THE 1993 INTERNATIONAL PHYSICS OLYMPIAD

United by a common interest in physics, high school students from around the world came to Williamsburg, Virginia, for a week of exams, tours and social activities.

Barbara Goss Levi

The US played host in July to the XXIV International Physics Olympiad, in which 201 top high school physics students from 41 nations competed in theoretical and experimental exams. Although the weeklong event, held this year in Williamsburg, Virginia, naturally fosters some international rivalry, its purpose is just as much to build friendships around a common interest in physics. The US organizing committee worked particularly hard to promote these friendships (see the summary on pages 42–43 by Arthur Eisenkraft, the executive director of the XXIV Olympiad.)

Origins

The International Physics Olympiad started as a competition among Eastern European countries, with Poland first hosting teams from Bulgaria, Czechoslovakia, Hungary and Romania in 1967. It was modeled after the International Mathematics Olympiad, which has been running since 1959, but the physics competition includes a laboratory as well as a theoretical component. Through 1975 the physics olympiad drew an average of eight teams per year, and then it began to grow, doubling by 1983 and more than redoubling by 1993. (See the table on page 44 for a list of this year's participating countries.) Argentina, Israel, Portugal and Taiwan sent observers to the 1993 competition with a view toward participating in future contests. And the delegation from the People's Republic of China paid special attention to the details, for that country will host the event next year in Beijing. Shen Keqi of the University of Beijing heads the planning efforts.

By attracting such worldwide participation, the olympiad is helping to set an international standard of excellence for students in physics. And that standard is high: The questions would challenge upper-level college physics majors and beginning graduate students. The increasing scale of the event adds a kind of glamour to the competition and increases the motivation for students (and their teachers) to reach the performance levels set by the olympiad examinations.

To be eligible for the physics olympiad, students must be 19 years or younger, and they cannot be attending a university. The youngest participant by far this year was 11-year-old Aksay Venkatesh of Australia, who walked into the opening ceremony bearing his nation's flag and out of the closing ceremony carrying a bronze medal. Of the 201 students enrolled in this year's competition, only five were women (one each from Austria and Mexico and three from Kuwait). Karia Ramirez from the Mexican team, which was competing for the first time, said that she and her teammates (like most first-year competitors) found it very tough but enjoyable. Accompanying each team of five students were two coaches, typically college or high school teachers who helped train the team.

Procedures

In the opening ceremony on Sunday, 11 July, Eisenkraft, who teaches at Fox Lane High School in Bedford, New York, observed that while Olympic athletes compete in large arenas, these students do battle at 3-foot by 6-foot tables. The students compete as individuals, not as teams. On Monday, the 201 students were seated in random order at an equal number of tables, strung out along the wide corridors of the sports arena at William and Mary College. There, separated from adjacent competitors by green curtains, they wrestled simultaneously for five hours with three theoretical questions. On Wednesday they returned to the arena to demonstrate their laboratory prowess by conducting two experiments in another five-hour period.

Observers were allowed to walk (quietly) through the aisles during the experimental exam. A tense silence prevailed as students carefully measured dewars of liquid nitrogen, timed oscillating magnets (to find the magnetic moment) and did calculations. At the end of the examination period, the students found their teammates to compare notes and relieve tension. They seemed quite excited about having worked with liquid nitrogen (whose heat of vaporization they were asked to measure); they thought the substance was "neat."

The host country must formulate the theoretical and

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Gold medal winners at the XXIV Physics Olympiad. Above: Nobel Prize winners Jerome Friedman (left), Leon Lederman and Val Fitch (right) applaud top scorers Harald Pfeiffer of Germany (second from left) and Junan Zhang of China (third from left). Right: The other 15 gold medalists, from eight nations, pose with their decorations around their necks. (Photos by Cecelia Brescia, AIP.)

experimental questions. The exam writers can assume knowledge of any topic that appears on the olympiad syllabus, which has the prior approval of all participating nations. This year's problems were field-tested by graduate and undergraduate students, including members of former olympiad teams. On the first day of the olympiad the coaches meet in what often turns into a marathon session to preview the theoretical questions. There they may vote to modify the problems or the assignment of points. If one of the questions is completely rejected, there is a spare exam question waiting in the wings, but no host country has yet resorted to its reserve question. This year the debate lasted only four hours, a short period by olympiad standards. After the discussion many of the coaches had to translate the problems into their native tongues in time for the exam papers to be waiting on the individual student's desks when the exam began at 8 am the next morning.

