Principled Uncertainty:

A Quantum Exploration of Maimonides' Perfect and Infinite God

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הִבִּיטוּ אֵלָיו וְנָהָרוּ

They looked to God and tunneled to Him

Psalms 34:6

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Preface

I've been writing this book for almost 25 years. In that sense it's autobiographical, much in the way that is any book that captures an author's dedication and imagination through multiple phases of life. In addition to the intellectual and spiritual journey that this book reflects, it also unexpectedly reveals where I have found my happiest moments. I've savored the occasions in which I've tried to teach the ideas in this book to my children from a very young age. Possibly inappropriate, due to the esoteric nature of some of the material, I've nevertheless preached to my reluctant audience the concepts of how quantum mechanics relates to Judaism. I've learned that anything can be lectured at a five-year-old. In many ways, the beauty of trying to write on a clean slate is unparalleled – uncorrupted by any sense of intuition that we develop as we grow. Of course, not anything can be learned by a five-year-old, but that has never stopped teachers from trying. It has given me much selfish joy to push the limits of my children's understanding and intuition and challenge them to reconcile their burgeoning belief with their internal sense of logic. I write this book with endless gratitude to God for the moments when I saw flickers of understanding in my young children and flashes of challenges and corrections ignite from them as they grew.

This book is my attempt to synthesize many of the disparate things that I believe but, more importantly, to advocate for the need to leverage scientific knowledge in pursuit of theology. Maimonides begins *The Guide of the Perplexed* with a letter to his pupil, Rabbi Joseph

son of Judah. He recounts how he began instructing Rabbi Joseph in astronomy and mathematics. Only after Rabbi Joseph proved his ability to understand scientific subjects did Maimonides feel that his student could be taught the secrets of the prophetic books.[1] It was not merely a test of acumen that led Maimonides to begin religious instruction with a scientific grounding. Intelligence could have been easily probed with examinations of Talmudic insight. Rather, Maimonides believed this background was an essential prerequisite in the pursuit of Divine matters.

In modern discussions of science and religion, the topic of whether science is foundational to religious pursuit is overshadowed by the more frequent attempts at reconciliation between the two. Reconciliation implies that co-existence or consistency is the goal of study. However, this goal is far less important than the need for uncovering religious truth. The search should not be for consistency; it should be for understanding.

Along this path, searching for understanding, I have been blessed with many teachers who taught me things before I had earned the right to learn them. My grandfather, Harry Aranoff, *z"l*, taught me the possibility for rational belief from the time of my earliest intellectual memories. Prof. Mark Kasevich helped me build intuition for quantum measurement and appreciate the need to push the limits of quantum applicability. Rabbi Prof. Isadore Twersky, *z"l*, opened to me a life-changing world of Maimonides.

I've been doubly blessed to have dear friends who are also my teachers. They suffered through drafts of this book that were very hard to read – with incomplete, fleeting ideas exacerbated by opaque allusions and scientific jargon. I am grateful that they have helped me clarify my thoughts and words. Ari Kushner, *z"l*, was a steadfast sounding board when this book was only a few diagrams on the back of a napkin, and he was a traveling companion who shared and encouraged the passion for what became a decades' long journey. Mayer Bick and Yair

1. Moses Maimonides, *The Guide of the Perplexed* (Chicago: Univ. of Chicago, 1963) pp. 3–4.

Listokin provided detailed feedback from their close weekly study that challenged me and sharpened my focus with critical but encouraging insight. Zvi Septimus provided encyclopedic perspective and practical guidance on reaching towards my audience. Maya Bernstein gave an exhaustive editorial read and provided consistent reminders to see the poetry in what I was trying to write. Additional thanks to my family and friends who indulged countless conversations and provided feedback as I immersed in this effort: Andy Tuchman, Micole Tuchman, Oren Koslowe, Noam Silverman, Daniel Silverberg, David Hiltzik, Martin Handwerker, and David Atri. Lance Rutter created the illustrations with artistic clarity. I am truly grateful to each of them.

My daughter, Danelle, reviewed the Biblical and Rabbinic footnotes – and provided many technical corrections and insightful additions with her growing scholarship. It was my exuberant joy each time she discovered an important mistake in the manuscript. It is good to be reminded that being wrong can bring much happiness – *nitzchuni banai*. Natalia pushed the limits of my logical arguments and held me accountable for their reductive extensions. I am grateful for her passion to pursue understanding and find her own scientifically inspired spiritual path. Adin and Nurielle grew up taking quantum teleportation for granted and building intuition for their own de Broglie waves. I have been blessed with the privilege of learning with them, watching with anticipation as their understanding develops, and watching their own excitement as the texts begin to open to them. Adrielle is just beginning her journey and reminds me what infinite curiosity resembles.

I am grateful to my editor, Rabbi Alec Goldstein and Kodesh Press, for helping to make this book a reality. R. Goldstein provided valuable suggestions to improve clarity and logical consistency, offering scholarly perspectives on alternative textual interpretations while continuing to respect my style and vision.

I am grateful to my parents, Shera and Alan Tuchman, for instilling in our family an insatiable quest for knowledge of those things which cannot be understood and a practical grounding to know when to accept such limitations.

I began this journey with Beth, *z"l*, who inspired me to search for answers with pure faith, a love of humanity, and the seriousness of thought infused with contagious excitement that was her hallmark.

I have continued this journey with Liora, who encourages me along the path of intellectual exploration while also reminding me, by example, not to let philosophical pursuits obstruct an awareness of those in need or mute an appreciation of the beauty in the world.

