

WOMEN PHYSICISTS: PROGRESS?

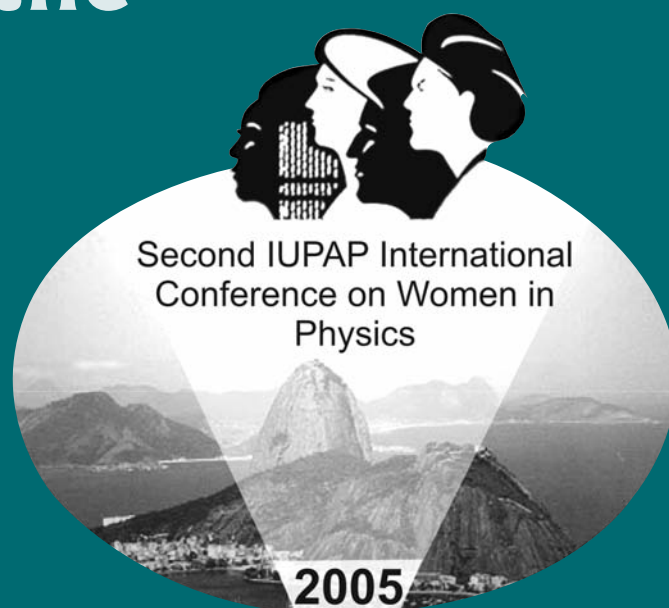
A report from the UK delegation

The Second International Conference on Women in Physics took place in May 2005 in Rio de Janeiro, Brazil. This paper is a report from the UK delegation. It aims to present the conclusions from the Rio meeting, and to review and build upon progress, within the UK and beyond.

It became apparent at the meeting that the UK is positioned at the forefront of considering and addressing the under-representation of women physicists. This under-representation remains, however, a serious problem. Only 21% of UK physics undergraduates are women, and 4% of physics professors. There are very strong economic drivers to increase the number of women in the scientific workforce. Many women do not give a future career as a physicist due consideration and others leave physics as a result of a sense of isolation or an unfavourable career structure. Women are, on average, still paid less than men for equal work.

There is no room for complacency and in this report we draw attention to:

1. the importance of continuously gathering good data, collected over a period of years, to assess whether the situation is improving and show which measures are most effective.
2. the importance of evaluating the initiatives currently in place, such as site visits and mentoring, and building upon them.



3. new initiatives such as professional development workshops, including women on the organising committees and as speakers at all major UK physics conferences, giving credit for the time spent on activities promoting diversity and including gender diversity as a factor in the Research Assessment Exercise.
4. the importance of considering all age groups, from schoolgirls, to women in senior academic, industrial and administrative positions.
5. the advantages of flexible and innovative working patterns.
6. women in industry, who, as a more diverse grouping, are harder to monitor.
7. proposals to improve the position of women in physics world-wide to which we hope the UK will contribute fully.

The 2005 UK Delegation

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1. Background to the Rio IUPAP meeting

In March 2002 the International Union of Pure and Applied Physics (IUPAP) organised its first international conference on Women in Physics in the UNESCO building in Paris. The aims were to understand the reasons for the under-representation of women in physics worldwide and to formulate strategies to address the imbalance. The meeting was attended by over 300 delegates from 65 countries, many of whom held senior positions in academia, research laboratories and national physical societies. The delegates passed a number of resolutions supported by recommendations of ways of improving the situation of women at each stage of their career. The full proceedings of the meeting can be found at the conference website¹.

On their return the UK team wrote a major report, *Women Physicists Speak*, that described the situation for women physicists in the UK at that time and put the resolutions and recommendations in the UK context. This can be downloaded from the Women in Physics Group (WIPG) website². The report led to the setting up of an Institute of Physics (IoP) working party which proposed several initiatives aiming at encouraging more women to pursue physics careers and improving the climate for women within the physics community. This took place against a background of several national initiatives aimed at progress for women in Science, Engineering and Technology (SET).

At the close of the Paris meeting conference delegates recommended that there should be a second international conference in 2005.

The Second IUPAP Conference on Women in Physics¹ was held in Rio de Janeiro, Brazil, from 23-25 May 2005. Thanks to generous funding from EPSRC, PPARC, IoP, the University of Leicester and the UKRC the UK was able to send a delegation of 11 scientists, which included two women working in industry.

Discussions at the Rio conference focussed on progress since 2002, the effectiveness of programmes in place and ideas for new approaches to increase the participation of women in physics. We considered the strong similarities in the situations experienced by women physicists worldwide, together with the differences arising from the wealth of each country and its culture. Different nations have been willing, or able, to put different degrees of effort in to promoting women in physics. Increasingly the UK is seen as a leader in implementing ideas and good practice. The Institute of Physics should be commended for its role in this.

This document is a report from the UK delegation which aims to review and build on progress within the UK. The report is a follow-up to *Women Physicists Speak*. It draws particularly on the resolutions and recommendations of the Second IUPAP Conference on Women in Physics, given in Appendices 1 and 2, and on *Set Fair: Progress in the UK*³, a plenary talk summarising progress within the UK presented at the meeting by Ann Marks, the Chair of the Women in Physics Group of the Institute of Physics. Physics is taken to include astronomy at most junctures in the report.

