STUDIES IN THE SPIRITUALITY OF JESUITS

Physics Research, a Search for God

TIMOTHY E. TOOHIG, S.J.

31/2 · MARCH 1999

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Of all things . . .

Did you know that 4,561 Jesuits and 73,759 non-Jesuits were educating more than 1,500,000 students (1,583,555, to be precise) around the world? Or that as part of that total there are in the United States 234,575 students and 1,233 Jesuit and 28,721 non-Jesuit personnel in our schools? Lest the mind reel if I add even more numbers, I shall simply note that if you want to find out more, much more, about Jesuit education around the world, write to the Curia in Rome for the recent issue of *Education SJ* (1998, no. 2), put out by the International Center for Jesuit Education.

"Jesuits and Jews" is a title that surely attracts attention, as well it might. The first international congress of Jesuits working in the field of Jewish-Christian relations was held just three months ago in Krakow, Poland. It included thirty-nine Jesuits from nine different assistancies. Discussion focused on four main areas: (1) biblical themes of relevance for Jewish-Christian relations today; (2) historical questions of Christian attitudes towards Jews and the experience of the Holocaust in Jewish-Christian relations after the war; (3) the encounter with modern Jewish thought; and (4) interreligious concerns in the state of Israel. The congress met near Oswiecim, the site of the infamous death camps of Auschwitz and Birkenau. More information? For this too contact the Curia in Rome and the organizer of the congress, Fr. Thomas Michel, S.J.

Just a year ago I commented on my own participation in a meeting at Georgetown on "Human Rights versus Prejudice, Intolerance, and Demonization." One of its topics was the demonization of the Jews. I was invited to present a conference on the demonization of the Jesuits. It was soberly instructive to reflect how often the same basic shibboleths, canards, and lies were used in the quite separate demonizations of both Jesuits and Jews. For a refresher on St. Ignatius and the Jews, see the essay with that same title that STUDIES published in September 1981 (vol. 13, no. 4). James Reites, S.J., of Santa Clara University, its author, was one of the participants in the recent meeting in Krakow.

In the last issue of STUDIES, I asked whether "present-day Jesuits still read books with any frequency" and made some remarks about the circumstances surrounding Fr. Jacques Dupuis's new book, *A Christian Theology of Religious Pluralism.* I then suggested that our readers might have something to say in "Letters to the Editor" on the subject. The result was several thoughtful letters, published in this present issue of STUDIES.

Here I shall take note of only one new book, *When in Doubt, Sing: Prayer in Daily Life* (New York: Harper Collins, 1999; xxiv +422 pp.; $24.00). This marvelous work from the pen of Jane Redmont deserves and, I hope, will receive long reviews; but in these few opening pages of STUDIES, I can offer only brief observations. For once, the publicity release that usually accompanies a book is right on the mark. The book is "a practical, insightful and highly readable guide." It is "anchored in the belief that our whole self prays—heart and mind, body and soul, spirit and flesh." Each chapter begins with a lovely and apposite epigraph and ends with several pages of suggested prayers, brief sample readings, and meditations drawn not only from the Roman Catholicism but from a great variety of other religious traditions. Ms. Redmont asks you "to forget what you've learned if it no longer works for you, but to remember the traditions and practices that nourish and sustain you." Much of the book arose from her own experience of prayer in the midst of a variegated life as at times theologian, Catholic lay minister, social activist, writer, chaplain at a university Catholic Center, executive director of a region of the National Conference of Christians and Jews, and a dialogue partner with Jews, Christians, and Muslims. The author writes against the background of a woman born of Jewish parents who became Unitarian and raised their daughter in that faith; she became a Catholic as a young adult. Much of this background is reflected in her book. The titles of some of the twenty-seven chapters give evidence of the author's down-to-earth practicality: "Beginning Where You Are, Not Where You Ought to Be"; "Praying with Anger"; "Pronouns, Poets, and the Desire for God: Language and Prayer"; "Writing as Meditation and Prayer"; and "When In Doubt, Sing: Music as Prayer." This is a book that delights, surprises, instructs, and helps the reader to a fresh and personal life of prayer.

The Seminar on Jesuit Spirituality and the Institute of Jesuit Sources are separate entities, but both draw on the staff of the IJS. So it is good news that the Institute will soon have two new full-time Jesuit staff members and associate editors. They are Carl Starkloff, presently a professor of theology at Regis in Toronto, and Frank Brennan, former professor of English, graduate dean, academic vice-president, and, most recently, pastor of a parish. They will both be of immense help in the publication projects of the Institute, which include the publication of a translation of three of Robert de Nobili's works from Latin and Tamil into English, another of the Aldama commentaries on the *Constitutions of the Society of Jesus,* and what we hope will be a two-volume set—one containing some six hundred letters of Ignatius of Loyola and the other his major published works: the *Spiritual Exercises,* the *Constitutions,* the *Autobiography,* and the *Spiritual Diary.* I am both delighted at these new additions to the staff and remain thankful to John McCarthy, Martin O'Keefe, and Nicholas Pope (now in Rome) for all they have done on what has been a skeleton staff for better than a year.

You may have noticed a change in the title that precedes these notes. It is no longer "For your information. . . ." For some time I have been looking for a name more descriptive of these ruminations. Thanks to Jean Schlueter, one of our readers, who suggested the phrase "Of all things . . ." (which was enthusiastically seconded by members of the staff here), I now have a title that is both descriptive and maybe, in certain cases when our readers see the comments that follow it, exclamatory.

John W. Padberg, S.J.
Editor

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PHYSICS RESEARCH, A SEARCH FOR GOD

A Euphoric Experience

The basic thesis I would like to explore here is that the pursuit of physics is, at root, a spiritual endeavor. Viewed from the Christian tradition, physics research is, as I would assert, an intuitive search for God in the sense that Karl Rahner writes about an anonymous knowledge of God.[1] This assertion is based on my experience of over thirty years as a high-energy physicist involved in research in physics while pursuing a parallel career in spirituality within the Jesuit tradition. My research has been nourished by interaction with my colleagues in physics, as well as by an abiding interest in the history of physics.

When I was a graduate student at the Johns Hopkins University, my doctoral dissertation involved the discovery of a new fundamental particle of matter, the η meson.[2] In those prequark days, we thought it to be an elementary particle, one of the ultimate building blocks of matter. The euphoria I sensed in that moment of discovery was like what one experiences in moments of consolation in a retreat. In a sense, what follows is an application of Ignatian discernment of spirits to that moment and to similar moments in my experience and in the reported experiences of others engaged in the same search. On the occasion of Max Planck's sixtieth birthday, Albert Einstein testified that such experiences are an essential part of physics research:

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[1] Karl Rahner, *Foundations of Christian Faith* (New York: Crossroad, 1993), 21.

[2] **Meson:** A subnuclear particle constituted by a quark (see below) and an antiquark (for example, π = "up" quark [υ] + anti-down quark [dbar]. π = udbar).

