Tenacce and Salito sat in the room that Frank DeAngelo had called the recreation room except that there was little recreation to be had: no television, no pool table; just a couch, a few chairs—only one of which was comfortable—the card table and that well-worn deck of cards. Tenacce began dealing but stopped short.

“I’m startin’ ta get a little worried about the kid.”

Salito nodded. “Me, too.”

“I mean, he’s been locked up in that room for three days now.”

“That seems ta be the way he works, though. He did the same thing in France.”

“I’m also startin’ ta get a little antsy ta find out what’s in that book.” Tenacce shifted restlessly in his seat. “And I have ta tell ya, it concerns me more than a little that he won’t tell me what he’s gonna do with it.” As he spoke, he fingered his pistol, which he had continued to keep holstered against his left ribcage despite their seclusion.

“So what are you gonna do? Shoot ‘im?”

Tenacce suddenly realized where his right hand was. “I might,” he said.

A look of panic poured over Salito’s countenance.

“Relax. You know it’s just my nervous habit.”

“But you’re right. If it says what we don’t want it to ….”

“We’re gonna have ta do somethin’.”

Tenacce’s right hand began to move reflexively again but he caught it before it left his side.

“I think we should go check on ‘im,” said Salito.

“The worst he can do is tell us ta go away.”

They leapt up simultaneously. As they approached the door, there was a knock. The door opened and there stood Danny Tenacce, his face white, his eyes glazed as if he had seen a ghost, not from the paucity of food and sleep which he had endured while he was sequestered, but because of what he had learned and what he was about to tell them. He collapsed on the sofa as if at the finish line of a marathon. He sat sprawled, sinking deeply into the soft cushions, arms and legs spread wide and motionless, mouth open but unable to speak. Tenacce and Salito became alarmed and started toward him. His words, however, stopped them both abruptly.

“You were right.”

“Come again,” said Tenacce, startled.

“You were right. Both of you. And McCleary.”

“About what?” Salito inquired.

“About everything.”

Salito moved forward and positioned herself facing Danny on the couch, grasping his left hand instinctively. “You mean about the book?”

“Yes. The book.”

Tenacce pulled a chair close to the two of them and leaned forward at the end of his seat. “So what did it say?”

“It’s a textbook. Of math and physics, mainly.” His words had suddenly become impassive.

Perplexed expressions appeared on the faces of Tenacce and Salito. “And how does that make us right?” Tenacce asked.

“Because he explains everything to her.” Danny’s eyes and his father’s interlocked. “You’d better bring over the leather chair and sit back.”

Tenacce did what was suggested. When his father was settled, Danny Tenacce righted his posture, pulled Salito toward him, and holding her hand tightly, took a deep breath.

“He arrives at the beginning from the end. Simple arithmetic—numbers, addition subtraction, multiplication, division—rigorously proven through number theory. Algebra and geometry, generalized. Calculus and linear algebra. Vectors and tensors. Covariant and contravariant derivatives and Christoffel symbols. Group theory, Lie algebra and topology—the most complex mathematical constructs—at times, drawn out in the sand with sticks; at other times, much to her delight, projected into the air as multicolored holograms; all of it communicated in such a clear, simple manner that a five year-old could understand. Then ‘write it in the way I have taught you,’ he would say. And she would record the information. On the papyrus. With a quill pen. He taught her to make ink. Those were the notes. The final draft came later, when she went to the cave.

“The symbols he uses—for numbers and mathematical operations.” Danny Tenacce waved his hands. “All very different than what we use today. That’s why it took so long. I had to read the text in its entirety to understand the nomenclature.

“With the mathematical foundation laid, he moves on to the physics. But here, the order is more conventional: classical mechanics, electromagnetism and waves; special and general relativity; quantum physics, quantum electrodynamics and quantum chromodynamics; then strings and branes.

“He explains how the physics leads to the chemistry and the chemistry to biology. Then he describes how it all happened.”

Salito regarded him with a mixture of intrigue and apprehension. “You mean how the world was made?”

“Our world and everything else.” His exhaustion had long since passed. Animated by the message and the interest of his audience, he drew in another voluminous breath, as if priming to deliver the entire narrative in a single exhaustive exhalation.

“In the beginning, there was God. And energy. Intense energy. All the energy in the universe in a ball the diameter of a Planck length—1.61619926 × 10-35 meters. 6.3629892 × 10-34 inches. Then he blew it apart, rapidly expanded space and all of the material in it, not just randomly but in a precisely calculated manner such that everything would end up exactly the way that he wanted it to. Fine-tuned the necessary parameters by the manner in which the initial explosion was executed. It was hot in that little ball before it exploded. Extremely hot. But as it expanded and cooled, the result would be the utopian state that was the reason for his creation. At least that was the plan. But for the plan to work, he needed some help.”

“Help,” Tenacce exclaimed. “He’s God. Why does he need help?”

“Maybe help wasn’t the best choice of words,” said Danny. “Let me explain. For every matter particle in nature, there’s an antiparticle, a particle that possesses the same mass but other properties that are precisely the opposite of its partner. The electron, with its electrical charge of -1, is paired with its antiparticle, the positron, a particle with the same mass but with a charge of +1. Quarks have antiquarks. Neutrinos have antineutrinos. Muons, antimuons, and so forth. And for the plan to work, the particles and antiparticles had to be separated. He entrusted this task to his highest archangel, Satan, a being endowed with mind and will and energy like Himself. But as you know, once empowered, Satan sought to annex God’s prize creation for himself. To do this, he interjected a few quanta of energy, in just the right way, near the beginning, in an attempt to steer the clump of energy, that was to become the earth and mankind and its supporting structures, to himself. Of course, God recognized it within a few Planck times but the damage was done.

“It’s just chaos theory. Just as McCleary described it. You start with a system in a given state—call it O. You establish a set of rules that the elements of the system will obey and set the system in motion. At time, t, it will be in state P. Obviously, if you start with a different set of conditions, set it in motion in a different way or alter the system as it evolves, you’ll end up with a state—call it R—that almost certainly differs from P. The earlier you make the alteration, or the longer you wait, the farther from state P your system, R, will wind up. In our world, a subset of that difference equates to things like hurricanes and earthquakes; pain, disease and death; and human behavior detrimental to the plan—in short, evil.

“Once God discovered the plot, he infused quanta of his own, into the system, and continues to infuse them, in an attempt to get things back as close as possible to perfection. But because of what was done to displace God’s original trajectory, state P—that originally intended state of perfection—can never be obtained. At least not completely.

“Fortunately, God possesses an exponentially greater store of energy available to alter the course of chaos than does his foe. Inevitably, Satan’s energy store will become depleted and he will cease to exist. Realizing this, Satan’s sole purpose became, and remains, to disrupt the plan of the Creator in the most sinister ways possible.”

“By throwing in more quanta, I guess. Knock things further off course.” conjectured Salito.

“Correct. But there’s another piece. Satan developed a mechanism to replenish his dwindling store of energy. You see,” he looked at Salito, “as you pointed out previously, the main means by which God redirects the trajectory is through humans. He gives us a soul. The soul interacts with the brain. The brain is part of the body which is part of the physical universe. The body’s just an inanimate machine. It’s the soul that makes it animate, allows us to actually have experiences. The original design was for all the experiences to be good. Euphoric actually. Pleasure in its purest form. We all know that Satan took care of that. But the soul has another role: to influence human behavior in a way that moves the course of chaos back toward its original goal. Of course, altering the physical world requires energy. God endows the soul with the energy to accomplish this task. But once that energy enters the physical world, it’s up for grabs. If it’s used in the way God intended, when the physical life of the person ends, the energy goes back to God. If not—well—you know where it goes. And Satan uses that energy for his machinations.”

Salito released her grip on Danny’s hands and faced him squarely. “But he’s God. Why doesn’t he just … fix it. Force things back on track.” She appeared annoyed.

“Well … Because. It’s not that easy. Not easy? It’s impossible, actually. He’s got an adversary. A formidable one. Do you have any idea how many alternate universes he had to pinch off just to get to the point we are today? That’s why it took so long. I mean, it’s akin to a miracle that we’ve gotten this close. And it’s ongoing. Both of them firing in quanta. Jockeying for position. The cosmic battle of good versus evil …” He felt her silence and the touch of her hand on his again. He looked up and saw her smiling.

“I see you’re finally catching on,” she said.

Danny Tenacce grinned in admiration. “Now I see why you’re such a good detective.”

Tenacce leaned back and issued the same sardonic half-grin that appeared on his face when he was about to question a suspect who he knew was guilty. “Is this stuff for real? I mean, you’re makin’ this up, right?”

Danny shook his head.

“You mean scientists have discovered evidence that this stuff is actually happenin’?”

“They have, but they don’t recognize it for what it is. Oh, they’ve described most of the phenomena all right; defined all the laws such that results of events can be predicted with great precision—at least to the limits of their knowledge. But they have no idea *why* these things are the way they are.

“Like what?”

“Quantum physics mainly. According to quantum physics, empty space is not empty. The so-called vacuum is roiling with activity. Particles, also known as quanta, are constantly being created and destroyed. Everywhere. In pairs. To keep the total amount of mass/energy in the universe constant. A particle comes into existence, then an antiparticle pops up, combines with it, and poof, they annihilate each other. An antiparticle gets thrown in, a particle is created almost immediately thereafter. It combines with the antiparticle and then they’re gone. Physicists have puzzled over how something can be made out of nothing, puzzled over it with no answer until they finally threw their hands up and said, ‘That’s just the way it is.’ But you know where the particles and antiparticles are coming from.”

Tenacce and Salito nodded that they did.

“Then there’s superimposition of states. Common sense tells you that you should be able to predict at what location you’ll find a particle at all times. However, quantum mechanics and experiments have suggested that this is not the case. If you measure a particle’s location, you’ll find it all right. It’s just that you can’t predict exactly where you’ll find the particle before you make your measurement. Instead, you can only specify a probability of finding a particle at a given location. And it could conceivably be found anywhere in the universe.

“For example, if you’re measuring the location of an electron in a laboratory in Los Angeles, most likely, you’ll find it in that laboratory, within about an angstrom radius. But there’s a tiny chance that you might find it in Chicago or New York or on Alpha Centauri.

“A thing called the wave function contains the information that specifies these probabilities. A probability amplitude is associated with each point in space. If you square that probability amplitude (i.e. multiply it together with itself—with its complex conjugate actually; they’re complex numbers, but that’s beyond the scope of this discussion), you get the probability of finding the particle at that point in space. It’s as if the particle is located everywhere at once. That’s all before measurement. Once you measure the particle, its location is known with one hundred percent certainty.”

“Kinda like the tree falling down in the forest thing,” said Tenacce.

“Exactly like it,” Danny replied. “It’s as if the particle isn’t real (that is, has no definite position—or momentum) unless you measure it. But did the measurement somehow cause the particle to settle into one place? Or are wave functions just mathematical tools to predict the results of experiments? Physicists have puzzled over these questions for decades. The explanation given by the Copenhagen interpretation of quantum physics, the most widely accepted interpretation, is *that’s just the way it is*. But we know why this is so.