The theoretical problems this year dealt with the electric field in the Earth's atmosphere, the laser forces on a transparent prism and the deflection of an electron beam by a charged wire. In a future issue of PHYSICS TODAY Anthony French of MIT, who was chair of the committee that designed this year's problems, will write about the historical development of the olympiad problems and discuss the experience of designing and grading them.

The coaches met two days later to approve the experimental examination. With this exam, the coaches do not have quite as much latitude in making changes, because the host nation has already assembled the equipment necessary for the roughly 200 students to perform two experiments each. One US committee member worked nearly full-time for a year preparing the equipment; needless to say he was somewhat taken aback when, in the course of the debate, one coach said, "I know you've probably spent several weeks on this question. . . ."

Although the coaches worried that some of the questions were too tough, many of the students did exceptionally well. Eisenkraft told PHYSICS TODAY that they always surprise the adults.

The graders, who come from the host country, do the best they can in the universal language of mathematics, but inevitably they miss vital information that a given student may have written in his or her native tongue. So the olympiad rules allow for arbitration between the graders and the coaches.

The medals are given to individuals, not to teams, and they are awarded on a type of curve. First the graders add the scores that each student received on the theoretical and experimental questions. The graders

Imagine planning eight days of weddings for 350 people. That's the level of detail the organizing committee had to contend with in putting together the XXIV International Physics Olympiad. Over a period of two years, we watched our initial ideas grow into an actual event, a celebration of academic excellence.

We began with the selection of the site. Our celebration required not just a place to administer an exam but a locale that offered cultural, scientific and recreational activities. The College of William and Mary in Williamsburg, Virginia, satisfied all of our needs. Cultural outlets ranged from the Colonial Williamsburg restoration and the college, which is celebrating its 300th anniversary, to the local community itself. The community was sufficiently cosmopolitan that when we arranged for each of the team leaders to spend an evening in a nearby home, every host family had some connection with the homeland of its visitors. Scientific activities included tours of the Continuous Electron Beam Accelerator Facility in Newport News, Virginia (see PHYSICS TODAY, August, page 17), and the NASA Langley Research Center in Hampton, Virginia, with its wind tunnels and F-15 fighter aircraft. For recreation we planned a refreshing afternoon at Water Country USA (what better release after a five-hour physics exam?), a day at the Busch Gardens amusement park and Duracell's day at Virginia Beach. Moreover, we had at William and Mary two exceptional local coordinators—Hans von Baeyer and Roy Champion, both of the physics department. Von Baeyer specified as his required olympiad ingredients "food, fairness and fun"—besides "fysics," of course.

And there certainly was physics. The focus of the olympiad is the exam, comprising both theoretical problems and laboratory investigations. This exam had to challenge some of the best students in the world and discriminate among them. Furthermore, this year's exam becomes the American legacy to the training of hundreds of thousands of students, who will take it as they prepare for future competitions. The US was honored to have Anthony French of MIT as the chair of the committee that wrote the problems. The committee's yearlong effort paid off when the international collection of team leaders gave the problems high marks for comprehensiveness and creativity.

Physics activities were not restricted to sitting at tables solving theoretical problems or teasing out nature's secrets at lab benches. The students and their team leaders were also entertained by physics demonstration shows: Richard Berg of the University of Maryland gave his physics IQ test, which delightfully uncovered some misconceptions held by the olympiad students, leaders and other guests. Richard Minnix and Rae Carpenter of the Virginia Military Institute got some participants to sit on nails, appear to fly (it's done with mirrors) and "view" music on soap bubbles. (Many of the visiting leaders took copious notes during this show so that they might export some of the inexpensive physics demonstrations to their own countries.) Finally, Loren Winters of the North Carolina School of Science and Math used strobe photography to show us things that happen too quickly for the human eye to see under normal conditions.

More physics activities took place in the IBM computer workshop (when leaders or helpers weren't using the machines to translate exams into 30 languages or prepare databases about the students). Jack Wilson of Rensselaer Polytechnic Institute, who was in charge of the computer facilities, introduced visitors to the latest in using computers to teach physics. In a hands-on workshop on Thursday morning, students learned to use computers together with videodisc images and sensor data from microcomputer-based labs.