2. The wider context

This report is written at a time when economic and social pressures are causing the Government to recognise, increasingly, the need to support women in their dual role within the workforce and the family. An initiative, likely to be of particular relevance to the highly qualified women seeking a career in SET, is the flexible working legislation, which facilitates and legitimises the wish of individuals to maintain an optimum balance between their home and working lives. Other developments have included an increase in state maternity benefits, a pledge by the Labour Government to extend maternity and paternity leave, tax-subsidised vouchers for childcare, and increased nursery and after school care provision. Increasingly, it is seen as the right of both women and men to expect a fulfilling career.

The UK Government has recently focussed particular attention on the attraction and retention of women in SET which is seen as making an important contribution to the future health of the UK economy. The ball was set rolling by the publication of the Roberts Report *SET for Success*⁴ in 2002, highlighting a future shortage of graduates in SET subjects. The report noted the under-representation of girls studying science at A-level and identified women as an under-used resource within the scientific workforce.

Following this Baroness Susan Greenfield, Director of the Royal Institution, was asked to lead an enquiry on how to improve the recruitment and retention of women in SET, increase the number of women in policy making and recognise women's achievement and contribution to SET. The report *Set Fair: A Report on Women in SET*⁵ published in 2002 recommended a Science Resources Centre to provide an infrastructure for women in SET organisations and initiatives, pump-priming schemes for networking, mentoring and returners' programmes, improved statistical monitoring, a part-time/job-sharing incentive scheme and a programme for high flyers.

The Department of Trade and Industry responded quickly with the publication, in April 2003, of *A Strategy for Women in SET*⁶ (2003). This led to the setting up in 2004 of a central UK Resource Centre⁷ (UKRC) for Women in SET, encouraging women in a range of traditionally male career sectors from academic science and industry to construction. The UKRC is based in Bradford, England and has been funded for three years, receiving a £2.8 million additional boost in March 2005.

The Institute of Physics and UKRC have funded an Open University returners' course⁸ starting in October 2005 which will be free for two years. Funds have been made available for travel grants and awards have been made to Higher Education Institutions to support schemes to retain women undergraduates.

The National Mentoring network, MentorSET⁹, initially funded by the Government is now funded by UKRC for a further two years.

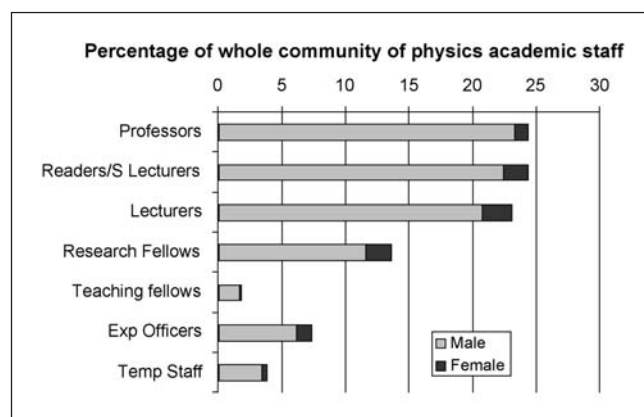
The Roberts *Review of the Research Assessment*¹⁰ (2003) drew attention to issues concerning women in research and as a result scientific professional bodies have recently implemented a range of initiatives to attract and retain female scientists. The Wellcome Trust has introduced new 2-4 year career re-entry fellowships. The Royal Society has expanded the Dorothy Hodgkin Fellowships, set up the Rosalind Franklin Award and introduced relocation fellowships, designed for 'trailing spouses'. Women in SET groups have been set up at establishments run by the Council for the Central Laboratory of the Research Councils. PPARC, EPSRC and the Royal Society now pay extensions to grants to cover maternity leave and funding is available to cover the extra cost of childcare incurred when attending conferences.

The European Union has also made a strong commitment to Mainstreaming Gender equality. Applications for EU funding have to explain how the proposal has been structured to try to remove any gender bias in their subject.

This multi-pronged approach has raised the profile of women in SET nationally and has major implications for women in physics.

3. How many women physicists?

Despite the investment of time needed to collect comprehensive and reliable data, it is a vital step in assessing whether the situation is improving and which measures are most effective in driving that improvement. Several useful steps have been taken in this direction over the past 3 years. An Institute of Physics Report, *A Survey of Academic Appointments in Physics 1999-2004*¹¹, includes data on the number of women academic physicists in the UK broken down by seniority and field.



Currently 22% of A-level physics candidates are girls, 21% of first degrees in physics and 18% of PhDs are awarded to women. 9% of the research and teaching faculty in physics at universities are women. The women are disproportionately represented in the lower grades, 15% researchers dropping to 4% professors. It is of interest to note that 17% of arriving staff were women as compared to 7% of leaving staff suggesting that, although women are seriously underrepresented, the trend is in the right direction.

