Soul Matters in Science
Stories from the life of a physicist

(a work-in-progress toward book publication)

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Prologue

In the spirit of local-color literature, also called regionalism in the late 19th century, this book will share personal accounts of historical events in the life of the author. The objective hoped-for in this work is to make vivid a host of unlikely events that present strong evidence for the handiwork of God.

Introduction

Shortly before the 50th anniversary of the launch of Sputnik, a request was made to the American Physical Society, from an American radio-news agency, for testimonials from physicists about the Russian space-accomplishment. My response to that agency's questions now follow:

If you've been around long enough to remember, what do you recall of Sputnik?

At the time of its launch I was 15 years of age, a student in high school and beginning to contemplate a career in physics. I was old enough to appreciate the technological significance of the Russian achievement. This appreciation was enhanced by my growing up in Oak Ridge, TN; whose role in World War II, in ushering in the nuclear age, also resulted in a very positive influence on science education in that community. Similar excellence must also have been true of the influence at that time of scientists in Los Alamos, NM.

What story can you tell, if any, that embodies Sputnik's effect?

My father was a coal miner—who worked in the mountains of Virginia near where I was born in Big Stone Gap. His and mother's decision to move our family to Oak Ridge, before I reached school age, was the means for sowing in me seeds of great interest in physics. About the time of Sputnik's launch I was privileged like few other students anywhere else, to inspect an early generation transistor. Texas Instruments had started their manufacturing line just a few years earlier, and only visionary scientists and engineers had appreciation for the fact that these new solid state devices would in due time revolutionize the world. Primed with excitement over the novelty of the transistor, which as part of the integrated circuit birthed the information age in which we live; I was enthralled by this latest triumph—the Earth's first artificial satellite.

Did Sputnik's launch and the American response galvanize you in any way?

My older brother, Palmer; who like myself was trained in physics at the University of Tennessee--retired recently from Marshall Space Flight Center in Huntsville, AL, following his influential NASA career that lasted more than four decades. In the 1950's, Palmer and I were building black-powder rockets. The passion we shared for this science-centered hobby was greatly boosted by Sputnik; the collective events had a long-term influence on our view of physics, both pure and applied. Russia's success in launching Sputnik was a significant factor in the establishment of our career

paths. I don't doubt that Sputnik also played a role in the following unusual development. Not only are my brother and I both PhD physicists, but one of my two sisters married a PhD physicist, who recently retired from the faculty of the University of Georgia. The other of my fraternal twin sisters is an MD; and for a coal miner father and a mother with less than a high school education to have realized this level of success with their children—is in the minds of most, no small achievement.

What in your career and life can you trace back to the Sputnik launch?

I view the era of Sputnik as the second of three distinct periods that influenced my life greatly. Historically, all three of these periods have stood out because of their great importance, not only to the United States, but to the whole world. The first period I have already mentioned—the race for nuclear superiority and Oak Ridge's influence on my life at an early age. Also as noted above, Sputnik influenced me greatly at the time in my life when most students, largely because of their educational exposure, begin to contemplate a career path. Developments of the 1940's and 1950's allowed me, for example, to be a student of calculus in high school at a time when few students at other places had a chance to learn the mathematics that is so central to physics education. The third period, during the time of the cold war, demonstrated the importance to our nation of physics training. I personally developed the key elements of the thermal signature algorithms used in the only test of our nation's antisatellite system during the Reagan 'Star-Wars' era. My physics training provided means for the generation of a simple computer algorithm whose effectiveness was proven on 13 September 1985; when the system built by the team of LTV in Dallas and Boeing in Seattle-- was used to target and destroy satellite P78-1. While refining my algorithms in the span of a few earlier years, essentially the same thermal codes were used to determine that Cosmos 1402 was not as serious a threat as had been initially feared. The craft had experienced a failure during the nominal end-of-life method of dealing with these nuclear powered satellites that were used to spy on the U.S. fleet. The rocket used to boost the reactor to a high orbit failed, and so radioactive material was destined to fall to earth during the de-orbit that would soon happen because of atmospheric drag. These events would have been more serious had the reactor been active as opposed to passive. A measure of the concern to the U.S. public (not to mention the Department of Defense) can be gauged by the article that appeared in Time magazine on 13 January 1983, titled "Cosmos 1402 is out of control". By comparing ground-based measurements with predictions generated by my thermal signature codes, it was determined that the reactor was passive.

In your experience and observations, what are the specific, lasting effects of Sputnik (cultural, technological, etc.)?

Our nation's commitment to excellence in science has been one of 'fits and starts". A pattern of 'supply and demand', having a period of roughly 20 or 30 years, evidenced itself during the 20th century. Too much of that cycle has been regulated by fear, which in the case of Sputnik forced us to 'play catch-up'. Then after we had caught up to and surpassed the Russians in response to Kennedy's resolve to put our astronauts on the moon, we slipped into a politically driven, lackadaisical place. The American public is mostly oblivious to the fact that we are in the process of systematically losing much of what made America great. Left unchecked, this decline will impact America with dramatic, adverse consequences. Physics played the pivotal role in the generation of so many of the ideas that were most influential in determining the course of technological evolution during the 20th century. Yet the profession in this country is now trying desperately to recover from a serious state of decline over the last couple of decades. There are few words to adequately describe the anger I feel for how the importance of physics is so under-represented to vast segments of the student population of America. Few other educational systems anywhere, including those we label as 'third-world', share such a poor attitude toward this science that is foundational to all the others. The American public seems to have lost sight of the fact that physics was primarily the discipline that allowed us to catch up with the Russians in the space race following Sputnik. They fail to recognize that physics, practiced by Americans following Sputnik, radically changed our world for the better-- because of the technologies it made possible.

How would you compare/contrast American's response to Sputnik and its response to today's threats of global terrorism, a rising China, or global warming?

In my opinion, the technological rise of China, in contrast to the stagnation and decline of America-- stems primarily from a single factor—the difference in cultural attitudes of the two countries when it comes to mathematics and physics. Chinese attitudes are today similar to what American attitudes were in the aftermath of Sputnik. Unfortunately, we have let our attitudes go 'sour' while China was

making theirs 'sweet'. Of course this assumes that what America achieved following Sputnik was 'better' for us and for the world; although there will always be misfits who disagree with this premise. One of my physics department colleagues here at Mercer University did a post-doc in the Peoples Republic, and he is married to a Chinese woman. Another of my departmental colleagues is Taiwanese. It is obvious from what is readily learned from the experiences of these men, independent of what should be evident to most American consumers—we need to take a serious look at what is being taught in America and how it is being taught. Has our education degenerated to a state of mediocrity or even worse? Is it true what was told me by one prominent Australian School of Education professor in New South Wales (who is well traveled in this country and positioned to judge): "science education in the United States is beyond redemption"? Could it be true that the same malaise has even infected other parts of our higher education? My oldest daughter who graduated summa cum laude a few years ago with a baccalaurate in English, transferred out of a School of Education program, and gave for her reason that she 'refused to participate in the dumbing down of America'.

What else should we know about this topic?

As I approach full-retirement-age, according to the definition of the Social Security Administration, I am viewed by most as enigmatic. Whereas the majority of physicists reach their 'crowning glory' (if at all) before age 55, I am at 65 just 'catching my 2nd wind'. Sputnik was one of the truly important factors among the many obvious factors that have operated synergetically during my career. Some non-obvious factors are equally important contributors to that synergy. These comprise some of the intangibles that defy measurement, and which characterize success when it is encountered. Recently a marvelous (but mostly unknown) quote by American physicist Joseph Henry was brought to my attention: "The seeds of great discoveries are constantly floating around, but they only take root in minds well prepared to receive them". It is tragic that so few of our educators are qualified to prepare the minds of their students to become candidates to receive seeds of discovery in physics. Failure of students to reach their full potential in physics and mathematics can be far reaching, and I explain my logic for this claim as follows. My research field is one involving chaos and complexity. A recent one of my articles, written on the topic of "mathematical methods of physics in chaos" was published in the 10th edition of the McGraw Hill Encyclopedia of Science and Technology. I also wrote for the 10th edition the article titled "Anharmonic Oscillator". Many people are now familiar with the 'butterfly effect', following the serendipitous discovery of 'deterministic chaos' by Edward Lorenz, as he modelled atmospheric convection. Whereas Lorenz's definition of the effect is mathematically precise (basis for use of the adjective 'deterministic'), I have come through the years to circumstantially appreciate a non-precise form of the butterfly effect. It is one of complexity type in which "the lives of little people trickle into big events". During my career I have witnessed it several times in dramatic fashion, as for example during the Cosmos 1402 incident. Little did I know at the time, that seemingly mundane physics has potential through the butterfly effect to influence headline news. What I recognize concerning humanity in general, is that this form of the butterfly effect is constantly at work for better or for worse, in the lives of individuals not yet known to the world. I hope that America can 'turn away' from the path we're presently following; so that we experience the better and not the worse. There is a spiritual, Christian element to my makeup which I refuse to separate from my efforts. Mine is a legacy that dates at least from the 1750's when my father's family moved to Virginia from Germany. I strongly believe that to reclaim proper attitudes toward science, America must resolve to maintain (and reclaim what has been lost) the core values on which our nation has rested for centuries. Not only did these core values influence the legal foundation of this nation; they were central to some of the greatest scientific discoveries of all time, such as Charles Townes' discovery of the laser (only one of many examples, few of which are known to the American public). Yet discussion of these attributes, which can be readily documented by sound bibliographic practice, tend to be viewed as politically incorrect. Too many Americans are thus deceived into believing that a bonafide scientist would have to 'check his brain at the door', before entering a facility that is concerned with theology. My hope is that attitude adjustments needed to strengthen America will never be suppressed by the forces that have been trying to carry physics in this country in the wrong direction.

End of the1st installment of the planned book

A Synergetic Mix

The Greek word for "work" is also the energy unit of the centimeter-gram-second

(CGS) system of units that was common during my student days, before conversion to the system international (SI) where the energy unit is the Joule (J). Addition of the prefix "syn" (together) yields synergy, which literally means "work together". "Synergism" is instead used by some, but I don't like the word, for reason of its similarity to other "ism's" like communism. One of my favorite New Testament verses from the Pauline epistles is Romans 8:28: "And we know that all things work together for good (synergetically) to them that love God, to them who are the called according to His purpose" (King James Version, KJV; my upbringing involving the KJV, it continues to be my favorite translation.)

