Chapter 4

Scholarship

4.1 Overview

During the past six years my scholarship has been even stronger than it was during my first five years at Berry. My scholarly activities can be divided into two major parts: technical research and scholarship of teaching. My most successful technical research is within the general area of my graduate work (quantum chaos), but I have taken my research in a direction very different from that of my prior work. My work during the last six years has focused on computational investigations of the asymmetric infinite square well system. I have applied the tools of periodic-orbit theory and perturbation theory to better understand the structure of the energy spectrum and the dynamics of quantum wave packets in this system. My work has revealed novel features in this system that are likely to be found in a wide class of similar models.

My pedagogical scholarship has emerged from my own classroom teaching. I have published papers and given presentations on the innovative curricular materials I have developed for the courses I teach at Berry. I am known internationally for using computer simulations to teach astronomy, and for incorporating computational problems in upper level classical mechanics courses. I also have engaged in various research projects with Berry students, often outside of my own area of expertise.

During this time period I have published six peer-reviewed articles, one of which had already been accepted for publication when I submitted my tenure dossier. I have had another peer-reviewed article accepted for publication (to be published in late 2012). I submitted another paper for publication in August, 2012. On all but one of these articles I am the first author and had primary responsibility for writing the manuscript. I also have published two invited book reviews and two articles in conference proceedings. Copies of my published and submitted articles and book reviews are available in Appendix E.

I have given numerous presentations and workshops at national and international conferences, some by invitation. I also have published 38 computer simulations, written one textbook and part of another, and created several new web pages to make my innovative curricular materials available to a wider audience. Several of my students have given presentations on our work at regional conferences and the Berry Symposium on Student Scholarship, and in some cases students have been co-authors on published works.

The complete list of my publications and presentations is given in Appendix F. Table 4.1 summarizes my scholarly productivity.

The quality of my work, and that of my student co-authors, is indicated by the quality of the journals in which I have published and the conferences at which I have presented. Table 4.2 shows acceptance rates, impact factors, and two other measures of journal influence (Paper Influence Index and Eigenfactor) for the journals in which I have published during the past six years (excluding the article that was accepted prior to Fall 2006). It should also be noted that all three journals are international journals which receive a significant number of submissions from outside the United States. *Physical Review E* is a technical journal, one of the top journals in the area of statistical and nonlinear physics. *The Physics Teacher* is a pedagogical journal focusing on physics and astronomy education at the high school and introductory college level. The *American Journal of Physics* publishes technical and pedagogical articles aimed at the advanced undergraduate and beginning graduate level.

Table 4.3 shows the numbers of citations for my published articles. The table shows the total number

Calendar Year	Published Papers	Presentations	Student Presentations	Total
2007	1*	5	3	9
2008	1	2	3	6
2009	1	8	1	10
2010	2	2	1	4
2011	1	3	0	4
2012†	1	3	0	4

* This article was accepted prior to Fall 2006 when I submitted my tenure dossier.
† The data for 2012 is incomplete. It includes one paper that has been accepted for publication and is likely to be published in late 2012.

Table 4.1: Summary of scholarship activities

Journal Title	Acc. Rate[a]	Impact Factor[b]	PII (Rank)[c]	EigenFactor (%ile)[d]
American Journal of Physics	25%	0.779	89.15 (1,696)	.005424 (72%)
The Physics Teacher	38%	NA	NA	NA
Physical Review E	62%	2.352	138.23 (1,099)	.241351 (100%)

[a] Acceptance rates for regular articles during 2010.
[b] From the 2010 Journal Citation Report published by Thomson ISI.
[c] Paper Influence Index (PII) from `Journal-Ranking.com`. Rank indicates the journal's rank by PII among *all 11,238* ranked journals in all fields. Note that the *American Journal of Physics* ranks 22^{nd} out of 86 multidisciplinary physics journals but ranks second out of 34 scientific education journals (behind only *Academic Medicine*). Likewise, *Physical Review E* ranks 7^{th} out of 54 mathematical physics journals. On the SCImago Journal Rankings (at `www.scimagojr.com`), *Physical Review E* ranks fourth of 24 journals in statistical and nonlinear physics, but 150^{th} out of all 533 physics journals ranked.
[d] The EigenFactor score rates the overall influence of a journal. Scores and percentiles are given at `www.eigenfactor.org`.

Table 4.2: Indicators of journal quality

of citations for each paper, the number of citations from papers not co-authored by me, and the number of citations from papers not co-authored by me or any of my co-authors. Although my recent work is not heavily cited, there are several factors that may explain this. My technical research is in a highly specialized area of physics, an area in which few other physicists work. Many of my publications are pedagogical in nature, and the influence of these articles is not well indicated by citation numbers since they are mostly used for classroom teaching rather than for further research. As an additional indication of the importance of my work I have included referee reports (and my responses) for my recent papers in Appendix F. I hope this information serves to indicate the level of respect with which my work is regarded by my peers.

4.2 Research with Students

The research I have conducted with Berry students is described below.

