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Education in Acoustics

Session 2aED: Tools for Teaching Advanced Acoustics

2aED1. Summer school for acoustics graduate students

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In addition to subject mastery and the focused effort required to complete a thesis project, graduate students also need to develop a broad understanding of their field and cultivate a familiarity with the larger community of researchers and practitioners. The "summer school" format has been shown to enhance both subject-matter breadth and build community awareness in physical acoustics. Physical Acoustics Summer School (PASS) has been held in late-May, in even-numbered years, since 1992. The format for each day is usually two three-hour lectures followed by evening discussion groups to answer questions and explore extensions of the day's lecture topics. One lecture session is typically dedicated to acoustics demonstrations. Attendance for the full week is required of all participants who also dine together three times each day. Venues are chosen to provide isolation that minimizes distraction and maximizes interactions among all participants. Typical enrollment has been ten distinguished lecturers (including many Silver Medal winners in Physical Acoustics), ten discussion leaders, and thirty graduate students. This format has been successfully extended to one other ASA Technical Committee: the marine bioacoustics community has held their summer school twice (SeaBASS). PASS has now been functioning long enough that former students have become lecturers.

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INTRODUCTION

The biannual meetings of the Acoustical Society of America are an important component in the education of graduate students. Those meetings provide a chance for graduate students to socialize with acoustics students and faculty from other universities, to hear and present short technical papers, and to mingle with senior members of the Society. Unfortunately, even though those meetings last a week, the vast scope of topics and the numerous parallel sessions organized by the thirteen Technical Committees and the several Administrative Committees (*e.g.*, Education in Acoustics, Archives & History, Student Council, Women in Acoustics, etc.) guarantees that the meetings are often hectic. In addition, papers presented in technical sessions are short, typically stress recent advances, and rarely provide more than a few minutes for questions and discussions on topics that are necessarily sharply focused. Interactions between students and senior members of the Society are similarly constrained due to the administrative responsibilities (*e.g.*, committee meetings) of senior Society members.

This paper will provide background on another way that graduate students can spend a week, in a much different context, that provides educational and personal interactions involving a smaller group of students, senior and mid-career acousticians. This “summer school” approach has proven to be both successful and enjoyable. The Physical Acoustics Summer School (PASS) has taken place eleven times, during even-numbered years, since 1992. More recently, the ASA’s Animal Bioacoustics Technical Committee has offered a similar week-long summer school experience that was judged successful enough that Bio-Acoustics Summer School (SeaBASS¹) was offered for the second time in the summer of 2012, with a third offering now being planned.

The goal of this review of the content and mechanics of PASS is to provide encouragement to other Technical Committees within the Society to consider providing this type of experience to their graduate students. Might a summer school be useful both for enhancing the training of graduate student in their areas and also strengthening their shared culture?

HISTORICAL ORIGINS

The International School of Physics "Enrico Fermi" was founded in 1953 by Societa' Italiana di Fisica (SIF) and consists of three or four advanced physics courses held every summer on the grounds of the Villa Monastero² in Varenna, Italy (on lake Como), near the Italian-Swiss border. Instructors are eminent scientists including 40 Nobel Prize winners over the past 60 years. Its aim is to promote and disseminate up-to-date information on current developments in various topics of contemporary physics. In 1974, the topic of one of the three courses offered that summer was “New Directions in Physical Acoustics.”³

The venue for the Enrico Fermi Summer School is a villa on the lake shown in Fig. 1. Typically, instructors live in the villa and others occupy hotels in that small town. Three-hour lectures are offered in the morning, followed by a long (4-hour) lunch break, with a second lecture starting in the late afternoon following a tea service in the area shown at the right in Fig. 1. All participants also gather for lunch and dinner. Figure 2 is a photo of the participants in the “New Directions in Physical Acoustics” E. Fermi Summer School.



FIGURE 1. Photographs of the Villa Monastero, on Lake Como, in Italy. It is the site of the Annual International School of Physics "Enrico Fermi" founded in 1953 by Societa' Italiana di Fisica. The summer school lectures are held in this villa which also provides lodging for the lecturers. Students are housed in hotels in the town of Varenna, a short walk from the villa.