“It’s because of 1) the way God put things in motion in the beginning, and 2) the alterations made to that initial trajectory by infusion of quanta into the system by God and Satan since then. Let’s face it, if God and the devil have the power to create and annihilate particles at will, then they can annihilate an electron with a positron in your LA lab and create an electron on Alpha Centauri. It would look just like your electron was everywhere before your measurement but your measurement somehow caused it to appear in Alpha Centauri. And the energy balance of the universe would remain the same before and after the manipulation. An alternative scenario is that the wave function of the entire universe, which has evolved deterministically according to the Schrodinger equation since the beginning of time and includes all the electrons in the universe *and* your measuring apparatus, is such that an electron was destined, from the beginning, to be present in Alpha Centauri and not in your LA lab at the time of your measurement. Again, it would be like the electron suddenly disappeared from your LA lab and reappeared in Alpha Centauri because of measurement.

“A gentleman named Bohm probably came closest to understanding it. He said that, like in classical physics, the universe is made of particles with a definite position at all times. And like in classical physics, each particle also has a definite velocity (that is, speed and direction of motion.) The difference is that, in Bohmian mechanics, the velocity is determined by the wave function. The same wave function that I described for you a few minutes ago. Bohm conceived of a thing called the quantum potential, a potential energy field determined by that wave function. The quantum potential creates a (nonlocal) force on particles that changes their velocities and guides them to where they’re supposed to go. Because the quantum potential is determined by the wave function, and its information content is therefore the same as the wave function, the behavior of particles reproduce the same experimental results as predicted by standard quantum mechanics.”

“Whatda ya mean ‘nonlocal’?” Tenacce inquired.

“I mean the force doesn’t have to ‘come in contact with’ the thing it’s acting on to influence it. For example, suppose you have a particle on earth and a particle on Alpha Centauri. Now picture a cloud of energy hovering over (but outside) the universe that creates a force that changes the velocity of both particles simultaneously. That force would be considered nonlocal. Does that help?”

Tenacce and Salito nodded that it did.

“Now back to the wave function. The wave function is governed by an equation called the Schrodinger equation. In the Schrodinger equation, the state of a system is determined by the preceding state and a thing called the Hamiltonian, which in the Schrodinger’s view, is constant. So the state of a system evolves deterministically in time, from the state that came before. And before that and before that. All the way to the initial state, at the beginning of time. You’d think that, if everything was determined, you ought to be able to predict the results of a given experiment, but you can’t. The reason is that the configuration of particles at the beginning of time was determined by a wave function such that their positions were indeterminate. Since you can’t know the position of particles at the beginning, you can’t determine their positions with certainty at later times either, later times to include times when experiments are done.

“Note that the etiologies of quantum randomness in Bohemian mechanics and the scenario described in the book differ. In Bohemian mechanics, as I just said, the etiology for that randomness is the unknowable initial random position distribution of particles. On the other hand, in the scenario described in the book, both the initial push by God that set the universe in motion and the initial configuration of particles are definite. What causes randomness in this scenario is the infusion of quanta into the system thereafter—brought about by God, Satan and that little piece of himself God gives to humans—an infusion spurred by free will, and therefore, not predictable.”

“So this Bohm is some kinda Grand Poohbah of physics or somethin’?” Tenacce waved his thick paws in the air in nebulous fashion for emphasis.

“Was. And no, he wasn’t. He got run out of the country by McCarthy for being a communist and not many physicists believe his theory has much merit.”

Tenacce raised his surprised brows, the hairs at their upper margins curling slightly with animosity at the mention of communism.

“I didn’t think much of his theory either. Until a few hours ago. But then *he* predicted it.”

Tenacce lifted himself upward with a grunt. “Who?”

“The author of the book. He tells her, ‘there will be one who finds the answer but will not know what he has found.’ Although he doesn’t give us a name, I think he may have been speaking of Bohm.

“So is that it? Tenacce inquired hopefully.

“Not by a long shot,” Danny Tenacce replied.

“What else is there?”

“Let’s start with what famed physicist Richard Feynman called ‘the only mystery’ in quantum mechanics: the double slit experiment.

“Fire bullets from a machine gun at a wall with two thin slits in it, one on the right called slit A and one on the left called slit B. Put another wall behind the slitted wall to serve as a detector. When a bullet hits the back wall it makes a dent to show you where it hit. Now close the left slit, leaving only the right open and shoot the machine gun. What happens? Well, it depends on how big the slits are, how close they are together and how far away the backstop is. But let’s suppose your slits are just a little wider than the diameter of your bullets, the slits aren’t too close together and the backstop is not too far away. What you get is a band of dents on the detection wall behind the right-hand slit. Cover the right hand slit and fire the gun and you get a row of dents behind the left-hand slit. Now open both slits and fire the gun. What do you get?”

“Two rows o’ dents, one behind each slit,” offered Tenacce.

“Correct,” said Danny. “Now do the same experiment with a light source that fires light particles or photons (or quanta, as they’re also called.) Put a white screen that can detect the photons behind the wall with the slits in it. If a photon hits the detection screen, it leaves a black mark. Now close the left slit, leaving only the right open and shine the light. What happens? As you might expect, you get a band of black on the detection screen behind the right-hand slit. Cover the right hand slit and shine the light and you get a band of black behind the left-hand slit. Now open both slits and shine the light. What do you get?”

Tenacce was quick to answer. “Two bands, one behind each slit.”

Danny made a sound like a game show buzzer. Tenacce scowled.

“What you get,” Danny said, “is what’s called an interference pattern: black bands alternating with white bands, the darkest black band being at the center of the detection screen, between slit A and B, the dark bands getting lighter and lighter the farther you get away from the center.”

“How does that come about, smart guy?” Tenacce snarled.

“Standard quantum mechanics teaching says that the light consists of waves that go through both slits simultaneously. The waves add up. Where the peaks add together, you get a wave with twice the amplitude of the individual waves and you get a black band. Where a peak from a wave traveling through one slit meets a trough coming from the other, the waves add up to zero amplitude and you get a white band.”

Tenacce and Salito seemed to comprehend this so Danny continued.

“Now change out your light source to a laser that can fire in one photon—one quantum—of light at a time and repeat the experiment. You close slit B and fire photons from the laser, one-by-one. You check your detector screen, and as expected, you see black blips appearing on your screen, most of them behind slit A. If you fire in enough of them, what you find is that they create a band of black behind slit A which tapers off in intensity as one moves away from the center of maximum intensity, just like you would if you shined a light and sent in billions of photons at once. If you close slit A and fire photons one-by-one, the same thing happens except the black mound you get has it’s maximum directly behind slit B. Now open both slits and fire photons one at a time. What do you get?

“You get the band thing,” responded Tenacce, eager to redeem himself.

Salito issued an impish grin. “Some of us call it an interference pattern.”

“That’s correct. The photons hit the detection screen one-by-one. But if you send in enough of them, you get an interference pattern—or the band thing, or whatever you want to call it—just like when you shined the light in a beam, sending in trillions of photons simultaneously.”

“Whoa,” cried Tenacce, making a stop sign his hands. “Ya said ya get the interference pattern because the light acts like waves?”

“That’s right.”

“So how does one o’ these photons, that’s a particle, make an interference pattern, like a wave? And a wave that’s gotta go through both slits at once ta make the interference pattern ta boot.”

“Those are great questions. And two of the greatest mysteries in quantum mechanics. Probably the main mysteries to which Feynman was referring.”

Tenacce shook his head in frustration. “It’s like they can’t make up their mind.”

“Who?”

“The photons.”

“They can’t decide whether they’re particles or waves,” said Salito.

“So which are they?”

“Both. At least they can be, though not at the same time. At least that’s what those who ascribe to the Copenhagen interpretation of quantum mechanics would say. The particles behave like a wave when both slits are open, a situation in which an observer would have no way of knowing which slit the particle goes through. And they behave like particles when only one slit is open, a situation where the particles can only go through one slit and an observer would necessarily know which slit the particles passed through. Some physicists say that’s just the way it is; shut up and calculate is their mantra. Others say that observer knowledge somehow causes the particles to behave one way or the other.”

Salito’s lips curled downward with dissatisfaction. “I don’t get what the observer has ta do with it. How does an observer make anything happen?”

“That’s what bothered Bohm. Bohm’s answer was that he or she (the observer) doesn’t have anything to do with it. You see, to Bohm, all particles have a definite position and each particle of light—each photon—only goes through one slit at a time. It’s the wave function that determines the particles’ velocity, and therefore, where they go. And the velocity of the particles in the brain of the observer as well, a brain that makes him or her cover or not cover a slit. But it’s not the covering or uncovering of a slit that causes the particles to behave in certain way. It’s the wave function of the universe that determines the velocities of the particles being studied and the particles that make up the slit and the particles that make up the observer’s brain and causes them all to behave the way they do; at the time of the measurement and at all other times—a wave function that’s determined by its state immediately before. And the state before that and the state before that, all the way back to the beginning of time. At least—according to renowned physicist John Bell—that’s the logical conclusion of Bohm’s theory as it was originally expounded. Superdeterminism is what Bell called it. (I’ll confuse you with his work in just a bit.)

“In contrast, later in his career, Bohm conceived of what he termed the implicate and explicate orders. The concepts are a bit nebulous but the implicate order is said to be a higher dimensional, deeper, more fundamental order that is unknowable to humans, an undivided whole that incorporates the wave function of the universe. The explicate order is basically the world in which we live. The implicate order is said to be enfolded and unfolds to give rise to the explicate order. The explicate order, in turn, enfolds back into the implicate order. And this movement, which Bohm calls the holomovement, takes place constantly and rapidly—perhaps at sub Planck times—at a subquantum level, the quantum mechanics with which we are familiar being but a limiting case of the holomovement just as classical physics is a limiting case of quantum mechanics and relativity. According to this theory, then, one might say that opening or closing the slits are events that occur in the explicate order. Which then enfold back into the implicate order. Which changes the wave function of the universe. Which unfolds again to determine the velocities of the particles. Which determine where the particles go. Which determine what kind of pattern the particles make on the screen.”

Danny inhaled and exhaled deeply to recover from the state of end expiratory exasperation in which his concatenated explanation had left him.

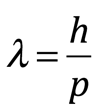
“Next question,” said Salito quickly. “Why don’t the bullets make the interference pattern?”

“Because particles—even macroscopic particles like bullets—aren’t exactly … particles.”

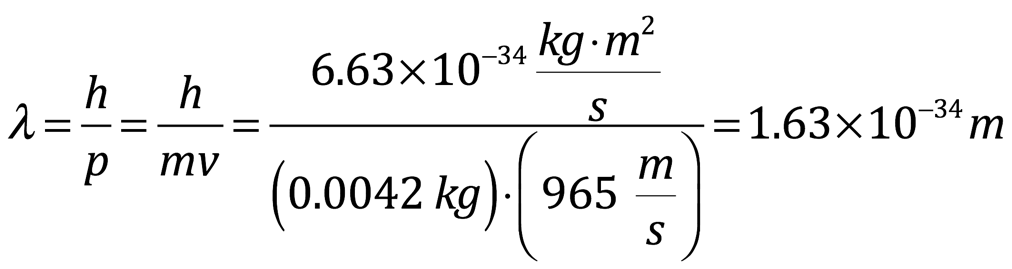
“What are they then?”

“They’re waves.”

“When I see a ball, I see a ball. I don’t see no wave.”

“That’s because the wavelength of the ball—and other macroscopic objects—is so small that you can’t see its wave behavior. Or detect it by any means. A physicist named de Broglie figured it out in 1927. The equation that he derived was  where  is the wavelength of the object,  is Planck’s constant and  is the momentum of the particle which is equal to the particle’s mass times its velocity.