תושלב"ע

Scientific Revelation

Introduction

Religion and science both pursue self-consistent definitions of truth that strive to leave their followers with a sense of gratifying understanding. While the lofty goal is similar and logical arguments fuel both endeavors, fundamentally, one relies on belief and the other on evidence. Thus, historical attempts to weave these pursuits together have not been successful in providing closure in either direction. When relegated to the polarities of proof or threat, or reduced to choosing between a caricatured defender or prosecutor of the faith, science will always fall short in filling the voids of uncertainty that religion exposes. Similarly, religion is not capable of providing evidence to explain fundamental limitations in understanding scientific observations. This frustration with lack of convergence has led to executions[1] and excommunications,[2] a steady stream of scientific Nobel laureates professing atheism and some religious philosophers demanding the abandonment of any search for truth from science.[3]

A less ambitious argument that there should be no attempt at juxtaposition has been proposed.[4] This philosophy argues that the orthogonal worlds need not be harmonized nor contrasted but simply left to their own spheres of influence; science is left to pursue an

1. See, e.g., Giordano Bruno (1548–1600).
2. See, e.g., Galileo Galilei (1564–1642).
3. Lev Shestov, *Athens and Jerusalem* (Ohio: Ohio University Press, 2016).
4. Stephen Jay Gould, *Rock of Ages* (NY: The Ballantine Publishing Group, 1999).

empirical study of the universe based on observational evidence, and religion remains focused on understanding life's meaning based on belief in a God. It is tempting to accept this peaceful co-existence and leave each scholarly pursuit to its own realm.

However, by accepting non-overlapping spheres of influence, even if one does believe that there is truth in both disciplines, the pursuit of the Divine suffers; the tools at the theologian's disposal are too few and insufficient for any to be discarded. Pursuit towards an understanding of God should leverage every method of human discovery and every artistic metaphor that creative thinking can invent. If poetic verse inspires emotional understanding of God's relationship with mankind, then scientific equations must inspire models of how to think about God's interaction with the physical universe. Science is not designed to provide proof nor refutation of God's existence. However, scientific understanding can provide a metaphorical framework for pursuing a personal God once faith is already established. This framework can be evaluated in terms of whether it is *rational*, defined by the ability to maintain both logical self-consistency and scientific compatibility. This approach has been pursued over the past millennium by scholars ranging from Maimonides (1135–1204)[5] to Isaac Newton (1643–1727).[6] It has succeeded in providing a framework for contemplating God's revelation and should not be judged by its inability to provide proof of God. Scientific principles should continue to be leveraged for religious studies at the frontier of innovation, as they were with Aristotelian and Newtonian physics.

The religious imperative to pursue science begins as a Biblical injunction with practical motivation and evolves into a philosophical requirement. Immediately after Adam and Eve are created, they are

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5. Moses Maimonides, *The Guide of the Perplexed* (Chicago: Univ. of Chicago, 1963) 3:51. Subsequent references to the *Guide* will be given in parenthesis in the text. Maimonides presents the analogy of the physical sciences as an entrance hall that serves as a prerequisite to entering the next level of metaphysics and eventually the inner chambers of approaching the Divine.
6. Isaac Newton, *The Principia*, 1687 (Reprinted by Powerline Publishing Group) Book 3, pp. 440–443.

commanded to "be fruitful and multiply, fill the land and conquer it" (Gen. 1:28). Inevitably, this conquest requires a reliance on technological and scientific innovation to survive in the face of destructive natural phenomena and as protection against physically overpowering creatures. From the very beginning of their existence, humans were destined and commanded to discover and innovate.

This necessity to pursue science is subsequently leveraged for the task of understanding God's hidden commandments. In the Book of Deuteronomy, the Bible focuses on the opaque commandments referred to as "*hukim*" (Deut. 4:5–6). This genre of commandments is traditionally interpreted as those that are not *a priori* logically derivable, e.g., the prohibition against wearing wool and linen in the same garment (Deut. 22:11). These contrast with the more intuitive commandments, e.g., the prohibition not to kill (Exod. 20:13) or the requirement to have fair weights and measures (Deut. 25:13–16). Although *hukim* may not have their purposes delineated, according to Maimonides one is required to delve deeply and attempt to uncover their meaning (*Guide* 3:26 and 3:31).[7] Maimonides believes that the intellectual exercise of ascertaining their meaning, including leveraging scientific knowledge, is a necessary condition for the observance of these types of commandments. Furthermore, the Talmud provides a unique explanation that the commandment to observe the *hukim* refers to the explicit obligation to calculate constellational orbits (BT *Shabbat* 75a). Thus, Maimonides' directive for leveraging science in understanding opaque Biblical commandments is, in general, strengthened by the Talmud's choice to frame the concept of *hukim* scientifically, within an astrophysics paradigm.

As a religious endeavor, understanding God's true intention behind the *hukim* is expected to be an asymptotic pursuit that eternally converges towards the solution but never quite achieves it. Complete knowledge of any scientific field similarly represents an asymptotically