FIGURE 2. Photograph of instructors, students, and other participants in the 1974 Enrico Fermi Summer School, “New Directions in Physical Acoustics,” that was held at the Villa Monastero, on Lake Como, in Italy. The older gentlemen seated in the front row are (left-to-right) Joe Hunter, R. Bruce Lindsay, Warren Mason, Daniel Sette, Isadore Rudnick, Klaus Dransfeld, Richard K. Cook, and Edward Carome. In part, the middle row includes Taylor Wang, Ralph Goodman, John de Klerk, and Sidney Yip. The upper row includes Joseph Heiserman, Steven Garrett, and Giuseppe Natale.

In the late 1980’s, almost all of the support for research and graduate education in Physical Acoustics was provided by the Physical Acoustics Program within the U.S. Navy’s Office of Naval Research. One of us (L.E.H.) was the ONR Scientific Officer, responsible for administration of that research program, but also saw his role as a facilitator for the growth and coherence of the field. At his suggestion, all of the Principle Investigators (PI) in that Program were called together for a meeting at Penn State in 1988, hosted by Dick Stern, to suggest ways to expand benefits of the ONR Physical Acoustics Program beyond individual grants to PIs. Based on the experience of some who had attend the Enrico Fermi Summer School, it was decided that a such a week-long school would cost about as much as a single-investigator grant and could produce results that were at least as valuable.

A follow-up meeting was held at the Naval Postgraduate School (NPS) in Monterey, CA, in late-June, 1990. At that time, there were several ONR PIs at NPS and the Asilomar Conference Center, which turned out to be an ideal venue for PASS 1992 through PASS 2006, was only a few miles from NPS. At that meeting, it was decided that the Summer School should be held in a venue with minimal distractions (accommodations at Asilomar had neither telephones nor televisions) and that could provide three meals on site so that discussions over meals would be encouraged, in addition to providing facilities for both lectures and informal evening discussion sections. Proximity to NPS also provided the opportunity to include an acoustics demonstration session using indigenous instrumentation. Although not as elegant as Villa Monastero, the Monterey Peninsula was just as scenic. The Asilomar Conference Center could not boast a culinary tradition equal to that of Northern Italy, but the food was adequate and the barbeques and bonfires by the beach were always memorable.

To encourage interactions among participants, only those willing to remain on-site for the full week’s activities were encouraged to apply. Also at that meeting, it was decided that there would be four categories of participants: Organizers, Lecturers, Discussion Leaders, and Students. The total number of attendees was limited to about fifty and the term “participant” was taken seriously for all attendees regardless of their “category.” Summer School was definitely intended to be a “contact sport”; no lecturers were allowed to come only to deliver their talk and depart.

PARTICIPANTS

Ten Lecturers would each be responsible to present one three-hour lecture. Those lectures were required to be comprehensive overviews of a subject area directed to the level of second-year graduate student. Lectures typically were senior academics or researchers with at least twenty years of experience. Lecturers were required to provide the viewgraphs they would be using in their lectures in advance along with two or three relevant “references.” The references were made available to the students upon acceptance and the viewgraphs were provided in a (thick!) three-ring binder upon registration along with a list-of-participants, room assignment, name tags, etc.⁴ Lectures were instructed to make their lectures pedagogical and comprehensive and **not** to focus only on their research. They could relate their introduction to their lecture topic to applications of contemporary interest and present new research results, but only after laying firm groundwork tied to necessary fundamentals.

There would also be ten Discussion Leaders, who were not Lecturers, but were willing to take responsibility for managing the evening discussion sections that followed that day’s lectures. Discussion Leaders were typically mid-career acousticians who might have also been chosen as Lecturers. (In fact, over time Lecturers and Discussion Leaders have “toggled” between those designations at subsequent PASS offerings.)