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> The longing to behold . . . pre-established harmony is the source of the inexhaustible persistence and patience with which we see Planck devoting himself to the most general problems of our science without letting himself be deflected by goals which are more profitable and easier to achieve. I have often heard that colleagues would like to attribute this attitude to exceptional will power and discipline; I believe entirely wrongly so. The emotional state that enables such achievements is similar to that of the religious person or the person in love; the daily pursuit does not originate from a design or program but from a direct need.[3]

In my experience, the physicists recognized as leaders of the field are characterized by a driving curiosity, approaching the obsessive, for a deeper understanding of the mystery of our universe. Correlative to this search for an understanding of the universe is a sense of excitement and of wonder, of consolation in moments of insight. Victor Weisskopf of MIT captures this experience in the titles of several of his books: *Knowledge and Wonder, The Privilege of Being a Physicist,* and *The Joy of Insight,* his autobiography. In these I hear an echo of St. Ignatius's account of his experience at Manresa: "Once, the manner in which God had created the world was presented to his understanding with great spiritual joy."[4]

Probably not coincidentally, leading physicists such as Weisskopf are also known for a dedication to human rights, to peaceful relations among peoples, and, particularly during the Cold War, to nuclear disarmament.[5] The examples that come to mind are of the human-rights activism of Andrei Sakharov in the Soviet Union, the formation of the Federation of American Scientists by the Los Alamos physicists in the aftermath of Hiroshima and Nagasaki, and the participation by many leading physicists in the Pugwash Conferences at Pugwash, Nova Scotia, which provided a forum for East-West dialogue during the Cold War period.

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[3] Abraham Pais, *"Subtle Is the Lord": The Science and Life of Albert Einstein* (Oxford and New York: Oxford University Press, 1982), 26.

[4] Ignatius of Loyola, St., *A Pilgrim's Testament: The Memoirs of Saint Ignatius of Loyola As Transcribed by Luis Gonçalvez da Camâra,* trans. Parmananda R. Divarkar (Saint Louis: Institute of Jesuit Sources, 1995), 40.

[5] Abraham Pais, *Niels Bohr's Times: In Physics, Philosophy, and Polity* (Oxford: Clarendon Press, 1991), 517.

My Credentials

Since 1947, when I entered Boston College, both our understanding of the basic constitution of matter and the conceptual framework in which we view the material universe have changed completely. We began that period with protons, neutrons, electrons (and their antimatter counterparts, positrons), plus a few odd particles found in the cosmic rays.[6] These constituted our knowledge of the building blocks of nature. The conceptual framework for research in elementary-particle physics was a microscopic probing for the ultimate constituents of matter and analysis of the forces that bound them together. The universe was probably "Steady State," eternally unchanging.

Today we know that most of what we thought were elementary particles are composite structures constituted from three families of pointlike particles, each family consisting of two quarks and two leptons.[7] We have a comprehensive theory, the Standard Model that accounts for their interactions and explains how they combine to form the whole zoo of subnuclear particles, of nuclei, and of atoms and molecules.[8] Since 1965, elementary-particle physics has turned its gaze outward to become a theory of the entire universe, where these families of elementary particles can be related by a

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[6] **Proton:** A positively charged subnuclear particle constituted by three quarks, two "up" and one "down" (uud). It is the lightest of the baryons.

Neutron: A neutral (uncharged) baryon which, together with the proton, constitutes the nucleus of a chemical element. The neutron is constituted by one "up" and two "down" quarks (udd).

[7] **Quark:** A pointlike, fractionally charged subnuclear particle that is the source of the strong (nuclear) force. There are three pairs of quarks: up - down, charmed - strange, bottom - top. Together with three pairs of leptons—electron - electron neutrino, muon - muon neutrino, tau - tau neutrino—they constitute all matter in the universe. All ordinary matter is composed of up and down quarks, electrons, and electron neutrinos. The other two pairs of quarks and leptons are only found in very-high-energy collisions or in the initial "Big Bang" at the beginning of the universe. Quarks are never found free in nature. They are always bound together to form hadrons—either baryons (quarks) or mesons (quark and antiquark).

Lepton: A pointlike, integrally charged subnuclear particle that is the source of the electroweak (electromagnetic plus weak) force. There are three pairs of leptons (see quark, above).

[8] **Standard Model:** A model for the elementary particles and their interactions that unifies the strong, weak, and electromagnetic forces, but not gravity. According to the Standard Model, the fundamental constituents of matter consist of three families of quarks and leptons. The quarks and leptons interact through the electroweak (electricity plus magnetism and radioactivity) force, while the quarks alone feel the strong (nuclear) force.

comprehensive theory to the origin and evolution of the universe in the "Big Bang."

At Johns Hopkins in the late fifties and early sixties, at Berkeley in the early and middle sixties, at the Brookhaven National Laboratory in the late sixties, at Fermilab in the seventies and early eighties, and at the Superconducting Supercollider (SSC) from the mid eighties through the early nineties, I was privileged to be a participant and involved spectator in that remarkable development.[9] Berkeley, Brookhaven, Fermilab, and the SSC (if it had been completed) had the highest-energy-particle accelerators in the periods noted and so were successively the frontier facilities for high-energy physics.[10]

In the same time frame, society, and with it the Church, was undergoing fundamental changes in orientation and understanding. In the Church this change was manifested, among other ways, in a new openness to Scripture and a renewal in liturgical understanding and practice. These developments, in turn, led to a renewed appreciation and understanding of prayer and spirituality and to concomitant developments in theology. The Society of Jesus responded to these developments with, among other activities, a renewal of the theory and practice of the Spiritual Exercises of St. Ignatius of Loyola, who was the founder of the Society.[11]

After completing my degree in physics at Hopkins in 1962, I resumed my preparation for the priesthood and began the requisite four years of studies in theology at Woodstock College near Baltimore, Maryland. The proximity of Woodstock to Baltimore allowed me to continue to involve myself in physics at Johns Hopkins during my years of theological training. Some twenty-two of the students of theology at Woodstock held advanced degrees in mathematics and the natural sciences. In order to remain scientifically alive, we formed a research institute at Woodstock (RINS) with support from the National Aeronautics and Space Administration (NASA) and the National Science Foundation (NSF). Such continued involvement in the

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[9] SSC **(Superconducting SuperCollider):** A particle accelerator (synchrotron), fifty-four miles in circumference, that was under construction around Waxahachie, Texas, until funding was canceled in 1994. The accelerator was designed with a beam energy of 20 TeV (trillion electron volts) to investigate the region of collision energy where theory indicates that a new fundamental understanding of the universe will be revealed.

[10] **Particle accelerator:** A device for accelerating elementary particles, usually protons or electrons, to high energies for experimentation or for medical or industrial applications. The most familiar of these are cyclotrons and linear accelerators.

[11] George E. Ganss, S.J., *The Spiritual Exercises of Saint Ignatius* (St. Louis: The Institute of Jesuit Sources, 1992).

area of physics in the context of theological studies encouraged us to ponder the spiritual dimension of that science.

Woodstock at that time, the period of the Second Vatican Council, had a remarkable faculty, some of whom were at the forefront of developments in the Church and the Society. Many of them, men such as John Courtney Murray and Gustave Weigel, were participants in the council as *periti* or observers. Others, such as Walter Burghardt and Joseph Fitzmyer, were leaders in the renewal of theology, homiletics, and Scripture. William Peters, one of the primary movers in the recovery of the Spiritual Exercises, directed a retreat incorporating his new insights.[12] Among our professors as well was David Stanley, one of the pioneers in recovering the use of Scripture with the Spiritual Exercises.[13]

During a pastoral year after completing theological studies, emboldened by youth and fresh from the experience of the full, thirty-day Spiritual Exercises, I began to give directed retreats based on the renewed understanding of the Exercises. From this beginning and throughout my whole career, thanks to the Sisters of Charity of Halifax and the Religious of the Cenacle, I was able to remain involved in spiritual direction and retreat work while pursuing my career as a physicist. In 1993 Congress canceled the SSC project. By the spring of 1994 I had completed my obligations to the project and severed my connection. Through the generosity of the Jesuit Institute at Boston College, I was provided with the time and opportunity to reflect more deeply on the connection between these two pursuits of mine, physics research and spirituality.