7. See also Maimonides, *Mishneh Torah*, *Hil. Temurah* (4:13) and *Hil. Me'ilah* (8:8). Subsequent references to the *Mishneh Torah* will be given in parenthesis in the text with the prefix *Hil.*

unachievable goal, with astrophysics presenting an illustrative example. Aristotle's proposed geocentric circular planetary orbits in the fourth century BCE were replaced with heliocentric orbits by Nicolaus Copernicus in 1532. In 1609, these were replaced by elliptical paths calculated by Johannes Kepler. Sixty years later, these laws of motion were advanced by Isaac Newton with an established foundational theory of gravity.[8] While this model reigned for 300 years, in 1915, Albert Einstein provided relativistic corrections to the precession of Mercury's orbit at its perihelion (point of closest proximity to the sun).[9] Einstein's predictions led to the first experimental proof of general relativity, achieved in 1954. This achievement illustrated that an apparently simple task to calculate planetary orbits, which the Bible commanded over 3000 years ago, is still an active field of scientific research today. Open questions remain concerning how to reconcile Einstein's general relativity with quantum mechanics, and inevitably, such a reconciliation will uncover further improvements to our ever-refined models. Thus, the reason behind the most hidden genre of commandments remains an asymptotic pursuit towards truth and understanding, even today. Science is presented as integral to the pursuit of religious knowledge, which is a never-ending journey.[10]

Scientific knowledge can be religiously impactful across a range of practical and exegetical applications, with varying degrees of theological implications for a *rational believer.*[11] This rational believer does

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8. Frank Shu, *The Physical Universe* (California: University Science Books, 1982) pp. 463–467.

9. Albert Einstein, *The Meaning of Relativity* (Princeton: Princeton University Press, 1922) pp. 94–97.

10. Isadore Twersky, *Introduction to the Code of Maimonides* (New Haven: Yale University Press, 1980) pp. 217–219.

11. Rabbi Soloveitchik, in *The Halakhic Mind*, uses the language of *homo religiosus* to denote the scholar who struggles with understanding the spiritual Divine, possesses an objective appetite for understanding the cosmos, and who does so with an eye towards answering the questions, "How should I act in daily life? How should I live according to the will of God?" (J.B. Soloveitchik, *The Halakhic Mind* [New York: Seth Press 1986] pp. 44, 78–79, 99). However, in his work *Halakhic Man*, R. Soloveitchik redefines *homo religiosus* as purely

not accept explicit contradictions that threaten her sense of logic and scientific knowledge of the world. However, she likewise is not looking to dismiss the Divine from her daily life nor eradicate its presence from her understanding of spiritual cannon. She is rational in that she does not dismiss what she knows to be scientifically or logically true in favor of religious dogma. Rather, she strives to apply her knowledge of the world to better understand what is religiously expected of her. Her scientific knowledge initially impacts her actions and her religious scholarship, but ultimately is most critical in how it can influence her beliefs and deepen her relationship with God.

First, scientific insight can assist in her functional practice and adherence to the commandments. Just as lunar orbital calculations impact practical matters like the arrangement of the calendar and when holidays are celebrated, knowledge of current science and engineering is critical to correctly determine more broadly the parameters of *halakhah*, the legal-religious adjudication of the commandments. Laws of prohibitions on the Sabbath concerning the use of LEDs and magnetic switches, the definition of brain death for advanced medical directives, and DNA identification of paternity for marriage and conversion, are issues that Rabbinic authorities continually encounter.[12] Scientific knowledge is thus necessary for the fulfillment of the particulars of the commandments.

Second, scientific insight can provide the rational believer with novel interpretations of esoteric passages in the Bible. While Biblical descriptions need not be taken literally, it is nevertheless, conciliatory

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spiritual, stripped of the scientific curiosity of "*cognitive man*" and further devoid of the motivations of the eponymous "*halakhic man*," whose persona craves to act in accord with the will of God (J.B. Soloveitchik, *Halakhic Man* [Philadelphia: JPS, 1983] pp. 13–19).

This work explores a theological pursuit that might be undertaken by *homo religiosus* of *The Halakhic Mind* but explicitly not by the persona of *homo religiosus* of *Halakhic Man*. Therefore, to avoid this ambiguity, this book uses the language of "rational believer," which is intended to capture the individual who pursues both the spiritual path as well as the legalistic/*halakhic* path, both from a perspective of faith and scientific process.

12. See, e.g., J. David Bleich, *DNA in Halakhah* (NY: KTAV Publishing, 2021).

for some to discover a scientifically compatible reading. At the revelation at Sinai, for example, the Israelites are described as being able to *see*, rather than *hear,* the sounds on the mountain (Exod. 20:15). This can potentially be explained through sonoluminescence,[13] which is the phenomenon whereby light is emitted by an acoustic excitation, rendering sound visible. Similarly, the mapping of seven days in the story of Creation to the billions of years since the Big Bang might be attributed to gravitational time dilation, which is an effect of relativity that causes time to advance much more slowly in the presence of massive gravitational fields.[14] The incredibly high density of the early universe could thereby explain time running much more slowly.

Similarly, science can be used to explain aspects of Biblical miracles by leveraging natural phenomena. For example, the 10 plagues brought upon ancient Egypt have been speculated to have been driven by toxic algae in the Nile and a volcanic eruption of the island of Santorini.[15] Such types of explanations shift the miraculous component of the narrative from the details of the event to its timing. While they provide an understanding of God's interactive methods that appear more harmonious with natural law, the presence of redemptive miracles and their representation of Divine intervention remain. Therefore, the religious believer is not using scientific explanations to dismiss miracles, but rather to understand how they manifest. She is inspired to bring her scientific knowledge to these intellectual interpretations of Biblical and Rabbinic writings.