About twenty-five to thirty students would be chosen based on a four-page application that required a short (one or two paragraph) description of their interest and qualifications for participation and a letter-of-recommendation from their thesis advisor. Applications are accepted through mid-February in the year that the school is offered. Non-student participants have to complete the same form but are not required to provide a recommendation letter, though they were required to provide citations for their five “most relevant” publications. The Summer School is advertised in the *Journal of the Acoustical Society of America* and by word-of-mouth at the institutions that provided the Lecturers and Discussion Leaders. To date, the number of student applications has been approximately equal to the number of students that could be accommodated so only a few applications have been rejected.

Figure 4 is the “Class Photo” from PASS 1994. That figure’s caption lists the participants and their home institutions. Although the participants varied from year-to-year, the distribution of universities and nationalities in the caption is typical of all eleven offerings to date.

ORGANIZING COMMITTEE

The dedication of the members of the Organizing Committee has been critical to the success of PASS. First Organizing Committee members were Logan Hargrove (ONR), Henry Bass (Ole Miss), and Anthony Atchley (NPS). That committee membership has continued to this day with Tom Matula replacing Prof. Bass upon Hank’s demise in 2008.⁵ The committee is augmented by an Administrative Assistant that manages applications and communications with participants. That Organizing Committee has the following responsibilities:

- Setting the dates for the school.
- Selecting the venue and negotiating the room and meal rates.
- Selecting lecture topics and soliciting appropriate Lecturers and Discussion Leaders.
- Evaluating student applications and selecting students.
- Evaluating the school based on survey forms collected on the final day from all participants.

CURRICULUM AND DAILY SCHEDULE

Lecture topics for the past eleven offerings of PASS vary, but have some consistency that is dictated by the active areas of research in Physical Acoustics. An example of the daily schedule for PASS 1994 is provided in Fig. 3, listing lecture topics, lecturers, discussion sessions, a demonstration lecture, and various social activities (*e.g.*, barbeque, graduation banquet). Typically, there will be lectures on the acoustics of solids (Jay Maynard, Veerle Keppens) that may include a lecture on a specific measurement technique (*e.g.*, Resonant Ultrasound Spectroscopy by Albert Migliori or Orson Anderson), or on measurement science and transduction in general (*e.g.*, fundamental thermal and statistical noise limitations by Tom Gabrielson, phase-sensitive signal processing by Albert Migliori). A general lecture on nonlinear acoustic has been given at all PASS offerings, although by different lecturers (*e.g.*, Werner Lauterborn, Mark Hamilton, Vic Sparrow, Steven Garrett).

FRIDAY 24 JUNE	SATURDAY 25 JUNE	SUNDAY 26 JUNE	MONDAY 27 JUNE	TUESDAY 28 JUNE	WEDNESDAY 29 JUNE	THURSDAY 30 JUNE	FRIDAY 01 JULY
	BREAKFAST 7:30 - 8:30	BREAKFAST 7:30 - 8:30	BREAKFAST 7:30 - 8:30	BREAKFAST 7:30 - 8:30	BREAKFAST 7:30 - 8:30	BREAKFAST 7:30 - 8:30	BREAKFAST 7:30 - 8:30
	H. E. BASS <i>Molecular Acoustics</i> 8:30 - 11:30	MORNING OPEN FOR DO-IT-YOURSELF GROUP SIGHT-SEEING	O.L. ANDERSON <i>Resonance Ultrasound Spectroscopy</i> 8:30 - 11:30	S. PUTTERMAN <i>Sonoluminescence</i> 8:30 - 11:30	B. C. DENARDO <i>Far-Off-Equilibrium Acoustic Phenomena</i> 8:30 - 11:30	G. W. SWIFT <i>Thermoacoustic Engines and Refrigerators</i> 8:30 - 11:30	CHECK OUT BEFORE NOON
	LUNCH 12:00 - 1:00	BRIDGE at NPS 12:00 - 1:00	GROUP PHOTO at FLAG POLE before LUNCH 12:00 - 1:00	LUNCH 12:00 - 1:00	LUNCH 12:00 - 1:00	LUNCH 12:00 - 1:00	LUNCH 12:00 - 1:00
REGISTRATION OPENS at 3:00	P. L. MARSTON <i>Drops & Bubbles: Experimental Aspects</i> 1:30 - 4:30	R. M. KEOLIAN <i>Acoustics Demonstrations and NPS VISIT</i> 1:30 - 4:30	S. L. GARRETT <i>Nonlinear Acoustics</i> 1:30 - 4:30	J. D. MAYNARD <i>Periodic, Random, & Quasiperiodic Media</i> 1:30 - 4:30	AFTERNOON OPEN FOR MONTEREY AQUARIUM VISIT	R. E. GREEN <i>Physical Acoustics in Materials Science</i> 1:30 - 4:30	
DINNER 6:00 - 7:00	DINNER 6:00 - 7:00	BBQ at PIT 6:00 - 7:00	DINNER 6:00 - 7:00	DINNER 6:00 - 7:00	BANQUET 6:00 - 7:00	DINNER 6:00 - 7:00	
INTRODUCTIONS AND ORIENTATION MEETING 7:30 - 9:30	SPLIT DISCUSSIONS IN COMMONS ROOMS 7:30 - 9:30	GROUP DISCUSSIONS IN MAIN LECTURE ROOM 7:30 - 9:30	EVENING OPEN FOR INDIVIDUAL ACTIVITIES OR INFORMAL DISCUSSIONS	SPLIT DISCUSSIONS IN COMMONS ROOMS 7:30 - 9:30	SPLIT DISCUSSIONS IN COMMONS ROOMS 7:30 - 9:30	GROUP DISCUSSIONS 7:30 - 8:30 BONFIRE at PIT 8:30	