Paideia and Wissenschaft

My father's Germanic origin is traceable at least to the 1600's. No doubt my abilities to do physics with its style of mathematics derive in large measure from wissenschaft (whose best English single-word translation is "science"). The name Peters is a patronymic, meaning "son of Peter (Simon, a disciple of Jesus Christ). The Latin expression on our coat of arms reads "Sans Dieu Rien", which translates "without God, (there is) nothing". I came to better appreciate the extent of this heritage on our family about two years ago after finally locating my great grandfather's grave in Scott County, VA. At the top of his granite gravestone are inscribed the words "Asleep in Jesus", and at the bottom "Death is eternal life, why should we weep". JTL Peters (26 July 1841-19 May 1923) served with Co. D of the 64th Virginia Mounted Infantry Regiment of the Confederate States of America.

Distinctly different from my paternal heritage is the influence of my mother. Largely on the basis of the "story-telling" tradition that is a rich part of Southern Mountain heritage, and following the publication by Mercer University Press of Brent Kennedy's book, we concluded that Mom's Melungeon heritage was significant. It is thus probable that much of the maternal side of my family tree was not carefully maintained, for reason of the ethnic cleansing that Kennedy has documented.

Just as our paternal heritage is largely wissenschaft, our maternal heritage is largely of the type described by the Greek word "paideia". It is used in the English word "encyclopedia", so that a limited single-word translation of paideia is "knowledge". A better interpretation is more in line with "philosophy of education". I view the word as a holistic (to include spiritual) combination of knowledge and wisdom. At least that's my view, following a course in classical Greek that I took after joining the faculty of The University of Mississippi in 1968, so that I could read the New Testament in its original language.

In my first year at Mercer University (1998), then-Provost Russsell G. Warren described to new faculty members the blend of paideia and wissenschaft that he viewed as principal attributes of outstanding faculty members of the university.

Although Mercer is a Baptist university founded by Jesse Mercer in 1833, it is quite different from those Baptist institutions labeled as "fundamentalists". In the last few years the university was pressured to terminate its longtime relationship with the Georgia Baptist Convention, for reason of our "liberal" policies. In actuality, as an original founder of the convention-- if Jesse Mercer were alive today, I believe he would align more nearly with Mercer's present views than those of the convention from which we recently separated. One of his quotes, which I believe to be still very needed in theological circles, is "Lord deliver us from an ignorant ministry". I cringe every time I hear a preacher try from the pulpit to emphasize some one of his points by means of an example from physics. I personally try to "know my limitations" relative to theology; preachers would do well to recognize their limitations relative to science. Unfortunately, some fundamentalists seem to believe that God has given them special revelations into the realities of the universe, including physics.

I especially like the position held by Charles Townes, inventor of the laser. A Nobel Laureate and a devout Christian, he spoke at Mercer University in 1999; the title of his talk was "Logic and Uncertainty in Science and Religion". He noted the present deficiencies (incomplete nature) of both fields, and the need that exists for the two to merge more perfectly—as correction to errors in both camps are realized. I attended the Berkeley celebration of his 90th birthday a few years ago and was impressed to hear a panel of world-class experts discuss issues that are thought by many to be taboo among scientists, such as the exercise of free-will. A measure of the stature of Townes is to be realized from a consideration of the stature of some of the participants at this conference—more than a dozen attendees were Nobel Laureates.

Townes came to our campus in the same time frame as the American Physical Society's Centennial Celebration in Atlanta. A poster advertising that conference to the world featured a single picture of two individuals, Madame Curie and Charles Townes. To have been selected by his peers for such a high honor speaks of the significance of this man's contributions to science. When he visited Texas Tech University in the early 1990's (my employer before Mercer), he mentioned the "inspirational" source of his recognition of the "population inversion" that is required for the MASER or LASER to work. I knew in my heart at that moment that Prof. Townes had to be as much a Man of God as he is a famous Man of Science. In other parts of this book I will attempt to document from reliable sources the fact that his great faith has not been a rare attribute of those who have shaped the history of physics.

I also count myself greatly blessed to have spent one-on-one time with his brother-in-law, Arthur Schawlow; whose idea it was to produce the optical maser, by means of mirrors on each end of the cavity containing the lasing medium. Prof. Schawlow pointed out that the word laser is really a misnomer, because the devices now so important to our lives are really oscillators rather than

amplifiers. Nobody wanted to label the device with its real acronym LOSER (light "oscillator" by stimulated emission of radiation). Schawlow also received the Nobel Prize and I learned from him an example of the politics that oftentimes stands in the way of scientific advances. On the basis of the theoretical paper by Schawlow and Townes, Ted Maiman at Hughes Research Laboratories built the first (ruby) laser around 1960. For reason of an editorial policy (too many papers dealing with optical masers), Maiman's paper on the subject was not considered for publication by Physical Review Letters. The Nature article that resulted was the better place for it anyway! It is remarkable how the first popular-to-physics-departments HeNe laser that I marveled over in the mid 1960's was at that time considered "an invention looking for an application".

At the end of his lecture at Mercer University, Townes entertained questions from the audience. What I remember most vividly was his response to a question about evil in the world, in spite of great scientific achievements. His terse answer was, "Man, have you never heard of sin?".

One of my own Inspirational moments

In the summer of 1987 I was employed at Kirtland AFB in Albuquerque, NM, as part of an AFOSR summer faculty program. The project was a natural outgrowth of the Reagan Star Wars era and my previous-to-TTU employment by LTV (having moved from Dallas to Lubbock in 1986). The Kirtland study was using a laser to radiate various samples in a vacuum chamber, with enough power to hopefully effect a measurable momentum transfer. Placing the sample on a torsion balance and measuring its deflection during irradiation was the means planned to evaluate the Star Wars concept. Having no problem with the basic idea, nevertheless I was not satisfied with the sensing approach that was being considered, which was to use a potentiometer to measure the angular displacement.
For reliable electrical function, the slider of a potentiometer must operate with contact friction. Believing that the experiment with such a sensor would be doomed to failure, I began thinking about "non-invasive" means for sensing the motion. Following experience with amateur (ham) radio in my early teen years (call sign K4OVO) electronics became a passion for me, as well as the aforementioned rocket science activities with my brother, Palmer. Of the two best candidates for high sensitivity, "contactless" sensing (capacitive and optical), I elected to try my hand at building a new style of transducer based on capacitance. My thinking was influenced by the semicircular electrodes of area varying units that were once common in the tank circuits of radio receivers. Such capacitors were standard in the days of vacuum tubes; they have since been mostly replaced with varactors, in which the thickness, and thus the capacitance of a reverse-biased diode junction is made adjustable by means of a voltage.

To make a long story short, the linear rotary differential capacitive transducer

(LRDCT) that was conceived at this time was the first example of "fully differential" capacitive sensors. The resulting LRDCT patent was owned by TTU (with Air Force "possible interest through contract involvement", if significant monetary gains ever materialized, which they did not). My later, personally owned Symmetric Differential Capacitive (SDC) transducer patent is a versatile variant of the LRDCT, which allows the measurement of translation as well as rotation. My colleague John Lee and I recently gave an invited paper on its potential value to scanning probe microscopy at an IMAPS conference in Arizona.

During patent processing that went into "file wrapper continuation", the US Patent Office examiner required, for claim acceptance, that the following expression be appended to the above (SDC transducer) title: "employing cross-coupled conductive plates to form equipotential pairs". His requirement was striking, since from my earliest thoughts about the technology, I had noted how the insulator strips form a cross in the electrodes of the most useful configurations of the invention. Since it is my heartfelt belief that this sensor was inspired by the Holy Spirit, it is altogether fitting that the very structure of the device points with vivid symbolism toward the cross on which Jesus Christ was crucified.
This invention has been a mainstay of much of my research over the last two decades. I jokingly tell folks that I have been like one who has only a hammer for a tool, so that everything looks like a nail. I have outfitted so many mechanical oscillators with the sensor, that it is probably true that nobody else has ever conducted a greater variety of pendulum experiments.

On that note, let me point out that one should not view the pendulum as some relic. I will elsewhere give examples of its recent use to better understand the greatest challenge to success of a modern, highly funded physics experiment, the Laser Interferometer Gravitational Observatory (LIGO). Through these personal stories; I hope to convince the reader that God has by means of my invention unlocked some mysteries that defied understanding (for reason of inherent complexity) to those who lived in previous generations. The primary factor to allow these developments only to those of the present age, was the introduction of powerful, yet user-friendly personal computers. My sensors are readily integrated with such computers, as seen, for example, in the VolksMeter seismograph. Created around an SDC array, it is a state-of-the-art digital instrument that allows novel means to investigate Earth motions at very low frequencies. Another of my instruments that functions with a torsion balance rather than a pendulum is the Computerized Cavendish Balance, sold by Tel-Atomic Inc. in Jackson, MI. Because of my career decision to concentrate on teaching as well as research, the Cavendish balance is a source of great personal satisfaction. It is being used by students of physics in a sizeable number of departments around the world.

End of the 2nd installment of the planned book, 30 Dec 08

Butterfly Effect Dynamics

The butterfly effect is a now common term first used by meteorologist Edward Lorenz. It derives from his accidental discovery of the 'sensitive dependence on initial conditions' concerning the dynamics of convection in the Earth's atmosphere. He presented a paper on the subject in 1972 at a meeting in Washington, D.C. of the American Association for the Advancement of Science, titled "*Does the flap of a butterfly's wings in Brazil set off a tornado in Texas"*.

In physical systems the effect can be described using a precise (deterministic) mathematical set of equations. In the case of the rigid pendulum with drive torques large enough to 'take the bob past vertical', myriad chaotic motions are possible because of the nonlinear equation of motion. Although nonlinearity is a necessary condition for chaos to result, it is not sufficient. For example, one large amplitude, non-chaotic motion of the same pendulum is an archetype of the heartbeat. A perturbing influence of the drive can change the motion to a state analogous to a heart attack. Correction for this 'calamity' can be effected by a suitably timed-in-phase 'pulse' that restores the normal 'beat' (analogous to the discharge of the capacitor in a defibrillator)'.

Of course with social dynamics involving chaotic systems (more suitably labeled complex), one should not be surprised by the observation of butterfly effect phenomena. The best current example is the election of Barack Obama as President of the United States. Who could have imagined, just a few years ago, the incredible path that his life has taken.

Some recent examples of my own butterfly-effect experiences

(1) A potentially dangerous satellite:

I have already mentioned the Cosmos 1402 event. Had the ASAT work not been classified—and if my name had been prominently associated with the determination that the ailing Russian satellite was inactive—my life would probably have taken a different course, because of pride. Last year, about two decades later, the Lord apparently decided I was finally 'sufficiently tempered' to handle some degree of 'fame'. The Navy was set to take out a U.S. satellite that was spewing hydrazine and thus potentially dangerous as it faced re-entry, due to low altitude atmospheric drag. The Navy plan was being touted by the news media as the first occasion for the U.S. to undertake such a mission. One of my former students, Travis Konzelman, knew otherwise and contacted the president of Mercer University to mention that the university's media people might want to talk to me about the matter. My resulting interview with TV and newspaper personnel took place fewer than 24 hours before the Navy's successful mission. This close-in-time-proximity factor was no doubt responsible for my picture being 'plastered' (along with references to the previous, actually-first Air Force mission) on the front page of the Macon Telegraph.