Third, and most importantly, the coupling of science and religion need not be limited to legalistic, reconciliatory, or intellectual applications. Rather, this inspired pairing should be pursued for its potential to be revelatory in fostering a sense of awe and aiding in pursuit of understanding the Divine. At the simplest level, the beauty of the natural universe should inspire religious wonder. It does not require

13. L. Crum, *Sonoluminescence,* Physics Today **47**, 22 (1994).
14. C. Misner, K. Thorne and J. Wheeler, *Gravitation* (NY: WH Freeman, 1997) p. 1054.
15. S. I Trevisanato, Med Hypotheses **67**, 187–90 (2006).

scholarship to appreciate the scale of galaxies and nebulae viewed through the Webb telescope or to feel an internal tremor when gazing into the Grand Canyon at sunset. These experiences motivate the visceral expression, "How great are your creations, God! You have made them all with wisdom!" (Ps. 104:24). This aesthetic and even majestic appreciation, however, is only the beginning of how science should inspire the rational believer. Science should convey not only Divine beauty but also understanding. Science enhances knowledge and appreciation of God, which consequently magnifies love for God (*Hil. Yesodei HaTorah*, ch. 2). Maimonides explains, *ha-ahavah hi ke-fi ha-hasagah*, "one's love for God is commensurate with one's knowledge and understanding" (*Guide* 3:51; *Hil. Teshuvah* 10:6).

Maimonides' encouragement of revelatory pursuit through scientific understanding was, however, constrained by its reliance on Aristotelian physics. Classical physics more broadly is intuitive and experiential, and it is largely driven by the attempt to explain an observed physical world. Newtonian physics and even Einstein's relativistic equations are predicated on a belief that physical systems are, in principle, uniquely determined. Experimental observations comprehensively measure this unique state of a physical system. Therefore, any religious-philosophical learnings from classical physics would represent an attempt to explain the Divine based on what we know, see, and feel. Such a classical view, however, which relies on measurable and intuitive quantities, significantly constrains the pursuit of understanding God. In pursuit of understanding the deep nature of the *human* existence, the eighteenth-century British philosopher David Hume recognized that an experiential approach, though unavoidable, would fail. He states, "'tis still certain we cannot go beyond experience; and any hypothesis that pretends to discover the ultimate original qualities of human nature ought at first to be rejected as presumptuous and chimerical."[16] An experiential pursuit of God would surely be destined to fail as well.

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16. D. Hume, *A Treatise of Human Nature* (Oxford: Oxford University Press, 1978) p. xvii.

Quantum mechanics, a revolutionary view of physics from the early 20th century, challenged the completeness of experiential truth. Its equations stipulate that a particle's reality can be described by a probability distribution called a *wavefunction*, rather than by a single value.[17] This description came with the shocking repercussion that the reality observed can be very different from the underlying reality prior to that observation. The laws of quantum mechanics are spooky,[18] in that they are far from intuitive or experiential. Even our knowledge of when these laws of quantum mechanics apply remains a topic of heated debate. In a quantum world, objects can teleport, be in multiple places at the same time, and behave in other ways that are classically forbidden. However, despite the seemingly fictional properties of these phenomena, they have been scientifically observed. Thus, analogies from quantum mechanics to explain the Divine would not be bound by the constraints of human intuition but would still leverage measured scientific fact. Facts are often significantly harder to accept than intuition when they are contradictory to that intuition gained from a lifetime of interaction with the world. Nevertheless, the facts that quantum mechanics have uncovered about how our universe operates can be illuminating in providing analogies to help in pursuit of God. Analogies from classical physics leverage what humans intuit in order to understand hints of God. Quantum analogies leverage scientific experiments which can cultivate new intuitions that are less constrained by an anthropocentric bias.

This power of analogy in deepening our understanding of God is certainly not relegated to the scientific realm. The Talmud makes use of explicit metaphors to explain Divine behavior, often, for example, comparing God to a mortal king: *mashal le-melekh basar ve-dam*, "a parable to a king of flesh and blood." For example, the Talmud describes the inadequacy of human praise for God by using the

17. A discussion of this Copenhagen interpretation of quantum mechanics will be presented in the following section.

18. Einstein famously dismissed quantum entanglement as "spooky action at a distance."

analogy of a king who is ignorantly praised by his subjects for his lesser possessions, when he should have been more accurately and thoroughly praised for his most valuable possessions (BT *Berakhot* 33b). The implication of this metaphor is that mankind does not even comprehend which qualities of God are the most deserving of praise. Ironically, a metaphor of a human king brought to deepen our understanding of God is used here to illustrate our inability to understand how to praise God.

All theological analogies, whether scientific or literary, are brought to suggest how one might think about God's interaction with the world and with mankind. While these metaphors are inevitably incomplete and not to be taken literally, they should not be relegated to irrelevance simply because they are not *true*. In the example above, God is not actually a mortal king. A metaphor, like a mathematical algorithm, should be judged by its utility, not its truth. An artificial intelligence classifier model that can recognize fraudulent behavior in credit card purchases with a high degree of accuracy cannot be described as *true*; it can simply be useful.

One cannot inquire of any metaphor describing how to think about God's interaction with the world as being true or false, but rather, as whether the metaphor has provided insight. For example, the relationship between mankind and God is often compared to the relationship between husband and wife. An entire book in the Biblical canon, Song of Songs, is, according to Jewish tradition, written to explore this metaphor. R. Akiva, a sage from the time of the Mishnah (a codification of the Jewish oral tradition in the early second century CE), explains that this love song is the holiest book in the cannon (Mishnah, *Yadayim* 3:5). Certainly, this metaphor is not *true*. God is not a physical husband to the physical wife of Israel. Nevertheless, the metaphor is extremely *useful*. It conveys a deep and holy love and a unique connection. It also conveys a clarion expectation of monogamy of which God tolerates no deviation. The explanation of the punishment for violating idolatry is seen by the prophet Jeremiah through the lens of an unfaithful wife (Jer. 3:8). Jeremiah preaches how idolatrous worship is nearly unforgiveable, and this metaphor of an adulterous betrayal resonates across millennia.