Of the members of the Institute of Physics the proportion of women has recently risen to 16%. The distribution of the 5,600 women members is skewed with age and includes 25% of all student members but only 3% of the Fellows. The 2004 IoP salary survey of its membership showed a clear differential in earnings between men and women – over £9,000 in the median of basic annual salary with the pattern repeated for bonuses and wages from other employment. Men's salaries increase steadily with age, reaching a maximum of nearly £46,000 at retirement. Women's salaries, however, increase steadily with age until about 40, at a median salary of £35,500 and then stay steady at this value until retirement. At retirement age the difference between annual salary of men and women is more than £10,000.

There is very little known about the career paths of women working as physicists in industry. Any data collection is immediately fraught with the difficulty of identifying who counts as a physicist - a first degree in physics is unlikely to be a sensible criterion - and it may be more appropriate to act in conjunction with other learned societies or through the auspices of the UK Resource Centre for women in SET.

It is important to collect data regularly to monitor the extent to which initiatives to encourage women into physics are having an effect. A very interesting report¹², presented in Rio, detailing the representation of women in physics at each stage of their career and analysing how this has changed with time has recently been published by the American Institute of Physics. In the USA the representation of women at all levels continues to increase: during 2003 women earned 22% of bachelor's degrees in physics and 18% of PhDs.

Women comprise 10% of the faculty in degree granting physics departments. However a steeper increase in the number of women gaining PhDs in biological sciences, chemistry and mathematics has led to an increased gap between physics and other fields (except engineering).

Examination of the academic 'pipeline' in the USA reveals that women disproportionately leave physics

between taking it in high school and earning a bachelor's degree. Thereafter women are represented at about the levels that would be expected based on degree production in the past. However these findings do not map directly on to the UK context because of the differing structure of undergraduate education in the USA. Moreover reaching the stage of a pipeline that does not leak has required considerable effort in encouraging women to take up careers in physics and in encouraging universities to hire women faculty.

4. Initiatives in Physics

The Institute of Physics responded with alacrity to many of the recommendations of the Paris IUPAP meeting. A working party was set up which recommended a wide-ranging series of initiatives to Council, based on the premise that 'the Institute should support girls and women at all career stages and also those likely to be influencing potential physicists'. Following the working party report a new full-time post was created to oversee gender issues and a committee reporting directly to Council, the Women in Physics Policy Committee, was created. This has recently evolved to cover a wider remit as the Diversity Committee. The Women in Physics Group continues to be proactive in promoting women's issues, pressing for change and facilitating networking. We summarise the initiatives. In many cases, later sections of the report provide a fuller discussion of implementation and outcomes to date:

1. Low membership rates for those on career breaks have been introduced. Career break grants have been set up to enable men or women taking career breaks to attend conferences to maintain Chartered Physicist status and to keep up to date.
2. An internal audit of the status of women within IoP Boards and committees was carried out and fact sheets written for IoP Groups and Committees to encourage women members.
3. A website with details of role models was set up.
4. The Institute has exchanged information with other interested parties concerning the scarcity of women in SET. For example the 3Rs¹³ (Recruitment, Retention, Returning) debate was held in September 2003.
5. A Career Break Survey¹⁴ of IoP members were published in 2004. Consequently, the IoP Careers website¹⁹ now has relevant advice and information.
6. £0.5M was allocated to a 'Girls into Physics' initiative. The report 'Yes She Can!' examined the best practice in teaching physics to school girls.

7. University site visits were set up based on those carried out by the American Institute of Physics. This has expanded to include other organisations. A report will be issued this year.
8. An IoP Diversity website¹⁴ is maintained which has information relevant to Women Physicists.
9. A study into women physicists and entrepreneurship has been commissioned¹⁴.
10. A sponsored seminar¹⁵ on the presentation of women scientists in TV drama was held in April 2005.
11. The Women in Physics Group¹⁶ (WIPG) of the Institute of Physics holds meeting for members enabling them to learn about career paths, support initiatives and best practice as well as to network and share experiences.
12. WIPG has run a series of heavily subsidized workshops targeting personal development for members. These have been organized in conjunction with the Women's Engineering Society and MentorSET.
13. The WIPG has set up an advisory panel comprising highly influential women physicists.
14. The Women in Physics Group has written the *Good University Guide*¹⁶ recommending good practice.
15. WIPG has joined MentorSET⁹ the government funded mentoring scheme for women in SET.
16. Efforts are being made to excite the interest of young children in physics by encouraging physicists to visit primary schools.
17. WIPG has an email discussion group for members.
18. All women physics undergraduates have free membership of the WIPG.

Other initiatives, not primarily driven by the IoP, include:

19. The Open University has developed a new course⁸ for women returners in SET. There are up to 150 places twice a year. This is free for the first two years. It is publicly funded via UKRC.

5. Encouraging more girls to study physics

A UK poster on encouraging girls to study physics was prepared for the 2002 IUPAP conference¹ on Women in Physics. Prior to 2002 there had been changes in science education in the UK, which ensured that physics was studied by all girls and boys to the age of sixteen and introduced two-tier courses for those aged 16-18. These changes increased the opportunities for girls to study physics. The poster also noted the university

'physics taster courses' for girls, the increased prominence of role models such as the IoP Travelling Schools' Lecture being delivered by a young woman, as well as numerous initiatives to encourage both girls and boys, including a series of IoP career posters.