I seek to understand from within my commitment as a Christian how the pursuit of physics relates to that commitment.

Physics in Another Dimension

I would like to present this topic in two stages. First, I would like to explore the development of physics: How does it proceed, and what are the motivations and rewards of those who devote their time to it? What

[12] William A. M. Peters, *The Spiritual Exercises of St. Ignatius: Exposition and Interpretation* (Jersey City: The Program to Adapt the Spiritual Exercises, 1968).

[13] David M. Stanley, *A Modern Scriptural Approach to the Spiritual Exercises* (St. Louis: The Institute of Jesuit Sources, 1971).

have physicists done and why do they do it? In the second stage, I would like to relate the results of the first stage to spirituality as understood by a committed Christian today. In a sense, this is an intramural study; I do not pretend to stand outside my commitment as a believing Christian, but rather to seek to understand from within that commitment how the pursuit of physics relates to my Christian commitment. In another sense, this is extramural in that I am, at the same time, giving an account of my commitment to physics even to those who may not share my Christian commitment.

A question might be raised. "Why physics?" In other words, as regards its connection with spirituality, is physics different from mathematics, from other sciences, or from the arts? If physics is a spiritual pursuit, as I believe and will attempt to elucidate, then why are not all of these fields of endeavor spiritual pursuits? My first answer is "I don't know." My experience is of physics. That being said, I believe that there is something different about physics, at least at its boundaries. The boundaries of physics today would be exemplified by high-energy physics, the area of physics that seeks to understand the ultimate structure of matter, its elementary constituents, and the forces that bind them.[14] The particle physicist confronted with the most fundamental questions concerning matter probably has a higher probability of facing the ultimate questions of existence. This impression that physics is different from other fields is reinforced by developments in the aftermath of the widespread acceptance, after 1965, of the "Big Bang" theory of the origin of the universe. Subsequent to that development, we came to realize that research in high-energy physics is tantamount to exploring the states of matter in the very earliest moments of the evolution of the universe. Experiments with the large-particle accelerators that are the primary tools of the high-energy physicist amount to reconstruction of states of matter close to the time of the Big Bang. This realization tended to fuse high-energy physics with cosmology. Along with cosmology, it seeks to understand the origins and ultimate fate of the universe itself. In a way that other fields do not, it searches for ultimate understanding. In the words of

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[14] For example, "We particle physicists share with all physicists the goal of explaining the world. We differ only by asking ever more basic questions. Like young children who relentlessly insist, Why?, particle physicists ask, Why is there light? Why are electrons light and protons heavy? Why are there electrons or protons, anyway?" (R. N. Cahn, in *Physics Today* 51, no. 11 [November 1998]: 57).

Stephen Hawking, "[O]ur goal is a complete understanding of the events around us, and of our own existence."[15]

The Enlightenment Muddies the Waters

An unfortunate legacy of the Enlightenment, now seemingly embedded in our Western culture, is the belief that the process of discovery in physics proceeds in a purely rationalistic manner. In this view, physics supposedly proceeds by deduction from first principles or by logical induction from experimental data. The roots of this belief may be found in the works of René Descartes (1596-1650) and Sir Isaac Newton (1642–1727). Their view of physics was colored for both men, in contrary ways, by theological considerations, by a search for certitude, by a desire to validate the existence of God in the face of a perceived atheism.[16] Descartes used a Universal Mathematics to validate the existence of the material world by deduction from the intuited existence of God.[17] Newton began with the real world and, using a Universal Mechanics, sought to validate the existence of God by logical induction. For both, certitude about the existence of God was linked with certitude about the existence of the real world. Paradoxically, their great scientific contributions were not made by logical inference from the science of their day, but by changing the very approach to science, by creative insights that fundamentally modified the science. For Descartes, an example of a creative insight would be the concept of a *conservation law,* on which much of modern physics is built;[18] for Newton, an example would be the concept of a *force,* without which there would be no modern physics.

High-energy physics, along with cosmology, seeks to understand the origins and ultimate fate of the universe itself.

Mathematics provided Descartes with a method by which certitude could be attained. Since, for Descartes, all science must be certain and since

[15] Stephen W. Hawking, *A Brief History of Time: From the Big Bang to Dark Holes* (Toronto and New York: Bantam Books, 1988), 169.

[16] Michael J. Buckley, *At the Origins of Modern Atheism* (New Haven and London: Yale University Press, 1987), chaps. 1 and 2.

[17] Stephen Gaukroger, *Descartes: An Intellectual Biography* (Oxford: Clarendon Press, 1995), 244.

[18] **Conservation law:** A statement that a given quantity remains invariant independently of the details of an event: for example, by the law of conservation of energy, the total energy, including the mass-energy ($E=mc^2$), of the products of the decay of a radioactive nucleus must add up to the energy of the original nucleus.

the only science that measured up to this stringent requirement is mathematics, then it was critically necessary to abstract and universalize the mathematical method. It was necessary to create a Universal Mathematics by which to investigate whatever a human being can come to know. The Universal Mathematics would be concerned with objects that are simple and can be grasped by intuition. It would then move from these simplicities into their implications by a carefully linked series of deductions. This is the "Cartesian method."

Richard Feynman is closer to the reality of how physics proceeds when he says, "[T]o solve any problem that has never been solved before, you have to leave the door to the unknown ajar. You have to permit the possibility that you do not have it exactly right."[19] Uncertainty, according to Feynman, is to be welcomed as the possibility of a new potential for human beings. The history of physics bears out Feynman's thesis. It is precisely in these areas of uncertainty that the breakthroughs in physics take place. The enormous effort and expense involved in designing, building, and exploiting a succession of ever-more-powerful particle accelerators is justified by the need to explore these areas of uncertainty if we are to understand our universe. *Pace* Descartes and Newton, we do not and cannot proceed just by deduction or induction from what we already know.

As an illustration, I recall working at Berkeley in the mid sixties on what was then called "The 200 BeV Project," which ultimately led to the creation of the Fermi National Accelerator Laboratory (Fermilab). (Later convention has changed BeV to GeV, for billion electron volts.) The planned energy of the machine was based on the perceived need to go beyond the energy of the existing most powerful particle accelerators, which were operating at 25 to 30 GeV, in order to make progress in understanding the structure of matter. Following a rule of thumb that a factor of ten above the available energies would be required to find new physics, the energy for the new facility was to be in the 200 to 300 GeV range. This dependence on faith in a rule of thumb was not a comfortable stance for physicists, so a working group of leading theoretical physicists was convened to give us a more substantive reason for building the machine. After careful consideration, these experts gave it as their opinion that the machine was not necessary, since it would only verify their theories; they were already comfortable with their conclusions and with the deductions and inferences they had reached by using data from the existing machines. However, there

[19] Richard P. Feynman, *The Meaning of It All: Thoughts of a Citizen Scientist* (Reading, Mass.: Addison-Wesley, 1998), 27.

were too many unresolved questions that lay beyond the capabilities of present facilities for us to accept this conclusion. So we put aside their advice and went ahead to build Fermilab, which now operates at 1 TeV (trillion electron volts). The theories that then prevailed have long since been discarded, and a far richer, far simpler understanding of the universe has emerged.

A New Worldview and New Worlds of Physics

We can conveniently divide the progress of physics between an early period, roughly the sixteenth to the eighteenth centuries, when theological concerns dominated discussions, and a modern period, beginning with the late nineteenth century, when physics was largely unencumbered by theological considerations. The early period roughly coincided with the great period of geographical exploration and expansion, as well as of religious upheavals in the West and missionary expansion in the newly opened areas of the world. The modern period roughly begins with the discovery of X-rays and the aftermath of the debates on Darwinian evolution.

