A Working Proposal for a

National Center for Physics Education (NCPE)

jointly supported by the AAPT and the APS

PURPOSE: To mobilize the physics community to support sustained, nationwide high school physics reform as a key component of broader K-12 science and math reform.

RATIONALE: Physics teachers are the representatives of the physics community in their schools and school districts. Only teachers can reform physics in their classrooms, but they need help from practicing physicists. To inspire students with the wonders of science and cultivate their abilities for scientific thinking, the physics teachers themselves must have ready access to the resources of the physics community. Such access can be supplied by nearby universities if the necessary infrastructure is in place.

ACTION: Physicists can contribute to high school science reform most effectively through a nationwide network of partnerships between university physics departments and alliances of high school physics teachers. The NCPE will support creation and operation of such a network to coordinate research in physics and physics education with science education reform at all levels.

ADVISORY BOARD: The purpose of the board is to promote participation by university physics departments and support by the broader physics community, including the AAPT, the APS and National Research Labs. Nobelist Leon Lederman has provisionally agreed to serve as founding chair and to engage the support of eminent physicists.

The *National Science Education Standards* (NRC 1996) pointedly avoid the issue of how to implement science education reform. The NCPE will fill that gap by creating a *nationwide infrastructure* that brings the full resources of the physics community to bear on the problems of shaping and implementing sustained K-12 science reform. Without participation of research scientists, science education reform is doomed to mediocrity, for research is the life-blood of science.

I. Reform Agenda. The sorry state of K-12 science education has been documented in many prominent reports (e.g. A Nation at Risk (1983), Shaping the Future (1996), TIMSS (1998)). This has lead to sweeping K-12 science education reform as a priority in *national science policy* (Committee on Science, 1998). The chief reasons are (Ehlers, 1999):

- *Technology pipeline*: To educate scientists and engineers for sustaining economic growth.
- *Workplace readiness*: To provide the technical foundation for an effective workforce.
- *Informed citizens:* To produce science literate citizens and consumers.

Reforms are needed along four main lines:

- **Pedagogical reform** to meet or exceed the *National Science Education Standards* (NSES). New evaluation instruments have documented serious deficiencies in conventional teaching methods as well as considerable improvements from research-based instructional designs. However, these advances have not yet been widely diffused or deeply assimilated by most physics teachers. Deeper reforms in curriculum and instruction are continually emerging from educational research, but adequate mechanisms to move them into the classroom are still lacking.

- **Technology infusion.** Electronic technology is rapidly becoming an integral part of modern society. It is already essential to modern science, engineering, manufacturing and many businesses. It is therefore imperative to incorporate technology into science curricula at all grade levels. Educational research has established that computers do little to enhance student learning without carefully designed adjustments to the curriculum implemented by a well-trained teacher. This is particularly true in physics courses, where students need to learn how to use the computer as a scientific tool for data acquisition, analysis and problem solving. The computer can enhance pedagogy, but not replace it. Therefore *infusion of computers into science classrooms must be coupled to reform in science pedagogy and teacher professional development.*
- **Incorporating contemporary science.** The main accomplishment of 20th century physics is arguably: unraveling the atomic structure of matter. This unifies physics and chemistry into a common science of the structure of matter and its properties. It also provides the foundation for electronic technology, molecular biology and astrophysics. Little of this astounding science has penetrated the K-12 curriculum except in occasional "gee-whiz" tidbits. More is not to be expected without participation of research scientists in the professional development of teachers and curriculum reform. As a gateway to the wonders of 21st century science, it is essential to establish an integrated science curriculum that initiates students into physics of the atomic world by the ninth grade.
- **Cultivating physics teachers to lead reform.** Physics teachers are especially well suited to serve as leaders of local science education reform with technology infusion. This has been established in a NSF-supported nationwide program of workshops to cultivate them as leaders of science teaching with technology in their schools and school districts. Though only about a quarter of inservice physics teachers have college degrees in physics, the vast majority are enthusiastic about learning and teaching physics and confident in their abilities to do so. Though most have had little opportunity to integrate the scientific use of technology into their teaching, they are eager and unafraid to do it. In short, physics teachers are eager and able to take full advantage of professional development programs to cultivate them as leaders of science education reform.

II. University-High School Partnerships for science education reform. The NCPE will advise and assist universities in creating and maintaining local partnerships to cultivate and support physics teachers as agents of science education reform in their school districts. A partnership begins with commitment from a physics department to support a local alliance of physics teachers with a program of professional development tailored to meet their needs. It extends to partnerships with schools and school districts to support the teachers as local agents of reform.

- **Teachers.** Ultimately, all reform takes place in the classroom. Therefore, *the key to reform is to cultivate teacher expertise.* The vast majority of physics teachers are under-prepared, isolated and overworked. However, they are also dedicated, able, excited about science and

hungering to learn more. Above all they need opportunities for professional growth and a supportive school environment.

Lifelong professional development is as essential for teachers as it is for doctors. Typically, it takes at least ten years to reach a high level of expertise in any profession. Few teachers have adequate opportunities for sustained professional development, and many have an inadequate background in science to start with, so most remain far from reaching their full potential as teachers.