In April 2002 the Roberts Report⁴ 2002 identified a future shortage of SET graduates and identified the small number of girls studying physical sciences as a key factor. This linked the problem to the national economy. The 3Rs debate emphasised the importance of good career advice and information so that girls do not reduce their opportunities to study physics unknowingly and pointed out that public misconceptions can have a negative influence.

The IoP invited numerous experts in the field to a seminar to discuss ways to encourage girls. Following this they set aside £0.5 million and set up a study into best practice which analysed the post 16 take-up of physics by girls in 1500 schools. The report, *Yes She Can*, which will be published soon, identified the characteristics of those schools that are most successful at recruiting girls. These include high teaching quality and high expectations. Successful teachers do not adjust lesson content to perceived interests but provide the 'big-picture' showing that physics makes sense of the physical world, and give contemporary applications of the uses of physics.

In parallel the Education Department of the Institute of Physics has worked to ensure that its career information is inclusive and the careers website has women and men at all stages of a wide range of careers as role models to help to overcome any negative image of physicists.

The work is ongoing. Generously, the IoP responded to the increases in undergraduate fees by offering 300 bursaries of £1000 each year from 2006¹⁸. These will be distributed to those in greatest need and, it is thought, will particularly benefit girls.

Also, remarkably, in 2005 the government white paper on *14-19 Education and Skills*¹⁷ announced plans to work with the IoP to address the problem of the poor up-take of physics by girls.

The second IUPAP conference on Women in Physics had one working group which concentrated entirely on issues related to encouraging girls to study physics and to take up physics as a career. Since 2002 many countries have run projects to encourage girls. It is too early to assess the long term benefits of these initiatives and careful monitoring of statistics is necessary to evaluate their effectiveness.

In Rio de Janeiro it was pointed out that if girls did not continue to study physics throughout their school careers they are severely limiting their career opportunities. Several examples were put forward of situations when girls are dissuaded from continuing with physics. These included unruly behaviour of boys, advice that physics is 'hard' and situations where girls do not receive as much attention as the boys. In many countries, the traditional role of women in society can put pressure on girls to move away from physics. This is even true in the UK where peer-pressure projects physics as not being 'cool'.

The 2005 Rio working groups recognised that the image of physics in society has a strong effect on young children; therefore activities which promote physics to the broader community should be encouraged, particularly those that provide positive representations of women physicists. Women at all stages of their careers should be featured in text books and in career information.

The differences in the experiences of young boys and girls are not limited to those within school. Many of the toys marketed specifically for girls lack opportunities to develop spatial awareness and logic. From the discussions, it became clear that this is a world-wide issue and consequently the development of gender-neutral, science promoting toys was recommended as a new challenge. This was included in the Conference Resolutions which are directed to the IUPAP General Assembly.

It was recommended that physicists should be encouraged to visit schools in order to communicate the enjoyment and fascination of physics to children from a very young age. Such outreach should be linked to the curriculum. It was agreed that schoolgirls benefit particularly from such contacts. It was particularly emphasised that good teachers should be recognised and teachers should be provided with training in gender issues.

Recommendations from the 2005 IUPAP conference which relate primarily to encouraging schoolgirls are:

- a) Develop excellent gender-inclusive educational materials for both primary and secondary schools.**
- b) Become involved with developing and implementing gender inclusive curricula**
- c) Encourage physicists to work with teachers to develop hands-on physics activities that are age appropriate and gender inclusive for both primary and secondary school children.**
- d) Provide opportunities for girls to do physics research starting in secondary schools.**

The wording emphasises that the National Physical Societies should both advocate and become involved with these activities.

In the UK there are ongoing initiatives covering many of the recommendations. However, the idea that girls should be given opportunities to do research is valuable. This could be provided through 'work experience' and would give girls an insight into life as a physicist.

The fact that in many countries girls are still only a small proportion of those studying physics as undergraduates was seen as evidence that there is much to be done. In the UK the proportion of girls taking A level Physics is increasing but the actual number of girls taking the examination is decreasing, because the boys' entries are dropping more rapidly. The introduction to the resolutions made the valuable point that what benefits girls will also benefit boys.

6. Improving the climate for women

There is increasing recognition that the problems of isolation felt by women in physics, as by any minority, should be addressed. There is also an increasing belief that these problems can be addressed given willingness on the part of colleagues and institutions to consider them and to act on best practice. A good proportion of the recommendations from the Rio conference focussed on improving the climate for women in physics. Many of the suggested actions are already in place in the UK which, together with the USA, was held up as an example of good practice in numerous areas. However there is still work to do extending and, particularly, evaluating the programmes now in place. We consider in turn some of the major recommendations from the Rio meeting:

TRAINING: Organise and make available to members and students professional development workshops on gender-sensitive mentoring, success skills and leadership

Improved training is required for both genders at all levels. Women (and men) should realise that publication record is not the only criteria for appointment to a tenured academic position and advancement within that position. They should be given opportunities to teach and to gain feedback on their teaching. They should be offered guidance in presenting their work through posters and seminars and in the best way of writing research proposals and soliciting funding. Advice should be available on interview skills, negotiating, teamwork, how to build up research collaborations and project management. It was noted that any initiatives should be fully accessible to women in terms of practical aspects such as childcare.

