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Book Review Article

An Intellectual Mind-Twister for Our Readers:

Going to the Outer Limits of Cosmology

Time One: Discover How the Universe Began

Colin Gillespie

In Association with Big Fizz, Inc., 2013

In a book unlike any other, Colin Gillespie, a physicist, sets out to explore the origin of space and time, examining 47 of the major "problems" of physics for clues, which he examines within the format of a highly literate detective story. Although a discussion of advanced theories of cosmology is not within the usual purview of this Journal, and will necessarily have to pass muster in refereed scientific journals, we have found *Time One* so fascinating and so challenging that we have found it irresistible to bring the book to our readers' attention. Our review here consists of two parts: one by our associate editor, who is not a physicist; and one by Dr. David Miller, who is, who launches into a detailed discussion of *Time One*'s theory, which he finds sufficiently compelling not to dismiss out of hand. The book will almost certainly not appeal to all readers. Its appeal is, in fact, rather limited: to those who are competent to deal with the intricacies of advanced physics, and to others if they are drawn to writing that is provocative and challenging, or to what seems a new genre of intellectually interactive literature that invites the reader into active participation.

Key Words: *Time One*, Colin Gillespie, origin of space and time, cosmology, physics, theory of Fizzion, detective genre, scientific method.

Part One: Comments by Dwight D. Murphey, associate editor:

This article is going to be a very different one for readers of *The Journal of Social, Political and Economic Studies*. We are including a review of a book about physics, or more specifically about physics-as-cosmology. That is a subject outside our normal purview, but we have been attracted to Colin Gillespie's *Time One* because it is a book that casts its intellectual net far beyond physics as such. To be sure, it *is* loaded with discussions of advanced concepts in present-day cosmology (47 "problems," in fact, by the author's count). But the book is more than that, and has the aura of a new genre of communication, one that brings together the arts of a novelist, the learning of a literary scholar, and the intricacies of scientific inquiry – all mixed with a spirit of playful gamesmanship, inviting others into a community of thought that is hoped to continue through blogs on the Internet. The result is so unique that it would seem unpardonable not to alert our readers to it and to let such a book pass unnoticed.

One way of seeing the book is as a dialogue that proceeds on three levels. First, there is a conversation, so to speak, among the protagonist, his imaginary detective Frank, and the real detective, also named Frank, about what the "clues" derived from a review of the 47 major issues in physics may reveal about "the Beginning," by which Gillespie means the very start of existence. (The 47 "problems" include such things as string theory, quantum gravity, special and general relativity, dark matter and dark energy, and "time's arrow.") Second, the narrative in effect is a conversation between the author and the reader. It invites the reader into the investigation, causing an active mental process on the reader's part in interaction with the protagonist, since it would seem impossible to be intellectually passive while reading this book. Third, there is the conversation that has occurred over the centuries within the science of physics and within the thinking of a great many scientists, philosophers and literary figures whom Gillespie brings into the book by extensive quotations and references.

It is to be supposed that *Time One* will interest physicists *per se* as a theory of the origin both of space and time. As a person of little scientific background, I couldn't assure myself of this, however, until I gave a copy to David Miller, a space physicist and friend whose own review appears later as part of this article. The book struck me as perhaps wildly speculative, since it declines to see space and time as always-existing givens, but rather thinks it necessary to provide a theory to explain how even *they* came into being. Without space and time, Gillespie reasons, there would be no setting for the Big Bang that most physicists today consider the origin of the universe. Gillespie speaks of a "quantum of space" that he calls a "Fleck," which is postulated to be so small that nothing can be smaller, and that replicates itself like expanding foam (a process he calls "Fizzion") to create the space we know. Each expansion is done in a "Tock," and this is the creation of time. These terms themselves have an aura of *Alice in Wonderland* about them, so it is easy to see why I have had my doubts that it is anything but fantasy. That doubt still remains, but it helped remove my irresolution about whether we should do a review when I found that Miller does indeed take Gillespie's theory seriously. It also helps to know, from reading *The Scientific American* over the years, that quite of lot of fanciful thinking about cosmology has recently been taken seriously. When we reflect on how modern science has extended farther and farther into realms of the unseen, producing magnificent results, we know there is reason for someone who is not a scientist to tread lightly toward such "fanciful thinking," giving it lots of latitude.