“Say our bullets are 22 caliber, have a mass of 4.2 grams and have a speed of 965 meters per second. That means that the wavelength of one of our bullets is



“So that means that the separation between black bands on the screen is 1.63 x 10-34 meters. Obviously, there’s no way that you could see this separation. Or resolve it in any other way. The wave functions of all of the particles of lead in a bullet add up to make one large spike of probability amplitude that’s concentrated over an approximately 5.6 millimeter area and tiny side lobes to the function that create an interference pattern whose peaks are too close together, and of too small an amplitude, to detect. So the bullets appear to be in just one place and behave as such when subjected to the double slit experiment.

“It turns out that electrons, other atomic and subatomic particles, and everything else are actually waves. The reason that tiny things like electrons look like particles is because they’re really wave packets, blip-like waves of probability amplitude sharply localized in space with side lobes extending throughout the rest of space such that their probability amplitudes are effectively zero except at the site of the blip. And as I just told you, the reason that macroscopic objects appear localized is because their wavelengths are so short.”

“So I’m guessing’ from that smirk on your face that it gets worse,” said Tenacce.

“Considerably,” Danny replied.

“Next put a tiny device at slit A that can determine whether or not a photon passes through that slit. Open both slits and fire the photons at the wall one-by-one. What happens?”

“Ya get the band thing,” Tenacce shouted before Salito could react.

“Aaarrrnnnt,” Danny buzzed. “You get one band behind each slit, just like you would if you opened one slit at a time.

Tenacce threw up his hands in disgust as if he had lost another game of Pokemon on his cellphone. “How’s that?”

“That’s the million-dollar question. You know the kinds of things that traditional quantum physicists would say. Some would say that that’s just the way it is. Others would say that knowledge of the path of the particles by the observer, given to the observer by the detector behind the left-hand slit, causes the particles to behave like particles while the observer’s lack of knowledge about the particles’ path that occurs when the detector behind the left-hand slit is left open, causes the particles to behave in a wave-like fashion.

“On the other hand, Bohm—at least the early Bohm—would say that the wave function of the universe, which has evolved deterministically since the beginning of time, determines the velocity of the particles being studied, and the particles that make up the slit, and the particles that make up the observers brain, and the particles that make up the detector behind the left-hand slit and causes them to behave like they do, at the time of the measurement and at all other times. The later Bohm would have said that the details of the experimental setup are features of the explicate order that enfold and feed back onto the implicate order, causing a change in the waveform of the universe. Which unfolds and determines the velocities of the particles. Which determine the paths taken by the particles. Which determine the pattern seen on the screen.”

Danny could see that Tenacce and Salito were troubled by this and were about to start at him. He cut them off before they could. “Then there’s entanglement,” he said.

“Let’s look at a photon, a particle of light. It’s electromagnetic energy and consists of an electrical field and a magnetic field. The light wave is moving (or propagating) in what I’ll call the z-direction. The strength (or amplitude) of the electric field wavers back and forth regularly (that is, oscillates) in a plane perpendicular to the direction of propagation, call it the x-z plane. The amplitude of the magnetic field oscillates in what I’ll call the y-z plane. The electric and magnetic fields always oscillate in directions perpendicular to each other and the direction of motion of the photon is always perpendicular to the direction of oscillation of the electric and magnetic fields. According to the conventions I’ve laid out, if the electric field oscillates in the x-z plane, we say that the photon’s plane of polarization is at 0°. Or, another way of saying it is that the photon is polarized in the zero degree direction. Now suppose we rotate the plane of polarization clockwise such that the new plane of polarization makes a 45° angle with the x-z plane. The angle of polarization of the light is now said to be 45°. Rotate the polarization plane 90° and the angle of polarization is 90°; Rotate it 123° and the angle of polarization is 123°, and so forth.

“There are devices called polarization filters that function as follows: they will let a photon through 100% of the time if it is polarized at the angle at which the device is set; it will block the photon 100% of the time if it is set at an angle 90 degrees different from the angle at which the photon is polarized; and it will let the photon through some but not all of the time, if the angle of polarization differs from the filter’s setting by some angle other than 90 degrees, the probability of it getting through being a function of the angle of difference. Individual photons will either get through or not get through but if you send in enough photons, then the percentage that get through will be the same as the probability of an individual photon getting through. And one more thing: once a photon passes through a filter, it assumes the polarization angle at which the filter was set. That is, a photon that’s polarized at 45° before it reaches a 90° filter will emerge from the filter polarized at 90°, if it passes through. In the vernacular of standard quantum mechanics, the interaction with the filter (which essentially constitutes a measurement, if we care to look) causes collapse of the photon’s wave function to 90°.

“Now photons can be split into what are called entangled pairs. The details of how this is done are not important. What’s important is how the entangled pairs behave. Say you create the pair in a lab in Chicago and send each member of the pair off in opposite directions, one to LA and the other to New York. You put a filter in the path of each photon in both the LA and New York laboratories, and just behind each filter, you put a detector. If the photon gets through the filter, it will register on the detector. Set the filters in both laboratories to 0°. Check to see if the photon got through in each lab simultaneously. Do this over and over again for many photons. If all of the photon get through and register on the detector in one lab, then all will get through and register on the detector in the other lab. If no photons get through in the lab on the east coast, then they won’t get through in the lab on the west coast either. Now set the filters to another angle but make sure it’s the same in both labs and check the detectors. The same thing happens; if all of the photon gets through in one lab, they’ll also all get through in the other, and visa versa.”

“That’s easy enough ta explain,” said Salito. “When the photons get entangled, they get sent off with some kinda program about how they’re gonna act when they get measured in a certain way.”

“That’s kind of what Einstein—and Podolsky and Rosen—said. But what happens if you set the filters in each lab to different values?”

“Hmm.” Salito regarded him with uncertainty.

“Why don’t ya tell us, Professa,” Tenacce cracked.

Do you want the long version or the short version?”

“The short version,” Tenacce and Salito said together.

“Ok then. Well, let’s say that you create entangled particles in your lab in Chicago and send them to your labs in LA and New York. In each of the LA and New York labs, you randomly and independently choose at what angle you’re going to set your filter. For simplicity, your choices of filter settings are limited to 0°, 120° and 240°. You fire off lots of entangled pairs and check to see what percentage of the time that the results in each laboratory agree; that is, what percentage of the time the photons either pass through the filter in both labs or don’t pass through the filter in both labs. You throw out the results if both labs randomly decide to set their filters to the same angle because you already know that the results will agree in both labs.” Danny nodded toward Salito. “If, as you and Einstein believe, the photons somehow communicate to each other, at the time of entanglement, how they will behave under various measurement conditions, measurements in each laboratory should agree one-third (or 33 percent) of the time. If quantum mechanics is correct, then measurements should agree only one-fourth (or 25 percent) of the time.”

“How’d ya come up with that?” Tenacce snarled.

Danny shrugged his shoulders, “That’s just the way it is.”

Both Salito and Tenacce were clearly left cold.

“You said you wanted the short version.”

Salito and Tenacce recalled that they did. “So have experiments been done ta test these possibilities?” Salito asked.

“Yes,” said Danny.

“So which is it?” Tenacce inquired with annoyance.

“Which is what?

“33 or 25 percent? Which one did they find?” Tenacce pursued.

“Neither.

“Neither!”

“Whatta ya mean neither?”

“I mean that, to my knowledge, the experiment that I’ve outlined hasn’t been done.”

Danny waited until they were about to accost him before he resumed. “But experiments have been done that test Bell’s theorem, the underlying theorem that our hypothetical experiment also seeks to test. The fundamental concept is the same. It’s just the details that are different, for practical/technical reasons.”

“And what do these experiments show?” Salito asked.

“They confirm the predictions of quantum mechanics … and I’m confident that if the experiment that I’ve outlined were actually to be performed, the percentage of times measurements would agree in the LA and New York labs would be twenty-five percent, not thirty-three and a third.”

Tenacce and Salito considered the information for a moment.

“I still don’t understand how this happens,” said Salito.

“Ditto,” said Tenacce.

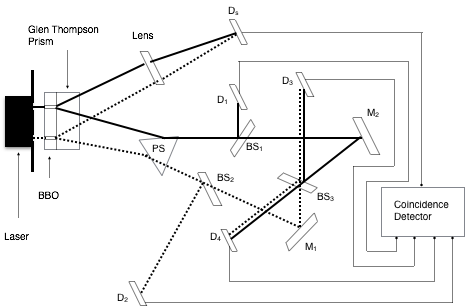
“The explanation according to standard quantum mechanics,” Danny replied, “is that the state of polarization of entangled particles is indeterminate. That is, until they’re measured. Then both photons instantaneously become polarized at the same angle.”

Salito thought out loud. “But how is that? I mean, it can’t be that one photon sends a signal ta the other cause you’re measuring both photons at the same time and the signal can’t go faster than the speed of light.”

Danny had long since ceased being surprised by her keenness. “No, it can’t. The standard interpretation is that, once the photons become entangled, their wave function becomes a combined wave function such that their polarizations are correlated. How this correlation comes about is obscure. That’s just the way it is. Shut up and calculate, remember? The Bohmian explanation is that the wave function of the system under consideration is the wave function of the universe, a wave function that incorporates the state of both photons and the experimental apparatus in both labs and the state of everything else, for that matter. And this wave function—whether it came to be in a predetermined fashion from the beginning of time or through the enfolding and unfolding of the implicate and explicate orders—causes the photons to move in such a way that the observed experimental results occur.”

“That’s weird,” Salito commented.

“It gets weirder. The granddaddy of quantum weirdness,” said Danny, “is the delayed choice quantum eraser experiment.” He pulled a whiteboard to where Tenacce and Salito sat and drew a diagram that was a rough likeness of this:



“You start with an argon laser and you fire single 351 nanometer wavelength photons at a double-slit screen. The photons go through both slits through a nonlinear beta barium borate crystal (BBO) which creates pairs of entangled photons each with half the energy (i.e. twice the wavelength, 702.2 nanometers) as the original photon. The possible paths of photons traveling through the upper slit are coded by solid heavy black lines; those traveling through the lower slit are coded with dotted lines. Each pair of entangled photons are then deflected by a Glen-Thompson prism either upward to detector  or downward to another prism, PS. At prism PS, the upper photons (depicted with a solid black line) will be directed to a beam splitter, , and the lower photons (depicted with a dotted line) will be directed to a second beam splitter, . Photons that go to detector  are called signal photons; those that go to PS are called idler photons.

“At , half of the photons, originally from the upper (solid black line) source, will be deflected upward to detector  while the other half will pass through to mirror . Similarly, at , half of the photons, originally from the lower (dotted line) source, will be deflected downward to detector  while the other half will pass through to mirror .

“If only detector  were present (no prism PS), then signal photons from upper (solid line) and lower (dotted line) slits would hit the  detector and an interference pattern would be created. However, with all the other elements in place, a single, wide band appears on . Why? I’ll delve into that later.

“Consider, first, what patterns emerge at detectors  and . If an idler photon hits , there’s only one way it could have gotten there—from the upper slit, along the solid black path. Likewise, if an idler photon hits , there’s only one way it could have gotten there—from the lower slit, along the dotted path. So single, narrow bands are seen on detectors  and . Note that if a photon hits one of these detectors, it imparts specific information about which path the photon took, to an observer (i.e., the experimenter). And because it’s entangled with its corresponding signal photon, as we’ll see, it influences the behavior of the signal photon.