FIGURE 3. Activity schedule for PASS 1994 with listing of daytime lectures, evening discussion sessions, an acoustics demonstration lecture, meals, and “formal” social activities (e.g., beachside barbeque, graduation banquet) and a free afternoon.

Other ubiquitous offerings are a thermoacoustics lecture (Greg Swift, Tom Hofler, Steve Garrett) and a lecture related to bubble dynamics, though the specific focus may range from sonoluminescence (Seth Putterman, Anthony Atchley) to medical ultrasonics (Larry Crum, Robin Cleveland, Tom Matula). Other topics have included determination of fundamental constants using resonant acoustical techniques in gases (Mike Moldover), molecular acoustics (Henry Bass), sound propagation in porous media (James Sabatier), infrasound (Tom Gabrielson, Milton Garces, Roger Waxler, Henry Bass), atmospheric acoustics (Rich Raspet, Roger Waxler), acoustic microscopy (Cal Quate), aeroacoustics (Jack Seiner), scattering (Phil Marston), acoustic signal processing (Carl Szuberla), and sometimes an introductory lecture that tries to provide a context for Physical Acoustics and the topics covered by the other lecturers (Albert Migliori, Anthony Atchley, Steven Garrett).

We have also been fortunate to have had a Demonstration Lecture at every PASS. When PASS was held at Asilomar, those demonstration lectures were held at the Naval Postgraduate School and coordinated by NPS faculty members (Robert Keolian, Bruce Denardo, Andres Larraza, Daphne Kapolka, Anthony Atchley). When PASS left Asilomar and was held at the Sunrise Springs Resort⁶ (2006, 2008, 2010), near Santa Fe, NM, the demonstration apparatus had to be “imported” with instrumentation (oscilloscopes, spectrum analyzers, amplifiers, etc.) provided by the Los Alamos National Laboratory. The most recent PASS 2012 was held at the University of Mississippi. The Demonstration Lecture was held at the National Center for Physical Acoustics, on the Ole Miss campus, which was able to provide excellent support for demonstrations (and a lab tour) under the supervision of Josh Gladden. PASS 2012 introduced a demonstration building session which allowed all of the participants to build and test their own ‘acoustic laser’ thermoacoustic engine demonstration device⁷ and to take that demonstration with them when they left.

Just as important as the explicit activities listed in the Daily Schedule of Fig. 3 are the opportunities for extended discussions that take place before and during meals, in the evening discussion groups, poolside, on the volleyball court, on long walks, and during breaks in the lectures. Students get to talk to other participants about their own research and occasionally give short talks about their work in the Discussion Sections. These relaxed discussions have provided graduate students with perspectives on their own research or suggestions for other experimental or theoretical approaches that did not occur to the members of their own thesis committees.