The NSES emphasizes that "coherent and integrated programs" supporting "lifelong professional development" of science teachers are essential for significant reform. They state

that "The conventional view of professional development for teachers needs to shift from technical training for specific skills to opportunities for intellectual professional growth." Such a program cannot be consistently maintained and enriched in any locality without dedicated support from a local university.

- **Local Physics Alliances (LPAs).** As in any profession, for continued professional growth teachers need the stimulus of interaction with their peers. Recognizing this need, the APS has sponsored formation of LPAs across the country. University physics departments should take advantage of this powerful mechanism for reform by organizing and supporting alliances in their localities.

  The LPA serves teachers as learning community and a base for collaborative efforts to improve curriculum and instruction. The university supports the LPA with professional development workshops, access to resources of the physics community at large, and assistance in reform. The LPAs serve schools as a professional community of *experts* in planning and assisting technology infusion into other science courses. That has the added benefit of inducing natural collaboration among physics, chemistry, math and biology teachers, so it contributes to integration of the science curriculum.

  Teacher ownership and control of each local alliance is essential, because it is a professional organization by and for the teachers. The relation of the alliance to the universities is one of *partnership*, with the common objective of promoting improvements in science teaching. The teachers assume responsibility for organizing and maintaining their own professional development, while the university provides an infrastructure to support it.

- **University Partners.** To keep pace with technology as well as science and education research, we need a rapid delivery system for incorporating advances into classroom practice and thereby driving educational reform. The traditional educational delivery system has enormous inertia and resistance to change. We need to short circuit it with direct delivery to inservice teachers, and, at the same time, work to inform school boards and administrations about the need to infuse both technology and teaching reform quickly.

  University partnerships with LPAs and school districts provide the local infrastructure needed to drive sustained and rapid science education reform. To that end, universities need to create and maintain rich professional development programs with graduate courses expressly designed to meet the needs of teachers and offered at times when teachers can take them. Most universities have sufficient resources to create viable partnerships but need advice and assistance in setting up and maintaining them. That will be supplied by the NCPE.

- **School District Partners.** Schools and school districts are ill-equipped to conduct professional development on their own, because they lack the necessary *expertise* in science and technology as well as the *resources* to keep up-to-date with advances in science curriculum materials and pedagogy. However, in most regions of the United States such resources are available at a nearby university, especially in the science, engineering and education faculties. School-university partnerships are needed to give the schools ready access to those resources. The primary mechanism for access will be through university support of inservice physics teachers as local agents of professional development and reform.

  To be successful in local reform, the leaders need support from their schools. They need technology in their classrooms. They need salaries while they participate in professional development during the summer. They need release time to work with other teachers during the year. Universities can help arrange this through partnerships with schools, in particular, to solicit external funding for local reforms.

III. NCPE Structure and Organization. Preliminary suggestions to get the NCPE started.

Staff and location. Presuming that the NCPE is sponsored jointly by the AAPT and the APS, it will be housed, at least initially, at the Center for Physics in College Park. An initial staff of one person will be needed to organize volunteers to get the project started and coordinate AIP support. For the most part, NCPE meetings and workshops will be held elsewhere, such as at supportive universities and in conjunction with APS/AAPT meetings.

The NCPE will provide support for two institutes with complementary missions outlined as follows:

Institute for Physics Teaching (IPT)

- training and support of Workshop Leaders
- critique and rapid infusion of new materials and insights from PER
- electronic networking of teachers
- evaluation and assessment of instruction

Institute for Physics Education Research (IPER)

- coordinate nationwide efforts in PER
- provide IPT with assistance, ideas, results and materials

New ideas, results or curriculum materials proposed for high school workshops or courses will be filtered through a **Committee of Master Teachers (CMT)** who will supervise their evaluation and adaptation by Action Research teams of inservice teachers. The CMT will oversee and assist the conduct of Workshops and Action Research by all participating partnerships. The CMT will be composed of expert teachers and leaders selected from the PTRA and elsewhere. Recipients of the AAPT Excellence in Pre-College Teaching Award will be invited to serve.

Educational Outreach and Training (EOT). A major mechanism for federally funded research projects, including National Labs, to influence science education in the schools is through EOT programs bringing inservice teachers into direct contact with research scientists. The influence of EOT programs can be greatly amplified and improved by linking them to the NCPE.

Physics Education Research (PER) and Evaluation is absolutely essential to continued growth in the scope and quality of the physics education reform. The well-documented success of the Modeling Workshop Project over nearly a decade is largely attributable to its thorough grounding in PER and its design for continued upgrades in methods and materials with strong PER input. All this will be inherited by the NCPE, but more will be needed.

Over the last decade PER has emerged as a viable subdiscipline of physics, with active research faculty in many universities, a new PER journal and yearly PER conferences. The NCPE will provide a means for AIP societies to promote PER input into science education reform. Here are two examples.

