

Physics at state colleges: both possible and crucial

By Edward F. Deveney

MTA Today
Volume 35, No.1/August-September 2004

Physics at state colleges:

By Edward F. Deveney

Imagine the mysterious yet ubiquitous electron. It is so small that for all we know it may have no size at all – and, worse yet, it is immersed in a sea of virtual particle-antiparticle pairs flinging it in and out of the “vacuum.” This is quantum physics.

Should the educated public care about quantum physics, or should it be ignored and left to the seemingly “quarky,” esoteric and out-of-touch physicists and philosophers? The



Edward Deveney

answer is clear if one considers that quantum physics is the most successful theory ever devised for understanding nature, from electrons to baseballs; that medicine and industry rely on quantum mechanics for lasers, semiconductors, CT scans, MRIs and PET scans (it is estimated that roughly 30 percent of the U.S. economy is the result of quantum mechanical innovation); and that quantum physics is also being used in attempts to construct a “theory of everything.”

Quantum physics education and research are available to students at major universities and at some elite private colleges. But is it also possible for students at Massachusetts state colleges to have such educational opportunities? Not only is it possible, it is critically important. Our hopes for future medical breakthroughs, strong economic growth and potential new and clean energy sources rely strongly on quantum physics.

Here at Bridgewater State College, several students and I have begun to build a program for experimental and theoretical studies in atomic, molecular and optical (AMO) quantum physics that is growing in parallel with a thriving physics department and physics major (this despite the humiliating lack of support from a state where college funding ranks as the lowest in the country, faculty salaries are stagnant at levels 10 to 20 percent below what our peers are paid, and a Board of Higher Education study cites a billion-dollar funding shortfall for infrastructure). (It is also notable that of the nine state colleges, only two are even able to offer a degree in physics, creating a potentially serious gap in the needed Massachusetts workforce and a glaring hole in the state college education curriculum.)

The AMO program I am developing is centered on a newly dedicated laser lab and research-quality “tunable” diode lasers (i.e., lasers with the ability to be tuned to a specific and controllable frequency).

The laser lab itself was established in “highly in demand” classroom space and so speaks loudly for strong administrative support.

The diode lasers are the direct result of the technological explosion of the 20th century, which owes so much to quantum physics. The fundamental idea of the tunable diode laser is from 2001 Nobel Prize laureate Carl Wieman, who needed simple, inexpensive but research-quality lasers. Previously, such tunable lasers, at the necessary frequencies, were costly (about \$100,000) and required significant maintenance. The new design uses standard optical components and semiconductor diode lasers (about \$100), not very different from those used in

both possible and crucial

laser pens and CD players. An entire laser assembly with electronic controls can be built for roughly \$4,000 or purchased for \$10,000.

In the first year of my program, BSC student Petr Liska ('01), began construction of the diode laser with the assistance of James Munise, a technical consultant in the sciences, and presented some of his work at the 2000 Center for Undergraduate Research symposium in Kentucky.

A year later, a second student, Scott Dallmeyer ('03), won an Adrian Tinsley Program Award (named in honor of a former BSC president) to continue the construction and perform the first experiments, which Scott later presented at the 2002 New England section of the American Physical Society meeting. Thanks to these efforts, Scott and I were able to finish construction of the laser, take diagnostic measurements of the laser itself and successfully observe the "fine structure" shift of energy in atomic rubidium, which is due to the interaction of the "spin" of a bound electron with the magnetic field created by its own orbital angular momentum.

My students and I have a bit more work ahead to measure the even smaller "hyper-fine" shift of energy, resulting from the interaction of the electron spin with the field of the protons within the nucleus, but it is within our grasp.

Our laser and some of the underlying techniques that we have begun to study were developed in part by several recent winners of the Nobel Prize in physics and have become important in biology, chemistry, communications and industry. My goals are to establish true physics mentoring opportunities and cross-disciplinary collaborations throughout the arts and sciences while updating and enhancing

The laser lab itself was established in 'highly in demand' classroom space and so speaks loudly for strong administrative support.

both the advanced and introductory student laboratories and reaching out into the general education curriculum. I do not, however, want to imply that I am placing an emphasis on original research and publication. Original contributions made at predominantly undergraduate institutions do indeed occur – and some are gems – but they are rare, particularly in physics.

Yes, despite the many difficulties, true AMO quantum physics has arrived at BSC. Many of us here believe, with this program as an example, that in many ways, our state colleges can offer as much or more than most private colleges, with our emphasis on faculty/student mentoring and all the good (but perhaps not always publishable) things that will happen as a result. In physics, here at BSC, we are fortunate to have an energetic and exciting new department of four Ph.D.s whose expertise covers astrophysics and solar physics, general relativity and gravitational lensing, physics education and art and experimental AMO and fundamental physics.

Our motto is, "Exciting things are happening at BSC." Yet, oddly enough (or perhaps not so oddly), the idea for this article began while I was participating in a union demonstration for a fair and equitable faculty contract at a recent BHE meeting.

Edward F. Deveney, Ph.D., is an associate professor of Physics at BSC.