The day at Busch Gardens provided a mixture of the scientific, cultural and recreational. The park opened three hours early so that our olympiad guests could have ample opportunity to analyze the physics of the three roller coasters there, taking measurements with force meters, stopwatches and calculators. (See the photo on the cover of this issue.) Many US high schools have programs in which students study the physics of amusement park rides, but David Wright of Tidewater Community College, Virginia, and Barbara Wolff-Reichert of Livingston High School, New Jersey, prepared a special workbook with particularly challenging questions. To answer these questions, the students were randomly assigned to teams of five, with each member from a different country. One team, for example, had a Bulgarian, a Canadian, a Cuban, a German and a Thai. It was our way of encouraging interaction among the students. At a barbecue hosted by Busch Gardens, the top teams were rewarded with memorabilia.

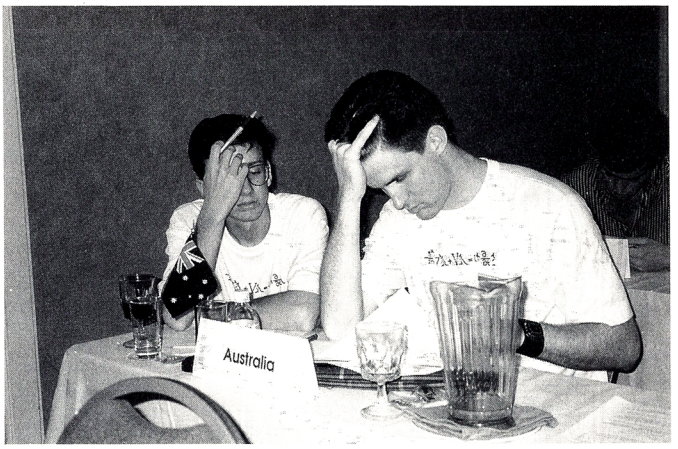
In the "paper olympics" directed one evening by Donna Berry Conner of the Roanoke County Schools, Virginia, students again worked in internationally mixed teams to form the strongest or the tallest structure made from a single piece of paper and to effect the slowest descent of a ball by using a container made of newspaper—lots of newspaper.

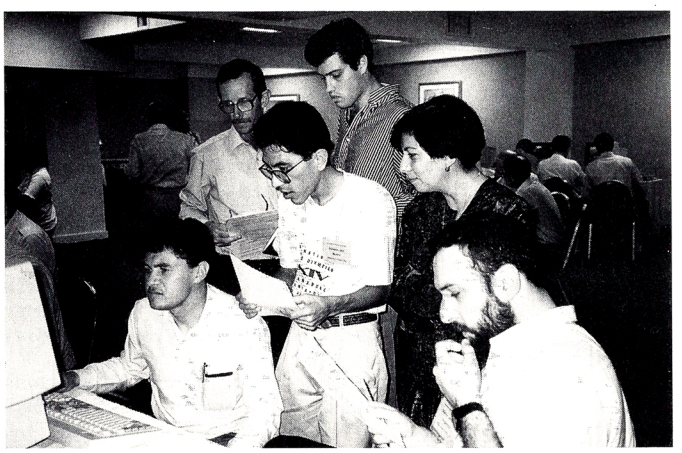
We built more community spirit at our "college deli night," when students wore college T-shirts (donated by 42 institutions) and ate pizza and submarine sandwiches. For entertainment we had a karaoke machine, which supplied background music and lyrics while participants sang along. Students who had seemed rather reserved most of the week came alive with microphone in hand. The Cubans and Mexicans made a hit singing and dancing to "La Bamba," and I gave my first and only public performance of "Twist and Shout." The night before the closing ceremony we had an "American night," with jazz and bluegrass music. Patricia Rourke of St. Stephen's and St. Agnes School in Alexandria, Virginia, choreographed the American night, the opening and closing ceremonies, and more.

It was essential to have guides for the olympiad students. The five students from each country were assigned one guide, who was responsible for acclimating them to the US as well as shepherding them to the activities. Most guides were from the local area, but ten were former US olympiad team members, who knew firsthand about olympiad emotions. Their presence made the event a reunion of sorts. One of the guides was 1992 gold medal winner Eric Miller, now a student at Harvard. At the opening ceremony Miller told the students, "While what you have learned of physics will doubtless prove important to you in the future, I believe that what you have learned of the process of science will prove even more important." As a guide for the Swedish team, Miller told me that he found it strange to see the event from another angle, without the pressure of the exams or the attention of the press.