To illustrate the sometimes 'small-world' nature of life's existence, consider the following sequence of events. My daughter Leslie Rohland works in real estate in Cartersville, GA, which is north of Atlanta, and about 130 miles from Macon. Soon after the Navy mission, Leslie was showing property to a client from Warner Robins (home of the well-known Air Force base), which is situated about 25 miles south of Macon. When the topic of the satellite-kill came up in conversations between the two ladies, Leslie was asked if she knew me. Her hearty affirmative response resulted in a copy of the newspaper article being given to my daughter.

(2) Two radically different Earthquakes

The VolksMeter (VM) seismograph that I created is a state-of –the-art instrument. It is the world's first fully-digital seismograph, and one primary component of the heart of its sensor electronics is the award winning AD7745/6 capacitance to digital converter, manufactured by Analog Devices. The commercial form of the seismograph evolved from an analog gravitational pendulum instrument that I created around 2005 to try and better understand the influence of the moon on Earth's dynamics. There is more to the matter of lunar influence than just the well-known tidal force (whether oceanic or crustal), and the first experimental efforts to consider its many complexities were undertaken by Lord Kelvin (with an understudy named George Darwin, son of the famous evolutionist).

(i) Andeman-Sumatra

While accumulating data with my novel gravitational pendulum, during a span that ultimately exceeded 18 months, the great Andeman-Sumatra event occurred. With a magnitude greater than 9, this enormously powerful earthquake generated a catastrophic tsunami that took many lives. My instrument that detected the event was designed around the world's first fully-differential capacitive transducer, the SDC sensor. It is the other primary component of the VolksMeter, and it 'marries' naturally to the AD7745. Recognizing the possibility of an inexpensive pendulum seismometer designed around the SDC electronics, Mercer University did a news release about the instrument. This news release circulated around the world, and in related stories that ensued, a German reporter labeled the instrument "Volks-seismometer". Another story that appeared in Popular Science magazine served as the catalyst for the creation of RLL Instruments that manufactures the instrument.

(ii) Lake Sinclair

A small earthquake centered on Lake Sinclair near Milledgeville, GA happened in late spring 2009. I went to the physics building on the Mercer campus Sunday morning, soon after the earthquake, to study the VM records. While there I was contacted by 13WMAZ, who requested an interview. Subsequently, portions of that interview appeared on the Sunday evening news, the late news of the same day, and also the following morning.

What really surprised me however, were comments from two widely separated TV viewers. I received a phone call from a friend in Fancy Gap, VA. Jeff Sehan indicated that he and Suzanne had seen me on TV out of Winston-Salem, NC. They facetiously noted, however, that they were initially unsure it was me, since my constant companion 'man's best friend' Rouxby (a year-old chocolate Labrador female) was not also prominently pictured.

The second surprise came from Mercer student Bo Broadwater, who is doing a dual major in engineering and physics. Bo's mother in Pell City, AL had seen me on TV and wanted to know if he knew Dr. Peters.

This small (uncommon) earthquake was probably triggered by lake-level changes, since Georgia transitioned from a previous-year drought to a very wet spring. Attention to this my stated cause for the earthquake, was probably a primary factor in the interview 'diffusing' through larger than usual geographical distances.

(3) Seminal ideas for a Med-School Clinical Study

I returned from an American Geophysical Union (AGU) San Francisco meeting with a small geophone. Such devices, which operate on the basis of Faraday's law with a coil and magnet, are well known to the petroleum prospecting world. They are also used to study some earthquakes, mostly those in the categories other than teleseisms.

Using a hardware/software package developed by the company that gifted me with this geophone (Symmetric Research), I had a hunch about an unconventional application; that this accelerometer-type device could be useful for studies of the heart. Although previous 'seismocardiography' studies with different-type accelerometers have been done, the characteristic frequencies of these previous sensors are higher than that of the geophone. As such, they are not as well suited to the measurement of some important, longer-period chest wall movements that result from the heartbeat.

A clinical study involving roughly 25 subjects resulted from this geophone idea. Conducted in the last two years, the study spun off some other possibilities. For example, by using another tool that I developed, called the 'cumulative spectral power' (CSP), it is possible to overcome various limitations of the previously-mentioned accelerometers. The CSP (frequency domain) algorithm could play a part in whether seismocardiography should ever become widely employed in medical diagnostics. A proposal concerned with the matter has been submitted to NIH.

(4) Who you know as opposed to what you know

I was part of an unsuccessful attempt at promotion from Associate Professor to Professor while at Texas Tech University. My unconventional research that was concerned with the 'mesodynamics' of mechanical systems was not well received by all my physics department colleagues. The letter that expressed my Dean's unwillingness to over-ride

objections by these colleagues includes a statement, “I hope that sometime in the future, Dr. Peters will be able to say “I told you so”.

Unfolding of the future to determine whether there is true significance to my claim that “mesoanelastic complexity” is quintessential, remains to be seen. In the meantime, through great travail my career has nevertheless experienced some gratifying triumphs that I next describe. In every case, ‘networking with a key individual’ was critical to the attainment of success.

(i) An invited “Tutorial on gravitational pendulum theory applied to seismic sensing of translation and rotation” (part of a BSSA Special Issue devoted to ‘rotational seismology’)
(ii) An invited paper, “Friction at the mesoscale”, published in Contemporary Physics.
(iii) Chapters on “mechanical oscillator damping” (both theory and experimental techniques), published in two prominent engineering handbooks,
(iv) Two articles published in the McGraw Hill Encyclopedia of Science and Technology, 10^{th} Ed.
(v) Influence on the direction of a ‘big science’ program, LIGO

In case (i), I never would have been invited to participate, were it not for USGS (deceased) seismologist, John Lahr. Many of my ideas related directly to seismology have met with considerable, unexpected resistance. Because of the passion that John and I shared for science education, I was able to meet and talk with him in ways that are disallowed to superficial interactions. John recommended me to the editor, Willie Lee, who was primarily responsible for the generation of the special issue.

In case (ii) the invited paper would never have happened had it not been for the interest shown in my research by Peter Milonni. Peter is one of the few (great) theorists who has chosen not to summarily ignore ‘dirty’ experimental science. Another great one, cut from the ‘same mold’ is Illinois Tech’s Tom Erber.

An interesting additional interchange occurred between Peter and myself. After seeing my journal article that is noted later in the context of a quote by famous astronomer Allan Sandage, Peter asked a (facetious) question for which he already knew my answer would have been ‘no’: “you didn’t have anything to do with the editor’s decision to print that quote where it is located, did you?”

In case (iii), it was the acquisition by Mercer’s Tarver Library, of various reference books by Clarence deSilva, that drew my attention to this author. Was it his two PhD’s, one from a prominent U.S. university, the other from a similarly well-known English one—that enabled him to address engineering problems in an unconventional manner that intrigued me? I contacted Clarence to tell him about some of my own work of related type. About a year or two later he gave me ‘carte blanche’ liberty to write two chapters on damping for one of his CRC engineering handbooks.

Case (iv) came about through the decision by my Mercer colleague Matt Marone, to place ‘online’ an instrument that I created. The multipurpose chaotic pendulum was configured to operate via the world wide web, and remote users could control it by means of frequency adjustment. As such, it was the first and only hardware-controllable chaotic pendulum, even though many web-sites exist where one can study ‘computer-emulated’ (numerically simulated) pendulums. Because of the Mercer online chaotic pendulum I was tasked by McGraw Hill to write an article concerned with math methods of chaos as practiced in physics. I was also asked about a previous version of their ‘anharmonic oscillator’ piece, since it mentioned the pendulum as an archetype of chaos. Unusual circumstances occasioned me to provide a new version of this article, in which I introduced the concept of ‘damping anharmonicity’, as well as providing a discussion of the well known ‘elastic’ type.

Case (v) resulted largely from my decision to engage in dialogue with amateur seismologists. Having learned through Larry Cochrane’s PSN of the outstanding work of John Lahr, I also became aware of IRIS. It was a key IRIS leader who was responsible for my participation in a conference in Tahoe City, CA that was concerned with ‘broadband seismology’. A statement at the time of this conference that I will not soon forget is one made by a world-class seismologist, who was seated at dinner across from me. Concerning my claims about seismometer damping (involving mesodynamics), he confessed that he “thought I was crazy” (after having recognized some of my claims to be true).

Also present at this conference was a LIGO scientist. I was eventually asked to review a paper written by this man and some of his colleagues. When I asked of his secretary how the editor came to select me for this task, I was told that he ‘found me’ because of my internet publications.

Butterfly features

Interactions responsible for the butterfly effect are highly dependent on their chronological order. The absence of a single component of the set of factors responsible for the path taken will generally result in a totally different path. In physics, that path is referred to as the phase space, which is a plot of momentum versus position. To most, it is remarkable how a single, seemingly insignificant piece, can be so important to the final outcome.

Some of the best minds of renaissance type could not grasp the significance of these complexities. For example, in spite of his great mathematical-physics abilities, Laplace is remembered for the following quote, now known as Laplace’s demon:

"We may regard the present state of the universe as the effect of its past and the cause of its future. An intellect which at any given moment knew all of the forces that animate nature and the mutual positions of the beings that compose it, if this intellect were vast enough to submit the data to analysis, could condense into a single formula the

movement of the greatest bodies of the universe and that of the lightest atom; for such an intellect nothing could be uncertain and the future just like the past would be present before its eyes."

— Marquis Pierre Simon de Laplace (1749-1827)

The tendency of far too many people is to believe (as exemplified by the now-recognized naivety of Laplace) that science devoid of theology 'has all the answers' to the problems faced by mankind. Another Laplace quote is:

"Your Highness, I have no need of this hypothesis."

(spoken to Napoleon on why his works on celestial mechanics make no mention of God)

Narrow-minded thinking is fostered by unwillingness to present balanced factual material. Too little attention is given by the popular media to publicizing the actual beliefs of some of the most outstanding scientists of all time.

Quotes by well known scientists

What follows are some quotes by some of the best known physicists/scientists who have ever lived.

Johannes Kepler:

(The man whose laws of planetary motion radically influenced the development of modern physics. Other than the following of his quotes, some things about him are known to most every student)

(1) "I wished to be a theologian; for a long time I was troubled, but now see how God is also praised through my work in astronomy".

(2) "I have, with the aid of God, who set my enthusiasm on fire and stirred in me an irrepressible desire, who kept my life and intelligence alert … at long last ….brought to light …" [his understanding after 25 years of intense struggles].