“Next consider what happens if an idler photon passes through prism PS. Well, whether they follow the solid black path or dotted path, they get reflected off of mirrors and end up at a third beam splitter, . If a photon enters  from the solid black path, it can either pass through to detector  or be deflected to . If it enters  from the dotted path, it can either be deflected to detector  or pass through to . Either way, photons hitting detectors  and  can get to that detector either along the solid pathway or the dotted pathway. Because there’s no way to tell from which slit a photon hitting detectors  and  came, an interference pattern builds up on both of these detectors.

“Because entangled photon pairs are emitted at the same time, you can correlate the behavior of photons that hit  with photons that hit detector , ,  or  at about the same time. You can do this with a coincidence detector, which works as follows: when a photon hits a detector, it sends an electronic signal over a wire to the coincidence detector. If photons hit detectors  and  in close temporal proximity, the coincidence detector plots the position where the photon hit the  detector, onto a graph called . If  and  register hits on the coincidence detector close together in time, then the  position is plotted on a graph called . Similarly, near simultaneous coincidence registration from  and  plot the position of the corresponding  hit onto graphs labeled  and , respectively. This is how the experimental setup teases out the possible relationships between the behavior of signal photons and the behavior of the various types of idler photons from the otherwise amorphous blob of signal I said was found on the  detector.

“And what do we find after this analysis is performed? We find that the  and  graphs show single peaks and the  and  graphs show interference patterns.  and  show single peaks because, as I alluded to just a minute ago, if the idler photon hits either or  (to help create the  and  maps) then an observer analyzing the data knows exactly which path the photon followed. This is tantamount to the experimenter observing the photon. Some physicists have suggested that the reason that the wave function collapses and a classical pattern (instead of an interference pattern) appears on a detector in the simple double slit experiment is because the act of observation somehow disturbs the photon. From this experiment, though, it’s clear that this can’t be the case since nothing interacts with the signal photons on their way to the  detector.

“What about  and ? Well, activation of the  and  detectors in close temporal proximity to  activation is what makes the  and  maps. Because both upper photons (that follow the solid black path) and lower photons (that follow the dotted black path) contribute to the interference pattern seen at  and , and the experimenter (observer) doesn’t know which path the photons took to get to those detectors, just like in the simple double slit experiment without an observer, an interference pattern is seen at . It seems, then, that the thing that determines what pattern the photons make on the  detector is whether or not the experimenter (observer) has knowledge of which path entangled idler photons take.”

Joe Tenacce thrusted his torso upright in arthritic discomfort, making a “T” with his hands before Danny could utter another word. “Hold on,” he said. “It looks like, from your picture, that the distance that the freons—”

“Photons, Lieutenant. Don’t pretend you don’t know what they are.”

“OK, photons,” Tenacce conceded. “The picture looks like the distances the photons travel ta , ,  and  are all longer than the distance ta . Is that right?”

“That’s right,” Danny confirmed.

“And since they’re all light, they all move at the same speed—the speed o’ light—correct?”

“Correct.”

“So the photons that go ta , ,  and  and get there after the tangled up photon has already hit the detector at , right? I mean, it’s gotta be true since they gotta travel a longer distance goin’ at the same speed.”

“OK.” Danny was smiling now.

“So how the hell does somethin’ that’s already happened get changed by somethin’ that happens later?”

“Answer that question and there’s a million-dollar prize waiting for you in Stockholm.”

Tenacce and Salito stared at the diagram on the whiteboard in silence.

“Physicists that subscribe to the standard interpretation of quantum physics have about as much to say about the cause of the phenomena observed in the delayed choice quantum eraser experiment as you do right now. Their answer is ‘that’s the way it is.’

“On the other hand, early Bohmians would say—and I’m starting to sound like a broken record—that the wave function of the universe, which has evolved deterministically since the beginning of time, determines the velocities of the particles that make up the experimental setup and the photons shot by the laser that become entangled; that these velocities determine the patterns the photons make on the detectors. And therefore, that these patterns were determined long ago. From the very start of the universe.

“Alternatively, according to later Bohmian theory—and I’m sounding like a broken record again—the experimental setup, which is part of the explicate order and was present before the experiment began, enfolds back into the implicate order. The implicate order, where the wave function resides, changes due to the experimental setup. Then the implicate order, that contains this wave function, unfolds and causes the observed pattern on the detectors.”

Tenacce slouched back down in his chair, even lower than he had before, similar to the way he had done in the classroom in his recalcitrant youth. “It seems ta me that this wave-form-o’-the-universe thing is just another way o’ sayin’ ‘that’s just the way it is.’”

“Exactly right. And Bohm made all kinds of attempts to figure out the nature of the wave function. He consorted with Indian gurus, dabbled in panpsychism and the paranormal, looked for the answer everywhere. Everywhere except where it actually was. But then, He predicted that it would happen this way—in the book. Bohm and other physicists—including myself when I was a budding physicist—couldn’t and haven’t been able to determine the essence of the wave function. But you know what it is. It’s simply the result of the way the little ball of energy was set in motion in the beginning and the effects of all of the quanta that have been introduced into, and taken from, the system ever since. Furthermore, Bohm spent the latter part of his life asking himself from where the wave function came. He never found out. But you know the answer to that question, too.”

Tenacce and Salito nodded that they did.

“So I guess,” said Salito after several seconds of contemplation, “what you’ve told us about—this quantum mechanics …” She parted her lips and allowed the words to trickle out cautiously. “It starts to open the door for the possibility that the miracles described in The Bible...”

“Might be true? Yes, leaves the door agape, actually. As I’ve discussed, quantum mechanics admits that a particle—say a molecule of water—can be in one place at one time, and in the next instant, be 100 meters away. The chances are minimal but not zero. So let’s see … if you had a 100 meter wide strip of water, average depth of the Red Sea is 490 meters, that’s a volume of 49,000 meters, times 100 cm per meter equals 4,900,000 cc, equals 4 x 106 cc, times 1 gram per cc, equals 4 x 106 g, divided by 18 grams of water per mole, equals 2.2 x 105 moles of water, times 6.02 x 1023 molecules of water per mole, equals about 1029 water molecules that would have to disappear from one place and reappear 100 yards away all at once. And you’d have to make that happen twice simultaneously to move two walls of water. So standard quantum mechanics would say that it’s not very likely. But standard quantum doesn’t take into account the mechanism of such movement. To be sure, it would take a mindful infusion of a massive number of quantum to accomplish the task, but as you said a few minutes ago: He is God, after all.”

“And the virgin birth?” Tenacce inquired, brows rising.

“That’s much easier. DNA is the genetic material that makes us who we are. It’s stored in the nucleus of every cell as chromosomes. A human being has twenty-three pairs of chromosomes, one pair of which determines gender. An XX pair makes you female. An XY pair makes you male. Egg and sperm cells, also known as gametes, are formed by a process of cell division called meiosis. From a normal cell with 46 chromosomes—23 pairs—meiosis first duplicates the genetic material then splits it into 4 cells, each with 23 chromosomes that are a (seemingly) random combination of genetic material from both the person’s mother and father. In the male, all four become viable sperm. In the female, three become what are called polar bodies and die off. Only one of each set of four becomes a viable ovum.”

“When Mary …”

“You’re talkin’ about the Virgin Mary?” Tenacce’s catholic reverence for the Virgin Mother made him bow a little as he spoke her name.

“Yes. The contribution to Mary’s genome from her mother was a normal set of 23 chromosomes including an X chromosome. However, the paternal gamete that contributed to Mary’s genome failed to undergo meiosis. The initial fertilized ovum that was destined to become Mary contained three sets of chromosomes, a situation referred to as the triploid state. Normally, triploid embryos die before birth. However, in Mary’s case, when the initial fertilized ovum underwent its first division, the maternal chromosomes duplicated themselves but the paternal contribution did not. The division produced two cells: one with maternal and paternal contributions containing XX sex chromosomes, the other with maternal and paternal contributions containing XY sex chromosomes. The cells descending from the cell that contained the XY sex chromosomes migrated to the ovaries and ultimately became gametes (that is, sex cells; eggs). The cells that descended from the cell containing the XX sex chromosomes became the rest of Mary’s body.”

“You said it was simple. Don’t sound so simple ta me,” groused Tenacce.

“Hang on. We’re almost there,” Danny said.

“In Mary’s case, one of her diploid gametes, called a primary oocyte, failed to undergo meiosis, due to a carryover mutation from her father. However, the proteins specified by Mary’s DNA created a milieu that caused it to be picked up by her fallopian tube and behave as if it were a fertilized egg (or zygote), beginning self-multiplication in the tube, migrating to the uterus, implanting itself there and, because of the presence of XY sex chromosomes, developing into a male offspring, a male offspring the least of whose accomplishments was the authoring of the book.”

Tenacce gazed at his son from under his skeptical brows. “I hate ta say it but it all sounds kinda contrived ta me.

“Agreed,” chimed Salito. “I mean, the father’s cell doesn’t undergo meiosis. Then inside the zygote, the maternal chromosomes duplicate but the paternal ones don’t. Then they line up just right so the chromosomes with XX and XY from different parents go to different cells. Then the cell with the XY chromosomes just happen ta migrate to the ovaries. Then everything goes just right and the unfertilized egg gets treated like its fertilized and winds up in a live birth?”

“You shouldn’t be surprised,” Danny replied. “After all, the information in the DNA of a single cell causes it to multiply and insures that the multiplying cells migrate past each other in just the right way, with just the right timing; prompting the right surface receptors to appear on cell surfaces at the right time, stopping cell movement in just the right place; instigating expression of just the right genes at just the right time so that some cells become nerve cells, some become heart muscle cells, some become skeletal muscle cells, others become cells of the GI tract, and they all get put together in just the right way to make a living, breathing human being. This happens about 353,000 times a day.

“It’s like about a gazillion rows of dominos all set up in interlocking rows. Here are the rules: if two rows intersect, and domino 1 gets to the intersection before domino 2, then the dominos in the row containing domino 1 continue to get knocked down past the intersection while the shared domino at the intersection, having been knocked over, stops the process from continuing past the intersection in the row containing domino 2. On the other hand, if both domino 1 and 2 reach the intersection simultaneously, the domino in each respective row past the intersection gets knocked over, continuing the process. The goal of the game is to knock over the domino at the end of a line of dominos that marks the end of the entire domino mass. The only way for that last domino to get toppled is for a few dominos—just the right ones—to be knocked over, with just the right timing, at the beginning of the game. The sequence of DNA in the genome of the zygote is what specifies which dominos—if you will—need to be knocked over, and with what timing, to assure that the process produces a viable offspring.

“But the DNA configuration that led Mary’s father’s primary spermatocyte to forgo meiosis, and the maternal contribution to the zygote that was to become Mary to replicate, and the paternal contribution to that zygote not to replicate, and the chromosomes in the zygote to line up in the right way, et cetera, et cetera—that DNA configuration is part of the universe. And the movement of things that make up the universe is determined by the wave function. And you both know who and what determines the wave function.”

Tenacce and Salito nodded that they did.

“God recognized that the world needed saving, so he threw in a few quanta, in the right place and the right time, in such a way that it was suboptimal for the enemy to stop it, and the result was a savior who was created at the optimal time and in the correct place, to save the world.”

There was a hint of a wince as Tenacce tensed his back muscles and sat up in his seat. “You been talkin’ about DNA, genes and chromosomes and stuff. And ya mentioned evolution. So I’m guessin’ that means that the world wasn’t really created in seven days.”

“It all depends on your definition of days, and time in general.”

“My definition o’ time?” Tenacce was bolt upright now. “Tick, tock. Tick, tock … that’s what I mean. What other kind o’ time is there?”