The Beginnings of Modern Physics

We might select Galileo Galilei (1564-1642) as an appropriate starting point in our examination of the progress of physics and the relationship between that progress and spirituality. In Galileo's lifetime, and largely due to his work, a new era in science was initiated. Prior to Galileo, the general principles that guided physics were philosophical: in the prevailing Aristotelian approach, nature was viewed from the top down. From the viewpoint of philosophy, humankind was the center of the universe, so it followed that the demesne of humankind, the earth, must be the center of the physical universe. In the *Dialogue concerning the Two Major Systems of the World,* Galileo took exception to the second of these statements by asserting that earth is not the center of the physical universe;[20] rather, the earth moves in an orbit around the sun. In asserting this he was denying, by implication, that humankind is the center of the universe. Paradoxically, the work in which he subverted the very basis of the prevailing pre-Copernican physics, his *Discourses and Mathematical Proofs concerning Two New Sciences,* created no stir.[21] Galileo's inspiration in the *Two New Sciences* was twofold. He

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[20] Galileo Galilei, *Dialogue concerning the Two Chief World Systems* (Berkeley and Los Angeles: University of California Press, 1970).

[21] Galileo Galilei, *Discourses and Mathematical Proofs concerning Two New Sciences,* trans. Henry Crew and Alfonso de Salvio, intro. Antonio Favaro (New York:

based his physics on observing how things behave under controlled conditions, and then expressed that behavior by a mathematical description that was susceptible to being tested against those observations. This seminal work was published when he was in his seventies, held under a form of house arrest. His successful description of projectile motion, including the accelerated motion due to gravity, clinched the case for his new approach over against the prevailing Aristotelian physics, which could only regard accelerated motion as a conundrum.

The prevailing Aristotelian approach to physics depended upon observation. Aristotle filled notebooks with observations of nature. What differs in Galileo's approach is the role of the observer. For Galileo, the observer was an active participant; he performed his observations under controlled conditions that allowed him to isolate the essential principles of the phenomenon under study. True to his Aristotelian roots, Galileo relied on observations; his contribution was a radical change in the conceptual approach to dealing with those observations. Through a leap of intuition, Galileo was able to arrive at a simplification that gave greater insight into the phenomenon involved and allowed it to be analyzed and reduced to a mathematical expression. How did he arrive at such a radical shift in concept? We don't know. What drove him to pursue these studies, as well as the studies of planetary motion? It would appear that he was driven by a burning curiosity, a consuming desire to decipher the mystery of the universe.

Descartes built on the work of Galileo to effect a further simplification in the understanding of the motion of bodies. In the *Two Sciences*, Galileo dealt with the *motion* of individual objects, of projectiles. Descartes introduced a new concept, the notion of the *quantity of motion*, what we know as momentum, as the fundamental concept for analyzing the interactions of mechanical objects. Utilizing this concept, Descartes introduced the notion of a *conservation law*, in this case the conservation of momentum. Applied to a complicated situation in which things are constantly changing, a conservation law is an assertion that some simple quantity remains the same. Today conservation laws are at the heart of our understanding of physics.

The Croatian Jesuit Roger Boscovich produced the first coherent description of an atomic theory.

Descartes had no way to predict the transfer of motion from one body to another. Newton rectified this lack by treating the transfer as a

Dover Publications, c. 1914).

continuous flow from one body to the other. He did this by formalizing a concept of *force.* Using this concept, he was then able to describe the transfer of momentum between bodies as a continuous flow and so was able to predict this transfer mathematically. Newton's contribution is embodied in the First, Second, and Third Laws of Motion, found in the *Philosophiæ naturalis principia mathematica,* commonly known as the *Principia.*[22] Once a force law is known, every detail of the motion can be predicted in Newtonian mechanics; everything can be calculated from first principles. The motions of the planets could not only be described but also predicted and their masses determined from the force laws. The laws that Newton formulated led to a connection, for the first time, of extraterrestrial and terrestrial bodies; the moon obeyed the same gravity that caused the apple to fall. The cosmos was no longer something mysterious, but obeyed the same laws as earthly bodies. The universe is just a great deterministic, mechanical system. For Newton this great system led inexorably back to the author of the system, to God.

Newton's mechanics did not account for *how* the force of gravity could reach out from one body to another. This was the missing element of the classical theory. There was no underlying mechanism to explain the action at a distance that seemed to be required. The solution to this came not from mechanics but from electricity and magnetism. The Croatian Jesuit Roger Boscovich (1711-87) had postulated, by extrapolation from Newton's concept of force, that forces are the basic physical realities.[23] He held, presciently, that bodies could not be composed of continuous matter, but of countless "pointlike" structures. The ultimate elements of matter are indivisible points, which are centers of force, a force that varies with the distance to other points. This is the first coherent description of an atomic theory.

The cosmos was no longer something mysterious, but obeyed the same laws as earthly bodies.

Michael Faraday (1791-1867), taking up this notion, postulated that forces act by filling the space around objects with what he called a *field,* which he visualized as *lines of force.* There is no longer a need for action at a distance; bodies act on one another through the force fields surrounding

[22] Sir Isaac Newton, *Philosophiæ principia mathematica,* 2 vols. (Berkeley, Los Angeles, London: University of California Press, 1962).

[23] Joseph MacDonnell, S.J., *Jesuit Geometers: A Study of Fifty-Six Prominent Jesuit Geometers . . .* (St. Louis: Institute of Jesuit Sources, 1989).

them. He went on to demonstrate that a changing electrical field generates a magnetic field and vice versa, so the two might sensibly be considered as different forms of a single field, the electromagnetic field. James Clerk Maxwell (1831-79), following Faraday, developed the equations of the electromagnetic field which bear his name, Maxwell's equations. In his *Treatise on Electricity and Magnetism* (1873), he demonstrated that electricity, magnetism, and light are different manifestations of the same phenomena.[24] He further demonstrated from the conservation laws for energy and momentum that *the electromagnetic field is real* and not a mathematical convenience. Fields possess energy and momentum and can exist independently of their sources. These developments brought to a close the development of classical physics and opened the way for a new worldview.

Einstein's preface to the 1931 edition of Newton's *Opticks* gives us an insight into the motivation of the architects of this new worldview and probably reveals as much about Einstein's motivation in physics as about Newton's.

> Fortunate Newton, happy childhood of science! . . . the conceptions which he used to reduce the material of experience to order seemed to flow spontaneously from experience itself, from the beautiful experiments which he ranged in order like playthings and describes with an affectionate wealth of detail. . . . his joy in creation and his minute precision are evident in every word and in every figure.[25]

Descartes and Newton, while laying the foundations for physics, had entangled their physics with theology. The theologians had abandoned the question of the existence of God, relegating it to the philosophers. The emerging physics took on the task of philosophy. Descartes had begun with ideas and established God as the guarantor of nature. Newton had begun with the phenomena of nature and established God as a force by which the phenomena were structured so that they could interact. By an inexorable process of rationalistic deduction (Descartes) or induction (Newton), physics served as natural theology. In the process of trying to establish the existence of God through physics, they distorted physics by eliminating the role of intuition and discovery from the understanding of physics. Ironically, the basis of both approaches was intuition. By the end of the eighteenth century, the Enlightenment had turned these arguments on their heads and eliminated the God question from physics.