Michael Faraday:

(Recognized as the greatest experimental physicist of all time by many who do experiment)

(1) "And therefore, brethren, we ought to value the privilege of knowing God's truth far beyond anything we can have in this world. The more we see the perfection of God's law fulfilled in Christ, the more we ought to thank God for His unspeakable gift"

(3) "His unspeakable gift in His beloved Son is the ground of no doubtful hope; and *there* is the rest for those who like you and me are drawing near the latter end of our terms here below"

(My own awareness of Faraday's faith was enhanced significantly because of John Walkup, an electrical engineering professor colleague at Texas Tech University. John retired from TTU to work full time in Christian service at his Alma Mater, Stanford University. Related to Faraday, John apprised me of Faraday's great faith and his membership in the Sandemanian Church The first quote is from a sermon delivered by Faraday to his church's congregation.).

Paul A. M. Dirac

(1) "Art and science have their meeting point in method."
(2) "God used beautiful mathematics in creating the world."
(3) "In science one tries to tell people, in such a way as to be understood by everyone, something that no one ever knew before. But in poetry, it's the exact opposite."
(4) "The fundamental laws necessary for the mathematical treatment of a large part of physics and the whole of chemistry are thus completely known, and the difficulty lies only in the fact that application of these laws leads to equations that are too complex to be solved."

(Modern physics pioneer Niels Bohr referred to Dirac as the "purest soul in physics").

Max Planck

(1) "Anybody who has been seriously engaged is scientific work of any kind realizes that over the entrance to the gates of the temple of science are written the words: 'Ye must have faith.' It is a quality which the scientist cannot dispense with."

(2) "All matter originates and exists only by virtue of a force... We must assume behind this force the existence of a conscious and intelligent Mind. This Mind is the matrix of all matter."

(3) "Science cannot solve the ultimate mystery of nature. And that is because, in the last analysis, we ourselves are a part of the mystery that we are trying to solve."

(4) "A new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die, and a new generation grows up that is familiar with it."

Blaise Pascal

In characterizing his conversion, Pascal described a "night of fire" in which he experienced a sense of "certitude" and "peace" moving from the "god of the philosophers" to the "God of Abraham, Isaac and Jacob and Jesus Christ".

Allan Sandage

If there were a Nobel Prize for astronomy, Sandage would have been a probable recipient. In the early 1950s, he inherited from Edwin Hubble the task of determining whether expansion of the universe was real. In the succeeding forty years, Sandage "established the discipline of observational cosmology". The following attachment-gif is a copy of a Sandage quote; it appeared on the last page of the article that I wrote with Tim Pritchett for the American Journal of Physics, titled “Not so simple harmonic oscillator”, when I was a Visiting Professor of Physics at the U. S. Military Academy at West Point.

TO GLORIFY GOD

As the universe of galaxies and stars became more dead numbers, like salt from an evaporated sea of mystery, Sandage remembered and mourned the wonder with which he had viewed the universe as a kid. That sense of wonder had vanished, he complained, after two weeks at Caltech. There followed thirty years of duty, inertia, and discontent. Astronomy, once an escape from the human morass, led back into it.

About the time he received his Ph.D., he told me, he remembered having asked his father what the purpose of life was and being disturbed at no getting an answer. His father didn't know, and that seemed ominous. The question Daddy couldn't answer had come back to haunt him. One day, he says, somebody told him, ''The purpose of life is to glorify God.''

''That sounded right,'' said Sandage. Sometime around 1980, Sandage said, he converted to Christianity. He would not divulge any more details. He didn't want to be a nihilist. Life was not a dreary accident. He repeated it, ''Life is not a dreary accident.''

Dennis Overbye, *Lonely Hearts of the Cosmos* (HarperCollins, New York, 1991), p. 393.

Since the time of this quote (1991), Sandage has spoken frequently of his faith in Christ, including the following comments:
“In reading the Bible I found peace. And I hoped it would be real. Now faith is that hope of Hebrews 11:1, the definition of faith that makes great sense to me: ‘the assurance of things hoped for, the conviction of
things not seen’. So, I willed myself a second time to go the next mile”
As writer Overbye has said about his use of this process, Sandage effectively followed Pascal’s additional “remedy” for unbelief, namely to “learn from those who were once bound like you and who now wager all they have”. Sandage’s conversion was, he says, ultimately enabled by the witness of “dedicated Christians” whom he admired for other reasons. “Knowing Christians who were also scientists whom I respected came as a surprise to me. It meant that it was possible to do science and have a faith”. These people of faith and science gave him the answer to the question of purpose. “And it was so simple. The answer struck home immediately. I just had to accept it. The answer is that the purpose of life is to glorify God. Everything followed from that, he adds, including “a mode of living that is not nihilistic”.

Saved from Self

My upbringing was influenced largely by shallow, fundamentalist Baptist thinking, that revolved around sermons frequently punctuated with the rhetorical question, "are you saved?" For many, the belief 'once saved, always saved' has been a point of fervent debate against those of the equally strong, but antipodal belief . As has been facetiously noted, this obsession is basis for a 'fire insurance policy'; i.e., guaranteed heaven as opposed to alternative hell. Concerning the latter, it has been said of some sermons that parishioners could nearly 'smell the smoke'.

What frequently gets overlooked by individuals obsessed with these thoughts is how much of God's grace is a part of our daily deliverance from calamity. I personally marvel at how the living human body seems to exist always on the edge of chaos. In the theory of 'self organized criticality' (SOC), advanced by Per Bak (with Tang and Wiesenfeld) the old adage "straw that broke the camel's back" is metaphorically realized by means of a physical reality. Avalanches result from a single grain of sand falling onto a cone of the same that has reached its critical angle of repose.

Recently I hypothesized an "SOC balancing process' that I labeled 'self-organized stability'. It is my belief that living systems are constantly in a state of dynamic 'tensions' between these two processes that are common to complex systems. Unlike static equilibrium, the dynamic case involves kinetic variations, and a commonly appreciated example is that of a person walking on stilts. The legs must constantly move the position of each stilt in a 'feedback dynamic involving the senses', to avoid falling.

My heartfelt belief is that God miraculously sustains those who put their trust in Him, by choosing the path, which by His grace, allows one to recognize Jesus Christ as Lord. Simon Peter (with whom I identify on many accounts) said the following about Jesus:

Acts 4:8-12
8 Then Peter, filled with the Holy Ghost, said unto them, Ye rulers of the people, and elders of Israel,
9 If we this day be examined of the good deed done to the impotent man, by what means he is made whole;
10 Be it known unto you all, and to all the people of Israel, that by the name of Jesus Christ of Nazareth, whom ye crucified, whom God raised from the dead, even by him doth this man stand here before you whole.
11 This is the stone which was set at nought of you builders, which is become the head of the corner.
12 Neither is there salvation in any other: for there is none other name under heaven given among men, whereby we must be saved.
(KJV)

From this 'back-drop' I now share some of my personal experiences that have forged my faith in Christ as being the Son of God as He claimed to be:

John 14:6-7

6 Jesus saith unto him, I am the way, the truth, and the life: no man cometh unto the Father, but by me.
7 If ye had known me, ye should have known my Father also: and from henceforth ye know him, and have seen him.
(KJV)

My 'start'

My use of the word 'self' is all-inclusive, meaning even our DNA makeup is part of the evolution of our lives under the active oversight of the Lord Almighty. Francis S. Collins, who oversaw the national human genome project, has addressed the DNA issue in his book, *The Language of God, A Scientist Presents Evidence for Belief.* Unlike the great influence on my life by the Church from an early age, Dr. Collins "... has described his parents as 'only nominally Christian' and by graduate school he considered himself an atheist. However, dealing with dying patients led him to question his religious views, and he investigated various faiths. He became an evangelical Christian after observing the faith of his critically ill patients and reading *Mere Christianity* by C. S. Lewis." A man of mystery to many because of his unwavering faith in Jesus Christ, Collins gave the first President's Lecture Series at Mercer University on 5 April 2007.

As a baby in 1942, I contracted bronchial pneumonia. Godly woman that she was, my mother prayed to the Lord for my healing, and like Hannah the mother of Samuel—promised the Lord that if He would spare me, I would be "lent to the Lord".

1 Sam 1:26-28
26 And she said, Oh my lord, as thy soul liveth, my lord, I am the woman that stood by thee here, praying unto the LORD.
27 For this child I prayed; and the LORD hath given me my petition which I asked of him:
28 Therefore also I have lent him to the LORD; as long as he liveth he shall be lent to the LORD. And he worshipped the LORD there.
(KJV)

One thing I don't doubt is the remarkable power of motherly prayers for their children, having witnessed so many examples from the lives of mothers in addition to my own.

Though on a few rare occasions I have witnessed some 'medicine-less, mind-boggling' miracles, God apparently chose during this time of my life, as an infant—to provide healing with sulfa drugs that early in WWII had become the "first and only effective antibiotic before penicillin". It is a tribute to the 'country doctor' general practitioner who treated me (as one who still at that time made house calls)—that he was a 'current practitioner', in spite of the mountain 'backwardness' of so much of Appalachia at that time. This same doctor had also presided at my birth, about a year earlier--at the same 'home place' where he now came to provide the sulfa drug treatment.

In my early Teens

I previously mentioned the influence of great scientific minds on my schooling where I grew up in Oak Ridge, TN. Though less damaging to one's faith in God in those days as compared to its present pervasiveness, there were still features of school curricula oriented toward the dismantlement of the 'superstitions of religion'. As a 'budding physicist' I suspect the probability was significant that I might move in just the opposite life-path direction to that of Francis Collins. So about that time in my life, God chose to intervene with two uncommon events. The first event, which preceded the second one by a few years, involved my Aunt Emma. "Emmy" had lived as an 'old maid' with our family from the time of my earliest memories. She was taken down prematurely and hospitalized because of pernicious anemia. But I believed that she was doing well and on the road to recovery at the hospital the times I ventured there with my parents to visit her. On this trip to the hospital, Mom and Dad went up to her room, while I stayed in the car in a 'near-sleep' condition. Before the event next described I had never been a direct part of any spiritual experience of the type that seemed to be more prevalent in my mother's family than that of my father's. But on this occasion, I became instantly aware of Emmy's departing from this life. When Mom and Dad came to the car shortly thereafter and told me that she had died; my response to them was "yes, I already knew".

The second event involved my father, who as an electrician at the gaseous diffusion (K-25) plant in Oak Ridge, was also an itinerant preacher. I used to accompany Dad on visits to various congregations; sometimes he would deliver the sermon, other times we both were there just to visit —as on this occasion when we attended a Pentecostal Holiness church in the mountains near Norton, VA, where Dad was born.