“Relative time.”

By the expression on his father’s face, Danny knew he had better elaborate.

“The time between each tick and tock varies depending on how fast you’re moving and what masses are present in the vicinity of your motion. Specifically, a clock that’s moving relative to you will appear to be ticking slower than one you have in your hand, the faster the relative motion the slower it will tick. Likewise, time will pass more slowly the nearer you get to a massive body (by that I mean an object having mass). The greater the mass the slower time passes.”

Both Tenacce and Salito appeared confused.

“So are you sayin’ that God’s really heavy?” Salito asked.

“Not exactly. A setup that more closely approximates the actual situation is this:

“We reside on a vesicle in spacetime called a brane. Our brane—call it the weak brane—has 3 dimensions of space, 1 of time and floats in a spacetime sea of 10 dimensions—9 of space and 1 of time (or 10 and 1, depending on how you look at things, but we won’t get into that here). Close to our brane is another 3 +1 brane (3 space and 1 time dimension) separated from us by a fifth spatial dimension. Call it the strong brane. This fifth dimension is very small, on the order of a Planck length which, as I’ve told you, equals approximately 1.6 x 10-35 meters. The particles associated with the weak brane stay on the weak brane and those associated with the strong brane stay on strong brane. The particles within a brane can interact with each other but particles on one brane can’t interact with particles on the other. Gravitons, the particles that transmit the force of gravity, however, are an exception. They can move between, and interact with particles on, both branes.

“Now the strong brane is called strong because it’s massive and it markedly curves spacetime. This means that the strength of gravity drops very sharply—exponentially—as one moves from the strong brane to the weak brane. Gravity is as strong on the strong brane as it would be very close to an enormously massive object—and time would move just as slowly. But because of the marked warping of spacetime, you only have to go about a Planck length before gravity is as weak (and time passes as quickly) as it would at a colossal distance from that enormous mass.

“Suppose God was located on the strong brane (perhaps we should call it the heaven brane) when he created our universe. He would say that the time it took to create us, on the weak brane, was a lot shorter than how long we would say that creation took. It’s not that simple, though. The mass is not distributed equally on the strong brane and the mass amount and distribution change with time. Also, the shape of the strong brane is irregular and changes with time. Furthermore, for an observer on earth, the rate at which time passes changes with the evolution of the universe; early on, when other matter was closer, time passed more slowly than now, when the universe is less dense and varies with the universe’s expansion rate. Thus, the rate of time passage varies with time, both for observers on the earth and on the strong brane. However, when all of these factors are taken into account, because of time dilation, the creation of the universe from the big bang to the dawn of man took six days (and one day of rest). At least from God’s point of view. On the other hand, from our point of view, it took 13.8 billion years.”

Tenacce’s lids and brows opened widely. “Branes and extra dimensions … Do scientists actually believe this sh…”

“Published by two well-respected theoretical physicists from Boston—a woman and a man—just recently. In 1999,” replied Danny nodding.

Salito sat quietly contemplating all that had been said. Tenacce rubbed his five o’clock shadow, gazing through the diagram of the branes. Then he turned his attention back to Danny. There was obvious hesitation as the words came out.

“So all this stuff about evolution. I guess—”

“All true. Not exactly how he planned it when he set everything in motion, because of the antipathetic maneuvering of the evil one. I believe he salvaged it relatively well.”

Tenacce frowned.

Salito seemed less troubled. “I can see how the stepwise creation story resembles evolution,” she said. “But what about the discrepancies? You know, plants and fruit trees before the stars, birds before land animals, Eve from Adam’s rib and stuff like that.”

“Oh it’s true. The woman came from the man’s rib,” said Danny. He strained to keep his expression deadpan.

Salito glared. He grinned.

“Seriously, though. She asked that very question.”

“And what did He tell her?”

“In so many words? Imagine you were God, and you were trying to inspire your follower to transcribe the story of creation for all posterity. The problem is, your follower doesn’t know the first thing about atomic particles, energy, forces and branes. So you tell him about water and land and stars and domes, and he writes it down the way he understands it. He has no idea about DNA or natural selection, so you tell him about the process of evolution, in as familiar terms as possible, but he’s still so confused about what you told him about the water and stars and so forth that he gets a few of the details mixed up. And he can’t count any higher than ten because that’s all the fingers he has, so rather than telling him about general relativity and numbers like 13.8 billion, you talk about seven days instead. And after he writes it all down, you insight a few dreams and visions so he tweaks it a little to make it a little closer to the truth. But when he’s done, you’re pleased with his work, because you know that your typical audience isn’t a young woman with an IQ of greater than 200 from whom your son will expel seven demons, nor is it a bunch of twenty-first century physicists. It’s billions of illiterate and nearly illiterate people over thousands of years plus a large number of additional people with some intelligence and education but who still couldn’t understand a more rigorous explanation if you gave it to them. The creation story is like the rest of the Bible—written such that it conveys the best understanding of the kingdom of God, to the greatest number of people, from the time that man was created until the time that it all ends.”

Tenacce’s eyes widened at this. “Speakin’ o’ the end, did he say how and when it’s gonna happen?”

“When? No. How? Yes.”

“And how is that?”

“How do you think?”

“In a bunch o’ mushroom clouds.”

“More or less.”

“So then there wasn’t any Adam and Eve, I suppose.”

“Oh, there was an Adam and Eve. They were the two God chose to perpetuate the kingdom. Through the natural evolution of the wave function and the modifications he produced in it, by infusing quanta at the proper points in spacetime, he induced genetic mutations that made their brains large and complex enough to carry out the plan he devised for them. To guide them, he spoke to them in visions. He didn’t actually materialize before them. Instead, he infused quanta into their brains, stimulating the correct neurons with the appropriate timing to make them see and hear him.”

“How come God doesn’t do that ta me, or you, or any of us today?” Salito protested.

“If you had a vision of God speaking to you, what would you think?”

“I’d think I was crackin’ up. OK, I see your point.”

“So was there a Garden of Eden and an apple?” Tenacce asked.

“There were both. Through these visions, he led them away from the remainder of their pre-humanoid contemporaries, to the perfect place. They and their progeny were destined to lifetimes of ignorant bliss, all needs cared for in that Garden utopia. God had made them simple creatures designed largely to imbibe the pleasures of their surrounding paradise. But he knew of the apple and his adversary’s plan. In giving them a well-developed neocortex and a small part of himself to modify activity in that neocortex that was contrary to his ends, God gave them the ability to override the natural pleasure-seeking tendencies that he had been forced to embed in their neural machinery for survival. Indeed, he warned them of the danger of that alluring red fruit but—you know the story—Satan, that clever devil, made his play; Adam and Eve succumbed. The apple wasn’t magic; just the vehicle that contained the mutagens that would create, in their offspring, brains that were larger and wired for aggression, gastrointestinal tracts that were incapable of digesting the delicacies that were plentiful in Eden and metabolic pathways that rendered the byproducts of what they could ingest, from the garden, toxic. I was always under the impression that God banished them from the garden to punish them for their disobedience. He didn’t banish them to punish them. He banished them to save them. Not only them, but those that came after them. He banished them to save his creation. And it wasn’t toward them that his anger was directed. It was the enemy. For them, Adam and Eve and their progeny, he had only pity (well, maybe a little anger) because, knowing everything, He knew what was in store for them; what was in store for us.”

Tenacce and Salito pondered what had been said but still eyed Danny with uncertainty.

“It’s just science,” Danny reassured them. “Or religion, whichever you prefer.”

Salito supinated her forearms and hands in a palms-up gesture of perplexity. “So why did he decide ta create the book in the first place? And why did he choose her as the one to tell it to? Why didn’t he tell all this to his disciples.”

“Let me answer the last two questions first. The explanation for why he conveyed all the information in the book to Mary is simple: she was the only one with sufficient intellect to understand it. She was a high-grade genius, and that genius had driven her to madness before he saved her. The ‘seven demons’ from which he extricated her were psychotic delusions and hallucination brought about by her self-reflection and realization of the hopelessness of her condition and that of mankind, in general, at the time before him. But he made it clear that the information in the book was secondary, that the information that was critical was guidance about how to live and a nontechnical description of the kingdom of God that the common man could understand. He also made it clear that the disciples would be the main agents responsible for disseminating his main message and that he had selected them specifically because they had the personal characteristics to make it all happen. One of those characteristics was being male; the opinions and viewpoints of females weren’t very highly regarded at the time.

“As for the second question, one reason that he told her what he did was that he enjoyed it. And he spent a lot of time doing it. As you might guess, such behavior was regarded with suspicion by his disciples. When they asked her what they did together, she told them. They had no clue about any of it and wondered why he would discuss such things, no less with a woman. These sentiments are well documented in the book and in document fragments collected into a gnostic gospel referred to as The Gospel of Mary. It may have contributed to the rumors, as well.

“As you might expect, after being saved and cared for and taught by him, Mary developed feelings for him. He understood this. Thus, when she made her feelings known, he let her down gently, sympathizing with her human condition, re-enforcing that he was of a different nature and that such a relationship was not realizable. Her initial response was one of shame and despair but he quickly allayed her distress and they finished their work. She writes that, despite recognizing that a normal mortal romantic relationship was not a possibility, he was the only one she had loved or would ever love. She has frequently been portrayed as a prostitute, perhaps because she has been misidentified as the sinful woman, described in Luke 7:47, who washes Jesus’ feet with her tears, a misconception amplified by a homily delivered in 591 by Pope Gregory the Great. Nothing could have been farther from the truth.

“I’ve given you one reason why He authored the book. However, there must have been a second, more essential impetus for its formulation than just mutual intellectual enjoyment. I say this because He went to great lengths to make sure that the book was encrypted and hidden such that it might be rediscovered at the appropriate time. What purpose it will have, at that time, the book does not specify. However, I can’t help but thinking that the time for the book’s revelation may be now.”

The prospect that they might somehow become part of history left them all solemn for a moment. Salito broke the silence.

“So what do physicists think about religion?”

“Most are atheists.”

Salitos eyes opened with surprise. “You told us how space can expand or contract and how time can run faster or slower depending on how fast a thing is moving or how much mass is near your measuring stick or clock. You told us how light can behave like a particle or a wave, depending on whether or not it thinks it’s being watched, like it’s got a mind of its own. You described how particles can be in one place one instant, and in the next second, disappear from that the spot where they were and materialize in spot a light-year away. They can somehow know how their entangled partners are behaving and behave, instantaneously, in the same or opposite way, even though their partners may be on the other side of the universe. And evidently, they can also predict the future because the pattern they form on a detector depends on what their entangled partners do, even though the particles forming the pattern have already hit the screen before their entangled counterparts do what they’re gonna do. I’m sorry, but this all sounds a lot like what most people would call magic.

“Now I admit, The Bible has some stuff that sounds a lot like magic, too: the parting of the Red Sea, turning water into wine, curing blindness and raising people from the dead. But the physics that you told us scientists accept in current times, especially quantum physics, provides a mechanism for all the stuff described in The Bible to happen. Now I don’t know what you think, but to me, relativity and quantum mechanics and the other stuff that physicists believe in are no less outrageous than the stuff that happened in The Bible. And at least The Bible gives an explanation as to why the world is the way it is.”

“And I’ve presented you with far from the whole picture.”

“Like, what didn’t ya tell us?” asked Tenacce.