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[24] James Clerk Maxwell, *A Treatise on Electricity and Magnetism*, 2 vols. (New York: Dover Publications, 1954).

[25] Sir Isaac Newton, *Opticks* (New York: Dover Publications, 1979).

> The idea that theology and physics are two distinct branches of knowledge thus took, from its first germination in Copernicus till its final promulgation by Lagrange, almost two centuries to attain clearness in the minds of investigators. Whether the lead belongs to Laplace or to Lagrange, there was no doubt that the physical scientists had grown weary of theological conflict and physicotheology. After the work of Diderot and d'Holbach, the theological explanation had become a hypothesis and not a very useful one at that. It was better to discard the issues that gave it birth; better for physics, in concern for its own integrity, to cut it loose.[26]

The Modern Period

Towards the end of the nineteenth century, nagging problems had emerged with respect to the neat, deterministic world picture provided by classical Newtonian physics—the problem of relative motion and simultaneity, of the blackbody radiation spectrum, of the photoelectric effect, of the atomic structure of matter.[27] Physics was now free to investigate these problems without the encumbrance of theology. Newtonian mechanics gave way to relativistic mechanics, the wave theory of light gave way to wave-particle duality, quantum theory was born, and the determinism of classical physics gave way to Heisenberg's uncertainty principle. A new era was born. Rather than pursue all of these developments in detail, I would like to examine the accomplishments and motivations of two of the chief protagonists in these developments: Albert Einstein (1879-1955) and Niels Bohr (1885-1962).

Descartes and Newton, while laying the foundations for physics, had entangled their physics with theology.

Why Do Physicists . . . ?

Einstein and Bohr are interesting in our context for their apparently contrasting positions towards spiritual reality, towards religion, towards God. Einstein was a Jew who was very conscious of and "owned" his

[26] Buckley, *At the Origins,* 326.

[27] **Blackbody radiation:** The spectrum of radiation emitted by a perfectly black body when heated. This spectrum is a function of the temperature of the black body, being dominantly red at lower temperatures, like a glowing coal, and becoming dominantly blue at higher temperatures.

Jewishness and was positive in regard to religion. Abraham Pais, an intimate of Einstein, in a prefatory passage to his biography of Einstein, quotes the physicist as saying that "[s]cience without religion is lame, religion without science is blind."[28] Pais goes on to note Einstein's personal creed: "A religious person is devout in the sense that he has no doubt of the significance of those super-personal objects and goals which neither require nor are capable of rational foundation" (319). He writes further that Einstein's

> was not a life of prayer and worship. Yet he lived by a deep faith—a faith not capable of rational foundation—that there are laws of Nature to be discovered. His lifelong pursuit was to discover them. His realism and his optimism are illuminated by his remark: "Subtle is the Lord, but malicious He is not." When asked by a colleague what he meant by that, he replied: "Nature hides her secret because of her essential loftiness, but not by means of ruse."[29]

Bohr, on the other hand, professed himself completely indifferent to religion. Before his marriage he formally resigned his membership in the Lutheran church, the state church of Denmark. Pais, also the biographer of Bohr, has given us the recollections of Margrethe Bohr, Niels's wife, about Bohr's responses to religion during his youth:

> There was a period of about a year . . . [he was] 14 or 15 or something like that . . . where he took it very seriously; he got taken by it. Then it suddenly went *[sic]* all over. It was nothing for him. Then he went to his father, who had left him quite alone in this regard, and said to him, "I cannot understand how I could be so taken by all this; it means nothing whatsoever to me." And then his father didn't say anything; he just smiled. And then Niels says, "[A]nd this smile has taught me so much which I never forgot." So they never exerted any influence but let him do what he liked. . . . And since then it had no interest for him.[30]

Albert Einstein writes that invention is not the product of logical thought, even though the final product is tied to a logical structure.

We are fascinated by this contrast in orientation towards spiritual reality in two brilliant individuals who are absorbed in the same search for the ultimate understanding of reality. Pais,

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[28] Pais, *"Subtle Is the Lord,"* 319.

[29] Ibid, prefatory citation.

[30] Pais, *Niels Bohr's Times,* 134.

describing an episode with Bohr long after Einstein's death, describes the remarkable synergism between the two:

> Bohr would relive the struggles that it took before the content of quantum mechanics was understood and accepted. . . . This, I am convinced, was Bohr's inexhaustible source of identity. Einstein appeared forever as his leading spiritual partner—even after the latter's death he would argue with him as if Einstein were still alive.[31]

What is the motivation, the common vision that harnesses them? Clearly it is not religion, or lack of religion.

- *Einstein*

Einstein burst onto the physics scene in 1905 with three major theoretical contributions—on the quantum nature of light, on special relativity, and on Brownian motion.[32] Each of these major breakthroughs had antecedents in the work of other investigators—the quantum nature of light in the work of Planck on blackbody radiation, the relative motion of inertial systems in that of Lorenz and Michelson, and the Brownian motion in the work of Stokes and others on Avogadro's number.[33] In Einstein's hands the Brownian motion gave direct evidence of the reality of molecules, of the atomic structure of matter. In each case Einstein brought new fundamental conceptual insights to the problem. Pais notes, relative to the publication on Brownian motion, that

> [i]t bristles with new ideas: particles in suspension behave like molecules in solution; there is a relation between diffusion and viscosity; the mean square displacement of the particles can be related to the diffusion coefficient. The final conclusion, that Avogadro's number can essentially be determined from observations with an ordinary microscope, never fails to cause a moment of astonishment even if one has read the paper before and therefore knows the punch line.[34]

What was it that Einstein was seeking? What drove him to a life of such singular dedication and productivity? We get some insight from his own testimony as witnessed in his own writings and in Pais's biography. In his late sixties he singled out one particular experience from the earliest period of his life and described how it set him on his course:

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[31] Ibid., 8.

[32] **Brownian motion:** The random motion of particles suspended in a solution.

[33] **Avogadro's number:** The number of molecules in a gram-mole of a substance.

[34] Pais, *"Subtle Is the Lord,"* 56.

> 'I experienced a miracle . . . as a child of four or five when my father showed me a compass.' It excited him so much that he 'trembled and grew cold.' He thought that there had to be something behind objects that lay deeply hidden. . . . 'The development of [our] world of thought is in a certain sense a flight away from the miraculous.' (37)

A later insight appears in his address to Planck, cited above, on the occasion of Planck's sixtieth birthday: "The emotional state that enables such achievements is similar to that of the religious person or the person in love; the daily pursuit does not originate from a design or program but from a direct need" (26).

In his final autobiographical note, Einstein discusses how he arrived at the fundamental insight into special relativity, one of the truly seminal insights of physics and one that has also had profound philosophical consequences. He was driven to the special theory mostly by aesthetic arguments, that is, arguments of simplicity. Sometime between October 1895 and the early fall of 1896, the question came to him: "If one runs after a light wave with [a velocity equal to the] light velocity, then one would encounter a time-independent wave field. However, something like that does not seem to exist!" (131). Einstein says that this was the first juvenile thought experiment that has to do with the special theory of relativity. He adds: *"Invention is not the product of logical thought, even though the final product is tied to a logical structure"* (131, emphasis added).

Elsewhere he was more explicit in asserting, *pace* Newton, the creative nature of the scientific process.

> We now know that science cannot grow out of empiricism alone, that in the constructions of science *we need to use free invention which only a posteriori can be confronted with experience as to its usefulness.* This fact could elude earlier generations, to whom theoretical creation seemed to grow inductively out of empiricism without the creative influence of a free construction of concepts. The more primitive the status of science is, the more readily can the scientist live under the illusion that he is a pure empiricist. In the nineteenth century, many still believed that Newton's fundamental rule "Hypotheses non fingo" should underlie all healthy natural science.[35]

Continuing in the same vein, his vision of the enterprise reveals itself.