- To ensure high quality results from IPT workshops and action research, evaluation and feedback should be supplied by independent PER Teams, composed of PER postdocs and graduate students directed by established PER faculty. To support such activities, it will be necessary to solicit external funding.
- As federal funding is stimulating a rapid expansion of EOT programs, the need for PER research to ensure the quality of their products is becoming critical, especially in the proliferating domain of Internet resources. It seems to be an article of faith that greater access to information will improve education, but there are many reasons to be skeptical. Many Web sites are glitzy and enticing but pedagogically flawed. How can teachers and students separate the good stuff from the bad? Teachers are encouraged to incorporate Web stuff into their courses, but will this contribute to greater fragmentation of an already fragmented curriculum? The problems are many and difficult. Few teachers, researchers and Web masters in the EOT programs have the PER expertise to address them. It is essential to engage PER specialists.

IV. Workshops to Drive Sustained and Rapid Science Education Reform

Physics education research and development has recently emerged as a respectable academic discipline within university physics departments. This will accelerate new developments in physics pedagogy, curriculum materials and technology-enabled instruction.

Figure 3 is the schematic for a rapid response system to drive physics education reform. The NCPE processes and feeds the latest developments to a national network of local and regional University-HS partnerships. It will conduct annual Workshops to train and inform teachers and faculty leading the partnerships. Master teachers will be the principal agents of reform, linking educational research and development to the reform of classroom teaching. As indicated in the Figure, they will incorporate new results into their Workshop courses for other teachers and feed new ideas and materials to action research teams to be evaluated and adapted for classroom use by the teachers. Thereby the master teachers will provide a continual stimulus to upgrade local partnerships.

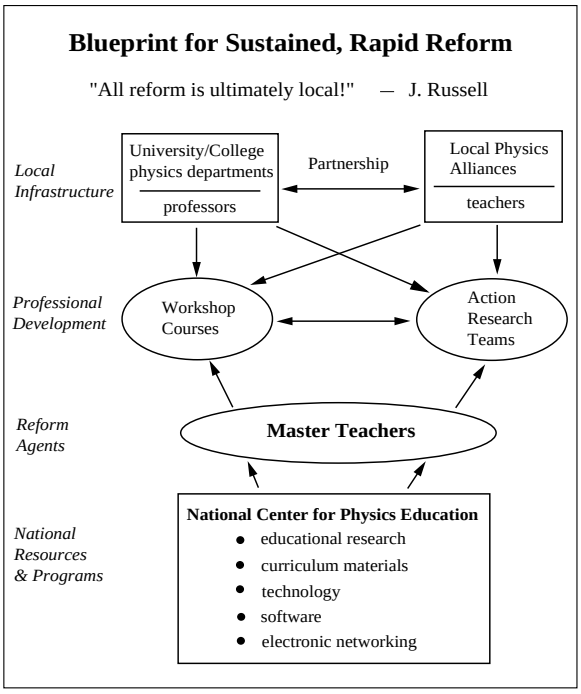

Figure 3.

The principal activity of the NCPE will be to organize meetings and workshops to drive science education reform, especially to energize, inform and consolidate a growing community of leaders. Many years of NSF support have led to the development of the following workshops, which can be offered as soon as the NCPE is prepared to sponsor them:

- **Workshops on University–High School Partnerships** for parties from university physics departments who are interested in establishing a partnership in their own locality. Preferably each party will include a faculty member and a high school physics teacher with leadership potential. The workshop will provide detailed plans to start a partnership and keep it growing, along with specific examples of successful implementation. Model proposals and other materials will be supplied to help each party develop its own plan. A half-day workshop is already scheduled for the August 2000 AAPT meeting.
- **Modeling Workshops I & II** for professional development of inservice physics teachers. (Intensive 4-week workshops in two successive summers). They follow the proven format developed by the Modeling Workshop Project over the last decade, including an inquiry pedagogy and emphasis on **Action Research Teams** as a primary means for evaluating and integrating new ideas and materials into the curriculum. These workshops provide a detailed model for local workshops that can be implemented by University–High School partnerships, and they train leaders to conduct them. A leadership version of these workshops can be arranged for experienced PTRAs. Detailed information about the Modeling Workshops is available at the website: http://modeling.la.asu.edu/modeling.html Modeling Workshops can be offered as soon as the NCPE is prepared to sponsor them.

- **Leadership Workshops** (several @ 2 weeks each). This is a core activity, keeping lead teachers at partnership sites up-to-date on education innovations, curriculum materials, classroom technology, instructional techniques, LPA formation & strengthening, and preparing them to lead new workshops at their home partnerships. Action Research Teams composed of members from different partnerships will work on specific topics or modules, such as those generated by outreach programs. This will stimulate and inform further work back home. The workshops are for teachers, but faculty partners are welcome to attend even if only for a few days. These workshops can begin as soon as the NCPE has enlisted a few universities to start developing partnerships.

Workshops will be conducted under the *Peer Teaching Principle*, which holds that professionals are best taught by peers who are well-versed in the objectives, methods and problems of the profession. This means that the master physics teachers themselves will be responsible for the design and conduct of all workshops for other teachers. University professors and educational researchers will play facilitory roles only.

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