“Like the many worlds theory. According to this theory, every possible outcome of any quantum experiment exists simultaneously. In separate universes. And this is true for every point in time. Take a particle. At a given time, t, a copy of that particle in each possible position exists, each in a separate universe. In an infinite array of separate universes, actually. Because the particle could possibly be in any of an infinite number of positions in the moment after t, and in an infinite number of positions in the moment after that and after that, and after that. Ad infinitum. And each of these universes could exist in conjunction with an infinite number of configurations of other things in the universe. The possibilities are endless. Literally. And the particle would have some probability of being in all of these universes at once. A superimposition of states, if you will. But when a measurement is made, the particle selects—and I use the term ‘selects’ loosely—which array of universes to exist in next. Those universes being the ones that contain the particle at the position at which it was measured.”

Tenacce was astounded. “You’re tellin’ me that’s a real scientific theory?”

“Sounds more like somethin’ out of a science fiction novel,” added Salito.

“Yes, it’s a real theory. All quite mathematically consistent, actually. In fact, in at least one survey, twenty percent of physicists favored the many worlds theory to be the correct interpretation of quantum mechanics. And yes, science fiction writers love it.”

“So what else have ya been holdin’ back from us,” griped Tenacce.

“I’ve also been concealing from you the fact that the energy and matter that we can sense accounts for only 5% of the contents of the 3 brane on which we live. 25% is dark matter and 70% is dark energy and we can’t see or sense any of this. Not to mention the six—or seven—other dimensions of space that we can’t detect. Indeed, The Bible depicts the kingdom of God as consisting of a lot more than meets the eye and the picture that’s emerging in modern physics is exactly that.”

“Dark matter and dark energy? What are they?” Salito inquired.

“In a word, dark matter consists of all the particles that physicists think we should be finding but haven’t found yet or never will be able to.”

“And dark energy?”

“Why that’s just the energy that God and the devil are constantly infusing into our 3-brane in their battle for cosmic supremacy.”

“From what ya been tellin’ us, it sounds like, if anybody oughta be believers, it oughta be scientists,” said Tenacce.

“You’d thinks so,” Danny replied.

“So why aren’t they?”

“There are a couple of reasons. For some, it’s for the same reason that I didn’t believe—arrogance. They can’t figure it out and can’t admit that there might be something that they can’t understand. Or that there’s someone—or some thing—smarter than they are. The most extreme example of this is the belief held by some physicists that if a theory can’t be tested, it can’t be correct. I can certainly see why scientists would *prefer* to evaluate only theories that can be tested because these are the only ones that they can prove. But to say that something can only be true if they can prove it using their limited tool set is frankly illogical. In the book, in fact, He scoffs at the vanity of what he calls ‘future men of wisdom’, stating that their vanity will ‘blind them.’

“The second main reason why scientists tend not to be believers is that the enemy has done a superb job of convincing them otherwise. It’s the problem of evil that they just can’t get past. Satan has inoculated the world with enough evil such that the world looks more like a by-product of the random walk of a bunch of mindless particles than the guided culmination of a powerful and benevolent creator. Biased by this viewpoint then, God’s guarantee to the faithful, of eternal peace and happiness with him in heaven after their spacetime speck of suffering in the 3-brane has ended, sounds like pie in the sky, like an ice cream sundae dangled before a child if he of she fulfills his or her promise to behave.

“There are some things that are, that can never be tested. Physicists test for new particles by accelerating particles (such as protons) around long underground tunnels, currently up to a couple miles in circumference, in opposite directions, until they attain very high energies. Then they smash them together. When this happens, a bunch of particles come flying out and hit detectors. The total amount of energy that comes out has to equal the total amount of energy that was present in the accelerated particles prior to the collision. It follows that the highest energy particle that can be detected from these collisions can have no higher energy than the amount of energy that was put in, and usually less since more than one type of particle comes out of each collision. Technology limits the energy to which particles can be accelerated thus there is an upper limit of energy for the particles that can be detected (i.e., if a particle exists whose energy—and thus mass—is above that limit, then it can’t be detected).

“Likewise, in order for a particle to be detected, it has to interact with atoms that make up the detector. If it doesn’t, it, too, cannot be detected.

“The book says that there are many particles of both types—too heavy and too weakly interacting to be detected—present in the universe.

“Another problem that man will never be able to probe by experiments is consciousness. I described for you earlier, in my discussion of the creation story, how God hovers on a brane that I called the strong brane—or the heaven brane—separated from our 3-brane by an extra dimension that’s about a Planck length away. Even though it’s right next to us, we can’t detect it because most of the particles that make up our brane are confined to our brane and most of the particles that make up the heaven brane are confined to the heaven brane; they can’t interact. Only a few types of particles can interact with particles on the both branes. Gravitons are one. The others are the ones that God and Satan and human souls use to modify chaos.

He turned to Salito. “It’s just as you described it; God lends a piece of himself to us—the soul, a cloud of conscious energy—that interacts with our brains, from the heavy brane, over an infinitesimal length. In a timeframe so brief that it appears, to us, instantaneous. Interactions that allow us to experience the world as well as willfully modify our thoughts and behavior. The particles used by the soul to interact with the physical world are heavy (i.e. their mass is large). But mass equals energy. Therefore, it would take a particle collision with a huge amount of energy to detect these heavy particles, an amount of energy that can never be attained. Thus, these heavy particles will never be detected. In addition, these particles only interact with the brains of conscious humans. So even if they were lighter, they could only be detected if we collided conscious human brains at high-energy. I don’t think we’ll be doing that experiment anytime soon, unless there’s another Joseph Mengele on the horizon.

“That’s not to say that the workings of the universe can’t or won’t be elucidated on theoretical grounds. As I mentioned previously, he predicts that, at some point, the answer will be found but will not be recognized. He also states, in the next breath—in a tone that sounds rather perfunctory—that if scientists ultimately appreciate the answer for what it is, they will simply have figured out how God did it.”

“What about the Bible being the definitive word o’ God?” Tenacce asked protectively.

“When it comes to interpretation of the Bible,” replied Danny, “I think Thomas Aquinas and Galileo got it right. Aquinas said, in so many words, that God purposely included what he called obscurities, figurative language and ambiguous signs in the Bible so that individuals have some wiggle room in its interpretation; that if the individual approaches the task with a sincere heart, then the appropriate interpretation will come to them. Personally, I wonder if He didn’t include these ambiguities—in part—to allow for alternate interpretations that might be required to account for future scientific advances. Aquinas also warns—in so many words—that if a believer encounters scientific evidence that is obviously true, but which appears to contradict scripture, he or she should avoid immediately defending scripture, lest he or she should be scorned; the implication being that the believer should, instead, consider another interpretation that incorporates the new evidence. Similarly, Galileo stated that ‘the Holy Bible never speaks untruth’; that scientific findings will never contradict scripture, at least when scripture is correctly interpreted.”

Salito and Tenacce wriggled uncomfortably in their seats. Tenacce forced himself up from his chair and stretched his arms ceiling-ward. His fingers barely reached the top of head. Salito and Danny were genuinely impressed with the magnitude and variety of crepitus that his movements incited. They sensed that the maneuver was a prelude to articulation of an issue that was paramount to all of them so they waited patiently for him to speak.

“Ya told us how a person’s soul can affect their brain and change the way they act and think. I can see how that can happen. What I have a harder time seein’ is how the world can affect the soul. I mean, that’s important ‘cause how can ya tell the brain how ta make ya act in the world if ya don’t know what’s goin’ on in the world. And what ya think and how ya act is important ‘cause that’s what determines whether you’re good or evil. And that’s what determines what happens ta your soul when you—you know—”

“Die?”

“Exactly. Does your book o’ answers have any answers about that?”

“Yes, He addresses the subject quite extensively. Using concepts with which you’re both quite familiar.

“In the book, the soul is likened to a compass. The needle of the compass is deflected toward the heaven brane—or northward to follow the analogy of the compass—by the positive energy of God. It’s deflected southward by the negative energy of Satan, through the events of the physical world, toward the much smaller 3 plus 1 brane occupied by Satan; a brane separated by another Planck length or so from our world, on the negative side of that same dimension on which the heaven brane lies. You can add to the positive energy—deflect the needle northward—by good thoughts or good deeds—all the things that you’re told to do as a kid …”

“You mean all the things that I told ya ta do as a kid,” Tenacce interjected.

“Yes, all the things you and Mom told me to do that I didn’t do when I left home—going to church, reading the Bible, etc. They’re not magic. They just help to train the mind and direct it toward good thoughts and deeds. Of course, the greatest positive defections come from thoughts and acts of love and kindness.

“On the other hand, evil thoughts, often brought about by the worldly circumstances created by Satan, deflect the needle southward. More grave sins, mortal sins, create a greater southward deflection than venial sins. Energy from the soul is needed to pull the needle northward again. Repentance provides this energy. Confession can help with this.”

“And Christ’s crucifixion …”

“At the time of the crucifixion, the world was infested with Satan’s negative energy, an infestation that threatened the vary foundations of civilization. At Christ’s earthly demised, this negative energy and its attendant force of evil were siphoned away—en masse—giving the world’s inhabitants a new start. I know it sounds like magic, but I assure you, it had a physical basis—perhaps not what we would call physical—but a basis, none the less. As does the fate of the human soul at the end of life.

“The direction in which the needle points at the time of death determines the ultimate fate of the soul. If the needle is pointing northward, it moves into the fifth dimension on the positive side; if negative, it migrates to the negative portion of the fifth dimension axis. In the end time, when the devil runs out of energy, the brane on which Satan formerly dwelled will collapse into a black hole, a small dense focus of energy and heat.”

“You’re talkin’ about hell,” said Tenacce.

“I am. The gravitational attraction of this black hole will overwhelm the energy of the souls hovering on the negative axis and devour them. As for the souls on the positive axis, eventually, they will be pulled to the heaven brane, although how long it takes to get there depends on how closely the needle points toward the north pole.”

“Kinda like purgatory,” Tenacce elaborated.

“That’s my conclusion.”

“It all sounds pretty Catholic to me.” Salito crossed her legs, her denim shorts riding up high.

Danny attempted not to notice her sleekly feminine muscularity. “Very Catholic,” he said. “I guess the doctrines had to have come from somewhere. But these are just the mechanisms. The precepts and how to implement them are the important things. And, as you know, they’re described in another book.”

Tenacce dissatisfaction was uncontainable. “Yeah, but this business about needles and compasses is kinda vague, ain’t it. I mean, ya been tellin’ us exactly which particles do what and writin’ down equations for everything else. The book’s gotta say somethin’ about those things when it comes ta the thing that matters most.”

“Seems you’re taking a shine to all of the science and math.”

“I kinda am.”

“And there are several things we wanna know,” Salito added.

“Such as?”

Tenacce bulled ahead before Salito could speak. “Exactly whatta ya mean by positive and negative energy o’ the soul? Northward or southward deflection of the compass?”

“He explains it in the third part of the book,” Danny replied.

Salito, determined not to go unheard, wedged herself into the conversation. “Why does the soul get pulled ta the heaven brain if the soul has positive energy or toward the hell brane if it has negative energy?”

“He explains it in the third part of the book,” Danny repeated.

Salito shifted her bare legs restlessly. “How does communion and good thoughts or deeds give your soul this positive energy you’re talkin’ about? How do evil thoughts and deeds create negative energy? How does confession or repentance suck the negative energy outta the soul? In short, how do the things that happen in the world change the state of the soul?”