Words of caution are in order, however, for most readers:

The book will be quickly put aside by general readers unless they belong to what we might suppose is a rather limited group: people who relish an intellectual challenge, actually enjoy dealing with difficult subject-matter, and are intrigued rather than turned off by an author's deliberate obscurities, which Gillespie relishes and may have included to lend an air of mystery. (Someone who appreciates William Faulkner's *The Sound and the Fury,* say, will fit well into the latter category.) If a reader thinks he may meet this description, a good test to take before acquiring a copy of *Time One* will be to read David Miller's rather detailed discussion in the second part of this article. Miller doesn't dangle obscurities and paradoxes in front of us there, but he does lead us through the type of material that provides the substance of Gillespie's book. A reader will find Miller's discussion lucid, but perhaps somewhat more difficult than Gillespie's discussion when Miller gets into the physics as such. Those who pass the test posed by Miller's review either because they are adept at the science or because they have lively minds that enjoy a challenge are likely to find *Time One* much to their liking.

For my part, I seem to fit into the second of these categories. I find the cosmology fascinating and appreciate the many literary and scientific quotations with which Gillespie precedes each of the rather short chapters and that find their way, also, into his text. I do, however, find the attempt to fashion the narrative into a "detective novel" rather pedestrian. The characters, other than the main narrator (assigned the role of "researcher/investigator"), have only a shadowy, off-and-on presence and there is minimal plot development involving them. It is especially in this aspect that Gillespie goes out of his way to make an already complex book even more complex by deliberate ambiguity. He has a detective named Frank, and then an imaginary detective, an inner-voice of the protagonist, whom he confusingly also names Frank. Reference is often made, especially at the beginning of chapters, to "he" without identifying which Frank is being referred to, and the reader is left to unscramble it. Gillespie also loves paradoxes, such as when he says "this is not the truth, but it is true," or "I am glad to know this though I'm not sure what I know." And a fair portion of what he says takes the form of purely arbitrary postulates. For example, he says that "the notion that the universe is finite from the first is central to a search for the Beginning" and "I feel sure the real beginning will have beauty." These sound good, but if we question them we are forced to ask what basis there is for saying them.

To explain why we have made this a "book review article" that contains my own review and one by a physicist, it is necessary to return again to the issue of whether Gillespie's theory should be rejected out of hand as undiluted speculation. At a number of points, Gillespie writes of the consensus that a theory, if it is to be considered scientific, must be "able to predict something that can be disproved." The hypothesis must be subject to falsifiability by being one that leads to predictions that can potentially be found to be wrong. This is Karl Popper's hypothesis-prediction-verification (or falsification) test, which is widely held to, as Gillespie says, by "many physicists." This test does not exhaust the way in which something qualifies to be considered "scientific," as we know, for example, if we think of collecting butterfly specimens and differentiating among their types. There, accurate observation is the key. Miller will suggest other ways observations or hypotheses of various kinds satisfy tests for being "scientific" (although I don't gather that any of these others apply to Gillespie's theory). Whatever the subject-matter, the concern over methodology has to do with how to assure effort's being reality-based, founded in things we can know. It is a concern about an economy of intellectual effort, realizing that the human mind can produce endless suppositions unless harnessed by a focus on proof. "Science" is intellectual effort that wants no longer to debate "how many angels can dance on the head of a pin." It is for this reason that science eschews teleological explanations for natural phenomena, since animistic, magical or other supernatural postulates can explain everything, all without any way of our knowing what is sound and what is not. The same might well apply to cosmological theories, which need somehow to be taken out of the realm of fancy.

This imperative, it would seem, is being given little emphasis in some aspects of modern physics. Gillespie cites LeeSmolin as arguing that "physics is in trouble. He says it is losing its connection to experimental test." Smolin is an astrophysicist who established the Perimeter Institute of Theoretical Physics in Canada, and is the author of the 2006 book*The Trouble With Physics* in which Smolin observes that string theory, though widely pursued, has not shown itself capable of producing predictions that can be checked, at least with current technology. The same is apparently the case with Gillespie's theory of "The Beginning." Significantly, he is open about this in *Time One*, where at the end of the book (p. 441) he says that he could not make out his case "in court if court there were for physics."

When I received an extra copy of *Time One*, I gave it to a friend, Dr. David Miller, to see what a physicist (in his case, a mathematician who has done a lot of work relating to our solar system) would think of it. It turned out that he was very much interested. In light of that interest, I asked him what specifically he thought on the question of the book's "science," with regard to whether the book's theory meets any criterion for being considered scientific. He has addressed that issue in the review that follows here. As you will see, he believes the theory is potentially testable. His response is not necessarily definitive (since it's likely that none will be, and Miller's reasoning will of course receive a more appropriate imprimatur by being published in a refereed physics journal), but it should play a significant role in the on-going conversation that Gillespie invites.