I had become aware of a sore on Dad's leg that (at that time) bore the 'several signs' of cancer. It had been bothering him for some time and looking worse every day. Toward the end of this church service, there was a time for prayer, with oil-anointing and the 'laying on of hands' by the elders. Dad ventured forward for prayer, and little was said between the two of us about this (to us unusual) service until the next day. Incredibly, the day after prayer for him, his sore was very visibly improved; and by the 3rd day, it was as though it had never existed. As I have mentioned to various ones through the years, from the perspective of my budding physics career, this experience just 'blew all my fuses'.

In my later Teens

I became 'love-struck' with a young lady, and our relationship was viewed unfavorably by my Dad; however, he never once spoke a negative word to me about her. His lack of endorsement derived from the significantly different circumstances of spirituality involving the two of us. And Dad was a strong believer in the importance of adhering to the scripture that is recorded in II Co. 6.14—"Be ye not unequally yoked together with unbelievers".

One afternoon Dad said to me, "Son, let's go up on the mountain to pray". Once there, my situation and I were "offered up to the Lord" in a way-- that at the time I didn't have a clue as to what was going on, nor could I have anticipated the events to soon follow. Within a short time the relationship I had considered to be 'true love' was

severed through uncommon circumstances. I came to see that those circumstances developed as the direct result of our mountain-top prayer time.

Even though my 'mountain-top' experience with Dad was on a knoll near Oak Ridge, TN, the mountains of Virginia have in my old(er) age been 'calling me home'. I will later give examples concerned with the importance of "place" in my life.

In my Early Twenties

I have always been fascinated with flying, and started working on a single-engine land, private rating when I was about 20 years old. As my first cross-country flight required for a license, I decided to fly from Karns (near Knoxville, TN) to Middlesboro, KY. It has been noted that youngsters shy of about age 20 lack development of the frontal lobe of the brain that is responsible for wise decisions. I can attest to my deficiency in this regard, considering the foolishness with which I made this flight in a Cessna 140 (tail-dragger). First of all, because I had traveled in the country between the two communities, I had the false expectation that I would easily recognize landmarks along the way. Second, I didn't consult the weather to learn that there was a significant left-quartering tailwind at flight altitude, even though it was not very noticeable on the ground where I took off. Finally, I didn't start my flight after first 'topping off' the fuel tank

My flight was of the type referred to as visual flight rules by 'dead reckoning'. (After the fact, I can attest to the reality of how wrong 'reckoning' might kill you.) I flew over some checkpoint towns that, from a cursory inspection of my onboard charts, suggested I was 'right on course'. When I reached the Kentucky border I flew right through a gap in the mountains, believing I was still on course. But Middlesboro near Cumberland Gap was not the Gap that I had passed through. (Later I learned of the several gaps that exist along that range of the Appalachians.)

Now low on fuel, I knew better than to run out of gas in this rugged place, so I backtracked until I encountered a highway. My instructor pilot's facetious reference to IFR as "I follow roads" (as opposed to 'instrument flight rules') now kicked into action for me. I believe it was only the grace of God (since by logic I should have catastrophically done otherwise), I chose to turn left rather than right. Then after only about five minutes I recognized Pennington Gap, VA, which I had frequently passed through when our family went to visit my Dad's grandparents in Norton, VA.

Approaching Pennington Gap, a newly graded airstrip on top of the mountain, next to the small city, came immediately into view. I am probably one of the first to ever land on that runway, before it was paved. When I got out of the airplane and rocked it I could hear no gasoline sloshing in the wing tanks. Like some teenagers with their Dad's car, I had 'come home on the fumes'.

Graduate Student days

Largely through determination, as opposed to a highly gifted intellect, my B.S. diploma from the University of Tennessee, Knoxville is labeled 'with highest honors'. My brother Palmer used to say: "My brother graduated summa cum laude, a friend magna cum laude, another friend cum laude, and I graduated 'Laude how cum'. Actually, Palmer's achievements at NASA Marshall are a legacy known to many. Even

my Mercer physics department colleague Matt Marone, who has worked closely with Palmer in Huntsville during a summer's faculty research program, speaks of him only with words of praise.

Success in many endeavors depends a great deal on determination; one has to just 'keep on keeping on'. My temptations to do otherwise would have no doubt caused my career to take a different direction if it were not for my older-by-3 ½-years-brother (in whose footsteps I frequently followed while growing up). Were it not also for the Lord's direct intervention, I would have 'thrown in the towel' before attaining the PhD.

It was on my way home from the last course required for the PhD that I was (to use a southern term) 'low as a snake's belly'. Married with our first child and strapped financially; I was sorely displeased with this math course that I was taking in Oak Ridge, rather than on the Knoxville campus. I had moved my family back to Oak Ridge to complete my degree (the research component) at Oak Ridge National Laboratory. On this evening ride home my mind was seriously engaged in thoughts about 'dropping out of school' and taking whatever job might come available.

Whether God caused my eardrums to vibrate, or He just spoke into my spirit, I don't know. But the word that was communicated that day remains vivid to this day, more than forty years later: "quit now and you will miss the most important parts of what I intend for your life".

God's word at that low time in my life has sustained me through many other hard times ever since. Only by wisdom attained through living, does one come to appreciate how nobody is immune to life's challenging setbacks. These can be seemingly severe and many in number, even though the Apostle Paul referred to such trials as "light afflictions" (II Co. 4.17).

I tell my students that 'vocation' is a word that derives from theology; that they must have a sense of purpose (a 'calling' from God) in all parts of their education/career path. Otherwise they will at some point suffer 'burnout'. Unfortunately, I see too many of them operating under the vicarious influence of parents, or from an expectation of wealth, by becoming a medical doctor.

As a Tenured Professor at Ole Miss

I accepted an assistant professor faculty position at the University of Mississippi immediately upon graduation with my PhD in 1968. In the following nine years at Ole Miss I became involved with home-church activities that were an outgrowth of the Charismatic renewal of the late 1960's. These activities evolved into the Discipleship movement of the 1970's; and as part of that movement, in 1977 we relocated from Mississippi to Texas, settling in the Dallas-Ft Worth Metroplex, mid-cities community of Arlington.

I could easily have missed God's will, relative to the affairs of this move, by believing that my physics career to that point in time, was simply a 'spring board' into full-time Christian ministry. God carefully thwarted all my heart's desires toward becoming a full time pastor, while at the same time providing circumstances, through the jobs given to me by two different aerospace employers – to significantly broaden my physics foundation.

Beginning the present summer of 2009 I have moved into the phased part (half-time for three years) of my retirement from Mercer University. I see the upcoming changes like the 'turning of a page' in my life, causing me to pause and remember the many unexpected 'turns that it has taken'.

End of the 3rd installment of the planned book,, July 2009

'Keys' that have made a difference

Preliminary background material

Nearly everybody is experienced with the use of small metal keys that are common to our daily lives. Most frequently these keys are used to lock and unlock the doors that separate our private holdings from the rest of the world. Though they are physically small, such keys wield tremendous influence in the affairs of life. It is no wonder then, that they word 'key' has come to have a variety of symbolic meanings. In advertising the Department of Physics at Mercer University, we have appealed to potential student majors to come and be a part of our quest to "unlock the mysteries of the universe".

More than any other science, physics has been 'key' to our limited understanding of the enormous complexities of nature, whether described as being part of the cosmic scale, the micro-scale, or anything in between.

The single-most distinctive attribute of any successful physics theory is its 'simplicity'. Ernest Rutherford, who studied alpha particle scattering by thin gold films, thereby discovered that atomic nuclei are very small compared to the size of their associated electron orbitals. One of his well-known quotes says:

All of physics is either impossible or trivial. It is impossible until you understand it and then it becomes trivial.

His opinion of physics as compared to the rest of the sciences is summed up by his comment,

All science is either physics or stamp collecting.

In similar manner, Albert Einstein said of science more generally

(1) Most of the fundamental ideas of science are essentially simple, and may, as a rule, be expressed in a language comprehensible to everyone.

(2) Everything should be as simple as it is, but not simpler.

Although specific use of the word key is not readily found in quotes of the most famous scientists, the following are examples from some other individuals:

Roger Bacon (1214-1294)
Mathematics is the door and key to the sciences.

John Van Vleck (b 1899, Nobel Prize Physics 1977)
... one can still say that quantum mechanics is the key to understanding magnetism. When one enters the first room with this key there are unexpected rooms beyond, but it is always the master key that unlocks each door.

Personal Testimony

During the last four decades, starting with graduate student research activities, my most significant personal successes have in each instance involved a distinctive 'key' insight. I now provide a chronological discussion of some of these keys.

(1) Challenge, as a student, of thermal coefficient differences

My PhD research was concerned with measuring the temperature dependence of various combinations of 3rd order elastic constants of copper single crystals, using harmonic distortion of ultrasound. Longitudinal sound pulses were introduced into one end of a given sample using a quartz transducer, and the displacement amplitudes of a pulse-echo pattern were measured for two different frequencies (fundamental and 2nd harmonic) at the other end of the sample, using a capacitive detector.

When the chamber of the cryostat holding the various components of this system was lowered below room temperature, differences in thermal coefficients of expansion of the various materials came into play in a disruptive manner. Conventional bonding agents used to secure the quartz-piece to the sample inevitably failed. Additionally, even if a proper bond could somehow be maintained, variations in the gap-space-dimension of the capacitive sensor would cause serious calibration difficulties.

The key to the bonding problem turned out to be quite simple. It was reasoned that if there were some way to remove the 'stickum' from ordinary tape, it might work better than the sophisticated (viscous) Dow Corning fluids being used to that point in time. It was found that by placing a piece of 'army surplus' tape on the sample, and then pouring liquid nitrogen over it, the cellophane backing could be peeled away, leaving a surface of adhesive on which the quartz transducer could then be placed and soundly 'stuck'. This bond proved viable for the full temperature range from 300 K to 77 K. Although my dissertation did not also encompass the lower range 77 K to 4.2 K (liquid Helium), other researchers found an equally simple 'key' to increase the temperature range. By 'hitting the stuck-quartz with a hammer' to break it into several (coherent related) pieces, the resulting 'expansion joints' permitted operation all the way from 300 K to 4.2 K.

The key to the gap-space problem required more sophisticated methods. With a lathe, a slot was cut in the ground-component of the capacitive sensor. The sample thus was made to sit on a flexible base whose altitude relative to the central (active) electrode could be controlled by means of the pressure of dry-nitrogen gas introduced to this cavity. Following a given temperature change, the gap would be reset to the same (earlier, corresponding to room-temperature) value by adjusting the gas pressure. This was accomplished by measuring the picoFarad's-level value of the sensor (inactive to ultrasound at this time of reset) using a capacitance bridge.