“The explanation he gives in the first portion of the book is akin to Bohm’s notion of implicate and explicate order. God and the soul are part of the implicate order. The holomovement is like a hologram: each part of the implicate order containing all of the information about the entire explicate order. Because the soul is part of the implicate order, when it unfolds, it affects multiple sites in the brain simultaneously. And because the soul has mind, when it’s aligned with God, the thoughts it creates ultimately move the flow of our world in a direction favorable to God. And when it’s not …. On the other hand, when the explicate order enfolds back into the implicate order, it carries with it information about the explicate order; that is, what’s happening in our world.”

Danny felt the silence and looked up to see them staring.

“I recognize that it’s vague, but he describes the mechanisms underlying all of these things about which you are inquiring in the third section of the book. And there’s a formula there. A collection of characters and symbols I’ve never seen before and that are not explained in what preceded it. I believe it’s the theory of everything. Not believe. I know it is. It’s all there in the final section.”

Tenacce and Salito expected him to continue speaking but he did not.

“So what does it say?” Tenacce asked finally.

“I don’t know.”

Tenacce’s brows rose in surprise. “Is it ‘cause ya don’t understand what he said?”

“No,” Danny replied.

Tenacce’s surprise turned to impatience. “What’s the problem then?”

“It’s encrypted.”

“That ain’t been a problem so far.”

“This is different.”

“In what way?”

“I’m not sure. I think it may be Quantum encryption.”

*Quantum encryption.* He had tossed the term out carelessly, albeit subconsciously, a throwback from his former habit of purposely using terms that his father did not understand to annoy him, a tactic he had used frequently before their relationship had changed. Danny’s regret was immediate. Accordingly, he relinquished his grip on Salito’s hand and returned to the whiteboard, initiating an explanation before his father’s irritation could set in.

“Quantum encryption: here’s how it works,” said Danny. “Or at least, here’s the basic idea. We’ve spoken previously about photons and how they can be polarized to a specific angle. So now consider a sender. Call her Alice. Alice wants to send a message to Bob. To this end, she is equipped with 4 single photon light-emitting diodes (spLED) that can generate single photons polarized at a given angle.

“Bob, on the receiving end, has two things: 1) polarizion filters and 2) a photon detector. More specifically, Bob has two types of filters. One—let’s call it a + filter—can be set to either 0° or 90°. The other type of filter he has—call it an X filter—can be set to either 45° or 135°. The type of filter used, + or X, determines what’s called the basis associated with that photon. Recall that a filter set at a given angle will only let photons through if they are polarized at that angle. And if a photon hits the filter and emerges from it, it will emerge polarized at the angle at which the filter is set.

“So Alice generates photons, one-by-one, polarized at one of four angles (0°, 90°, 45° or 135°) and sends them to Bob. The choice of polarization angle by Alice is randomly determined. After she sends a photon, she records 3 pieces of data about it. First, she associates a number with the photon to identify it. Second, she assigns a digital code to each photon depending on its angle of polarization. She does the latter as follows: if the photon she sends is polarized at 0° or 45°, she assigns a value of 1 and if the photon is polarized at 90° or 135°, she assigns a value of 0. Third, for each photon, Alice records what’s called a basis according to the following protocol: if the photon is polarized at 0° or 90°, she designates the basis as “+”; if the photon is polarized at 45° or 135°, she designates the basis as “X”. (The reason that she records the information the way she does, hopefully, will become apparent soon.)

“Once Alice emits a photon, she sends the photon over an unsecured connection to Bob. Bob, on the other end, has no idea at what angle the photon was polarized, so he picks a filter (or basis) with which to measure the photon (either + or X) at random. Theoretically, Bob could use his 0° or 90° filter if he chooses the + basis or his 45° or 135° filter if he chooses the X basis. However, for simplicity, let’s institute the following rules: if he chooses to measure the photon in the + basis, he sets his filter to 0°—every time—and if he chooses to measure the photon in the X basis, he sets his filter to 45°—every time. He then checks to see whether or not the photon passes through the filter. If it does, it registers on a detector he has previously placed behind the filter. If the photon registers on the detector, Bob assigns that photon a digital value of 1. If it does not register, he records a 0.

“Now if the incoming photon is polarized at 0°, and he chooses to use the + filter (set at 0°) it will register on the detector with 100% probability. However, if he uses the X filter to measure, the photon has a 50% chance of registering.”

“Why is that?” asked Salito.

“According to the classic interpretation of quantum physics—which works well in describing the phenomena—the photon is in what’s called a superimposition of states, 50% in the 0° polarization state and 50% in the 90° polarization state. It doesn’t assume a definite state, in this case either 0° or 90°, until a measurement is made.”

Tenacce scowled. “What about your boy Bohm?” he asked.

“My boy Bohm?” Danny chuckled. “My boy Bohm would say that polarization is not a property of a photon but of the wave function. Different polarization states are associated with different wave functions, the wave function determines photon velocity (which includes direction) and direction determines whether the path of the photon is or isn’t through the opening in a polarization filter.”

Tenacce deliberated briefly then nodded. “Makes sense. Anyway,” he continued, “gettin’ back ta what you were sayin’, if Alice’s photon is at 90°, and Bob chooses the + filter, then the photon won’t get through. That’s true a hundred percent o’ the time. Am I right?”

“You are. And what if Alice’s photon is polarized at 90° and Bob uses his X filter?”

“Half and half.”

“What about if Alice’s photon is polarized at 45° and Bob uses his X filter?”

“Gets through. A hundred percent.”

“You’re catching on. And if Alice’s photon is at 45° and Bob uses the + filter?”

“Fifty fifty.”

Salito joined in. “And if Alice’s photon is at 135° and Bob’s filter is X, it gets blocked. 100%. If he uses the + filter? Fifty fifty again.”

“OK, you got it. Let me make a little table to summarize,” said Danny as he turned to the whiteboard.

|  |  |  |
| --- | --- | --- |
| Polarization of Alice’s Photon | Basis of Bob’s Filter | |
|  | + (set at 0°) | X (set at 45°) |
| 0° | 1 (100%) | 1 (50%) 0 (50%) |
| 90° | 0 (100%) | 1 (50%) 0 (50%) |
| 45° | 1 (50%) 0 (50%) | 1 (100%) |
| 135° | 1 (50%) 0 (50%) | 0 (100%) |

“As I said before, the ‘1’s’ in the table mean the photon got through and registered on the detector; the ‘0’s’ mean it didn’t.

“But the point of this whole exercise is to get a secret key, a string of numbers that is known to Alice and Bob and nobody else. In this case, as you might surmise, it turns out to be a string of zeros and ones.

“How is this done? Well, once Bob has made his measurements, he records the same three pieces of information as Alice: photon number, basis and digital code that indicates whether a photon registered or not. Then Alice and Bob have a little conversation.

“In that conversation, they don’t directly tell each other what their secret key is. Instead, for each photon, Alice tells Bob what basis she used to generate the photon (although she doesn’t tell him at exactly what angle her photon is polarized; for example, she might tell Bob she used the + basis but doesn’t tell him if the photon she sent was polarized at 0° or 90°). Bob, for his part, tells Alice in which basis he measured. From the table, you can see that if the same basis was used to send and receive a photon, they know, with 100% certainty, at what angle Alice’s photon was polarized, and therefore, what digital code they should both use for their secret key.

“To see this, consider the following two examples. For both of these examples, assume that, in their conversation, Alice and Bob discover that their basis agrees and that, in each case, that basis is the + basis.

“In the first case, suppose that Alice’s photon is polarized at 0°. Bob measures with his filter set at 0°. The photon gets through and registers on the detector. Bob reasons that, since he and Alice agree on their basis, Alice’s photon must have been polarized at 0° or 90°. But since the photon got through his 0° filter, her photon must have been polarized at 0°. Why? Because if it had been polarized at 90°, it would not have passed through his filter. Bob and Alice have agreed in advance that if Alice’s photon is polarized at 0° then that correlates with a secret code digit of 1 and if it is polarized at 90°, that correlates with a secret key digit of 0. Bob has deduced that Alice’s photon was polarized at 0°. Thus, he knows that the secret key digit he recorded for that photon (i.e., 1) agrees with Alice’s secret key for that photon.

“Let’s look at a second example. In this case, suppose Alice’s photon is polarized at 90°. Bob again measures in the + basis, with the 0° filter. The result is that the photon does not pass through the filter, it does not register on the detector and Bob records a 0. He knows that Alice’s photon must have been polarized at 90°. How? Well, again, he knows that Alice’s basis is the same as his—the + basis. Therefore, her photon must have been polarized at either 0° or 90°. Since the photon did not get through his 0° detector, it must have been polarized at 90°. After all, if it had been polarized at 0°, it would have gotten through his filter and registered on his detector. Since Bob knows that Alice’s photon was polarized at 90°, he knows that she recorded a 0 for her secret key digit for that photon, as per their agreed-upon scheme (record 1 if her photon is polarized at 0°; record 0 if it’s polarized at 90°). And he also knows that the secret key digit he recorded for that photon, 0, agrees with Alice’s.

“We could go on and see what happens in the other 6 scenarios that could possibly occur but I think you get the concept: if 1) Alice and Bob agree on their basis 2) Alice and Bob agree on a protocol regarding what secret digit to record for each of the angles at which Alice’s sent photon could be polarized and 3) Bob knows at what angle his polarization filter is set for measurement (which, of course, he does), then the secret key that Bob and Alice generate will be the same.

“Accordingly, they save the data from photons on which they agree on basis and use that data for their key. On the other hand, if the basis used to generate and receive the photons differ, from the table, the digital codes generated for those photons will agree only 50% of the time, and randomly at that. Under those circumstances, they have no idea whether or not their digital codes agree. Therefore, they throw out this data and don’t use it to make their key.

Salito rubbed her cheeks and displayed a perplexed frown. “Is Alice and Bob’s ‘little conversation’ public?”

“It is,” Danny answered.

“And the connection that the photons are sent over are unsecured.”

Danny indicated that it was.

“So can’t somebody wiretap the conversation, intercept the photon, measure it and … somehow …” she waved her hands imprecisely, “figure out the secret key.”

“Not a chance. At least, not much of one. Suppose there’s an eavesdropper. Call her Eve …”

“Eve for eavesdropper. Cute,” said Salito.

Danny smiled. “I thought you’d like that. Unfortunately, I can’t take credit for it. Anyway, let’s say the strategy of our eavesdropper, Eve, is, like you said, to intercept Alice’s photon, measure it, and send it on to Bob. So Alice sends out a photon. Eve intercepts it. But this is before Alice and Bob have had their conversation in which they compare notes. So Eve is in the same boat as Bob. She must choose the basis to measure the photon at random. If she chooses the correct basis, then she will be able to correctly infer the digital code (0 or 1) for that photon every time. But since she’s choosing her basis at random, and there are two possibilities for choice of basis, her chances of guessing correctly is 50%. However, even if she guesses the basis incorrectly, there is a 50% chance that she will determine the digital code correctly. These odds are true for every photon. Thus, of the cases in which Alice and Bob send and measure a photon with the same basis (i.e. the cases that they will use to compile their secret key), Alice will guess the digital code correctly 75% of the time.”

Danny noted the hazy expressions on the faces of Salito and his father.

“Let me see if I can make things a bit clearer,” he said. “Say Alice polarizes her photon at 0° and Bob correctly measures in the + basis. One hundred percent of the time, the photon will pass through his filter and he will record a digital code of 1. Eve, on the other hand, will correctly measure in the + basis only 50% of the time, but when she does, she will correctly guess a digital code of 1 every time. However, on the occasions when she chooses the basis incorrectly, by chance, the photon will pass through her filter and she will record the correct digital code (1) one half of the time. One half of 50% is another 25%. Thus, Alice will guess the digital code (1) 75% of the time—50% of the time when she chooses the basis correctly and 25% when she doesn’t.”