Part Two: Comments by Dr. David Miller, space physicist:

Editor's note: To make it easier for the reader, we are presenting Miller's main line of argument in regular-sized type and have sub-indented and slightly reduced the print for parts of his discussion that are either more peripheral (in the sense that they don't directly apply to the *Time One* theory, though they are very worthwhile reading for their own sake) or are technical enough that a general reader may want them set apart so that the reader can choose whether or not to consider them carefully.

This may be an important book and without doubt it is an unusual one. Many deep issues in physics and cosmology have been considered mysterious or baffling, from finding a logically consistent way to unify general relativity and quantum mechanics, to understanding the dark energy that has been hypothesized to explain why the expansion of the universe has accelerated during the past several billion years, as revealed by many Hubble Space Telescope photographs of distant and ancient supernovae. However, Colin Gillespie is almost certainly the first author to treat these and many other physical questions and controversies as clues in a genuine mystery case, to be solved, as if the origin of the universe were a theft or murder, by a fictional detective.

In fact, Gillespie adds a second level of fictionality by depicting the solution of the mystery as coming from a detective imagined by the narrator of *Time One*, who is himself, as a dope-smoking beach bum computer hacker (and philosophy Ph. D. dropout) a fictional character at least as far out on the fringe of society as John D. MacDonald's houseboat-dwelling narrator and detective, Travis McGee, and drastically different from Gillespie himself, now retired from successful careers as first a physicist (Ph. D., 1967, from the University of Melbourne in his native Australia) and then a lawyer (admitted to the bar in Manitoba, Canada, 1981).

So is this book some kind of 444-page joke or an overgrown elaboration of postmodernist ideas of the unknowabilityor nonexistence of truth? It is neither. A person with sufficient patience to endure the games he plays with the conventions of detective fiction (not only the narrator and the fictionally fictional detective, but a prose style heavily laden with allusions to popular culture and a silly subplot about terrorists hoping to steal microscopic black holes [never yet observed in real life] from the Large Hadron Collider) can see that Gillespie really does believe that he has formulated a way to answer many of the biggest questions that have arisen in physics and cosmology since about 1900, and some that date back earlier.

His seriousness is soon clear in Parts I and II, "The Case History" and "The Cosmic Clues," where for a great many physics concepts and controversies he gives nonmathematical summaries that mostly are as good as anyone could reasonably desire. So far as this reviewer (a former Caltech physics major and current part-time space physics researcher familiar with many of the people and topics he discusses) knows about the ideas and attitudes of the sources for his many quotations, he seems fair in what he says about them.

Furthermore, although he assembles them in a notably unconventional and impressively ingenious way, many parts of his solution to the mystery of the origin of the universe are established mathematical concepts, or physical theories or observations.

For example, when he postulates that space is quantized in "Flecks" (his capitalization) whose sizes are the *Planck volume*, and time is quantized in "Tocks" of one *Planck time* duration, the italicized terms are from work in 1899 by Max Planck, the founder of quantum mechanics, who wanted to define natural physical units independent of the contingencies of human history and perception incorporated in the meter, the second, and other units used by physicists since well before his time. Gillespie's use of the Planck units probably depends on reasoning dating back to a 1957 paper in which several authors, including noted gravitation theorist John A. Wheeler, concluded that quantum fluctuations of the metric of space-time made it physically meaningless to consider any distance smaller than the Planck length, which is about 1.6×10^{-33} centimeters (so that the Planck volume in three dimensions is about 4×10^{-99} cubic centimeters) or any time shorter than the corresponding Planck time, in which light travels the

Planck length, and thus is about 5.4 x 10^{-44} seconds. Likewise, Gillespie takes advantage of the six extra dimensions of space postulated in prominent forms of superstring theory. These dimension are usually considered to be an awkward and implausible aspect of the theory, but have been found to be mathematically necessary to fulfill the theory's aim of constructing a logically consistent description of finite-sized objects with the properties required by established energetic particle theory and experiments.

Reversing the superstring approach that starts with the familiar three dimensions of space and one of time and then adds on the other six as a *Calabi-Yau manifold* that is approximately the Planck length in all directions (thus explaining why these dimensions are not observable), Gillespie starts by assuming that the Flecks are Planck-sized Calabi-Yau manifolds, and derives familiar space and time from the behavior of the Flecks as they "Fizzion" (his term) repeatedly during the "Big Fizz" (the foamy structure produced by the proliferation of Flecks makes him prefer this term to "the Big Bang") to create the universe.