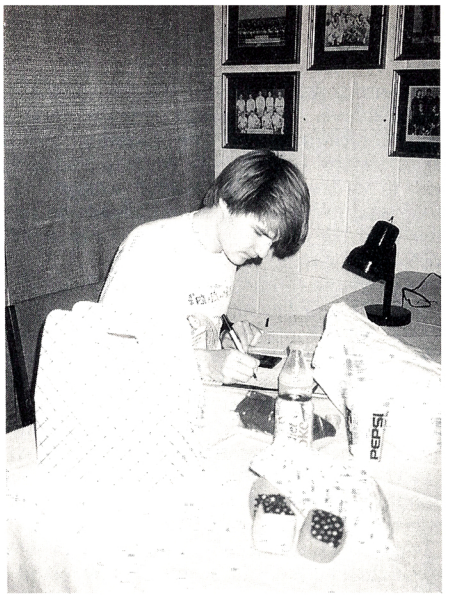
Olympiads, like weddings, require sending invitations, coordinating arrival times, arranging hotel accommodations and planning meals. We needed all avenues of modern communication—letters, phone calls, faxes and e-mail messages—to ensure that the 41 teams got the necessary visas, appropriate airline flights, health forms and so on. After months of correspondence, Yvette Van Hise of the High Technology High School in Lincroft, New Jersey, was pleased to welcome the participants in person. Delores Mason of AAPT, aided by the association's staff, worked tirelessly on such myriad details as hotels, meals and in-country transportation. Ken Ford and his staff at AIP helped raise funds, with assistance from Bernard Khoury of AAPT and James Stith of the US Military Academy.

As a follow-up to the olympiad, the organizing committee planned a number of activities. AIP has released a brief video news clip, and a program about the XXIV Olympiad is scheduled to be aired on the public television show "AT&T Presents" this fall. In the winter we plan to send olympiad packets to





Team leaders preoccupied with the exam. Top: Coaches for the Australian team study the proposed problems in the exam preview. Bottom: Team coaches from other nations gather around a computer to translate the exam for their students. (Photos by Bernard Khoury, AAPT.)



Students concentrating on both work and play. Above: US team member Dean Jens in the process of earning his gold medal. (Photo by Bernard Khoury, AAPT.) Below: Their exam behind them, members of the Cuban team model light-refracting glasses given to them during a tour of CEBAF. (Photo by Lori Powell, CEBAF.)

elementary schools that have requested them to introduce their students to physics and to the outstanding olympiad competitors. (If any principal writes to me on school letterhead, he or she can secure a packet.) We also plan to mail follow-up packages to this year's 200 participants to remind them of their experiences.

Some of the names I have mentioned—Champion, French, Khoury, Mason, Rourke, Van Hise, von Baeyer and Wilson—constituted (along with myself) the hardworking organizing committee for the XXIV Olympiad. We had lots of help: 30 exam graders from 28 colleges and universities; other college and high school teachers, who designed problems and prepared lab equipment; and many other people who worked in the local office, ran the computers or filled many other niches.

Leon Lederman, who was the chair of the XXIV International Physics Olympiad, spoke at both the opening and closing ceremonies. The opening ceremony featured the fife and drum corps of Williamsburg followed by a flag bearer from each nation, thus blending national pride with international goodwill. The closing ceremony included classical guitar and flute music and an *a cappella* performance of "The Star Spangled Banner." The highlight of the closing ceremony was the awarding of medals to the students by Nobel laureates Lederman, Jerome I. Friedman and Val Fitch.

The banquet following the closing ceremony traditionally includes a rendition of "Waltzing Matilda" by the Australian students. We tried to begin a new tradition by asking the students from each team to perform a folk song. The effort was a tremendous success. The Czechs and Slovaks sang together and drew loud applause from everyone. The final song started with a group of 15 students from different nations singing "We Are the World." In an impromptu manner, students from the audience began to converge on the stage to join in. Before long the students from all 41 nations were crowded onstage, waving miniature flags and singing. It was a moving finale to the XXIV Olympiad: We had succeeded in building a sense of community and in moving the world a little bit forward.

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then determine which three students earned the highest combined scores. The average of these three scores sets the scale for the medals. The minimum level for a gold medal is set by taking 90% of that average and then truncating it down to the nearest integer. The cutoffs for silver and bronze medals and honorable mentions are calculated in the same manner using values of 78%, 65% and 50%, respectively.

In this year's competition, Junan Zhang of China and Harald Pfeiffer of Germany tied for the top score, with 40.65 out of 50 possible points. Gold medals were awarded to 17 students from 10 countries (see the photos on page 41). Silver medals went to 16 students, bronzes to 32 and honorable mentions to 38.