An interesting suggestion from Rio was to *design a suite of one-day professional development workshops tailored to physics and suitable for offering at any major physics or physics-education conference*. This would help to avoid duplication of effort between countries and ensure that well-tested and evaluated training tools are available to as many physicists as possible in a convenient location.

It is also important to consider whether women-only training workshops, focussing on the particular problems faced by women for example, isolation, confidence and the role of women within the family provide a useful addition to the training opportunities available. A good example of an existing programme is the FORWARD to Professorship workshops in the USA. This is partially funded by an ADVANCE grant from the National Science Foundation which provides money for projects that contribute to institutional change for increasing the presence of women in science. Participants attend sessions on planning and funding research, negotiation strategies, and creating strategies for balancing family and career, including how to deal with 'negatives' (!) such as having a baby and how to say no 'firmly but nicely' to yet another committee.

WIPG has run a series of heavily subsidized personal development workshops for members. These have been organized in conjunction with Women Engineering Society and MentorSET. Topics so far have included emotional intelligence in the SET workplace, transferable skills, enhancing professional impact: influencing and persuading, and motivation. Nothing has thus far been aimed specifically at women academics and this may be an area to trial in the future.

Of the women who have successfully undertaken postgraduate studies in physics, a significant fraction chooses not to pursue careers in physics. The reasons are diverse, such as the attractiveness of careers outside physics and the insecurity of a series of multiple, temporary post-doc positions. To understand the problem more fully research is needed, looking at both women and men.

ENVIRONMENT: Champion working environments and practices that operate transparently, value and respect women, treat them equitably with men, and are 'family friendly'.

An important step in this direction is the introduction of flexible working legislation. Academic jobs are such that they lend themselves easily to innovative working practices such as job sharing and reduced working hours. These possibilities should be available to women in both research assistant and tenured posts. They should not be seen as indicating a lack of commitment and should not

lead to discrimination against those trying to take the next step up the career ladder. We should aim to foster a climate where combining motherhood and a successful career in academia or industry should be seen as normal, not the preserve of superwoman. It should be made clear that it is possible to achieve worthwhile results in research without giving up family life.

The early career, as a Research Assistant or Lecturer poses particular problems for women because it coincides with a stage in their lives when they may face the two-body problem - finding a position in the same place as their partners - and when women are most likely to want to start a family. The Royal Society has responded to this by introducing UK Relocation Fellowships. These aim to help researchers in the UK who wish to move to follow a partner who has changed place of work and moved a significant distance within the UK. The relocating partner does not have to be a scientific researcher. Salary and research expenses are provided in order for the recipient to relocate and continue their research career with the minimum of disruption. It is expected that the transitional funding provided by the fellowship will allow time to apply for long-term support or negotiate a permanent position. This is an important step but it does not address the problems of couples who feel that the best career step is to work in a prestigious institution overseas where it is likely to be difficult to obtain two positions simultaneously. Any attempt to address this will need an international initiative. A conference recommendation noted that this is an area which could be worked upon by IUPAP.

A recent study, commissioned by the Department of Trade and Industry (*Maximising Returns*, DTI, January 2002) estimates that approximately 50,000 female science, engineering and technology (SET) trained graduates are currently out of the workforce, with the figure for men at around 75,000. The study also revealed that, of those women who do return to employment, approximately two-thirds return to non-SET occupations as routes back into the workforce simply do not exist. Thus there are clear economic reasons to allow (mostly) women the flexibility to plan career breaks and their subsequent return to work.

Following the publication of *Women Physicists Speak*² the IoP introduced career break grants to enable men or women on career breaks to attend conferences and low fee membership rates¹⁹ to enable those on career breaks to maintain the CPhys qualification and to keep up to date. They may attend all IoP conferences at the student rate.

A Career Break survey¹⁴ of IoP members was published in 2004. This found that approximately 20% of women members of the IoP have taken a career break at some times during their lives, the majority to care for children. Of these only 40% went back to their previous employer upon returning to work. There is, in particular, a marked attrition of women from the industrial sector as a result of career breaks. A clear message from the survey was that the IoP had a useful role to play in disseminating information on opportunities for retraining, such as those offered by the Daphne Jackson Trust, and on helping members stay in touch whilst on a career break. Consequently, the IoP Careers website¹⁹ now has relevant advice and information.

It will be interesting to see the effect legislation encouraging flexible working has on the pattern of career breaks: one might expect a move to shorter breaks and more part-time working. We encourage the Institute to monitor how this is working with the aim of ensuring that women have real choices that will not have a negative effect on their future career advancement.