(2) ``Hidden-line'' image construction

Previously mentioned was my creation of some simple algorithms to estimate the thermal signature of satellites for the anti-satellite program. During operation, these computer codes were required at a given time to generate a `picture' of the target as `seen' by the

miniature vehicle interceptor corresponding to this time. The conventional approach to this problem would have been to construct a `stick-diagram-image' of the target satellite. Dynamics of the intercept disallow the target image from being static, and because the image could change rapidly in character, speed of the calculation was an important factor. At this time in the early 1980's there were some fast stick-diagram calculators, but they were of the type which disregarded `hidden lines' of the pictured object. Allowance of these hidden lines would have been tantamount to assuming that the MV had `x-ray vision', with which everything both front and back of the target would be simultaneously visible from a single specified line of sight direction. Couple this artificiality with the actual emissivity of components and the thermal dynamic features of the problem, such codes would have produced greatly inaccurate estimates of the target's radiant intensity.

My unique key to solving the problem, which proved to be highly successful, was one that drew upon my knowledge of quantum phenomena in physics. Instead of working with lines to represent relevant components of the object, quantum-like component identifiers were employed. Specifics of the methodology employed will not be specified, since some parts of the process may remain classified even to the present, now more than 20 years later.

(3) Fully-differential capacitive transducers

Mentioned earlier was my invention of the LRDCT, which was the first fully differential capacitive transducer. It is capable of functioning both as a sensor and also as an actuator. My idea for it grew out of electronics experience that I had acquired as a teen-age radio amateur operator. Specifically, my invention has some features of similarity to the variable capacitor that was used to tune (for listening to a given station) the tank circuit in (old) analog radios. These variable capacitors employed interleaved, semicircular plates ganged in two independent multi-plate arrays—one gang being spatially fixed and the other gang being able to rotate around an axle corresponding to the centers of all the semicircles. The `size' of this variable capacitor is governed by how much area is `shared' by the two sets of plates, determined by the angular displacement of the rotor set relative to the stator set. The other parameter which inversely influences the capacitance is the (gap) spacing between adjacent plates, which for these devices was constrained to be constant.

The key to superior performance of fully-differential (or doubly-differential) sensors is their greater symmetry, as compared to the earlier (singly-differential) technology. Although the least sophisticated capacitive sensor with a single active element could be used in some applications, it was long ago found that a pair of active elements operating differentially (in phase opposition) provides a better signal to noise ratio. A pair of properly configured differential sensors (four active elements) improves performance even further; and it is a great surprise how many years it took for this innovation to come on the electronics scene.

Roger Bacon's quote mentioned earlier ("Mathematics is the door and key to the sciences") figured heavily into my creation of the 'Symmetric Differential Capacitive' (SDC) transducer that has become foundational to the instruments that use my 2nd patent. It was through considerations of the math of topology that I was able to 'morph' the LRDCT into its more versatile SDC form. This form is basic to the (i) Computerized

Cavendish balance sold by Tel-Atomic Inc. and the (ii) VolksMeter seismograph sold by RLL Instruments. The reader will recall my previous comments concerning the 'cross' that exists in the insulator strips of the most common embodiment of this transducer. I give glory to God for its creation, which was inspired by the Holy Spirit.

(4) Computerized Cavendish Balance

From not long after Henry Cavendish's first measurement of the universal (Newtonian) gravitational force that exists between laboratory-sized masses, students of physics have found the repetition of his famous experiment to be so difficult as to be labeled 'curse-worthy'. The experiment is concerned with estimating 'big G' (a very small force proportionality constant, as opposed to 'little' $g = 9.8\ m/s^2$, the gravitational acceleration of the Earth near its surface. Because the force being measured is so very small (billions of times weaker than the weight of the masses of the balance due to the Earth's gravity), the only way to measure it is with a long-period torsion balance (having an oscillation repeat time of at least two or three minutes). This instrument, which is also called a torsional pendulum, is designed for ideal rotational displacements that result from changes in the force of gravity due to position changes of two large masses that interact with smaller masses on the boom of the instrument. The balance cannot be constrained against ordinary simple (or conical) disruptive pendulum motions that are inevitable because of vibrations in the room that houses the instrument. For example, automobiles passing on roads outside the building are a common cause for concern in past experiments .

I found a simple means to effectively eliminate the adverse pendulous motions of the balance. It is one in which two SDC sensors are employed, situated on opposite ends of the boom of the balance. When the boom motion is ideal; i.e., only rotation about the fiber that supports the boom and its small masses, then the output signal from the two sensors is equal in magnitude but opposite in direciton. In other words, when one signal is going positive, the other is going negative by the same amount (phase opposition). On the other hand, a pendulous motion of the type that generates an undesirable signal (only one of the two possible directions of pendulum swing) —is one in which the two signals from the sensors is equal in magnitude but of the same phase. So by connecting the pair of motion detectors in electrical phase opposition, their combined response is such as to result in a 'mechanical common mode rejection'. The resulting output is dramatically more pure than what can be achieved with a single sensor. In turn, student experience with this classical experiment is greatly more enjoyable.

Origin of KEY insights

I believe that epiphanies responsible for key insights originate with God Himself. Just as Charles Townes described his recognition of "population inversion" (for masers and lasers to work) as being by 'inspiration', I believe that advances in understanding of science and technology derive from the inspiration of the Holy Spirit.

Although there is no way to document the actual possibility, I like to believe that with the Peters name I have inherited some attributes of (Godly positive) spiritual value that have been at work in my life, and which go all the way back to Simon Peter himself.

Notice from the following passage the mentioning of keys, when Jesus spoke to Peter concerning the Kingdom of Heaven.

Matt 16:15-20
15 He saith unto them, But whom say ye that I am?
16 And Simon Peter answered and said, Thou art the Christ, the Son of the living God.
17 And Jesus answered and said unto him, Blessed art thou, Simon Barjona: for flesh and blood hath not revealed it unto thee, but my Father which is in heaven.
18 And I say also unto thee, That thou art Peter, and upon this rock I will build my church; and the gates of hell shall not prevail against it.
19 And I will give unto thee the **keys** of the kingdom of heaven: and whatsoever thou shalt bind on earth shall be bound in heaven: and whatsoever thou shalt loose on earth shall be loosed in heaven.
20 Then charged he his disciples that they should tell no man that he was Jesus the Christ.

The Influence of Others

Earlier, in the quotes of Allan Sandage I noted Pascal's "remedy" for unbelief, namely to "learn from those who were once bound like you and who now wager all they have". As also noted, it was the powerful influence of some Christians who had given their all for Jesus--that was key to the conversion of Francis Collins.

Both these cases illustrate the following—it is possible for one's life (style) to become so admired that others want to pattern themselves accordingly. There are also "significant-other" types of influence. Unlike with my father, whom I diligently attempted to emulate when growing up, there are those who have made a huge difference in my life, but for different reasons. These are people who were reasonably close friends, but whom I did not know well enough for their influence to compare with that of a parent. These (in my opinion) "instruments of the almighty" provided 'power to effect change' in circumstances because of others with whom they had influence due to uncommon respect that had been earned. An example-person of this type that I have already mentioned is Peter Milonni. In due time, in continued development of this book, I hope to provide detailed discussions of the influence of others for whom I give heartfelt thanks to God for the crossing of our paths in life.

End of the 4th installment of the planned book,, Aug 2009

Publications

In the history of science in the last century, at least in the core disciplines of physics and chemistry, the concept of "publish or perish" has governed the lives of those trying to succeed in academia. This university tradition has revolved around peer-reviewed papers, submitted for publication consideration to the editors of 'bonafide' journals. Although I have had satisfactory success in publishing papers of this type, it became clear to me about 15 years ago that this 'medium' for the distribution of

significant new discoveries is severely limited and probably headed the 'way of the dinosaur'. The 'inertia' of the review process, which is afflicted with delays in publication, involving referees prone to strong prejudice against new ideas – has caused major changes to the methods with which scientific information is now being distributed. The biggest single influence in this matter is the internet.

As with so many creative advances in technology, physics once again played the primary role in the development of the internet. "Tim Berners-Lee, a scientist at CERN, invented the World Wide Web (WWW) in 1989. The Web was originally conceived and developed to meet the demand for automatic information sharing between scientists working in different universities and institutes all over the world." http://public.web.cern.ch/public/en/About/Web-en.html

When I first encountered the Google search engine, while a visiting professor at West Point (1995-1997) I didn't have to be a 'rocket scientist' to recognize the great potential of this internet tool that had recently come on the scene. The potential for Google's positive influence on the communication of scientific discoveries should no longer be in question.

When I joined Mercer University in 1998 I told one of my colleagues (Matt Marone) that, God-willing, a primary one of my objectives as chairman of the physics department of the university—would be to establish a 'web-presence' for our department. It was an objective that I presently view as intimately connected to the objective of this book, which I mentioned in the prologue; i.e., "…. to make vivid a host of unlikely events that present strong evidence for the handiwork of God."

I now provide some Google data in support of my claim that Mercer Physics has indeed attained an international web-presence. Concerned with 'key-words' applicable to my own research, this data will also give the reader considerable insight into the nature (both the breadth and the depth) of my personal endeavors. Breadth is not likely to be debated, since the variety of categories cited will be seen to be uncommonly large. Some readers will want to immediately conclude that "Peters must be a 'jack-of-all-trades' and master of none". I believe otherwise; that the Google numerical rankings of my papers also make a statement concerning the quality of what has been published. The full truth of their importance, or lack thereof, remains largely to be determined. If their significance proves commensurate with the high rankings noted, then praise-be to the Lord who must be credited for such success. It is a great personal challenge for me to describe and give God the proper Glory for His influence in my life, without appearing to be full of the very pride which He hates.

Traditionalists will reject my claim that what is being presented is a reasonable measure of scientific excellence, Their position stands in stark contrast with the views of some of the very editors responsible for maintaining their biased view (remember my former comment concerning LIGO; i.e., "..., I was told that he (the editor of the journal) 'found me' because of my internet publications.")

Internet Visibility

In addition to its properties that were just described, as justification for the figure's inclusion in this book; the following gif also shows something else. It is akin to what I have observed through the years, concerning various colleagues, when I met them in their office/library. The totality of the reference books these scientists accumulated through the years 'told a story' about their passions. Their collection speaks to 'who they are' scientifically. It's not unlike what I've heard said: "show me your checkbook and I will show you where your heart is". The manner in which we expend ourselves financial-wise and time-wise shows up eventually in what we will have collected.