4.2.1 Jeff Tucker

During the 2006-2007 academic year I worked with physics major Jeff Tucker to investigate statistical properties of the distribution of prime numbers. Jeff wrote software to compute the number variance, skewness, and excess for sequences of prime numbers, as well as sets of so-called "random prime numbers" (such as Cramer and Hawkins primes). Our results showed that although the Cramer and Hawkins primes rapidly approached Poisson statistics as the length of the sequence increased, the real primes approached Poisson statistics much more slowly. Jeff presented this work at an undergraduate mathematics research conference

Title of Article	Citations	Excl. Self	Excl. Co-authors	Preprints
High harmonic generation ...	9	7	5	1
Changes in Floquet-state ...	25	23	17	2
Phase-space picture ...	10	9	3	1
A computational approach ...	5	4	4	0
Localization of Floquet ...	2	2	1	0
Random numbers ...	1	1	1	4
Computation in classical ...	3	3	3	0
Quantum signatures ...	3	1	1	0

Table 4.3: Citations of prior work

and wrote a paper that was published in the conference proceedings. He also presented at the Student Symposium. I extended some of Jeff's work and presented the results at a regional physics meeting.

4.2.2 Molly Nelson

From 2007 to 2008 I worked with physics (and English) major Molly Nelson on investigating level spacings in simple quantum systems. Eventually we decided to investigate level spacings in the asymmetric infinite square well and Molly quickly discovered some unusual features in the distribution of level spacings. I was able to explain these features using periodic-orbit theory. Molly presented her work at a regional physics meeting and at the Student Symposium, and we published a paper together in a highly respected physics journal (*Physical Review E*).

4.2.3 Tim Margrave

In spring and summer 2008 I worked with physics major Tim Margrave to study student views about the nature of science. With assistance from a Faculty Development Grant (see Appendix F) we surveyed junior and senior science majors at Berry using an instrument called the Epistemological Beliefs About Physical Science (EBAPS) survey. We administered the survey online and Tim entered the data into a spreadsheet and carried out most of the statistical analysis. We found notable differences in the responses between life science (BIO and ANS) majors and physical science (CHM and PHY) majors. Tim presented his work at the Student Symposium, but I have not yet found time to turn this work into a paper and submit it for publication.

4.2.4 Andrew Duty

In summer 2008 physics major Andrew Duty completed a directed study under my supervision in which we recreated several early experiments on atmospheric pressure, particularly those made famous by Blaise Pascal. We recorded these experiments and demonstrations photographically and on video. The eventual plan was to create online curricular materials to educate students about these experiments and about the concept of air pressure. Unfortunately, Andrew left Berry before this larger project was completed. I still hope to produce these online curricular materials and write a paper describing this work for *The Physics Teacher*.

4.2.5 Robby Boston and Seth Camp

In summer 2007 physics major Robby Boston worked with me to investigate wave packet revivals in the asymmetric infinite square well. We encountered some problems in the work and I suggested further work to identify, and hopefully correct, these problems. Although Robby did present his work at the Student Symposium, he did not follow through on the additional work and the project languished for a while. In summer 2009 I recruited physics major Seth Camp to restart the project from scratch. Seth did a much better job and soon solved the problems Robby had encountered (and even showed that some things I thought

were errors were really correct). Seth presented our work at the Student Symposium and also at a regional physics conference. We published a paper describing our work in the *American Journal of Physics*.

4.2.6 Kalen Maloney

Kalen Maloney, a physics major and experienced amateur astronomer, worked with me during summer 2011 to renovate Berry's Pew Observatory. As part of this work he successfully mounted and aligned our newly donated 6 inch apochromatic refractor. Kalen and I began initial efforts to use this telescope for digital astrophotography. Kalen continued to assist me in these efforts sporadically (when I had time) throughout the 2011-2012 academic year. We hope to start taking high quality digital images of nebulae soon.

4.3 Future Work

I am currently working in collaboration with Christopher Graney of Jefferson Community & Technical College in Louisville, KY on a project investigating the historial debate between Robert Hooke and Isaac Newton on the path of a body falling on a rotating Earth. I have created a computer simulation to show the path of the body, as viewed from Earth or from out in space, under a variety of conditions and assumptions. My simulations have shown that a sketch made by Newton and sent to Hooke is actually a very accurate rendering of the path under certain reasonable assumptions, in spite of the criticism this sketch drew from Hooke and from more recent historians. I gave a talk on this work at the 2012 Summer AAPT meeting and we hope to publish a paper describing this work in *The Physics Teacher*.

I hope to publish some of the work I have done in the past with Berry undergraduates, particularly Jeff Tucker's work on the statistics of prime numbers, Tim Margrave's study of student views about science, and Andrew Duty's recreation of Pascal's air pressure experiments. In addition, I expect to publish several more articles in *The Physics Teacher* about the activities I have developed for AST 120 and 121. I submitted one such paper this past August. I also have a contract with Springer to write a book on using the *Maxima* computer algebra system to teach classical mechanics.

In the long term my major scholarship goal is to promote the use of history in the teaching of science. To this end I hope to publish my textbook *The Scale of the Universe*, as well as the curricular materials I have developed to go with it. One of the editors at Yale University Press has expressed interest in the book and I am currently working on a formal proposal to submit to that publisher. I intend to publish a paper on teaching historical astronomy in the *Astronomy Education Review*. I hope to give many presentations on this topic, including public lectures at Berry or the Tellus science museum. Eventually I hope to also publish the textbook for the Copernican Revolution course, which was written by Paul Wallace and modified by me. I also plan to continue publishing new computer simulations for use in teaching astronomy and physics.

Although my scholarship interests are primarily pedagogical, I do hope to continue my technical research on the dynamics of quantum wells. I have several ideas about possible projects. I expect to initiate these projects when I find a student who is interested in working on one of them.