- Aurora: Physics Alive (Lars Ake Holmgren, Sweden)
- Bar des Sciences (Daniel Raichvarg, France)
- Physics from Heaven to Earth (Peter Uylings, Netherlands)
- The Two Faces of Physics (Ivan Lalov, Bulgaria)
- Physics with a Computer (Angel Franco, Spain)
- Light and Colour (Harri Montonen, Finland)

# *The workshops*

Throughout the festival, participants met in small groups to discuss various themes related to physics education. Physics On Stage provided a unique opportunity for the opinions of teachers and educators to be heard. Over 500 experts on physics teaching and popularisation took part in the workshops; including physics teachers, university lecturers and researchers, experts on curriculum development, science communicators, scientific and educational journalists, representatives of ministries and European organisations. Their experiences, opinions and suggestions were combined to form a valid and representative expression of the will of the European physics community.

The topics of the workshops were suggested in advance of the festival week and questions were posed to initiate the discussions. These questions, along with short summaries of the discussions and recommendations from each workshop, are presented here. Full reports from each workshop and the explanations for the recommendations are published on the website http://www.cern.ch/pos and in a separate document, available from Helen Wilson, Executive Coordinator for Physics On Stage, ESTEC (ADM-RE), European Space Agency, Keplerlaan 1, 2200 AG Noordwijk, The Netherlands.

On the final day of the festival, participants voted on the recommendations, choosing one from each workshop that they believed to be the most important. The recommendations with the highest number of votes are marked with an asterisk (*) in the following pages.

***Focus on Teachers***

***The Role of History and Philosophy in Physics Education***

***The Place of the Internet in Physics Education***

# 1. Mapping the Crisis

**Leader: Wubbo Ockels (ESA)**

- Is there a crisis in physics education?
- Is there a shortage of students wishing to study physics?
- What are the causes of the perceived problems?


### *Summary*

Delegates from 11 countries participated in this workshop and provided supporting evidence from all 22 countries, showing that there is indeed a crisis in physics education.

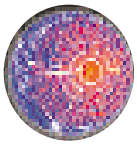
The main crisis relates to the narrow age distribution of physics teachers (average age is close to 50 years), combined with the severely reduced influx of new teachers (at the level of 5-10 teachers per million of the population). This situation will lead to a drastic reduction in the number of physics teachers in Europe within the next 5-10 years.

The numbers of students choosing to study physics at secondary school and at university are also declining, although interest in science does exist at the primary level.

Other problems that were discussed included; the low image of physics and teaching in society, the effects of current teaching methods on students, the export of good students from their home countries to the USA and the lure of physics students away from scientific research by wealthier industries.


### *Recommendations*

- Introduce a reward system for teacher training schemes, supported by industry and the scientific community, which highlights teaching skills.
- Organise a lobby to boost the image of physics and which would ensure that lack of money is not adversely affecting schools.
- Introduce physics into the mainstream (e.g. television, role models) to increase awareness of the connection between physics and daily life.*
- Increase political awareness of the problems outlined above.
- Make physics lessons more fun and less mathematical for the majority of students.
- Increase awareness that people trained in physics are very employable, in many areas of society.



# 2. Physics in Primary Education

**Leader: Rosemary Feasy (United Kingdom)**

- At what age should some form of science education begin?
- Insights from psychology about cognitive capabilities at various ages.
- What kind of physics should be taught? (conceptual or quantitative? practical or theoretical?)

## *Summary*

We identified several challenges facing science education for young children. Those were:
**i.** The level of teachers' knowledge and understanding in science/physics.
**ii.** The level of understanding about learning and teaching approaches.
**iii.** Teacher attitudes towards physics are often negative and stereotypical.
**iv.** Teachers need to be trained to know how to encourage children to think and work scientifically.
**v.** Physics should be presented to young children in appropriate contexts.
**vi.** Science should prepare young people for citizenship, they are the 'adults of the future' and this needs to be recognised.
**vii.** Teachers need to support children in developing different ways of recording and communicating in science; they should not rely on the written word alone.
**viii.** Teachers should consider physics in the home and local environment and make links with everyday life.

## *Recommendations*

- All children in the European Union should have access to science experiences from the earliest age, that is, at home and from kindergarten to the age of 12 and onwards.
- All teachers of young children should have access to professional development in science education. *
- The EC should set up a 'Virtual Resource Centre' based around an internet site.
- A European Association for Young Scientists should be created to provide opportunities for children to engage in informal science activities at home and in school.
- All European Research Centres should have an Education Division.