Implementation of many of the recommendations of the Robert's report has led to improved conditions for RAs. In particular both EPSRC and PPARC Fellowships now carry provision for maternity leave, part-time working and encourage applications from scientists who have taken a career break.

The American Physical Society has run site visits for several years. An extensive list of suggestions for best practice based on the experience accrued during these visits can be found on their website²⁰. Following the Paris meeting a pilot scheme of visits was implemented in the UK. So far 17 visits have taken place and a report on the scheme will be published this year.

The Athena SWAN Charter²¹ was launched in 2005 whereby Universities pledge to actively create a women friendly environment and to increase the number of women scientists in top academic posts. The progress of this initiative needs to be monitored and evaluated.

NETWORKING: Facilitate and support networking among women physicists at the local, national and international level.

Informal mentoring has taken place over many years through organisations such as WIPG and AWISE. More formal schemes are becoming an increasingly popular provision for many constituencies, such as women, new appointees and minorities. For example, MentorSET, a national mentoring scheme for women in SET funded by the UKRC, has over 150 pairs of mentor plus mentee currently in place. Feedback has shown that mentors as well as mentees benefit considerably from the scheme.

The IoP wishes to increase the number of women Fellows and one of the ways it is trying to do this is through a scheme which provides mentors for women applicants.

Recent meetings of the Women in Physics Group have been planned to keep women informed of developments for women physicists, career opportunities, role models, and to look for best practice by examining cultural differences.

The WIPG has a many to many mailing list for its members, providing opportunities to network and discuss relevant issues. Daphnet is another mailing list, which, as well as enabling members to contact one another, is a valuable distributor of information on women in science issues. CCLRC has set up a WiSET Group (Women in Science and Technology) at both Daresbury and RAL. Also, PPARC has a focus group on women.

One of the conclusions from the IoP Site Visits scheme was that women physics undergraduates tend to be comparatively isolated and that networking would help. The Institute has therefore given all the undergraduate women students free membership of WIPG and a student will be elected to the WIPG committee.

VISIBILITY: Ensure that physics-related conferences include women on the organising committee and as invited speakers. Feature female physicists as visible role models in textbooks and the media and ensure that they are considered for prizes and awards.

When issues regarding women in science are prominent at evaluation and review committee meetings or site visits, they acquire a visibility that increases the institution's motivation to address them. The recognition of women as significant contributors can also be reinforced by including women visibly in scholarly activities such as writing papers and proposals, participating in national and international conferences and giving seminars and invited talks.

Following the Paris meeting, IUPAP introduced policies aimed at enhancing the visibility of women physicists. Programme committees for IUPAP-sponsored conferences must now include a woman member. The commitment to women could be strengthened by asking for a statement on the application for funding as to the extent to which women will be encouraged as speakers and as participants.

Within the UK an internal audit of the status of women within IoP Boards and committees was carried out and fact sheets written for IoP Groups and Committees to encourage women members. It is important that these

steps are followed up and further audits should be planned to monitor whether there has been any improvement. Awareness could be raised by asking groups for feedback on how they have reacted to the challenge of increasing the participation of women. The IoP could also do more to encourage women as invited speakers at its own meetings.

Case studies of physics career paths²², which include those of several women, are available on the web. However, these do not provide particularly visible role models and are unlikely to be accessed by schoolchildren. It is important to distinguish between 'famous' role models and 'realistic' role models. For example, the image of Einstein, with his shock of white hair and seemingly superhuman intellectual achievements, will excite admiration but is not one that most people will gravitate towards or see as achievable. The most useful role models are everyday figures or those a few steps further up the career ladder: teachers for schoolgirls; graduate students and those who have spent a couple of years in their first jobs for undergraduate students; and post-docs and young lecturers for graduate students. The lack of female lecturers in most university departments cannot but fail to send out warning signals to female undergraduates pursuing a career in research, as does the lack of women speakers at seminars and conferences to graduate students and research assistants.

It is, however, important to recognise that service activities, ranging from mentoring to serving on committees, take time and effort. Similarly there is a limit to the number of seminars that it is possible to present. Quite often the 'only' woman has to take on a disproportionate load in these areas. Time spent on committee work is taken away from research or teaching productivity and should not be held against her when her performance is being evaluated. Thus institutions should give credit to such activities in their reward structures, so that both women and men, who are trying to help improve the institutional climate and increase the numbers and visibility of women physicists, are justly rewarded.

The build-up to the Research Assessment Exercise 2008 provides an important opportunity to underline the importance of providing a working environment where there is transparency in decision making, including decisions on hiring and promotion, and also on the distribution of budget with subsequent monitoring and reporting. Institutions should also be seen to be trying to increase the representation of women in science at all levels. If this became an RAE funding criterion, it would immediately focus the minds of institutions on the issues involved.

7. Women at the top

There is a dearth of women among physicists in positions of leadership worldwide. For women to feel equal partners with men in a technological society, they need to see women participating fully in various scientific endeavours ranging from policy making to research. Physics needs to be able to draw on the widest possible spectrum of talented individuals from both genders. Women often bring different management skills and insights that can be recognized and exploited.