Although it may seem that his ingenuity deserted him in his neglecting to explain what Calabi-Yau manifolds are, there probably is no explanation of why Calabi-Yau manifolds are genuine mathematical objects (hypothesized by Eugenio Calabi and proved by Shing-Tung Yau to satisfy Calabi's conjecture, hence their name) that would be both brief and comprehensible to large numbers of readers. Perhaps he decided to mention them without explanation, as if all readers would know what they were, because an adequate explanation would take several pages and be a digression from his main argument. Or perhaps he hoped that sufficiently curious readers would look them up on *Wikipedia*, although reading that article requires not only at least a little familiarity with some areas of advanced mathematics but also willingness to follow links to many other Wikipedia articles that explain various terms. In any case, since they cannot be embedded into three-dimensional space, the pinkish blob with red, white, and blue highlights surrounded by successively dimmer concentric bands of dull pink, shown in the middle of the front of the paper jacket as a Calabi-Yau manifold, must be assumed to depict some sort of cross-section or projection, and it will make sense only to those that already know how to interpret such images.

Even allowing for the references to familiar and unfamiliar mathematical and physical objects, *Time One* must be understood as not presenting a fully developed quantitative theory but a strategy or philosophy for building such a theory, or perhaps it should be called a blueprint for a class of theories. (This may be one reason, in addition to his radical rejection of many currently accepted assumptions in physics and cosmology, why Gillespie is presenting his work as a detective story instead of at conferences on physics or cosmology, or in papers for *Physical Review* or the *Astrophysical Journal.*)

There is a possible analogy here to the way the "Minimally Supersymmetric Standard Model" (MSSM) really is a whole class of theories, in this case defined (as stated by superstring theory critic Lee Smolin in a quotation in the Part II chapter on "The Problem of Parameters," p. 247) by 105 parameters (these are constants not predicted from a theory that appear in the equations that describe it, so that every possible set of parameter values would give a different set of predictions from the equations) in addition to the parameters of the Standard Model (19, according to the "Beyond the Standard Model" article in

Wikipedia; 35 of them in some version of the model criticized in the Smolin quote at the top of the Parameters chapter). This is so even though one of Gillespie's chief purposes is to present an understanding of the universe that is not subject to the proliferation of parameters in contemporary theories that he criticizes in the Parameters chapter and many others.

(Since the parameters are not predicted by the theory, they have to be determined experimentally. Three that date back long before the Standard Model, and are very widely known are *c*, the speed of light; Newton's constant *G*, in the formula for the gravitational force between two masses; and *h*, Planck's constant. The masses of the fundamental particles, such as the quarks and the newly discovered Higgs particle, are easily understood additional examples in the context of the Standard Model, and then there are some that are less easily described that, for example, affect the relative probabilities of different ways particles can decay in accelerator collision experiments. In a supersymmetry theory the additional parameters would include the masses ofsupersymmetric counterparts of the currently known particles, and parameters connected with the ways that supersymmetricparticles (which, if found, should all be unstable, probably with lifetimes that are very tiny fractions of a second) would decay into currently known types of particles.)

(Since Gillespie brings up the MSSM, it seems worth noting that, according to Lubos Motl (a Czech theoretical physicist, whose research is in superstring theory and who writes a blog called "The Reference Frame" in which, among many other things, he has posted discussions of the Higgs discovery), at a rest mass (in energy units) of 125 GeV/c^2, the Higgs particle is light enough that it is almost certainly not as predicted in the original Standard Model, but is consistent with the MSSM.)

Echoing others, like Smolin, Gillespie has at least two philosophical objections to current theories of energetic particle behavior, with their colossal numbers of parameters (see the definition of "parameters" given three paragraphs before this one): one is a conviction that a good theory should be simple and elegant, while these theories are complex and messy; the other is that with so many parameters the equations can be adjusted to agree with a huge range of observations after the observations are made, but they correspondingly have little if any predictive power. (For example, one can see from the *Wikipedia* article "Higgs boson," that in 2000, when the Large Electron Positron Collider was shut down to be replaced in the CERN tunnel by the Large Hadron Collider, the mass of the Higgs was only known to be somewhere in the range from 115 GeV/c^2 to 180 GeV/c^2.)