# 3. Physics in Secondary Education

**Leaders: Jean Collins (United Kingdom)**
**& Marie-Louise Zimmerman-Asta (Switzerland)**

- Should Physics be a compulsory component of the curriculum?
- Is pre-university training for future scientists or for the general education of future citizens?
- What level of mathematics is necessary?
- Should syllabuses be conceptual rather than quantitative
- How should physics be related to other subjects?

*This workshop was divided into two groups: (A and B) due to the large number of interested participants.*

### *Summary group A*

The unique opportunity to discuss with colleagues from countries around Europe at 'Physics on Stage' was used to the full in this workshop. Reports and an exchange of experiences and curriculum requirements in various countries formed the basis of the itinerary.
The first notable feature was that many experiences were common to us all. The second highlighted the many differences and great variety of criteria expected by the governing bodies of the respective school systems. The third and final point, discussed at length, was our area of common ground, namely the need to educate everyone to the relevance of Physics in this modern Scientific Age.
With these three points in mind the workshop members went on to develop their set of recommendations, aiming to be general enough for all members and precise enough to be helpful for development by governing bodies.

### *Recommendations, group A*

- Learning should be based on everyday life in contexts highlighting physics, past, present and future.
- Students' learning should incorporate experimental, theoretical, mathematical and ICT skills.
- A range of teaching methods must be used to enable students to become independent learners.
- To provide appropriate learning environments, teachers' skills need regular up-dating.

### *Recommendations, group A (cont.)*

- Government Criteria for physics teaching should provide enough flexibility in course design to allow context-based teaching.
- Adequate equipment, sufficient teacher training and the promotion of physics must be financed. *

### *Summary group B*

The participants of this workshop (from France, Belgium, Switzerland and Spain) considered that it is fundamental to carry out discussion groups at student and physics teacher levels about the status of physics education. They strongly felt that further workshops on various subjects would be beneficial. A comparison of pedagogical pratices in European countries would also be very valuable.

In this workshop, participants stressed the notion that physics is an important part of our culture today, and that it contributes to open-mindedness. The point was also made that for physics to be taught correctly, teachers must be competent in the subject, they must have been trained in didactics and pedagogy, and they need to have the attitude of a researcher. Further, good teacher training (for primary and secondary schools) is absolutely necessary.

### *Recommendations, group B*

- It should be recognised that Physics is absolutely necessary to everybody, because it is a part of today's culture.
- Physics teaching must develop a way of thinking for the majority of students that will never become scientists.
- Physics teaching should provide meaningful explanations to students all over the world, so it must be linked to reality.
- Physics teaching should be tuned to different school levels and different interest groups.
- As physics is an experimental science, teaching requires adequate human and material resources, reasonable class sizes and adapted schedules to develop different aspects of scientific methods.
- Teachers of physics require skills in physics, didactics, pedagogy, and an open-minded attitude. Thus, teacher training in accordance to those objectives is essential. *

# 4. Physics and Public Understanding

**Leader: Katarina Teplanova (Slovak Republic)**

- Do current syllabuses contribute to the public understanding of physics?
- To what extent do current syllabuses contribute to scientific literacy?
- How can the confusion between science and pseudo-science / science fiction be addressed?


### *Summary*

Science is not generally seen as a part of mainstream culture. Physics and chemistry are "negatively charged" (scientific language, atom bomb, nuclear power plants, pollution etc.). People tend to be afraid of science rather than attracted to it. Their motivation towards science and technology is poor, due to the ways in which science is introduced in schools and portrayed in the media. They believe that science is out of their interests. Knowing nothing about science is often not viewed as a bad thing, especially by girls.

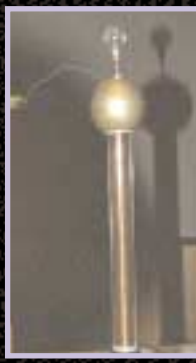
Scientists often assume that the public has no scientific understanding, whereas many people have detailed knowledge of some aspects of science – for example, the science involved in motor engineering or wine making.