The students who win medals are not the only ones who gain from the competition: Even those who participate in the training camps but are not chosen for the olympiad teams are stimulated by the questions they study as well as by their instructors and fellow students. Paul Tupper of Canada, who won an honorable mention, confessed that he had not been very interested in physics until he started training for the olympiad and was given challenging questions.

The US team

The US sent its first team to the olympiad in 1986, after Jack Wilson, then executive officer of the American Association of Physics Teachers, helped convince the governing board of the American Institute of Physics to send observers to the 1985 competition in Portoroz, Yugoslavia. AAPT is now in charge of selecting and training the US team, and AIP has the responsibility for fund-raising.

To select the US team AAPT sends information and application forms to high schools throughout the US, alerting teachers to the national exam given in February. The AAPT staff makes a considerable effort to get the word out to as many teachers as possible. They also try to reach interested students directly, by publishing articles in AAPT's own journals and the student magazine *Quantum*, published by the National Science Teachers Association and the Russian Academy of Sciences. The interested students usually take a preliminary test to determine whether they want to attempt the qualifying exam. In previous years as many as 700 students have taken the qualifying exam, which has both multiple-choice and open-response questions. There are no obvious trends as to the type of school from which the candidates come, except that those schools with strong physics programs enter students each year.

The top 75 performers from this screening exam take a semifinal exam in March. The semifinal has six open-response questions: four that are typically tougher than those on the qualifying exam and two very difficult olympiad-style questions. The exam is given in two 90-minute parts. Based on the scores from the exams as well as academic records and recommendations, the national coaches select the 20 members of the US physics team.

The 20 students come to the College Park campus of the University of Maryland for a one-week training program near the end of May. Actually, most students do some training before they arrive by practicing on sample exams mailed to them ahead of time, and many have already mastered one of the popular introductory college texts. The training period includes lessons, motivational lectures by research physicists, practical exams, laboratory work and cultural excursions. At the end of the week, the coaches select the five students who will represent the US in competition. The academic director for the 1993 US team was Larry Kirkpatrick of Montana State University, and the coaches were Theodore Vittitoe of Libertyville High School in Illinois and P. Wilson Bascom of Thomas S. Wootten High School in Rockville, Maryland.

Nations Participating in the XXIV International Physics Olympiad

Australia	Great Britain	Romania
Austria	Greece	Russia
Belgium	Hungary	Singapore
Bulgaria	Iceland	Slovak Republic
Canada	Indonesia	Slovenia
China	Italy	Spain
Colombia	Kuwait	Suriname
Croatia	Lithuania	Sweden
Cuba	Mexico	Thailand
Cyprus	Netherlands	Turkey
Czech Republic	Norway	Ukraine
Estonia	Philippines	United States
Finland	Poland	Vietnam
Germany	Republic of Korea	

The US team has brought home several medals each year it has participated, including at least one gold in each of the last three years. In 1989 Steve Gubser from Cherry Creek High School in Denver received the top score in the competition, having been inspired by a graduate of Cherry Creek, Paul Graham, who won a bronze in 1986 in Great Britain. The year of Gubser's stellar performance, President Bush invited the team members and their coaches to the White House to convey his congratulations.

The members of the 1993 US physics team all came home with honors (as had all members of the 1992 team). Dean Jens of Ankeny High School in Ankeny, Iowa, who had earned an honorable mention in Helsinki as a member of the 1992 squad, won a gold this time around. I asked Dean if he was disappointed not to go abroad again this year, and he said, No, he was enjoying the program put together by the US committee. Daniel Schepler, who just finished his junior year at Beavercreek High School in Ohio, won a silver medal. His father, Kenneth Schepler, does laser research at the Wright Patterson Air Force Base. One of the bronze medals went to Hal Burch of the Oklahoma School of Science and Mathematics in Oklahoma City, who said that he wouldn't have been at the olympiad if it hadn't been for the "magnet" school he attends. Another bronze went to Dmitri Linde of Gunn High School in Palo Alto, California, who lived in Moscow until three years ago; his parents, Andrei Linde and Renata Kallosh, are physicists at Stanford University. Chang Shih Chan of Northeast High School in Philadelphia received an honorable mention. Like Canada's Tupper, Chan found that the olympiad posed a welcome challenge; before the event he had learned most of his physics by reading on his own.

Apart from the physics these students have mastered, they are still teenagers and enjoyed the amusement park visits, beach outings and parties that accompanied the olympiad with the same gusto with which they greeted the competition. Inevitably each team stuck close together early in the week, but with enough forced interaction during the week, they started to mingle more easily. The organizers hope there will be further crossing of paths as some of the participants move on to careers in physics. ■