Google "footprint"
Aug 2009

General Physics papers

soul matters	74,	52,300,000	phonon maser	1 & 2,	428,000
old foundations new technologies	1,	33,000,000	fully differential capacitive	1 & 2,	368,000
computer acquisition and processing	12,	11,400,000	constant force oscillator	4,	353,000
atmospheric pressure correlation	2,	6,540,000	elastic anharmonicity	13,	337,000
nonlinear damping	1,	6,090,000	hurricane seismicity	1,	302,000
hurricane earth hum	2,	4,600,000	mesoscale friction	2 & 3,	290,000
resonance generation harmonic	10,	3,400,000	Cavendish balance	7 - 9,	329,000
earthquake evolution	1,	2,460,000	friction quantization	1 & 3,	316,000
anomaly approximation	1 & 2,	2,420,000	bistability	19,	247,000
damping theory	31 & 37,	2,280,000	harmonic oscillator resonance	19,	245,000
oscillator dissipation	23,	2,260,000	precursor warnings	1 - 3,	174,000
graphical transform	12,	2,050,000	acceleration spectral density	29,	172,000
mechanical oscillator	19,	2,010,000	capacitance microphones ultrasonic	4,	166,000
damping complexity	1 & 4,	1,890,000	mechanical cardiography	1,	138,000
copper nonlinearity parameters	15,	1,600,000	seismometer physics	3,	101,000
oscillator damping	3,	1,850,000	seismometer noise	5,	90,200
spreadsheet filtering	4,	1,540,000	microphone hydrophone	3,	87,000
not so simple oscillator	1,	1,420,000	seismometer performance	1 - 4,	86,900
capacitive servo device	1,	1,520,000	fft pedagogy	1,	76,200
experimental computational physics	1,	1,220,000	whirling catheter	1 - 3,	68,500
mouse sensor	20,	1,140,000	earthwaves	6,	67,600
earth seismic power	17,	995,000	microseisms	54,	59,000
electric power assisted steering	12,	994,000	tiltmeter	21,	58,700
variable gap detector	3,	891,000	earth eigenmodes	1,	55,500
capacitive sensor	40,	864,000	langmuir recoil	1,	40,700
fourier transform speed	9,	864,000	new tool seismology	4,	32,800
creep damping	2,	732,000	seismometer noise power	6,	23,000
linear capacitance transducer	4 & 5,	704,000	compound seismometer	1,	19,800
pressure sensor calibration	6,	682,000	mesodynamics	1,	11,500
remote respiratory monitor	1 - 3,	668,000	seismograph power spectral density	2,	10,300
digital seismograph	5,	535,000	full bridge extensometer	5,	13,500
coulomb damping	3,	494,000	seismometer capacitance	2,	10,300
			seismocardiography	2,	5,630
			volksmeter	1 - 6,	1,300

Pendulum papers

compound pendulum	29,	3,060,000	
pendulum art	35,	2,730,000	
online pendulum	3,	2,470,000	
pendulum theory	18,	1,940,000	
pendulum studies	17,	1,470,000	
optically driven pendulum	1,	1,260,000	
pendulum resonance response	3,	1,220,000	
pendulum period optimization	1,	962,000	
pendulum tide studies	3,	897,000	
folded pendulum measurements	1,	752,000	
pendulum adjustable trends	1 & 2,	713,000	
multipurpose pendulum	8 & 9,	649,000	
servo pendulum	26,	632,000	
rod pendulum	5,	631,000	
support constrained pendulum	1,	598,000	
torsion gravity pendulum	3,	295,000	
leaky pendulum	1 - 4,	425,000	
non classical pendulum	1,	408,000	
kater pendulum	3,	405,000	
hurricane monitoring pendulum	1,	374,000	
cavendish pendulum	8,	348,000	
soup can pendulum	3 - 5,	295,000	
torsion gravity pendulum	3,	291,000	
physical pendulum	98,	251,000	(B. H, Suits, MTU)
long period pendulum	6 & (3),	249,000	
flex pendulum	1 - 4,	167,000	
chaotic pendulum	7,	145,000	
seismograph pendulum	19,	122,000	
automated kater pendulum	1 - 6,	95,300	
pendulum period phasor	3,	69,500	(R. Newburgh)
precision kater pendulum	1 & 2,	42,200	
pendulum seismometer	4,	35,600	
pendulum period estimate	2,	23,600	
pendulum optimization theory	1,	16,300	
pan balance pendulum	1,	13,900	
tiltmeter pendulum	1,	8,190	

The numbers recorded in this figure were generated by the Google search engine around the end of August 2009. The first integer of the pair of numbers associated with a given 'key-word-group' corresponds to where the group (involving a paper that I published) was 'placed numerically', relative to the total number of relevant internet sites (second integer) discovered by the search engine. As a specific example, consider the case of *compound pendulum* (first item in the category **pendulum papers**).
These two words (without being enclosed by apostrophes (quote marks) that would force a 'literal search' for *compound* and *pendulum* in the order listed) were typed into Google. What Google returned was a total number of 3,060,000 sites having relevance in some context to the word group *compound pendulum*. What Google found, pertaining to a paper that I published (ranked 29 out of the total three million), was the article titled *Compound pendulum to monitor hurricanes and tropical storms*, online at http://arxiv.org/html/physics/0610092

Note that arxiv is an internet-based medium for the publication of scientific papers. It stands in stark contrast with conventional (journal) modes of article publication. Functioning without the afflictions of type mentioned above, it has gained considerable respect in the world of physics, and is no doubt a source of irritation to traditionalists. Though it must have experienced a lot of opposition immediately following its inception, arxiv is now officially recognized by the American Physical Society http://aps.arxiv.org/

Dynamic nature of Google

The nature of the constantly evolving internet is such that the numbers provided in the preceding figure, (corresponding to late August 2009) differ from what was seen in early April 2009. A comparison of numbers for some exemplary key word cases,

corresponding to the two dates indicated, are shown in the next figure.

	2 April 2009		24 Aug 2009	
organized stability	1,	13,900,000	1,	8,720,000
Reynolds number	5,	9,600,000	68,	3,960,000
earth hum	2,	4,000,000	83,	4,490,000
stirling engine	**4,**	**2,100,000**	**173,**	**487,000**
earth oscillations	1,	1,270,000	5,	1,270,000
compound bow	3,	769,000	23,	730,000
differential capacitive	1,	744,000	13,	2,230,000
internal friction	1,	682,000	3,	1,290,000
harmonic oscillator potential	1,	648,000	4,	1,920,000
universal damping	1,	378,000	2,	411,000
linear damping	**1,**	**350,000**	**2,**	**2,400,000**
chaotic oscillator	**1,**	**330,000**	**3,**	**1,580,000**
hysteretic damping	1,	267,000	5,	729,000
digital seismometer	1,	178,000	1,	127,000
21st century pendulum	1,	167,000	1,	162,000
pendulum damping	**1,**	**164,000**	**4,**	**890,000**
cumulative spectral power	1,	141,000	1,	59,000
Compton energy scale	1,	110,000	1,	717,000
yo yo oscillator	1,	55,000	1,	56,000
damping anharmonicity	1,	43,000	3,	108,000

The cases for which anomalously large changes were noted have been high-lighted using bold font.

Google 'methods'

I have no direct knowledge of how Google arrives at the numbers displayed in the preceding figures. Why then, for example, the total number of sites concerned with the *stirling engine* would undergo a four-fold-size reduction is a mystery to me. I do have some thoughts concerning the Google-prominence of my personal publications, which I now share.

What is least important, in my opinion

In the early days of 'googling', some 'shysters' tried to peddle gimmicks which they claimed would improve the search-engine 'standing' of a given web-site. For example, the 'meta-tags' being then highly touted proved in time to be of little practical significance.

I used to think that 'popularity' of a given site was the single-most important factor in its "numerical-placement" by Google. A lot of people must believe in this concept, since 'hit-counters' remain prominently displayed on many web-pages.

Presumably then, as the number of visits to a page increases, that page will 'percolate' upwards, toward the top of the total list of sites recognized by Google.

What is most important, in my opinion

Concerning internet 'visibility' as gauged by Google, what I've come to believe as the single-most important factor is 'plurality involving connectivity'. Stated simply, the larger the number of sites containing mutually related key words (especially in titles and abstracts), the higher is the probability that those key words will be encountered by the Google 'spider' as it 'goes about doing its job'. The higher the probability of key-word encounters by its spider, the closer to the top of the Google list will be the sites that specifically utilize those keywords.

Believing in this postulate, I began years ago to post many of my articles on the web. Some papers were placed on my personal (Mercer Physics) webpage and other papers were placed on arxiv. For that matter, some papers have been posted to both places; and moreover, they include a subset of hardcopy (refereed) journal publications.

So has my postulate proven true? I submit to the reader that the numbers of the above two figures speak for themselves on the matter. In time and in some cases, I found a posted paper appeared almost immediately as the first item of the first page of millions of sites recognized by Google. I was so surprised by this happening that I had actually even wondered if one of the founders of Google had noted my work (for reason of related physics passion) and 'flagged' my work for special recognition. Considering this to be in reality a vanishingly small probability, I have reached the conclusion that *plurality involving connectivity* is the key to internet visibility. Surprisingly from my perspective, I have experienced great difficulty in trying to 'sale my approach' to others.

Benefits of Web-Visibility

There are a host of benefits to be realized from the web-publication of scientific results, assuming those results are readily discoverable. Some individuals object to this claim, and cite for their reason the proliferation by 'crackpots' of worthless postings, that have no scientific merit whatsoever. It is true that the internet is a place where one can find foolishness as well as truth. Attempts to 'weed out' the former and leave only the latter, by allowing only peer-reviewed journals for the publication of scientific discoveries, is (as I noted earlier) a short-sighted view of our evolving technological world.

That my approach has proven valuable can be judged by means of the very tool with which the approach was refined; i.e., the Google search engine. I now provide some exemplary evidence for its success.

The engineering world

Mechanical oscillator damping is a very important physics discipline that has been mostly ignored by theoretical physicists. Through two-decades of intense study, I have developed a meaningful but unconventional theory of damping. One of the best indicators of its significance is the manner in which this theory has come to be viewed by engineers. After all, engineers are concerned with what works, and they want something simple enough to be understood (remember Einstein's quote concerning simplicity). That

my theory has gained engineering acceptance can be verified by going to the following site

http://www.mechanicalengineeringnetbase.com/ejournals/books/book_summary/toc.asp?id=6434

Forefront physics

I mentioned earlier how a former dean stated in a letter of (promotion) refusal the 'hope that Peters might eventually be able to say I told you so" (concerning the importance of my work involved with mesodynamics). Recently I received an email from a theorist (individual influenced by J. Kondo) that contained the following paragraph:

"Your experimental investigation has been very deep, bringing out a new discovery in the intrinsic friction quantization. It may lead even to a path quantum …. Feynman's work has been very mysterious indeed as he took over to the path on which great brains like Hamilton-Jacobi worked but for the quantum of a path, a start and an end corresponding to an instant which has remained undefined so far…. we may surely be discovering a secret of nature so far hidden due to topological abstractions and some prejudices as seen in the history of physics."