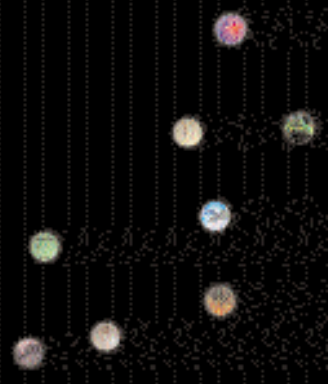
There are insufficient institutions responsible for the public understanding of science. We need more interactive museums and science centres, focussed on issues such as: the Public Relations of Science, non-formal lifelong learning, research into the public understanding of science, questions that aid learning and motivation, the support of schools with current scientific knowledge, teacher training, and so on.


### *Recommendations*

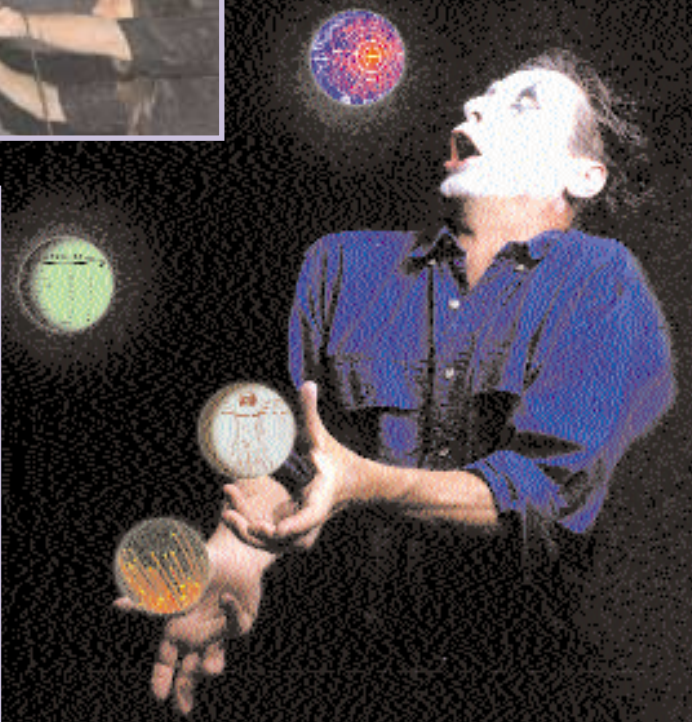
- Collaborate to provide courses in science communication for journalists, policy makers, scientists, science students etc. *
- Bring physics to the people through the establishment of community based science centres and outreach programmes.
- Sell physics to the media by making it accessible and relevant to the public and through linking physics to other disciplines. *
- Look for effective ways to respond to people's needs and interests.
- Value and expect the communication of scientific research.

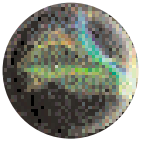
# *Souvenirs from a 5-da*





# ay Physics Melting Pot





# 5. Role of History and Philosophy in Physics Education

**Leaders: Anne Brumfitt (Netherlands)**
**& Nicholas Witkowski (France)**

- What part should the history of physics play in physics education ?
- How should physics education address the belief that science is either right or wrong ?
- Should moral responsibilities be considered as part of physics education ?

## *Summary*

One of the main conclusions reached in this workshop was that the history of science is currently underused as a pedagogical tool in physics teaching. Most of the time, due to poorly-informed teachers and lack of interest from the curriculum makers, some very short (and often unfair) biographies are quickly presented whenever time is left at the end of the lesson. It is in fact possible to teach physics without any reference to history, but all the participants in the workshop think that a clear and deep understanding of scientific notions can only be acquired through a good grasping of their history.
We believe that the history of science, and the philosophical views which go with it, is one of the solutions to the current crisis of physics teaching.

## *Recommendations*

- History and philosophy of science should be part of the training of physics teachers. *
- Information about successful and unsuccessful uses of history of science in teaching should be collected and made widely available.
- Historical and physical societies should be encouraged to collaborate.
- Through the history and philosophy of science (HPS), a more realistic image of science should be given. Tools should be developed to address social issues involving science.
- Use HPS to clarify the relationship between the scientific world view and those from other fields of knowledge.

# 6. Consideration of the Major Issues of Today

**Leader: Adam Kovach (Hungary)**

- Physics education and today's major issues.
- In what way should bioengineering, environmental concerns, natural disasters, energy resources, sustainability, nuclear science, etc.. be included in physics education?