While these Biblical and Rabbinic metaphors provide resonant emotions that frame our understanding of God, it is powerful to seek illuminating metaphors outside of the scope of human experience and intuition. This endeavor is not necessarily limited to quantum mechanical or other scientific pursuits, although that is the scope of this book. Furthermore, the line between science and humanities is often not perfectly delineated. For example, even the conceptual underpinnings of quantum mechanics might have their origin in the humanities, possibly influenced by the Surrealist movement. This artistic, literary, and philosophical movement began in Europe in the post–World War I era and advocated for the suspension of human intuition and beliefs about what is real. It preached an openness to dream-like reality, different from human physical perceptions, thereby sharing an abstraction of intuitive reality with quantum mechanics. This mantle was adopted by artists such as René Magritte and Salvador Dali, both of whom pursued beauty and truth through artistic expression that contradicted the experiential world of classical physics. The Surrealist movement's origins predated the seminal works of Werner Heisenberg (1901–1976) and Erwin Schrödinger (1887–1961) which launched quantum mechanics, and its impact on them, while speculative, is certainly possible. It is difficult to prove whether the ethos of Surrealism influenced the early quantum thinkers or whether a broader trend in abstract thinking influenced both. Thus, a student of religion looking for revelation could potentially turn to Surrealist analogies rather than quantum experiments or could seek inspiration from both.[19]

Nevertheless, the rational believer, relying on eclectic analogies to pursue God, might be better served when she can assert that the

19. This duality of intellectual causality is presented by R. Soloveitchik as the fundamental issue that divides between Kantianism and Neo-Kantianism (Soloveitchik, *The Halakhic Mind*, pp. 62–65). He questions: "Does the 'logos' [reason] move from sense experience to a postulated world or conversely?" R. Soloveitchik answers this dilemma a few pages later (p. 74), with his belief that "it is impossible to gain any insight into the subjective stream unless we have previously acquired objective aspects."

analogies themselves are on a proven, objective, foundation. While revelatory inspiration can be internalized from both knowledge in the humanities and the sciences, for some, it will be a safer leap across the chasm to faith accompanied by analogies that have been experimentally demonstrated. While the two paths are complementary, this book will pursue the approach of learning from scientific examples, with an emphasis on extracting detailed analogies from quantum mechanics that are intended to help pursue an understanding of God.

In 1993, Hans Bethe, one of the founding fathers of quantum mechanics, gave a public lecture about an interaction he had with Albert Einstein.[20] He began by recounting a conversation he had in which Einstein uttered the famous quote concerning his dismissal or discomfort with the random outcomes and probability distributions predicted by quantum mechanics: "I refuse to believe that God plays dice with the Universe." Bethe then described how he responded: "Albert, stop telling God what He cannot do." Two great physicists, who were likely both religiously agnostic, could not resist the temptation to recognize that quantum mechanics has Divine implications.

The temptation to leverage quantum mechanics for theological questions is amplified since a quantum universe requires concepts that have religious undertones. While religion postulates a deeper reality hidden from human perception, quantum mechanics posits a description of reality that cannot be directly observed (e.g., the wavefunction in the Copenhagen interpretation). Religion often advocates for a Divine presence that can observe and interact with this hidden world, and quantum mechanics theorizes an "Observer," responsible for influencing the trajectories of all particles. While foundational interpretations of quantum mechanics do not require this Observer to be conscious, the Observer is nevertheless responsible for the physical world that humanity experiences – blurring the line

20. H. Bethe, Public lecture at Harvard University, 1993. A similar conversation was recounted by Niels Bohr in "Discussion with Einstein on Epistemological Problems in Atomic Physics," in *Albert Einstein, Philosopher–Scientist*, ed. Paul Arthur Shilpp (Harper, 1949) p. 211.

between underlying quantum states and their collapse into classical observables. Scientifically, this observational role need not be random nor unconscious, but could be intentional, which would then provide the possibility for religious chords. The semantic distance to render such an intentional "Observer" – who impacts the entire universe and causes particles to choose trajectories – coterminous with "God" is vanishingly small.

While these scientific metaphors provide new modalities for discussing theological questions, if they are applied to historical Rabbinic exegesis, the challenge of anachronistic application must be addressed. A belief in Divine omniscience could justify the presence of references to concepts such as quantum mechanics and general relativity within Biblical verses. One could believe that some verses, which are currently opaque, were written with Divine intention to be decoded and understood by future generations with more advanced scientific knowledge. However, it is not logically possible to similarly ascribe such allusions to Rabbinic commentary. Such an attribution would require the early Rabbinic authors to have been implying a quantum interpretation that they could not have known. Any claims of discovery of metaphorical references to quantum mechanics in Rabbinic literature, therefore, must be understood as representing an intuition for some of the *concepts* that quantum mechanics explains and not as references to any of the formalism of quantum mechanics.

Medieval Rabbinic scholars' lack of knowledge of modern science does not preclude the utility of quantum analogies from providing a deeper level of understanding of their writings. Even if these sages lacked knowledge of mathematical formalism, principles from modern disciplines might, nevertheless, permeate their thought. Looking for explanation from quantum mechanics in Rabbinic thought is not anachronistic by recognizing that the inspiration for those conceptual, albeit not quantitative, thoughts can be intuited by brilliant minds. Intuition for scientific and mathematical truths, even those truths such as indeterminism, uncertainty, and the ability to experience forbidden regimes, need not be based on formal knowledge of the subject. Historical examples in game theory and number theory

and a personal anecdote with calculus illustrate how informal and untrained intuition can recognize hidden patterns that reflect a more rigorous formalism.