> Newton, forgive me. . . . The concepts which you created are guiding our thinking in physics even today, although we now know that they will have

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[35] Ibid., 14, emphasis added.

> to be replaced by others farther removed from the sphere of immediate experience, if we aim at a profounder understanding of relationships. (14)

He expresses the deep consolation he experiences from this search for universal principles. "It is a wonderful feeling to recognize the unifying features of a complex of phenomena which present themselves as quite unconnected in the direct experience of the senses" (57).

Einstein's description of his experience of discovery in physics is strikingly like that of St. Ignatius describing his vision of creation by the river Cardoner and his response to that vision.

> While he was seated there, the eyes of his understanding began to be opened; not that he saw any vision, but he understood and learned many things, both spiritual matters and matters of faith and of scholarship and this with so great an enlightenment that everything seemed new to him.
>
> The details that he understood then, though there were many, cannot be stated, but only that he experienced a great clarity in his understanding.[36]

So, what do we have? We have Einstein driven by a desire to see ever more deeply into the mystery of the structure of the universe, proceeding by reflection and intuition to unveil the universal principles underlying phenomena, seeking simplicity beneath the complexity, and experiencing deep excitement and joy when those principles revealed themselves. And we have Ignatius seeking to "find God in all things." Ignatius speaks of "consolation" as a guiding experience in his search; Einstein speaks of "deep excitement and joy" in his search. Ignatius's vision at the Cardoner was decisive in his life and led him on a service of the Church and mankind that was to last until the end of his days. Einstein's life exhibits a like lifelong service to science with a notable dedication to mankind, a deep commitment to society, to peace and justice.[37]

- *Bohr*

Bohr's interest in physics was sparked by his father, Christian Bohr, also a scientist. Christian Bohr's description of the role of science in his life is probably a good description also for Niels, who was so strongly influenced by his father.

> When I speak of that period of my earliest childhood which I can clearly recollect myself, then like the whole of my later life it was characterized to the highest degree by one single gift, if I may call it such, which goes back

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[36] *Pilgrim's Testament,* 42f.

[37] Albert Einstein, *Out of My Later Years* (New York: Wings Books, 1993).

> as far as I can remember, and which was never out of my mind for a single week, I dare say hardly a single day . . . the love of natural science. . . . it still dominates my life.[38]

It was Bohr who conceived the familiar picture of the atom as a nucleus surrounded by whirling electrons. Pais summarizes Bohr's achievements in 1913.

> The very existence of line (and band) spectra suggests, he noted, that electrons move in discrete stationary orbits inside atoms and molecules. Spectra (including X-ray spectra) arise because of quantum jumps between these states. (It would take until the 1980s before such individual jumps were directly observed.) The quantitative confirmation of these ideas by his treatment of hydrogen and ionized helium mark *[sic]* a turning point in the physics of the twentieth century and the high point in Bohr's creative career. The insistence on the role of the outermost ring of electrons as the seat of most chemical properties of the elements, in particular their valences, constitutes the first step toward quantum chemistry. . . . he may be considered the father of the atom. (152)

Bohr would go on to play a significant role in nuclear physics, including the liquid-drop model, which provided the basis for understanding fission. The sharp distinction between atomic/molecular and nuclear physics begins with his realization that the β-rays, very-high-energy electrons observed in radioactive decay, must emanate from the nucleus, and are not due to the electrons orbiting the nucleus whose transitions give rise to the visible spectrum.

From my own life I would describe what the physicist experiences, what motivates and characterizes this search, as an experience of deep interior joy along with a sense of freedom and responsibility for that freedom. There is an experience of openness to limitless possibility, of transcendence.

When we look at Bohr's method of doing physics, we see that it is very different from Einstein's. Bohr's method was qualitative, imaginative, done on a public stage, as it were, in the famous institute at Copenhagen that he founded and ran. However, they are alike in their intuitive approach to physical problems. Probably the outstanding example of this leap of intuition in Bohr's case is his model of the atom, which set the stage for the quantum theory.

Rutherford had demonstrated that the atom consisted of a positively charged nucleus, where essentially all of the mass of the atom was concen-

[38] Pais, *Niels Bohr's Times,* 98.

trated, surrounded by a cloud of negatively charged electrons balancing the charge of the nucleus. According to classical physics, electrons moving in a circle would lose energy by radiating electromagnetic energy. As they lost energy, they should rapidly spiral in, drawn by the positive charge of the nucleus. Within a fraction of a second, they should be absorbed by the nucleus; the atom as revealed by Rutherford's experiments should not exist. Pais characterizes Bohr's solution to this conundrum of the stability of electron orbits in the hydrogen atom: "Bohr circumvented this disaster, by introducing one of the most audacious postulates ever seen in physics. He simply assumed that the electron does not spiral in, thereby contravening all knowledge about radiation up till then!"[39]

Another insight into Bohr's approach is supplied by Heisenberg, reporting on a breakthrough lecture series by Bohr:

> Each one of his carefully formulated sentences revealed a long chain of underlying thoughts, of philosophical reflections, hinted at but never fully expressed. I found this approach highly exciting; what he said seemed both new and not quite new at the same time. We could clearly sense that he had reached his results not so much by calculations and demonstrations as by intuition and inspiration and that he found it difficult to justify his findings before Göttingen's famous school of mathematics. (205)

Krarners recalled about these lectures: "[T]he truth was that Bohr, with divine vision, had created and deepened a synthesis between spectroscopic and chemical results" (205).

Like Einstein, Bohr exhibits a lifelong service of science with notable dedication to mankind. He was the driving force at the center of efforts to internationalize control of nuclear energy in order to eliminate the nuclear-arms race.

Physics Unchained

In the modern period, the pursuit of physics is freed from the theology (and atheology) that had burdened it from Newton and Descartes through Diderot and d'Holbach. Pursued for its own sake, it experiences itself as a legitimate, free-standing human endeavor. In the testimonies by and about Bohr and Einstein, we have insight into what drives that endeavor. Bohr and Einstein are alike in being absorbed in the search for a deeper understanding of the very basic structures of the universe. Both proceed with a deep faith in the existence of an underlying simplicity in the

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[39] Ibid., 147 (emphasis added).

structure of matter. They are engaged with the physics community but are able to perceive the truly crucial questions and to move intuitively beyond conventional solutions to fundamentally new ways to approach solutions. They do this with a profound and serene confidence in their perceived visions. Both exhibit an orientation to an original, intuitive experience that is always present, that precedes and is more basic than any notion that they might arrive at by reflection or by persuasion.

From my own life I would describe what the physicist experiences, what motivates and characterizes this search, as an experience of deep interior joy along with a sense of freedom and responsibility for that freedom. There is an experience of openness to limitless possibility, of transcendence.

How can we understand this phenomenon of deep faith in an original, intuitive experience? Can this intuitive drive be related to other pursuits that involve a person's whole being? Can it point to an underlying spirituality? I have found it instructive in this regard to reflect on my experience in light of the theology of Karl Rahner, one of the outstanding theologians of our century. Rahner's theology is particularly attractive for a physicist in that Rahner, like the physicist, begins with data, the data of experience, and is careful not to reach beyond what can be justified by those data. His is an incarnational theology, a theology that treats of the world as real, as the locus of God's activity in our regard.