### *Summary*

We agreed that the main issue of concern to society is the problem of sustainable development. All societies are addressing the big questions, for example: should the consumption and demands of future societies follow the recent exponential growth – or should we take a different route?
The delicate balance of the world is being profoundly affected by human activities. How must we act to maintain the development route of mankind? We should enable future generations to address and solve these problems.
The children we teach now are the decision makers of the future. The knowledge and skills we give them will enable them to make, or not make, the right decisions. Physics underpins the new technologies, many of which may play a role in solving some the problems of sustainability. However, all the delegates reported that society has an often negative attitude to physics, founded on a history of nuclear accidents, government cover-ups and the over-optimism of scientists in the immediate post-war years.

### *Recommendations*

- It should be recognised that Physics has immediate relevance in understanding and solving problems of sustainable development and growth.
- A curriculum should address the above issues, and the immediate impact of physics to everyday life, based on a complex inter-disciplinary approach.*
- The pace of research and the increasing availability of information calls for relevant and on-going teacher training.
- International co-operation should form an integral part of the development of curricula at local and national levels.
- Students and teachers should be given reliable information from a variety of sources, which is up-to-date and free from propaganda.
- The curriculum should enable students to take reasoned decisions, weighing up evidence and risk in a social and economic context.

# 7. Women and Physics

**Leaders: Cecilia Jarlskog (CERN)**

- What are the statistics? (national contributions)
- What can be done to even out the gender imbalance in certain countries?
- Why do women chose other science subjects (e.g. biology) over physics?

## *Summary*

We discussed mostly two issues: 1) men and women, and 2) boys and girls (future men and women)

We looked into statistics, such as those of the European Union and the American Institute of Physics. In a nutshell, there is a big difference in the way men and women appear on the science career maps; there are very few women towards the top of the academic hierarchy. This is actually true for all sciences not just physics. Even in "soft" sciences men dominate at the top of the academic ladder.

Our conclusion was that there is plenty of subconscious discrimination against women in many countries. We suggest that all men and women be constantly reminded of this hidden danger.

We discussed the behaviour of girls and boys in school. The participants felt that girls often lack confidence, they think their work is not so important and that physics is not for them. Teachers should be sensitive to these issues and take them into account when teaching physics. They should emphasize cultural, historical, humanistic, musical, and medical aspects of physics – aspects which are often more appealing to girls.

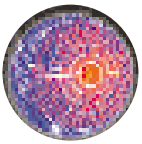
## *Recommendations*

- Gender awareness should be included in the education of teachers. Physics lessons should include physics that girls will like. *
- Help women with small children by, for example, providing childcare, part-time jobs, and taking into account effective age.

*And some more radical suggestions:*

- Let girls start school one year earlier than boys.
- Separate schools for boys and girls.

# 8. Physics and Toys



**Leaders: Hubert Biezeveld (Netherlands)**
**& Rafael Garcia Molina (Spain)**

- What role does ‘play’ have in learning physics?
- What kind of toys illustrate physical principles?
- Comparison of different experiences.

## *Summary*

We agreed more or less about the following 15 statements:

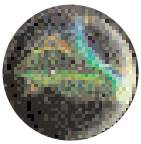
- Toys are great starters
- Toys can introduce new concepts
- Toys that raise questions are the best
- Toys should lead to investigations
- Toys catch attention and stimulate discussion

- Toys cross language barriers
- Toys prove that physics is everywhere around us
- Toys are essential for starting physics in primary school
- Toys help people understand technology
- Toys are cheap

- Toys are the champion motivators
- Toys give the feeling anyone can do physics
- Toys strike a emotional string
- Toys make pupils feel the teacher is one of them
- Toys are not just for fun; they are for joy and joy lasts longer

## *Recommendations*

- Make teachers aware that toys have a high motivating function: they provoke questions and lead naturally to investigations. *
- Encourage teachers to join children in playing with toys and make learning fun.
- Toys and scientific understanding should be part of elementary teachers‘ training.
- Increase awareness that toys help in crossing language-barriers.



# 9. The Place of the Internet in Physics Education

**Leader: Robert Cailliau (CERN)**

- How can schools benefit from the information available over the internet?
- How can the internet be used to promote communication?
- Are present facilities satisfactory?

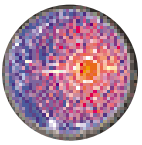
## Summary

In the last ten years, the development and rapid growth of the so-called Information Society has changed the way in which many of us live our daily lives.
New tools are touching all the spheres of our activity, and education has been one of the most important goals from the beginning.
The power of the Internet as a tool is not in doubt, but this is not enough: we have the tool, but we must learn how to use it for education. This is one of the biggest challenges for Internet-related education projects: how to use the Internet, how to organise the vast amount of data available, how to coordinate all the different groups that are working towards the same goals but in different places, etc...
During this workshop some of those problems were discussed, and we had the opportunity to discover how different countries face them. The lack of an organisation to coordinate the efforts of separate groups seemed to be the main problem, as well as who could support and finance such an organisation.
It was clear in the end that coordination, cooperation and sharing of experiences are the fundamental initial steps to introduce the Internet into Physics education.