For example, a Mishnah in tractate *Ketuvot* describes a case in which the assets of a deceased husband must be divided among his three surviving wives in amounts determined by stipulations in the marriage contracts or *ketuvot* (BT *Ketuvot* 93a). The Mishnah states that the contracts record different debt obligations of 100, 200, and 300 *dinar* (unit of currency) for the three wives, sequentially. If the husband's total estate were valued at 100 *dinar*, they would receive equal shares of 33⅓. However, if the total estate were valued at 200 *dinar*, the first wife would receive 50, the second, 75 and the third, 75. For a 300 *dinar* estate, the first wife would receive 50, the second, 100, and the third, 150. Superficially, the first example seems to divide equally, and the third example divides in pro-rated allocations. However, the example of a 200-*dinar* estate is difficult to explain. The ensuing passage in the Talmud attempts to uncover a unifying logic behind all three allocations, hoping to extract principles that could be applied to arbitrary monetary values of the estate, even for cases not delineated. The Talmud, however, fails to achieve such a generic principle. It concludes that the Mishnah was authored by R. Natan and not by the more authoritative R. Yehudah and is therefore not legally binding. The Talmud avoids the need to discover an applicable principle since the Mishnah's delineated allocations would not be legally implemented.

Nevertheless, Israel Aumunn, Nobel laureate for economics, successfully derived a game theory interpretation that consistently explains R. Natan's logic across the Mishnah's three cases. He demonstrates that the principle of "equal division of the contested sum" explains the three examples.[21] This principle means that each set of two wives evenly split the amount of the estate that they contest.

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21. Y. Aumann, "*Be-Inyan Mi She-Hayah Nasui Shalosh Nashim*" [Regarding One who was Married to Three Wives (Moriah)]. Jerusalem: *Machon Yerushalayim* **22** (3–4): 98–107 (1999).

For example, if the first two wives divide an estate of 150, the first contested 100 *dinar* would be split evenly, and the remaining 50 would go to the second wife. While this principle is complicated to apply (but easier to check), Aumunn proves that the allocations listed are the only solutions that follow this game theory principle. Thus, the paradigm in the Mishnah is the same for all three cases and could be universally applicable to arbitrary situations. It is not conceivable that R. Natan, a scholar of Roman times, was versed in modern game theory. He would not have been able to prove mathematically that "equal division of the contested sum" provided optimum and unique solutions. Rather, R. Natan's brilliance likely allowed him to intuit an equitable, generic solution that he illustrated with three examples, without reliance on formal mathematical game theory. Aumunn was able to explain the Mishnah using formulas from game theory. However, he was also able to illustrate a conceptual principle that R. Natan could have been relying on intuitively without the rigorous mathematical proof. Thus, reliance on game theory to explain the Mishnah is not anachronistic, since R. Natan may have intuited the underlying conceptual paradigm.

In the field of number theory, a more recent illustration of this principle is found. In 1995, Andrew Wiles proved Fermat's last theorem that had been sitting unproven for over 350 years.[22] Pierre de Fermat (1607–1665) had written that no three positive integers could satisfy the equation $a^n + b^n = c^n$, for any $n>2$. Fermat wrote in the margin of a publication that he had proven this assertion but that the proof was too large to fit in the margin. In ultimately proving the theorem, Wiles leveraged modern techniques in number theory, including the Taniyama–Shimura conjecture from 1955.[23] Clearly, Wiles was utilizing advances that were unavailable to Fermat in the year 1637.

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22. S. Singh, *Fermat's Last Theorem* (New York: Anchor Books, 1997).

23. The Taniyama-Shimura conjecture was first proposed in different forms between 1955–1957. It states that elliptic curves are related to modular forms, and this mapping is a critical component of Wiles' proof. It was proven for all elliptic curves in 2001 and is now called the Modularity Theorem.

Nevertheless, if Fermat had indeed surmised an approach to support his theorem, he might have intuited a strategy philosophically in line with Wiles' eventual proof. Wiles' utilization of techniques unavailable to Fermat does not detract from the beauty of his solution, nor should it discourage our attempt to thereby shed light on what Fermat might have intended. A modern formalism allows us to access and render exoteric an historical intuition that may have been previously only surmised by a few. Application of a formalism simply allows a broader population to understand and apply the thinking and intentions of the original, inspired authors.

Finally, as an anecdotal illustration, there is a story in my family about my grandfather, Harry Aranoff, *z"l*, who was an autodidact and attended minimal formal school in rural Pennsylvania. As the eldest in the family, he was forced to work at the family warehouse and was not afforded the luxury of a college education. The lore is that my grandfather drove to pick up my grandmother, Freda Aranoff, *z"l*, for a date. When he arrived, he found my grandmother's older sister struggling over a calculus assignment, a subject that my grandfather had never studied. Despite her sister's skepticism, he offered to help. My grandfather, with a minimal math background, studied the optimization problem and confidently gave the correct answer. He wasn't able to articulate the way he solved it; he simply knew what the answer was. My grandfather surely did not take the derivative of a function to determine the maximum for the solution, yet his intelligence gave him intuition for the answer. This insight not only demonstrated that informal creativity coupled with brilliance can intuit the answer of an unknown mathematical formalism, but that it also could captivate a future wife.