FIGURE 4. Photograph of instructors, students, and other participants in the 1994 Physical Acoustics Summer School (PASS 1994) held at the Asilomar Conference Center, in Pacific Grove, CA. Starting in the **Back Row**, left-to-right: Orson Anderson (UCLA), Ling-Lin Gao (Yale), Tian Ming (Georgia Tech.), Jay Lightfoot (Ole Miss), Steven Garrett (Naval Postgraduate School), Moises Levy (U. Wisconsin – Milwaukee), Mike Haden (Los Alamos National Lab), Jay Maynard (Penn State), Jeff Olson (Los Alamos National Lab), Greg Swift (Los Alamos National Lab), Brad Barber (UCLA), and Chris Kwiatkowski (Washington State U.). **Second Row:** John Allen (U. Washington-Seattle), D. Felipe Gaitan (Ole Miss), Doug Shields (Ole Miss), Don Isaak (UCLA), Wolfgang Sachse (Cornell), Keith Gillis (National Institute for Standards and Technology), Charles Jin (Tektronix, Inc.), Jeff Schindall (U. Washington – Seattle), Dan Russell (Penn State), and Raul Esquivel-Sirvent (Ohio U.). **Third Row:** Seth Putterman (UCLA), Bruce Denardo (UCLA), Keith Weninger (UCLA), Craig Hodgson (Stanford), Henry Bass (Ole Miss), Logan Hargrove (Office of Naval Research), Doug Meegan (U. Texas – Austin), Robin Cleveland (U. Texas – Austin), Anthony Atchley (Naval Postgraduate School), and Scott Backhaus (UC-Berkeley). **Fourth Row:** John Kordomenos (Ole Miss), Ashok Gopinath (Naval Postgraduate School), Mark Hamilton (U. Texas – Austin), David Brown (Naval Postgraduate School), Ken Kolbeck (U. Illinois – Urbana), Keith Olree (Ole Miss), Chris Lawrenson (Ole Miss), Phil Marston (Washington State U.), Bob Green (Johns Hopkins), and Barry Martin (C.S.I.R.O., Australia). **Fifth Row:** Ekaterina Knight (U. Texas – Austin), Bob Hiller (UCLA), Amit Lal (UC-Berkeley), Paul Elmore (Ole Miss), Karen Gibson (Washington State U.), David Gardner (Los Alamos National Lab), and W. Pat Arnott (Desert Research Institute). **Front Row:** Katie Bretz (Cornell), Sandra Smith (Ole Miss), Debashis Dasgupta (U. Wisconsin – Milwaukee), Robert Keolian (Naval Postgraduate School), Hong Zhang (U. Wisconsin – Milwaukee), and Ming Yang (Georgia Tech.).

CONCLUSIONS

The Physical Acoustics Summer School has been offered eleven times from 1992 through 2012 and we hope that the resources will continue to be made available to continue this biennial convocation of highly motivated graduate students and experienced and altruistic practitioners. This summer school experience has enhanced both the breadth of the students and faculty. It has produced a social coherence that could not otherwise be cultivated in a field that is so small that most graduate students and faculty are fairly isolated and otherwise would only have the opportunity to interact at meetings of professional societies, usually meetings of the Acoustical Society of America. In the span of two decades, we have seen participants who attended PASS as students return as Discussion Leaders and Lecturers. One of us (T. J. M.) has gone from a PASS student to become a member of the Organizing Committee.

Evaluation surveys completed by all participants on the last day of every PASS have unanimously declared that the week well-spent, academically and social valuable and enjoyable, and the participants would like to repeat the experience and recommend it to others. More recently, this format has been twice successfully duplicated by the Animal Bioacoustics Technical Committee. Figure 5 shows the schedule from the latest offering of SeaBASS¹ that is comparable to Fig. 3 for PASS.