## Recommendations

- Join the European School Net: it federates other nets.
- Guarantee financing and future website existence.
- Do quality research, by and with teachers at schools, on the learning process in internet-based teaching.
- Research, develop and evaluate different methods of using internet resources.*
- Bring internet-based teaching into professional development programmes in each country.

# 10. New Tools in the Classroom



**Leaders: Richard Hammond (United Kingdom)**
**& David Nixon (United Kingdom)**

- How can new technology be used to improve physics education?
- What benefits can computers and CD-ROMs bring to lessons?
- How can they be used for projects and demonstrations?

***Summary***

Physics is exciting not only to physicists but also to young people. We must continue to find ways to excite and motivate young people to explore and enjoy the beauty of this subject. New technology provides opportunities to do this, for example, by enabling the sharing of ideas and information between more people than ever before.

The variation in the use of new tools in Physics education reflects the differences that exist in society as a whole. It is clear from members of the workshop that there are great differences between the provision of new technologies and the associated training needed to use them effectively in the countries represented. If Physics education is to help prepare young people for our ever-changing technological society it must involve new technologies in its delivery. This must only be done in such a way as to add value and enhance learning. It should involve training for all Physics educators to provide the opportunity for all young people to experience the use of new technologies.

***Recommendations***

- Funding agencies must recognise the financial implications of introducing and maintaining in schools.
- Financial support for Information and Communication Technology (ICT) training must provide experience which includes an understanding of pedagogy.*
- There is a need for the development of a central database to enable the exchange of information on the use of ICT in physics education.
- Physics teaching should reflect society and use ICT, where appropriate, to add value and extend the learning experience.
- Partnerships should be developed between schools, higher education and industry to enable pupils to access and experience new technologies.
- There is a need to develop compatibility amongst the equipment used for ICT.

# 11. ESO, ESA, CERN and the EU

**Leaders: Claus Madsen (ESO)**
**& Clovis de Matos (ESA)**

- What contribution could / should European science organisations make to physics education?
- At what levels should contributions be made?
- What proposals are there for the long term?

## Summary

European science organisations have already begun activities to stimulate scientific awareness and interest in the natural sciences. Important experience has been gained, upon which more coherent programmes may be developed.
Delegates from 11 different countries participated in this workshop and debated directly with represents from CERN, ESA, ESO and the EC how to build on existing achievements. Emphasis was put on education as a key priority for Europe. The dissemination of knowledge through existing networks and their improvement through a synergetic coordination between the European and national organisations was discussed. Ways to involve teachers in European educational programmes and to increase their interaction with European scientific organisations were also assessed.
Regarding funding; it was stressed that European educational programmes, funded by European science organisations, should be complemented with support programmes sponsored by the European Commission (6th framework programme and possibly other EC programmes).

## Recommendations

- Education is a key priority for Europe and European science organisations and the EC must be involved in its development.
- Education and outreach should be integrated with research projects using a 1% share of their budget. *
- The EC, the European physics organisations (POs) and endorsed teacher networks and national organisations should promote both short and long term activities.
- POs should have teachers in residence to allow in-service training and outreach activities, supported by EC programmes.
- POs should have teachers-in-residence to allow in-service training and outreach activities, supported by EC programmes.
- Extracts from PO databases should be tailored for educational use.

# 12. Focus On Teachers

**Leaders: Rosa Maria Ros (Spain)**
**& Brenda Jennison (United Kingdom)**

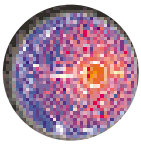
- What is the condition of the job market?
- What is the social status of teachers? Is this acceptable?
- Do we need more collaboration across Europe regarding physics education? Should there be a European physics curriculum?

## *Summary*

The group looked at the factors affecting the recruitment of teachers and how these can be changed to improve the crisis facing physics teaching. In some countries there is a critical shortage of physics teachers and a lack of real quality in those that are recruited. In other countries the situation is not yet critical, but the failure to reach recruitment targets is recognised in all of the countries that we discussed.