Only time will tell if this talented (non-crackpot) person's thoughts concerning the importance of my fundamental research have any chance of being correct. One thing is for certain, however, validation would never have come to a place of consideration without my having posted papers on the internet. Those postings include some postulates that were summarily rejected when I attempted about 15 years ago to publish a paper in Physical Review Letters. It was my mentioning this failure to Art Schawlow that allowed me to learn of the fiasco (mentioned earlier) involving Ted Maiman's ruby laser. Prof. Schawlow told me "consider it a compliment that my paper had been rejected by them", and then told me the Maiman story.

End of the 5th installment of the planned book,, Sep 2009

Academic Arrogance

One of my colleagues tells the story of how his mother admonished him, as he left home to attend college, "don't come home an educated fool". This professor took to heart his mother's warning; too many others in higher education either didn't have a wise person to influence them, or they chose to ignore that wisdom. It is remarkable how a PhD can master skills required for the `terminal degree', while at the same time `be clueless' when it comes to matters of `common sense'. Their naivety is clear when they open their mouth. They fail to heed the following wisdom of Solomon:

Prov 17:27-28

27 He that hath knowledge spareth his words: and a man of understanding is of an excellent spirit.

28 Even a fool, when he holdeth his peace, is counted wise: and he that shutteth his

lips is esteemed a man of understanding.
(KJV)

In recent months I have grown to appreciate a marvelous hybrid. Concerning this animal which was Harry Truman's favorite, he said, "the mule has more horse-sense than a horse; it knows when to stop eating and it knows when to stop working". (quote from John Hauer's book, ``The natural superiority of the mule", Lyons Press 2006. ISBN: 1592288642)
In my experience, too few faculty members have possessed the positive attributes of the mule. Being more like the negative attributes of a horse, they will `work themselves to death' on counterproductive causes, with a devotion that defies logic. Of course the mule is not perfect; a Texas politician recently described his opinion of a 2nd stimulus package that was being considered by Congress with the comment, "there is no education in the 2nd kick of a mule".

Although baccalaureate (and higher) degrees are a prerequisite for success in many endeavors, a degree is not of itself sufficient (is not a guarantee) for success. Those of us engaged in the study of deterministic chaos recognize something of similar scientific type. Although nonlinearity is a necessary condition, it is not of itself a sufficient condition for chaos. Unfortunately, too many teachers have missed the critical point of sufficiency. They view their highly specialized PhD as an achievement which qualifies them to teach anything they should fancy-to-consider. And since they usually rise from the ranks of faculty of which they were once a part (often in accord with the Peter-principle), this malady is not one from which college deans and other administrators have acquired immunity. Scripture from the book of Proverbs is applicable to their situation:

Prov 26:12
12 Seest thou a man wise in his own conceit? there is more hope of a fool than of him.
(KJV)

Could it be true, that like obesity in the United States, academic arrogance is now epidemic?
It is hard to know just how many academicians actually worship the various `gods (idols)' of their profession. My experience suggests that their number may already be a majority, with their fraction of the total being one of steady increase

Mythical Assumptions that are `Busted'

. Because physics is the cornerstone of all the sciences, it is especially easy for some to believe that physics must always be altogether trustworthy. From my own career I will now describe an example of how wrong this belief can be. In turn, the following comment is worthy of note in passing—if physics has been (even recently) wrong on some fundamental issues, should the conclusions of an `inconvenient truth' concerning our planet's climate be viewed as sacrosanct?

Viscous damping of the harmonic oscillator – a myth from physics

The simple harmonic oscillator (SHO) is central to the study of most oscillator types. Its beauty derives from the simplicity of its linear differential equation, a math-

expression we call the equation of motion. For many real systems, even some whose elastic properties are obviously nonlinear, the SHO provides a starting place with which one can begin to build a model that is reasonably adequate (within recognized limitations) for describing system behavior.

In the absence of an external drive, an oscillator eventually ceases to vibrate; so the basic SHO equation of motion, that involves only the elastic force, must be modified to include a damping term. The simplest possible additive term is one called viscous damping. It is the product of a damping coefficient and the velocity--of the mass, if it is connected to a spring that approximately obeys Hooke's Law. The resulting equation of motion is still wonderfully simple, as compared to the nonlinear damping that describes virtually every real system. It should be noted, however, that there is no spring of importance to engineers that actually obeys Hooke's law.

Some have gone to extreme lengths to try and prove the universality of viscous damping. They want so badly for their assumption to be true, that they teach it that way to their students. They are so blinded by their wish for penultimate simplicity, that their textbooks give the impression that viscous damping is sacrosanct. Their practice is not helped by the fact that mathematicians are delighted to work with only with a linear differential equation. And so the SHO with damping has become one of the most famous problems encountered by students of mathematics as well as students of physics.

I would have far less complaint with the writers of textbooks dealing with the subject, if they were to expand their description of the SHO. In other words, they should provide a caveat that says something about the suitability, or lack thereof, of their equations, relative to applied physics and engineering. Unfortunately, the vast majority of book authors are oblivious to this need. So some students eventually become teachers themselves, and the folly persists through yet another generation. Such has been the case since the 1920's. If the physics community had at that time paid attention to the work of two of their own, we would not have persisted in this foolishness. For some oscillators, internal friction is not only important, but even the dominant source of damping. A classic experiment by Kimball and Lovell, showing that internal friction has a universal form, was apparently `lost in the dust of the thundering herd of those concerned with quantum mechanics'.

A. L. Kimball and D. E. Lovell, ``Internal friction in solids", Phys. Rev. 30, 948–959 (1927).

Some will question the validity of these claims (refusing to trust a paper that is eight decades old), since they are entrenched in the myth of viscous damping. It is indeed hard to change multi-generational, erroneous thinking.

I am encouraged by the fact that my two-decade study of the subject has finally received some recognition that was long time coming. `Nonlinear damping' typed as keywords into the Google search engine (without the `tick marks' on 16 Dec09), found my paper titled ``Nonlinear damping of the linear pendulum", published online at

http://arxiv.org/ftp/physics/papers/0306/0306081.pdf

listed at the top of the first page of 3.73 million sites. For the skeptic who would reply 'so what', consider the fact that significant parts of this paper also appear in `reputable' (peer reviewed) journal publications, as well as in two engineering reference books.

Power Spectral Density—the mythical form of seismology

The importance of the frequency domain was realized by physicists long ago. The output from an instrument such as a seismograph is a time trace. From an inspection of this trace by itself, interpretation of many subtleties of a complex signal is nearly impossible. Insights are obtained by extracting from this trace its spectral information. Just one common example involves the means for proving the identity of the person responsible for a given audio recording (such as the propaganda distributed by Osama bin Laden)..

The frequency domain information is obtained by calculating the Fourier transform of progressive segments of the time data. From these, one is able to better understand the mechanisms in operation during the generation of the signal. In the case of noise studies, concerned with determining the sensitivity of a given instrument, the frequency domain is indispensible.

Identification of the frequency dependence of power is the key to true understanding of many processes. Without the transfer of energy over time, from one system to another, there is no way any process is able to work—not even the instruments used to do the study. Thus power expenditure is quintessential. The function in common use to specify power in the frequency domain is referred to as the power spectral density (PSD). The convention with which it is commonly specified, originated in the world of electrical engineering. It is based on the power dissipated as heat in a one-ohm resistive load supplied by an electrical signal whose level is specified in volts. The instantaneous power in watts, at a given time, is given by the voltage squared, since the resistor has a one-ohm value. If the size of the resistor should be a different value, R, then the power is V-squared divided by R. One takes the Fourier transform of the time varying voltage, using the fast algorithm developed by Cooley and Tukey, and then uses this FFT to specify the PSD. It involves the square of the modulus (absolute value squared) of the FFT, and if the frequency is specified in linear- as opposed to log-form, the proper units of the PSD are W/Hz/mho, where mho is the unit of conductance (reciprocal resistance). Typically `mho' is not included in the specification; thus for absolute power considerations, it is imperative to recognize that the PSD of common use is really (and should be called) `specific' PSD. In the case of seismic signals, instead of the 'mho' of the electrical case, it is 'kg' that is implicitly present in the PSD. Thus the units are W/Hz/kg, which equals $m^2 / s^3 / Hz$.

The so-called 'PSD' used in the seismology world has units of $m^2 / s^4 / Hz$. Sometimes it is called the acceleration spectral density (ASD); since acceleration has units of m / s^2. It is obtained from the square of the modulus of the FFT of the acceleration-time-trace. It is impossible for an unmodified ASD to represent actual power, since its units are inconsistent with power. Specifically, the ASD units are

W/Hz/kg/s. In other words it is a description of frequency dependent power per unit time, not power! Some seismologists have replaced Hz of the ASD with reciprocal second to yield W/kg, believing that the expression must therefore be an acceptable power density. This cannot be justified, since the result is no longer a density function. Every density of physics involves a `per' something, and in the case of spectral densities, the ` per' is either Hz for the linear-case, or octave (or decade, or fraction thereof) for the log-case. My physics students are taught that if the units are wrong, then their solution to the problem is wrong! Dimensional analysis is one of the most powerful tools available to science and engineering. It continues to be routinely used by most everybody, but obviously not by seismologists when it comes to their ASD.

Is there a practical consequence to `mindless calculations` of this kind? The answer is unequivocally yes; if one wants to estimate the actual vibratory power of the earth. It is possible from the true (specific) PSD to estimate the total seismic vibratory power of the Earth, within the frequency range accessible to seismographs, by a simple use of the mass of the earth. This is a meaningful, unused number that will never be seriously considered by seismologists as long as they continue to believe the ASD to be a `power' spectral density. There is important information concerning the Earth `hiding in plain sight' before them.

The spectrum of background seismic noise is usually plotted versus log-frequency, because of the wide range of frequencies involved. What gets graphed from the ASD is (within a multiplicative constant) literally a plot of W/kg/octave; and yet seismologists label it $m^2 / s^4 / Hz$. A density plot of type per octave is not the same as type per Hz; and yet most users choose to ignore this fact. Physics students are rebuked for transforming a density function (such as the famous one by Planck that describes blackbody radiation), if they fail to recognize the influence of that transformation on the differential of the independent variable of the function. For example, Planck's law is not the same when specified in terms of frequency as opposed to wavelength. The transformation from frequency (or period) to log-frequency (or log-period) causes a `compression' of FFT components that is proportional to frequency. In other words, the differential of frequency is not the same as the differential of log-frequency. Compression that results from the transformation is the essence of the difference between the ASD and the specific (actual) PSD). I don't believe that seismologists are incapable of understanding this; they have just chosen to simply ignore the matter. In turn, as an example of consequence, they have no means to actually understand the frequency dependence (color) of ambient seismic noise. I have recently shown for the first time, that in the low frequency limit, ambient seismic noise is pink (1/f). It is a form that is ubiquitous to the universe, and it would be strange indeed, if the Earth were radically different, in a spectral sense, from so many other systems of nature.

End of the 6th installment of the planned book, 18 December 2009