

Hands-On Research

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(to be presented on behalf of H.L. Swinney, R. Roy and K. Showalter)

Introduction

Following the grand tradition of summer schools from the late 1940's, a program was launched on hands-on laboratory research and complementary mathematical modeling. The participants are mostly from developing countries where resources are limited and, as a consequence, laboratories equipped for cutting edge research are rare. Many participants know that modern science necessarily involves large expensive instrumentation and large teams of scientists, but are unable to follow their inclinations.

The idea for the first hands-on research school was developed in 2005 from discussions among Professors Harry Swinney (Austin Texas), Rajarshi Roy (University of Maryland) and Ken Showalter (University of West Virginia) concerning the plausibility of table-top physics for instruction and research in developing countries. The immediate challenge in planning a school was to find financial support and a location with the needed laboratory space, computers, lecture hall, etc. The organizers then contacted K. R. Sreenivasan, then the director of the Abdus Salam International Centre for Theoretical Physics (ICTP), who encouraged us to submit a proposal to that Centre. ICTP committed full administrative support for three Hands-On Research schools and committed funds for participant travel support. Grants came from various other sources. Typically, for the participation of students numbering between 30 and 40, 250-300 applications arrived from students from about 40-50 developing countries.

The program organizers recruited several more faculty members with known pedagogical skills and a commitment to the mission and the spirit of the school. These senior faculty and their assistants began preparing laboratory experiments and demonstrations during the year preceding the school. They developed experiments using inexpensive equipment such as webcams and USB computer interfaces. This presented numerous logistic challenges.

The following experiments correspond to the first program held in Ahmedabad (India). Since then, two others have been held in Sab Paulo (Brazil) and Cameroon (Africa). Arrangements for three more meetings have now been made in collaboration with ICTP.

Typical topics

Brownian motion, microscopy, and complex fluids
Boolean networks of electronic gates Daniel Lathrop
Mathematical modeling
Metronome synchronization, bouncing drops and thermal convection
Vibrated granular materials
Coupled chemical oscillators
Instabilities in flow between concentric rotating cylinders and a bouncing jet
Nonlinear dynamics and chaos in an electro-optic system

Dynamics of coupled nonlinear electronic circuits

Organization

Each school lasted two weeks. It usually consisted of lectures in mornings, which were followed up by laboratory sessions in the afternoons. The participants and faculty would occasionally focus on a major experiment for in-depth study. Participants were excited to see for themselves phenomena they had only read about before, and many encountered new phenomena and concepts. The enthusiasm and dedication of the participants for the laboratory sessions was remarkable. The hands-on sessions introduced apparatus that was reasonably simple yet relevant to current research, and exposed participants to many unanswered questions needing further research. Dinner for participants and faculty was typically served in the evening at a guest hostel, where the participants were housed. On one day, trips to local areas were organized.

The Hands-On Research school introduced laboratory methods to bright young scientists, some of whom have returned to their institutions with a new perspective and who can talk knowledgeably to others about laboratory research. Some participants in the school planned to introduce demonstrations and/or experiments into their curricula. A crucial component in the success of the Hands-On Research school was undoubtedly the dedication and enthusiasm of the faculty and their assistants, who spent much time in the previous year preparing experiments, as well as more than two weeks' time traveling to and teaching in the school.

The Future

The Hands-On Research schools have been very successful, though still in progress, and we have learned much from this experience. Part of the success is undoubtedly the faculty participation and dedication. In two instances, the experiments have been left in place after the school so that they may be used by the students at the host institution.