It will take time and effort to build up the number of women leaders in the field. Data should be collected on the ratio of men to women in top management and academic positions in leading universities, research institutes, professional societies and funding agencies. This will help to demonstrate the extent and location of the problem and to establish a baseline against which to measure future progress.

Best practices to achieve an increased representation of women include being proactive in developing a pool of female candidates and ensuring that the selection processes are transparent. Training in leadership, negotiation and communication skills is vital as are opportunities for mentoring and networking. Senior managers should be aware of gender issues and the possibility of unintentional bias.

The number of women physics professors in the UK is increasing rapidly, from 4 in 1995 to 15 in 2003 and 26 in 2005. However the number of professors is also increasing rapidly and therefore the percentage rise is less pronounced. 4.5% of the Fellows of the Royal Society are women. There are 6 women physicists.

The National Academy of Sciences in the US currently has 5/180 women fellows in physics and 2/80 in applied physics. The WITEC (European Association of Women in Science, Engineering and Technology) database was first developed in 1997, specifically to promote greater awareness of women in senior scientific positions.

IoP is now encouraging the nomination of women for prizes by writing to all women physics professors. During the re-structuring of the most prestigious of the IoP awards, the decision has been taken, for the first time, to name certain prizes after women physicists.

High level awards have been set up aimed primarily at women. The L'Oreal-Unesco Awards, for 5 women, one from each continent, were offered in materials science in 2005. The Royal Society has set up the Rosalind Franklin Award where, as part of the nomination process, all nominees are asked to put forward a proposal for a project that would raise the profile of women in SET in their host institution and/or field of expertise.

8. The International Context

With the ever increasing globalisation of science and technology and the opening up of new scientific superpowers in India and Japan it is becoming increasingly important to view physics from an international angle and the debate over attracting and retaining women in physics can be helpfully pursued on an international stage. A recommendation from the Rio conference is that the International Union of Pure and Applied Physics should set up a hub for a gender-related database of information collected by working groups on women in physics. This should include information and links on best practices related to attracting, retaining and advancing women in physics.

The variation in the percentage of women in physics at each stage of their career varies from country to country across the World. Plenary speakers at conference provided insight into current situations very different to those in the UK.

Zohra Ben Lakhdar, of the University of Tunis Elmanar, described the 20 years of patience and perseverance that it took her to found a research laboratory in Tunisia (the first research laboratory in that country). Despite the law on equal opportunities (1956), women generally stop work after achieving a PhD, usually because of family commitments. A network may be a solution which would give women the confidence to continue.

Tunisia's current objective is to become a "Pole of Excellence", to act as the bridge between Europe and Africa for Research.

Ling-An Wu, of the Chinese Academy of Sciences, spoke about the current Cultural Revolution, which is causing rapid expansion within the universities and changing the sense of values within China. Unfortunately, both job and age discrimination means that it is even harder for women in physics. A key factor is that the retirement age for women is 55, which is cutting short women physicists' careers at a stage of crucial development.

There was a strong feeling that the Women in Physics Groups across the World should maintain the links established at the conference in order to share information about best practice and develop networks.

The UK should be aware of and contribute fully to an international database of information and best practice concerning women in physics.

In countries where physics is regarded as a path to a secure future with exciting career prospects and good remuneration, the proportion of women physicists is highest. In the UK we must continue to work to improve the image of physics if we wish to increase the number of women in physics.

Appendix A: Conference Resolutions

(Adopted by the IUPAP General Assembly, October 2005)

Since the 1st IUPAP International Conference on Women in Physics (Paris, March 2002), more attention has been paid to including women in physics in many countries. Although some noticeable progress has been made, much more remains to be done before physics and its use in the countries of the world can benefit fully from the ideas and efforts of women. To promote the recruitment, retention, and advancement of women of all races and nationalities in physics, the representatives of the physics communities from 42 countries assembled in Rio de Janeiro unanimously recommend the following actions to the IUPAP 25th General Assembly in Cape Town, South Africa:

1. **Assign to the IUPAP Liaison Committees the important role in their countries of catalyzing women's participation in physics and reporting on progress.**
2. **Strongly encourage the physical societies in its member countries to share information and resources with physicists who are isolated.**
3. **Require organizers of the conferences it sponsors to improve their inclusion and encouragement of women, and request its member societies and other scientific unions to do the same.**
4. **Model exemplary institutional transparency in its policies, procedures, practices, and activities and increase the presence of women among its leadership.**
5. **Co-sponsor the development and encourage the use and translation of training modules on gender and race equity in physics, on physics education pedagogies and curricula, and on the recruitment, retention, and advancement of women.**
6. **Charge the IUPAP Working Group on Women in Physics to oversee a thorough international survey of the status of women in physics in 2007, organize the 3rd International Conference on Women in Physics in 2008, and report at the 26th IUPAP General Assembly in Fall 2008.**