In his *Foundations of Christian Faith,* Rahner examines the structure of knowledge and arrives at the relationship of the human person to God (20). The physicist in frontier research examines the physical world and arrives at knowledge of its ultimate structure. Are these two searches related? I believe they are. The notion of transcendence, which provides a starting point for Rahner's investigation, may also be the implicit motivation of the physicists' search.

The Physicists' Deeper Quest

What can we extract from the testimonials and experience of the physicists? How do physicists experience the process of discovery that is physics research? What does the historical progress of the field reveal? What do we learn from the testimonials of and about Einstein and Bohr and other outstanding practitioners of physics recounted above? There is an awareness of the limited nature of every tentative answer. Feynman expresses it thus: "[Y]ou have to leave the door to the unknown ajar."[40] Einstein speaks of

[40] Feynman, *Meaning of It,* 27.

"something behind objects that lay deeply hidden."[41] Bohr struggled with what lay at the root of quantum mechanics. Einstein to his last breath pursued a unified theory of all the forces of nature, a synthesis that always remained just out of reach. Today the high-energy-physics community continues the struggle to construct a model of reality beyond the Standard Model, one that will include gravity and proceed from first principles without the Standard Model's need for experimentally determined constants.

Arguably, this experience in physics of an awareness of an understanding of reality that is always beyond our current understanding corresponds to what Karl Rahner calls "transcendental experience." "Transcendental experience is the experience of transcendence, in which experience the structure of the subject and therefore also the ultimate structure of every conceivable object of knowledge are present together and in identity."[42] But what relevance would there be in equating the experience of physicists, and indeed of the field of physics, with "transcendental experience"? From an analysis of "transcendental experience," Rahner concludes, "[T]here is present in this transcendental experience an unthematic and anonymous knowledge of God" (21). So the identification of the experience of the physicists with transcendental experience, if credible, would say that the experience of physicists and of the field of physics in advancing the understanding of matter is, albeit anonymously, an experience of God (57).

You have to leave the door to the unknown ajar.

How would one verify such identification? What, according to Rahner, are the identifying characteristics of this "transcendental experience"? Rahner affirms that physics is a credible locus for such experience when he states that "every transcendental experience is mediated by a categorical encounter with concrete reality in our world" (52). But what elements should be present in the experience of the physicists, in the encounter with concrete reality which is physics research, to make plausible an identification of their experience of discovery with Rahner's transcendental experience?

Rahner discerns four properties in transcendental experience: subjectivity, personhood, responsibility, and freedom (28). What is meant by the first of these, subjectivity, becomes clearer, according to Rahner, when

[41] Pais, *"Subtle Is the Lord,"* 56.

[42] Rahner, *Foundations,* 20.

we say that human persons are transcendent beings. What does that mean and is the statement consistent with the testimonies of the physicists? In a passage that resonates with Hawking's view, as we shall see below, Rahner describes what he means when he states that a human person is a transcendent being.

> [Man] can place everything in question. In his openness to everything and anything, whatever can come to expression can be at least a question for him. . . . Man experiences himself as infinite possibility because in practice and in theory he necessarily places every sought-after result in question. He always situates it in a broader horizon that looms before him in its vastness. (31)

Let me compare that notion of transcendence with the experience of the physicists as described above, whether the searching of Galileo, Newton, and Maxwell in the classical period or of Einstein and Bohr in the later period. Stephen Hawking states that experience succinctly: "But physics and astronomy offered the hope of understanding where we came from and why we are here. I wanted to fathom the far depths of the universe. Maybe I have succeeded to a small extent, but there's still plenty I want to know."[43] Or we look at Pais' comment on Einstein towards the end of his life of searching:

> Physics remained at the center of Einstein's being in the final decade, during which, as I described earlier, he concentrated exclusively on unified field theory and on questions of principle regarding the quantum theory. His published work during that period includes eight papers on unified field theory, a contribution to *Dialectica,* written at the instigation of Pauli, in which he explained his views on quantum mechanics; and his necrology, as he called it, the important essay entitled *Autobiographisches.*[44]

All these works express a conviction that there is "something beyond," a comprehensive unification of all the forces of nature in the case of the unified-field theory, a deeper reality beyond the indeterminacy of Heisenberg in the case of quantum theory.

How does this relate to subjectivity? Rahner continues thus:

> Insofar as man is a transcendent being, he is confronted by himself, is responsible for himself, and hence is *person* and *subject.* . . . Something finite can experience itself as finite only if, as this conscious subject, it comes from something else which is not itself. This something else is not just

[43] Stephen Hawking, *Black Holes and Baby Universes* (New York: Bantam Books, 1994), 473.

[44] Pais, *"Subtle Is the Lord,"* 473.

> another *individual,* but *is the original unity that anticipates and is the fullness of every conceivable system* and of every individual and distinct subject.[45]

In the examples cited, both Hawking and Einstein are confronted by the mystery of the universe stretching without limit before them. They also know themselves as distinct subjects within the universe that they strive to understand, manifesting the second of Rahner's characteristics of transcendence experience, namely, personhood.

What of the other two characteristics, responsibility and freedom? Einstein provides a succinct illustration of these. There comes to mind his response to a student at the time he received a cable informing him that the bending of light by the sun was in agreement with his general relativistic prediction. The student asked what he would have said if there had been no confirmation. Einstein's reply is a classic expression of self-confidence, that is, of a free spirit taking responsibility for one's gifts: "Then I would have to pity the dear Lord. The theory is correct anyway."[46]

Where does this notion of transcendence lead, this notion of a primordial experience that beckons us limitlessly in freedom? How does it relate to what is done in physics?

> This self-communication to the human person as a free being who exists with the possibility of an absolute "yes" or "no" to God can be present, or can be understood, in two different ways. It can be understood as the antecedent situation of an *offer and a call* to a person's freedom on the one hand and, on the other hand, in the once again two-fold manner of the *response to this offer* of God's self-communication as a permanent existential of man. That is, this self-communication can be present as an acceptance or a rejection of God's self-communication by man's freedom. This transcendentality is beyond words.[47]

Is this what goes on in physics? Is the ever deeper personal penetration into the mystery of creation that we see in Newton, Maxwell, Einstein, Bohr, and more recent contributors like Hawking or Weinberg a manifestation of the self-communication of God? If so, why are they not all Christians? Rahner has this to say: "In principle, the original experience of God even in his self-communication can be so universal, so unthematic and so 'unreligious' that it takes place, unnamed but really, wherever we are living out our existence" (131). He goes on to make an observation that is particularly relevant to this examination of the notion of physics as spirituality.

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[45] Rahner, *Foundations,* 34 (emphasis added).

[46] Pais, *"Subtle Is the Lord,"* 30.

[47] Rahner, *Foundations,* 126.

> Even if by simple introspection, and by making his original, transcendental experiences thematic, a person could not individually discover such a transcendental experience of God's self-communication in grace, or could not express it by himself with unambiguous certainty, nevertheless, if this theological and dogmatic interpretation of his transcendental experience is offered to him by the history of revelation and by Christianity, he can recognize his own experience in it. (131)

Furthermore,

> [T]his offer of the absolutely incomprehensible, nameless and infinite God to man's freedom can be accepted in man's concrete and unthematic actualization of existence as his justification and salvation. *This is true even when in his historical conditioning this person interprets his existence, without fault, in a different way or in a non-Christian way, perhaps even in an atheistic way.* For wherever a person accepts his existence ultimately and unconditionally . . . he is accepting God. He is accepting not a mere God of nature, nor the mere nature of spirit; but rather he is accepting the God who gives himself in all of his incomprehensibility in the center and depths of his existence. (401, emphasis added)

The Christian Vision

Christianity would say that this experience of transcendence is an experience of a free, unmerited, and forgiving self-communication of God. This self-communication of God as personal and absolute mystery to a human person as a being of transcendence signifies from the outset a communication to that person as a spiritual and personal being. "God's self-communication" means that what is communicated is really God in his own being, and in this way it is a communication for the sake of knowing and possessing God in immediate vision and love. For the Catholic and Christian this is a moment of grace. And in this grace there is included a moment of revelation in the proper, although transcendental, sense.