Brilliant intuition, hidden behind the statements and philosophies of early scholars, can thus be extracted millennia later with tools that contextualize and formalize previously inexplicable statements. In our pursuit of understanding God and concomitantly, in attempting to extract theological understanding from ancient scholars, modern tools such as quantum mechanics can be revealing. Simultaneously, analogies that shatter the limits of human intuition must also be

entertained in our endeavor to expand the limits of Divine exploration. Once again, quantum mechanics provides a language. Quantum mechanics is therefore a useful philosophical tool to both discover hidden meaning in the words of Rabbinic tradition, as well as to provide new paradigms for relating to God. Such an endeavor must constrain and define the specific theological questions that will be pursued and the corresponding and foundational assumptions about God and faith that are presupposed.

Relying primarily on a Maimonidean theology, this book will focus on three related characteristics of an indescribable God. First, this book assumes that God is perfect, and therefore perfection can be expected from His manner in creating the universe.[24] Second, it assumes that God is omnipotent, which translates into God's ability to do anything, only bound by a self-imposed decision to be bound. Third, it assumes that God is infinite, which would extend in any dimension, spatial, temporal, or otherwise. Under these assumptions, a lack of perfection in mankind is therefore by Divine design and explicit intention.

These assumptions, coupled with a collection of quantum analogies and corresponding experimental facts, lay the groundwork for a journey towards exploring the ways in which God might interact with the world. Part II introduces the journey with an attempt to leverage quantum observations to construct a self-consistent framework for an attentive and personal God that does not contradict a vision of Divine perfection. This section addresses why it is possible to believe that God interacts with mankind without suspending scientific law. Part III explores how a scientific understanding of quantum tunneling properties may offer motivation for why the pursuit of a relationship between mankind and an infinite God is worthwhile. This section addresses why it is logically possible to believe that mankind can interact with God. The final part concludes with a reading of a Talmudic passage

24. There are clear Biblical examples in which God appears to express regret or reconsideration (see, e.g., Exod. 32:14 and Gen. 6:6); however, these can be interpreted as pedagogical examples for human behavior.

that leverages the quantum mechanical metaphors developed in the prior two sections. This will provide an explicit illustration of how quantum properties can be used as an exegetical tool to understand a Rabbinic narrative.

Ultimately, faith is a choice and not an exercise in scientific proof. But it does not need to be an irrational choice. There is no scientific alternative that can answer fundamental questions of origin and meaning. Therefore, it is neither more nor less rational to believe in God than it is to insist that God does not exist. There is no incontrovertible scientific evidence in either direction. Quantum mechanics provides metaphors which are useful in suggesting a path to explain a Divine presence and interaction without compromising the three fundamental assumptions listed above: perfection, omnipotence, and infinitude.

The Kotzker Rebbe, R. Menachem Mendel of Kotzk (1787–1859), famously stated that God resides where you invite Him in. Quantum mechanics provides the framework for a rational invitation.

Quantum Observation: Rational Providence and Prayer

Introduction: A Perfect God[1]

The Aristotelian concept of eternal Divine perfection[2] is prominent in medieval Rabbinic descriptions of God. Maimonides embraces this view of Divine perfection in his description of creation *ex nihilo*. He explains, "Now the works of the Deity are most perfect, and with regard to them there is no possibility of an excess or a deficiency. Accordingly, they are of necessity permanently established as they are, for there is no possibility of something calling for a change in them" (*Guide* 2:28, 2:30). The world was perfectly created by a perfect Creator with a perfect set of physical laws, and therefore, cannot deviate from that perfection: *ha-tzur, tamim pa'olo*, "the Rock [God] whose actions are all perfect" (Deut. 32:4).[3]

Changes in nature would also be synonymous with a change in

1. An earlier version of this section was published initially under the title "Quantum Mechanical Divine Providence and Rational Prayer," in the memorial volume for Dr. Beth Samuels, *z"l, Wisdom of Batsheva* (NJ: KTAV, 2009) p. 43, with the following dedication: "In memory of Beth Samuels, *z"l*, whose love of God, truth, life and humanity motivates this attempt at their reconciliation."

2. Aristotle, *The Metaphysics* (Dover Publications, 2018) XII:7 pp. 274–278.

3. Nachmanides explains that all actions that emanate from God are perfect and complete and will never change for eternity (commentary on Deut. 32:4). Centuries later, Newton echoes this Aristotelian concept, "The Supreme God is a Being eternal, infinite, absolutely perfect" (Newton, *The Principia*, p. 440).

the will of God as it pertains to the physical world. According to Maimonides, although God does have the power to deviate from His natural law, doing so would undermine the perfectly eternal relevance of God's Biblical teachings to the physical world. Since the Bible is a timeless, perfect blueprint for how mankind is to interact with the physical world, it should account for future circumstances. Perfection is an absolute term. Thus, any future deviation necessarily invalidates the perfection of the blueprint. Similarly, whereas God has the power to also change mankind's nature, such as by removing the evil inclination, He never has nor will, for doing so would violate the eternality of the Bible's relevance for humanity (*Guide* 3:32).[4] Prof. Isadore Twersky summarizes Maimonides' belief that "the laws of nature, cosmic as well as human, remain immutable."[5]

This Rabbinic desire for the immutability of the Divine Bible extends to historical changes as well. While Sinaitic revelation of Biblical law at a specific historical moment in time does betray a lack of retroactive, temporal homogeneity, it does not necessitate the type of deviation that would be indicative of imperfection. One could posit that the need for a point-in-time revelation was built into the initial intended blueprint corresponding to an evolutionary stage when the world was ready for Biblical law. Nevertheless, sensitivity to this issue is reflected in the Rabbinic desire to portray Biblical law as historically immutable. Allusions to the existence and relevance of Biblical law before revelation (albeit not as legally binding *halakhah*) exist in Rabbinic literature related to practices of the Patriarchs. The Mishnah in *Kiddushin* (4:14) states, "We find that Abraham our patriarch observed the entire Torah even before it was revealed" (see also BT *Yoma* 28b). Rashi (R. Shlomo Yitzchaki, d. 1105) suggests that

4. Ironically, the Talmud recounts a narrative in which the prophet Zechariah guides the sages to remove mankind's evil inclination, initially for idolatry and subsequently for sexual drive. While successful at face value, this subjugation results in the suppression of all procreation, indicating the ultimate failure and imperfection of this endeavor to change human nature (BT *Sanhedrin* 64a).
5. Twersky, *Introduction to the Code of Maimonides*, p. 390.