Appendix B: Conference Recommendations

The discussion sessions developed many specific recommendations to help physics benefit fully from the ideas and efforts of talented women of all races throughout the world. Many of the recommendations combine ideas from two or more of the discussion sessions. The recommendations will not all be applicable to all countries or situations. They should be reviewed, and the applicable ones should be translated and adapted for dissemination and implementation in each country. The challenge of increasing the participation of women and girls of all races and ethnicities in physics and related fields requires the commitment and engagement of women and men alike. Conference participants, IUPAP Liaison Committee members, and readers of these Proceedings have a responsibility to take action. We urge the IUPAP Liaison Committees and the Physical Societies in each country to disseminate these recommendations and advocate, implement, and monitor actions to recruit, retain, and advance more women in physics at all levels. Experience around the world has shown that actions that improve physics for women also benefit men. More detail on the recommendations, including examples of model programs in various countries, is provided in the Discussion Summaries in these Proceedings.

For IUPAP liaisons and physical societies:

1. Ensure that your country has an active Working Group (or Committee) on Women in Physics. If not, create one, and support the implementation of its recommendations. For some countries with few physicists, a Working Group on Women in Science would be appropriate instead.
2. Advocate and become involved in developing and implementing excellent, gender-inclusive science teaching, curricula, and educational materials for primary and secondary schools. Encourage physicists to partner with educators to find or create age-appropriate, gender-inclusive, hands-on physics experiments that students can do in primary and secondary schools. Offer girls opportunities to do physics research starting in secondary school.
3. Sponsor the translation and, if necessary, licensing, of effective gender-inclusive pedagogical materials from the Internet and other sources for use with your country's students in your native language(s).
4. Educate the general public about the positive impact of physics on daily life and the variety of physics careers that serve society. Feature female physicists as visible role models in textbooks and the media, and ensure they are considered for prizes and awards.
5. Encourage universities to make their physics programs more interdisciplinary, by offering courses, seminars, research projects, and degrees that join physics with other disciplines, such as biology, medicine, chemistry, computing, and engineering.
6. Organize and make available to members and students professional-development workshops on gender-sensitive mentoring, success skills, and leadership. Ensure women have access to effective mentoring.
7. Champion working environments that operate transparently, value and respect women, treat them equitably with men, and are "family friendly." "Family-friendly" workplaces have, for example, accessible child care, provisions for paid parental leave, position or fellowship end-date extensions for expectant and new mothers, methods to help both members of a dual-career couple find suitable positions, assistance for people returning after a career break, and flexible work schedules, even for employees in temporary positions (like graduate students and postdocs).
8. Facilitate and support networking among women physicists at the local, national, and international level. This support is especially critical in countries where women physicists are few and far between.
9. Ensure that physics-related conferences include women on the organizing committee and as invited speakers. Arrange for affordable, quality child care to be accessible to conference participants.
10. Advocate with the government and public and private funding agencies to make fellowships available to physicists seeking to return to science after a lengthy career break.
11. Assist with international surveys and national studies related to the status of women in physics, solutions for the dual-career problem, and other topics important to the profession. Obtain, monitor, and regularly report national and institution-by-institution gender-disaggregated statistics on education, hiring, awards, professional-society committee membership, and conference participation in physics.

For the IUPAP working group on women in physics:

12. Expand its website to provide in addition to networking and news an international hub for gender-related database information collected by the national working groups on women in physics, along with information and links on international best practices related to attracting, retaining, and advancing women in physics (such as outreach targeting girls, curricula, mentoring, networking, awards and fellowships, family-friendly practices, solutions to the dual-career problem, and site visits to study and improve institutional climate).
13. Support women physicists worldwide by designing a suite of one-day professional-development workshops tailored to physics and suitable for offering at any major physics or physics-education conference.

14. Establish an international network relationship with national and regional Women in Physics organizations, science-teachers' associations, national and international networks for women in science and engineering, and organizations working to advance the role of women in society at large.
15. Encourage continuing research in partnership with social scientists to quantify and understand the causes and effects of regional differences in the percentage of women in physics at all levels.
16. Conduct a thorough international survey of the status of women in physics to compare with the survey reported at the First Conference (Paris, 2002), and report the results by 2008.

For women and men in physics:

17. Translate, disseminate, and take action to implement the resolutions and recommendations of this Conference. Report to the IUPAP Working Group on Women in Physics on the results.
18. Network, network, network.
19. Support and encourage girls and women in physics and promote their visibility.
20. Challenge negative and counterproductive attitudes and behavior that degrade the climate for women.
21. Find one or more mentors for yourself and become a supportive mentor for others.
22. Take credit for your achievements. Be a good collaborator, but don't let others steal your ideas and results.
23. Volunteer to help the Physical Society in your country or region implement the recommendations, above.
24. Identify best practices that should be shared internationally, and bring them to the attention of the IUPAP Working Group on Women in Physics for posting on its website.
25. Prior to the year 2008, individuals and country working groups should arrange for the collection, analysis, and reporting of data related to the participation and advancement of women and the actions taken to improve the status of women in physics. The results will be presented at the Third IUPAP International Conference on Women in Physics and reported at the IUPAP General Assembly in 2008.

Appendix C: References

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