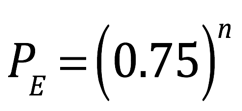
“Let’s take another example,” he said. “Say Alice polarizes her photon at 135° and Bob correctly measures in the X basis (set at 45°). One hundred percent of the time, the photon will fail to pass through his filter and he will record a digital code of 0. Eve, on the other hand, will correctly measure in the X basis only 50% of the time, but when she does, she will correctly guess the digital code of 0 every time. However, on the occasions when she chooses the basis incorrectly, by chance, the photon will not pass through her filter and she will record the correct digital code, 0, one half of the time. One half of 50% is another 25%. Thus, again, Alice will guess the correct digital code (0) 75% of the time.

“We could repeat the argument for photons polarized at 45° and 90°, but I hope you’ll trust me when I say that the result will be the same: Eve will guess correctly 75% of the time.

“So what are the chances that Eve will correctly guess the entire secret key? Well, it depends on how long the key is. If the key is one digit long then the chance of Eve guessing it is 75%. Two digits long and it’s (0.75) x (0.75) = (0.75)2 = 0.56 = 56%. Three digits and it’s lower: (0.75) x (0.75) x (0.75) = (0.75)3 = 0.42 or 42%.”

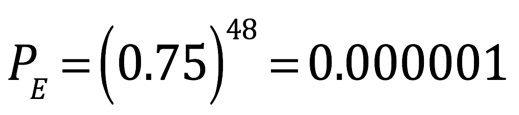
“I see a pattern here,” interjected Tenacce.

“That’s because there is one,” said Danny. “The formula to determine the likelihood that Eve will resolve the entire secret key (PE) is:



where n is the number of photons evaluated in which Alice and Bob use the same basis.

“If, for instance, Alice and Bob, use 48 photons for their key, then the chance that Eve will guess it is:

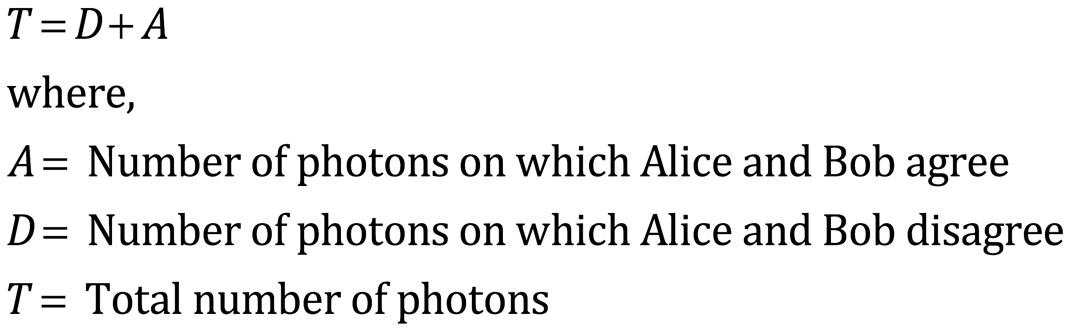


“That’s about a 1 in a million.

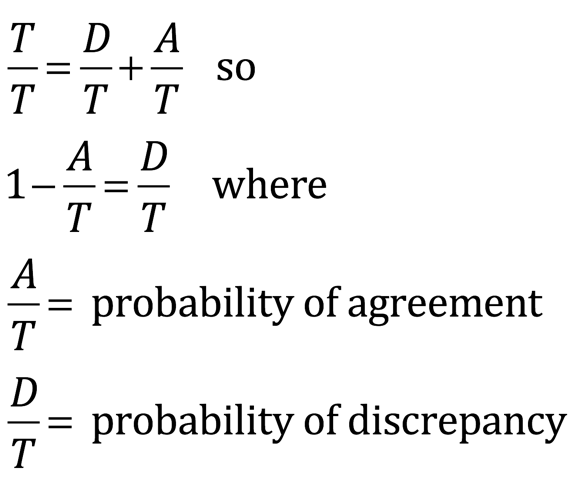
“Alice and Bob can also use such an analysis to tell whether someone is eavesdropping. What they would do is take a sample of data from the photons where they agreed on a basis. Theoretically, they should record the same digital code 100% of the time. Therefore, if they find any discrepancies at all, they know that someone is listening in. This is because discrepancies can only occur if Eve guesses wrong. An example of how this could happen is as follows:

“Alice sends out a 0° photon. Eve guesses wrong and uses an X filter. The photon hits the X filter in a fifty-fifty superimposition of the 45° and 135° states. Eve sets her filter at 45°. Then 50% of the time, the photon gets through, now polarized at 45° and gets to Bob. But Bob is using the + filter, so 50% of 50% (or 25%) of the time, he measures a 0 instead of a 1. If Eve weren’t there, Bob would measure 1 correctly 100% of the time. However, with Eve around, Bob gets 75% right and 25% wrong—same as Eve.

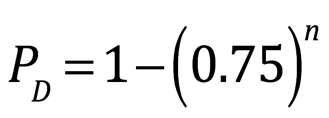
“Now, [the total number of photons Alice and Bob evaluate] = [the number of photons where Alice and Bob agree (A)] + [the number of photons where Alice and Bob disagree (D)]. To express this as probabilities, divide both sides by [the total number of photons evaluated]. Mathematically:

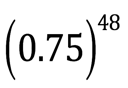


and



“It follows then that the probability of finding a discrepancy, and thus detecting the presence of Eve (), equals one minus the probability of agreement. But we already said, the probability of agreement between Alice and Bob when Eve is listening in equals the probability that Eve guesses right. And I already told you that that probability equals (0.75)n. Therefore:



“So for example, if Alice and Bob wanted to make the probability of detecting Eve () = 0.999999, they’d use n = 48 (i.e., sample data on 48 of the photons in which they employed the same basis; recall that  = 0.000001; 1 – 0.000001 = 0.999999). If they found discrepancies, then they’d know Eve was eavesdropping. If not, then they could be 99.9999% certain that Eve was not listening. If this degree of certainty were acceptable to them, then they’d use their data for a secret key (although they would throw out the 48 data points that they used to check for an eavesdropper since that analysis would have been done publicly).

Tenacce scratched his facial stubble. “How is Bob gonna compare notes with Alice—or in this case, Mary—if Alice, or Mary, died two thousand years ago.”

“Maybe Mary left—more accurately, hid—her part of the information somewhere.”

“Probably did a pretty good job of it, too, judgin’ from our previous dealins’ with her. Next question. How is she gonna send us these photons, or entangled particles, or whatever, if she’s dead.”

Salito joined the conversation. “And why would most of the book be encrypted in one way, and the last section in another?”

Danny Tenacce shrugged. “These are all good questions. I don’t know. Actually, I’m not even sure if I’m dealing with quantum encryption. Or some type of superencryption. Or just a very long public key encryption code that would be impossible to crack without a quantum computer—which has yet to be invented. Either way, I need help. That’s why I contacted Rajiv Namboothiri.”

“You did what!” Tenacce was wild-eyed and standing now. “Whatta ya wanna do? Get us killed? These guys got ….”

Tenacce could feel Salito’s glare, the one instigated by memories of evading bullets in Central Park and crawling through raw sewage. His eyes focused on Salito as he restarted. “What I meant ta say was, these guys got a knack for trackin’ cellphones. Even burners.”

“Father Frank contacted him. Not by phone. By email.”

“And you don’t think that The Knights might be watchin’ and listenin’ ta him?”

“He’s a Brother. Remember? He’s got software that makes it impossible to trace the IP address from which he sends a message. We’re talking Tor on steroids.”

“Tor?” Tenacce stared blankly.

Salito explained. “Tor is a web browser used by people in the deep web that hides the location of your IP address by bouncing your message from server to server. The last server along the chain is where it looks like the message originated. I guess what Father Frank has must be better.”

“Father Frank made sure he used the same software to communicate back,” Danny reassured. “And no one has reason to suspect a connection between Raji and Father Frank anyway.”

Salito detected a characteristic twitch in Tenacce’s shoulder, a twitch that she knew meant that Tenacce was disturbed; disturbed not by her possession of knowledge, but rather, that knowledge existed that could be useful in solving a crime, and that he did not possess it. As always, he recovered quickly.

“Why da ya have ta know what the equation says? You already know the important part.”

“Because I want to understand it. All of it. Completely.”

Tenacce noted his resolve and altered his course. “Who is this Raja Nabootagarten anyway.”

Danny smiled at his father’s intentional mispronunciation. “He’s a friend from Princeton. A computer guy who specializes in quantum computing. A world authority, actually. And he’s harmless. The only thing he thinks about is quantum computing. And running. The guy’s come close to winning the New York marathon. Believe me, his only motive in coming here is to see if he can solve this quantum encryption problem.”

“He’s coming here!” Tenacce railed. He started forward. Salito stopped him.

There was a knock.

“Speak of the devil.”

“I hope not,” Tenacce muttered.

Danny opened the door. Frank DeAngelo ushered in a slight, bronze-skinned man that looked about seventeen, with thick, black-rimmed glasses and a crop of unkept black hair. He sported the Princeton uniform: kaki’s, a long-sleeve striped Polo shirt and brown loafers. Innocuous-looking is the word that Tenacce would have used to describe his initial assessment, if he had known it.

“Look who I found,” Father DeAngelo pronounced.

“Thanks, Father,” said Danny to DeAngelo. Then he turned to his friend. “Raji, thanks for coming.”

The little man responded with an utterance that, to Tenacce, sounded like his tongue had been tied into a knot. Danny Tenacce and Salito, however, appeared to understand. Danny made the necessary introductions. To Tenacce, the man’s limp handshake seemed to confirm his primary appraisal. A brief conversation about matters of little importance ensued; Danny had already discerned, from his previous email correspondences, that he had been suspended from Princeton and that he was regarded as a fugitive. The niceties ran their course in short order.

Danny Tenacce faced his former Princeton colleague. “Well, Raji, we’d better get going. We—or should I say, you—have got your work cut out for you.”

Danny started for the doorway. The little man reached for his suitcase.

Tenacce, who never trusted his initial impressions completely, slid past the arm Salito had extended to deter him. “Whoa, whoa! Not so fast. What’s in the bag?” Now he was walking toward the man and his valise.

Danny Tenacce and Salito began talking at Tenacce simultaneously.

“I just have some clothes and the necessary equipment,” the little man tootled, stepping back.

Father DeAngelo stopped the commotion. “I tossed him and searched the suitcase before he came down.”

“Does he have a weapon?”

“No Joe, no weapon,” Frank assured.

Tenacce halted his march.

Danny regarded them all with incredulity. “You frisked him? Come on, Raji.” Danny picked up the case and pulled his friend from the room.

All eyes were on Tenacce. Tenacce shook his head. “I don’t like it. We don’t know this guy from Adam.”

“Danny knows him,” Salito returned.

“Yeah, and love is blind.”

Salito opened her mouth to express her shock but there was no sound.

“Trust in the Lord, Joe,” said DeAngelo.

“You’re a priest. That’s what you always say.”

DeAngelo nodded in the affirmative with that serene, condescending, clergyman smile that tended to leave the salty law enforcement veteran annoyed.

“Yes, I do,” said the lanky priest as he ducked under the archway and closed the door behind him.