Lot, Abraham's nephew, observed the obligation of eating matzah on Passover (commentary on Gen. 19:3, Gen. 32:5). Without addressing the logical inconsistencies and practical challenges of observation of the commandments in pre-revelation time periods, these Rabbinic sentiments highlight a desire to establish a perfect immutable Biblical law that would accompany immutable natural law.

Divine providence, however, appears to demand continuous, fundamental changes in natural law which therefore strain a scientifically compatible and logically consistent theology. Experientially, scientific laws are predictive; therefore, how can there be room for Divine miracles that violate observed, predictive laws of physics? If natural law is perfect and immutable, how could God intervene and affect change?

While the pursuit of rational belief requires balancing scientific empirical reality and the emotion of spirituality and tradition, these principles are not inherently contradictory. A rational believer should not be asked to abandon her sense of logic and science. Like any religion, Judaism mandates certain principles of faith, such as providence, that are beyond the scope of scientific proof, but Judaism does not require an acceptance of realities that are logically inconsistent or are in direct contradiction to scientific laws. At a minimum, the rational believer should strive to find an approach of reconciliation. More impactfully, science provides a framework for developing and expanding rational belief.

Absent such an illuminating path, the rational believer might otherwise be tempted to pursue an intellectually safer theology. She might champion the seemingly logical assumption that miraculous, Divine providence would violate the perfect predictability of physical law and thereby its possibility would even challenge God's perfection. Reluctantly, she might relegate the role of God to an abstract concept rather than an interactive presence in the world of mankind.

Without incontrovertible proof of Divine interaction, which would always remain elusive, God's presence could be construed purely as a paradigm by which one is obligated to be guided and with which one is required to connect through the acquisition of knowledge. Her devoted pursuit of Divine knowledge would follow the injunction of

bekhol derakhekha da'eihu, "in all your endeavors you should know Him" (Prov. 3:6). This pursuit could still be undertaken without belief in interaction. She could maintain fidelity to the strict performance of all Biblical and Rabbinic commandments, as well as to the observance of a general ethical code, and thereby might still successfully feel closeness with a non-intervening God.

However, this approach would still preclude a relationship with a personal God. The rational believer would struggle with reconciling this path with a tradition that embraces miraculous Divine providence,[6] and it would negate countless explicit Biblical examples[7] of the bi-directional relationship between mankind and God (*Guide* 3:17). Accordingly, a rational believer is left with a tension between the desire, need, and precedent for a responsive and interactive God and the conflicting belief that such miraculous interaction might not be scientifically compatible nor logically consistent with Divine perfection.

Although this apparent conflict between objective scientific thought and Divine personal intervention manifests itself throughout many aspects of theology, it is perhaps most clearly present in the context of prayer. Here, the tension is not merely academic but rather determines the practical parameters of prayer. Specifically, does rational belief limit prayer to an objective endeavor that does not allow

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6. Nachmanides, in his commentary on Exod. 20:2 (the first of the Ten Commandments), explains that God refers to Himself as "the Lord who took Israel out from Egyptian slavery" to emphasize that the foundation of all belief and acceptance of God's Law hinges on the recognition that freedom from Egypt occurred with Divine providence, "*be-hashgachah mimeno yatzu*." For a discussion of this commentary, see, e.g., H. Lookstein, *Tefillin and God's Kingship*, Tradition 4, 66–78 (1961).

7. Anecdotal examples such as God's relationship with Abraham, Isaac, and Jacob as well as legal/ethical examples such as the prohibition against oppressing the poor ("If he [the oppressed] cries out to Me, I will hear, for I am merciful," Exod. 22:26) are direct Biblical illustrations of the numerous examples of God's responding to an individual's plea. Although, philosophically, one is free to interpret these verses metaphorically, religiously it is difficult if not impossible to reconcile such readings with millennia of Rabbinic teachings.

for petitionary supplication whether for global or personal requests?[8] Is the point of prayer simply to heighten awareness of God's greatness through a meditative power and induce humility and gratitude for His presence? Or is it possible to find a scientifically compatible and logically consistent perspective and still pray for Divine intervention within the very same scientific laws that are harmonious with one's belief?

These questions can be addressed by challenging the premise that all events are bound by the causality of experiential physical law. While according to classical physics causality is sacrosanct, quantum mechanics demonstrates that a universe bound by natural law does not have definite, predictable causality. Quantum mechanics thereby provides analogies that are useful in thinking differently about Divine providence and corresponding prayer while maintaining a logically self-consistent theology of Divine perfection. The theological ramifications of quantum theory reveal themselves, since God is thereby able to operate *within* the laws of physics (rather than *suspend* the laws of physics), while also maintaining a providential relationship with the individual. Within the context of quantum mechanics, the lightest touch of Divine observation is sufficient to affect change.

8. Y. Leibowitz, *Judaism, Human Values, and the Jewish State* (Cambridge: Harvard Univ., 1992); Y. Leibowitz, *The Spiritual and Religious Meaning of Victory and Might*, Tradition **10** (1969): 5–11.