## *Recommendations*

- Teachers' conditions of service need to be improved (working hours, preparation time, technical help, support, training and professional development, promotion prospects).
- Teachers' salaries and pensions should be brought in line with those of other professionals with comparable qualifications.
- Teachers need a good training before, and further professional development during, their careers and teachers, like other professionals, need regular paid leave in order to improve their knowledge and skills.
- We recommend the promotion of personal contact between ordinary classroom teachers in different European countries in order to exchange and share teaching ideas.
- We recommend that, because of the growing crisis, an audit of the quality, quantity and competences of teachers throughout Europe be carried out.
- In most countries, respect for teachers by pupils, parents, governments and society is falling - this can be improved with more positive and active support for teachers.



# 13. Curriculum Development

**Leader: Fernand Wagner (EAAE)**

- ◆ Comparison of new curriculum projects.
- ◆ Exchanging ideas: sharing and adapting.
- ◆ What organisation is neccessary to ensure that good ideas are widely used?


## *Summary*

With respect to the complexity of the curriculum situation in Europe the workshop concentrated on a number of issues that seems to be central to physics teaching in all countries and may contribute to cross national inspiration. The wide-ranging discussion within the workshop sessions was structured by the following questions:

- What is the purpose of the curriculum ?
- Should the curriculum aim at science for all or only for the specialists?
- How much autonomy should be allowed for the teacher, and how much for the student ?
- Should the curriculum contain only the contents or should it also describe the contexts ?
- How should the curriculum deal with methods and outcomes ?
- What is the connection between the curriculum and assessment ?
- How can continuity in the progress of education be guaranteed ?
- How should a new curriculum be developed ?
- How should innovation be reflected in curricula ?
- How should constraints be addressed ?


## *Recommendations*

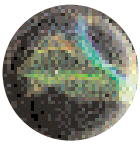
- ◆ There is a need for curricula that clearly indicate : the content, the contexts, teaching methods, the degree of flexibility, and the expected outcomes.
- ◆ The process of development of a curriculum should include the steps: innovation, participation, realisation, evaluation.
- ◆ A curriculum should enable continuous development and the government should enable the realisation of the curriculum.
- ◆ There is no need for a single European curriculum, but there is a necessity to discuss the variety of solutions. *

# THE FAIR

For Physics On Stage, both floors of CERN's main building were transformed into a lively and colourful physics teaching fair. Delegates of the festival and passers-by played with the Slovakian "Schola Ludus" display: hand-made tubes in wooden frames that showed fluid phenomena in a fun and original way. A group of Portuguese students demonstrated chaos theory with a water wheel, the Polish delegation decorated their stand with gingerbread hearts reading "$E = mc^2$" , and Austrian delegates took a walk of the fair with their spider-like robots which were steered via the internet by their colleagues in Vienna.

Each participating country had a stand to display their best projects and ideas, selected through the national events. Belgium even installed their Experion Science Truck outside the main building. A constant stream of visitors made their way through the fascinating and highly creative displays. This was where the spirit of Physics On Stage manifested itself most clearly: delegates constantly exchanged their views, originated ideas for projects and made new contacts.

Dr. Philippe Busquin, European Commissioner for Research, spent several hours at the festival. His active involvement and obvious enjoyment of the fair were a great source of motivation and inspiration for the participants as well as for the organisational team. The European Commission and the Directors-General of ESA, ESO and CERN, who also visited the festival, demonstrated strong political support to the Physics on Stage Festival and its outcome.



# List of Participants to the final festival

*This list contains the names of the pre-registered participants of the Physics On Stage festival, but does not reflect the many local teachers, world-wide journalists, CERN employees, and other last-minute arrivals who participated in some part of the festival.*

**Austria**
K Albrecht
T Duenbostl
W Faerber
C Gottfried
G Groemer
H Hergan
J Huber
L Mathelitsch
A Mayer
P Oswald
C Wutte
R Ziegelbecker

**Belgium**
M Beddegenoots
A Dambrenez
H De Visscher
W Ginkels
P Goldberg
J-M Kayls
A Martegani
P Nardone
J Oliver
P Rudolf
L Urbain
R Van Peteghem
B Van Tiggelen
K Vandenbussche
Y Verbist-Scieur