A physicist dedicates his whole life to unraveling the mysteries of the universe, and trusts his insights even when they involve fundamental changes in the accepted concepts governing that universe, for example, the concept of relativity. If this is accepting God, as Rahner asserts, then, all anonymously, physics research is a search for God. "[F]or this reason a Christian stands beyond all of the pluralistic confusion and hopes that in this beyond an ultimate 'yes' is hidden in everyone who is of good will" (401).

So, Where Does It Lead Me?

This essay began as a personal search for understanding. It is fair to ask, "What impact has this understanding had on my life, on my spirituality?" The response to this is multifaceted. First, it removes the vocational ambiguity implied by the term "hyphenated priest," a source of such anxiety in the sixties and seventies. While I have never experienced this ambiguity in my own life, it is helpful to have an articulated theological basis for the unity of my vocation as a priest who is a physicist. Secondly, it identifies physics research, the lifelong work of my colleagues and me, as praise of God—at the core of our reason for existence: "to praise, reverence, and serve God, and thus enter into eternal life." This elucidation is deeply satisfying. It adds a deeper, spiritual dimension to the collegiality experienced in the physics-research community. Beyond every stripe of belief and unbelief, the bond that we experience is, at depth, a brotherhood and sisterhood in the Lord. There is a wonderful wholeness and a deep spiritual joy from this realization.

A somewhat different question is how this perceived unity of the physicist's quest and the search for God flows into my spiritual life, my explicit relationship with God. The perceived unity that allows me to find the mystery of God in physics research leads me to approach the mystery of redemption with the same rigor and deep reverence that characterize the physics search. Two words that characterize the physics search are honesty and authenticity: an unrelenting honesty in confronting data, even when they might contradict my previous experience and expectations, and an authenticity, an integrity that acknowledges the mystery, the tentative quality of both our knowledge and our ignorance. The physicist is able to say in all simplicity, "I don't know," or, "I don't understand." The not knowing or not understanding becomes an opening to the mystery, a spur and a locus for further searching. And this honesty and authenticity color his whole life, not just his physics. So, for myself, to the extent that I am authentically a physicist, these characteristics also color my spiritual quest.

This understanding removes the vocational ambiguity implied by the term "hyphenated priest" and identifies physics research, the lifelong work of my colleagues and me, as praise of God—at the core of our reason for existence.

Where does this lead? By internalizing Rahner's theology as expressed coherently in his *Foundations*, I achieve a coherent, explicit basis for my spirituality (21). In the first instance, in prayer and especially in the Eucharist, the prayer and the celebration must be consistent with the reality I profess—that it is an encounter with the living God, with a God who is a person. That encounter becomes an experience, a dialogue with the God who is present. To celebrate the Eucharist is to be conscious of being present to and addressing the Father, of gathering the congregation into that prayer and with them offering to the Father the offering of the Son. In the celebration I experience a deep sense of presence to the congregation—of a common presence to the Father and of the Father present to us, and an experience of the love of the Son for the Father and his offering in love for me and for each member of the congregation. A physicist takes seriously and wrestles with the reality of the world of matter. I find that the same seriousness and engagement flow into the reality of the world of spirit.

In a similar way, this openness to God's presence and the sense of mystery leads to a renewed approach to the Spiritual Exercises of St. Ignatius. That questing which characterizes my life as a physicist, a hunger for an ever deeper penetration of the mystery without doubting the present reality, carries over into the experience of the Christian mystery. Rather than the Spiritual Exercises being a pondering of the great truths of salvation history, I have found them to be an experience of being caught up with Christ in his great work of salvation. I have experienced redemption at an ever deeper level as a reality in my life. And I have found myself loving with the heart of Christ and longing for the redemption, for wholeness and eternal life with the Lord for all my brothers and sisters. "All things were created through him, and without him nothing has come to be."

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LETTERS TO THE EDITOR

Editor:

With regard to your comment on Fr. Dupuis's book *Toward A Christian Theology of Religious Pluralism,* which appeared in the recent issue of STUDIES IN THE SPIRITUALITY OF JESUITS, I would like to be one of those who will write you to express a bit of their opinions.

I happen to be one who has read Fr. Dupuis's book. I am very happy about Fr. Dupuis's positive attitude towards other world religions in his book. But I also have an impression that some of Fr. Dupuis's views may need to be clarified lest they become misleading. I can only give one or two examples. Fr. Dupuis said that Jesus is still "constitutive" for universal salvation after he praised extremely highly other world religions. I think he may need to explain more fully why Jesus is still "constitutive" in such a case. Regarding the place of the Church in salvation, Vatican II taught that "whosoever, knowing that the Catholic Church was made necessary by God through Jesus Christ, would refuse to enter her or to remain in her could not be saved" (*Ad gentes,* no. 7). Dupuis seems to give me an impression that this is not so: as long as one belongs to a religion, [he seems to say,] one has no need to enter the Catholic Church, no matter what.

Fr. Dupuis has said many praiseworthy things in his book and has accomplished a lot for the Church in his career. He is not being investigated for these, but for those areas that may cause serious problems. A person might be right most of the time, but this does not mean that he or she is right all the time. In terms of the "secretive" nature of the investigation process, I think we could give the Church authority the benefit of the doubt, that the "secretiveness" is ultimately beneficial to Fr. Dupuis and the Church. Many good things are done in "secret."

In view of the many recent writings by Christian authors on world religions that tend to play down the divinity and significance of Christ and therefore the great harm done to the Christian faith, one can understand some "chill wind of suspicion" from Rome. As Jesuits, we should not sensationalize this incident of Fr. Dupuis but pray that he can come out clean from the investigation and that the Church's faith remains intact.

God bless you in your good work!

Sincerely,

Augustine Tsang, S.J.
Faber House
Cambridge, Mass. 02138

Editor:

I am a novice of the New Orleans Province. I was reading your FYI section at the beginning of the most recent STUDIES, and what you wrote struck a common chord with my sentiments, so I thought I would drop you a line as requested and let you know what they are. As first-year novices, we have read parts of the documents of GC 34 and I do recall being left with the impression that we are called to inter-religious dialogue and to work towards ecumenism. As we were reading this, the criticisms of Tony DeMello were just coming out. During our group discussion I commented that it is a shame that what we are called to do as Jesuits will most likely result in our being censored. In other words, if we do what GC 34 and the Society asks of us, we will be criticized. I appreciated your comments and encourage you and others to continue writing despite the risks. After all, we are called to be companions of Christ and to carry the cross associated with it.

Lenten blessings,

Anthony Borrow, N.S.J.

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Editor:

You asked whether "present-day Jesuits still read books with any frequency." Here are the titles of three I have read recently, that is, in the past year. They are *The Life of Thomas More* by Peter Ackroyd, *The Stripping of the Altars* by Eamon Duffy, and *Cranmer* by an author whose name I forget. There were others, but I remember these three the best. Summer supply work provides the leisure once available in the juniorate to devour both French and English authors.

Michael Marchlewski, S.J.

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