SCHEDULE						
	Sunday June 17	Monday June 18	Tuesday June 19	Wednesday June 20	Thursday June 21	Friday June 22
7:00-8:00		Breakfast and Welcome by E. Liszka of ARL	Breakfast	Breakfast	Breakfast	Breakfast
8:00-12:00		A. Frankel <i>Introduction to Acoustics & Propagation</i>	M. Hastings <i>Hearing</i>	S. Parks <i>Effects of noise on marine mammal behavior</i>	H. Klinck <i>Passive Acoustic Monitoring - marine mammals</i>	P. Nachtigall <i>Echolocation</i>
12:00-13:00	Registration opens at 16:00	Lunch	Lunch	Lunch	Lunch	Lunch and closing remarks
13:00-17:00	Software Installation workshop (16:00- 20:00)	S. Van Parijs <i>Acoustic Behavior and Communication</i>	D. Houser <i>Marine Mammal Biology & Physiology</i>	R. Gentry <i>Hot Topic: Noise</i> ----- <i>CareerPanels</i>	J. Luskovich <i>Passive Acoustic Monitoring - fish & invertebrates</i>	J. Warren <i>Active Acoustics</i>
18:00-19:30	Dinner	Dinner	Dinner	Dinner	Dinner	Closing Dinner
19:30-22:00	Participant Introductions and Social	Poster Session and Social	Spikes Baseball game	Informal Career Discussions	Evening in Downtown State College	

FIGURE 5. The activity schedule for SeaBASS 2012 has a similar structure to the PASS schedule shown in Fig. 3.

In retrospect, some critical components for success include:

- Lecturers who understand that their lectures are primarily intended to be pedagogical and not a catalog of accomplishments of their own research groups.
- Lectures are intended to provide context; the content comes from participant interactions.
- All participants must agree to full-time participation. No “drive by” lecturers will be accepted. This requires that the dates be determined early enough that distinguished lectures are able to exclude other commitments.
- A venue that is sufficiently isolated from any surrounding distractions that there is no impetus to leave for alternate entertainment, dining, etc.
- An Organizing Committee, supported by an Administrative Assistant that understands “the mission” and will oversee preparations (*e.g.*, applications, reservations, meals, transportation, lecture and discussion space quality, etc.) in a timely and professional manner.

ACKNOWLEDGEMENTS

The cost of a PASS is on the order of \$60K to \$80K, primarily to cover lodging and meals for participants. (Organizing Committee members, Lecturers, and Discussion Leaders are volunteers and receive no salary or honorarium for their participation and have to pay for their own transportation.) Thanks to the generosity of the National Center for Physical Acoustics, the salary of the Administrative Assistant (originally Libby Furr, currently George Atkins) has not been included in that cost. Advertising in their *Journal* and support for some additional expenses (through Physical Acoustics Technical Committee “Technical Initiatives”) have been donated by the Acoustical Society of America. From 1992 through 2008, the full cost of PASS had been borne by the Physical Acoustics Program within the U.S. Navy’s Office of Naval Research. With the termination of the Physical Acoustics Program within the Physics Division of ONR, subsequent offerings have received the generous support of the U. S. Army Office of Scientific Research, the National Center for Physical Acoustics at the University of Mississippi, and The Applied Research Laboratories at Penn State and at the University of Texas, Austin.

REFERENCES

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1. http://www.arl.psu.edu/documents/FinalReport2012_Web.pdf
 2. <http://www.villamonastero.eu/>
 3. D. Sette, editor, *New Directions in Physical Acoustics*, Proc. International School of Physics “E. Fermi”, Course LXIII, (Soc. Italiana de Fisica, Bologna, Italy, 1976).
 4. As technology advanced, the slides have been made available on CD-ROM and most recently on a memory stick (thumb drive). The electronic media has made it easier to transport the slides and references back home after PASS but the availability of printed lecture slides during the school is critical since students usually take notes on the printed versions and then only take the pages with notes back to their home institution.
 5. <http://news.olemiss.edu/henry-bass/#.UNn0doZ1yig>
 6. <http://www.sunrisesprings.com/>
 7. <http://www.acs.psu.edu/thermoacoustics/refrigeration/laserdemo.htm>