**Bulgaria**
V Angelova
G Borisov
V Golev
V Ivanov
I Lalov
P Lazarova
S Pavlova
V Radeva
J Raykova-Bozova
A Vavrek

**Czech Republic**
V Bdinkova
J Dolejsi
Z Drozd
L Dvorak
J Houfkova
I Koudelkova
B Patc
Z Polak
J Rames
K Rauner
J Trna
M Urbanova

**Denmark**
M Bohm
M Jensen
L Ohlenschlaeger
E-B Olesen

**Finland**
H Kasurinen
I Koivistoinen
J Kytömäki
S Mäkelä
H Montonen
M Säily
M Sarimaa
T Suvanto

**France**
M-C Baurrier
L Beck
A de Bellefon
N Calvat
F Cano
D Cornuejols
V Coutellier
A Druel
J Eisenstaedt
M Goffard
M Gourgeot
J-L Heudier
G Jouve
J-M Monget
V Periquet-Salles
C Pinet
D Raichvarg
Y Saquin
M Schwob
J Treiner
M Wafra
N Witkowski

**Germany**
B Apell
U Backhaus
U Behrens
H Beneke
G Born
W Brozzo
J Brucherseifer
K Buschhüter
D Champion
N Coldewey
H Deger
H Ding
G Döbbeling
P Engelhardt
U Ernst
M Euler
C-A Feldmann
P Feltes
L Fiesser
J Frercks
B Freytag
K Gehrmann
H Genz
W Gollub
C Gurlitt-Satori
J Gutschank
G Hacker
A Hänel
I Heber
P Heering
M Hienz
P Hobe
A Jungermann
D Kaack
J Kirstein
W Knaak
M Kobel
D Kobras
U Langenbuch
H Look
M Ludwig
O Lührs
A Markus
V Martini
J Miericke
U Neundorf
C Pawek
O Persson
U Petzschler
G Riedl
F Riess
M Rode
G Sauer
T Schäpers
D Schmitz
E Sieker
B Steinrücken
W Stetzenbach
P Stinner
R Szostak
R Thiel
M Vollmer
W Warland
W Welz
R-P Wittkowsky
E Woppowa
H-C Zapp
R Zeh
S Zwiorek

**Greece**
C Chantzopoulos
E Christodoulides-Tsitopoulous
I Gatsios
C Ioannidis
K Kampouris
D Karounias
S Kasdaglis
I Kopanas
D Markogiannakis
M Metaxa
M Panagiotopoulos
N Papastamatiou
F Plattakis
N Tracas

**Hungary**
M Bocz
S Csajagi
B Jarosievitz
I Kispal
A Kovach
A Lang
A Mester
A Nagy
G Naray-Szabo

K Pilath
Z Rajkovits
Z Sebestyen
L Zsudel

**Ireland**
J Connolly
A Cronin
E Cunningham
G Douglas
I Elliott
C Flynn
K Gallagher
A Hackett
J Harkin
P Healy
S Jackson
A Kelly
F Mitchell
J Murphy
R O'Donavan
A Thielemans
D Thurston

**Italy**
R Antolini
L Barberini
F Biondo
GN Cabizza
L Ceccacci
I Cocco
V De Chiara
E De Masi
A Devoto
U Donzelli
A Evoli
L Follini
F Guadagnini
A Janni
F Latella
G Magliarditi
F Mantovani
C Marzotto
M V Massidda
A Misiano
V Montel
C Palici di Suni
M Pancaldi
B Pecori
G Pegna
S Perugini Cigni
G Pezzi
S Pugliese Jona
G Rinaudo
C Romagnino
G Torzo
S Vannucci Giromini
G Zappala
P Zorzi

**Luxembourg**
F Wagner

**Netherlands**
A Bedford-Brumfitt
H Biezeveld
C Drucker
P J de Leeuw
M Engelbarts
D Hoekzema
T Hofstetter
A Kleyn
L Malthot
T Scholten
G Schooten
K Smith
P Uylings
P van Yperen
P Verhagen
H Verstappen
C L Vlaanderen
R Wielinga

**Norway**
C Angell
G Arge
H Bruvoll
V Engstrom
K Hetland
H Kolderup
K Odegaard
E Oterhom

**Poland**
J Brojan
T Calka
Z Golab-Meyer
M Golka
S Grabowski
J Jarosz
L Jochymska
S Kalinowski
R Kantorek-Palka
T Laskowska
A Ludwikowski
A Milosz
J Mostowski
W Mroszczyk
W Natorf
W Nawrocik
B Piatek
K Raczkowska-Tomczak
T Skoskiewicz
A Smolski
A Strugala
I Strzalkowski
A Szczygielska
H Szburska
J Tokar
N Tomaszewska
W Wegrzyk
M Zaborowska-Kusmierek

**Portugal**
J Antunes
A Baptista
A Campos
A Costa
M Estima
E Figueira
C Fiolhais
V Lopes
F Melo
A Noronha
L Novais
M Novais
P Pombo
C Rodrigues
D Silva
M Sousa
G Ventura

**Slovak Republic**
J Benuska
V Biznarova
J Demko
D Krupa
M Makuch
J Stanicek
K Teplanovà
E Vojtelova

**Spain**
A Bramon
M Cabrerizo
A Cortel
M L de Pedraza
M del Arco
A del Mazo
A Franco
R Garcia
J Gonzales-Lopez
F Jauregui
D Martinez-Delgado
M Merino
J Mira
P Nacenta
M Novell
P Padro
X Pardo
J Pastor
A Rivera
R-M Ros
C Sampedro-Villasan
M Sanchis
J Sanz
J Tome
J Varela
M P Varela
C Wagner
E Zabala

**Sweden**
E Berglund
H Bervenmark
J Enger
O Finnhult
L A Holmgren
K Humling
B Lingons
B Lockhart
C Nilsson
A Ölme
A-E Olsson
O Östklint
U Siren-Peura
S Sollerman
M Ullerstam
A Vaesterberg

**Switzerland**
D Chatellard
E Lindemann
F Gassmann
H Muhry
D Vite
M Zimmermann-Asta

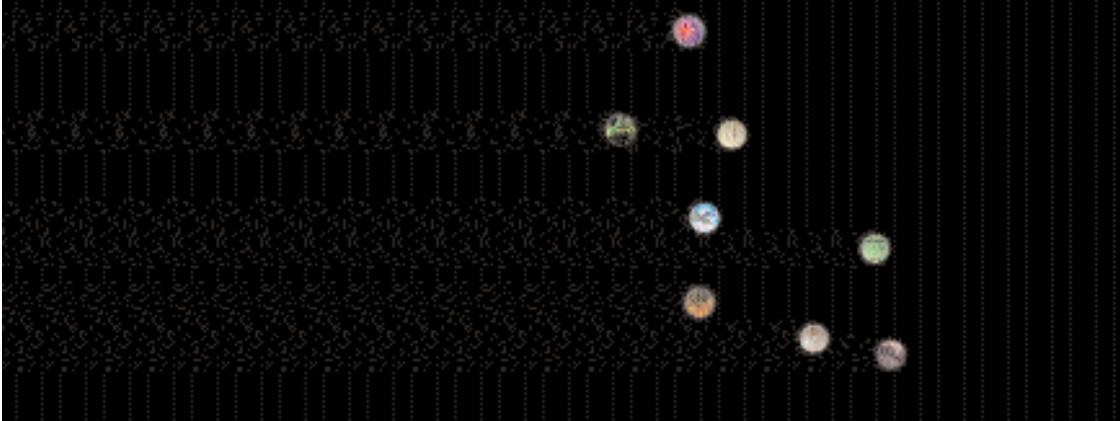
**United Kingdom**
M Barnes
S Chapman
R Clegg
J Collins
A Davies
K Davies
S Farmer
R Feasey
D Gault
M Gluyas
W Gluyas
R Hammond
M Hollins
J Jardine
B Jennison
B Keogh
M Luck
A Marshall
S Medley
G Moore
A Morrison
S Naylor
D Nixon
J Ogborn
K Parker
J Parkhouse
M Parkinson
M Penston
A Pickwick
V Piper
D Sandford-Smith
M Shaw
C Shepherd
D Smith
E Swinbank
M Whitehouse

# *The Future of Physics On Stage*

The International Steering Committee and their organisations are committed to building on the outstanding success of Physics On Stage, maintaining and developing the network of contacts and providing support for future educational programmes.

The events of the year 2000 have catalysed a debate about physics education at a high political level. The problems that were highlighted by Physics On Stage and the solutions suggested at the final festival are being given serious consideration. The recommendations have been forwarded to the European Commission who, together with the European research organisations, ESO, ESA and CERN, have formed a dedicated working group to address the future of the Physics On Stage endeavour.

In addition, the European Physical Society (EPS) is in the process of setting up a Division of Physics Education with sections for pre-university and university level physics education. The Physics On Stage workshops identified important work that needs to be done and which will be considered by the new division.



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