In discussing this second point, when he refers to issues of scientific truth he mostly seems to be referring to what is at least the popular understanding of the *falsifiability criterion* of philosopher Karl Popper: a theory is scientific only if it is vulnerable to being falsified.

However, in strict logical terms falsifiability only applies to *universally quantified* statements, which is to say that in mathematical logic notation they would appear in some form such as “"***x*** ***P***(***x***)”, read as “for all ***x***, ***x*** has property ***P***,” or perhaps more briefly and colloquially, “all ***x***’s are ***P***’s.” Obviously, such a claim is disproved by a single counterexample of an ***x*** that is not a ***P***. On the other hand, mathematical logicians also give approximately equal consideration to *existentially quantified*statements, which have the form “$***x*** ***P***(***x***)”, read as “there exists an ***x*** (or at least one ***x***) such that ***x*** has property ***P***” or more briefly, “there exists at least one ***x*** that is a ***P***.” Clearly, for existentially quantified statements the focus is on confirmation, since one can see immediately that such a claim is proved true by finding an ***x*** that is a ***P***.

Furthermore, existentially quantified assertions also are significant in science. For example, Murray Gell-Mann's prediction of the existence (under proper conditions) of the omega minus particle did not state that every particle collision that could produce an omega minus would do so, but only that it would happen sometimes. This prediction was considered to be confirmed when an experimental run in 1964 of 50,000 bubble chamber photographs turned up three containing tracks with the predicted characteristics, and so he was awarded the Nobel Prize in Physics a few years later.

Complementarily, Eddington’s observation during a total solar eclipse in 1919 of gravitational lensing of light passing near the sun that agreed exactly (up to the precision of the measurements) with the prediction of general relativity was only a confirmation of the universal prediction implicit in Einstein’s equations that this would always happen when light passed close to the sun, but it also contradicted the inference from Newton’s theory of gravity that light would not be affected by the sun’s gravity, so the disproof of the Newtonian theory, along with general relativity’s quantitative explanations of the anomalous perihelion shift of Mercury and the tiny red shifts of light emitted from massive stars, created strong attitudes in favor of general relativity in the aftermath of Eddington’s announcement of his eclipse results.

On the other hand, in a phase of scientific history that probably has been mostly forgotten, and that Gillespie does not mention, the attention given Einstein prompted a number of other physicists and mathematicians to formulate competing geometric theories of gravitation in the next several decades after 1919. These were eventually merged into a system of equations that were known as the “parameterized post-Newtonian formalism.” Eventually, experiments and astronomical observations were devised for situations in which the other theories predicted outcomes detectably different from the predictions of general relativity, and each time the results agreed with general relativity and disagreed with the other theories, so all of them have now been disproved and for many years no one has attempted any new theories of this kind. Perhaps this sort of situation should be considered to be more a part of the psychology of scientists than of the philosophy of science, but such a history of failures naturally discourages further efforts in the same direction, and it also seems natural to have high confidence in the truth of a theory that has successfully withstood many challenges over a number of decades.

(Perhaps it is also not too much of a digression to observe that in many fields of science, such as various areas of geophysics, biomedical science, and social science, the research topics are not in the form of either universally or existentially quantified statements, but are probabilistic statements about patterns of phenomena. In these situations issues of disproof and confirmation become quantitative rather than absolute, so that they have to be treated in terms of statistics: how far and how frequently (as a fraction of all observations) do actual events have to depart from expectations before one concludes that the expectations should be revised to agree more closely with the observations; and how much agreement with predictions has to occur before one starts relying on the predictions for practical purposes?

Subtleties and complexities like these seem to be well beyond simplistic ideas of falsifiability as a test of whether a theory is scientific.)

It also seems worth remembering that it can be very difficult to determine what a theory actually predicts. For example, although quantum mechanics was formulated in the Twenties, it was not until the Eighties that supercomputer technology became able to verify by large calculations of numerical approximations that the appropriate form of Schroedinger's Equation predicts the electromagnetic spectrum of neutral helium. This calculation could not be done earlier because the influence of helium's two electrons on each other eliminates the simplifications that allowed much easier high-precision computations of the spectra of the hydrogen atom and the He^+ and H_2^+ ions to be done decades before. Likewise, it is only in the last few years that huge lattice gauge calculations have verified that the decades-old Standard Model successfully predicts the ratios of the mass of the proton to the masses of several short-lived hadrons. It seems reasonable to wonder whether something comparable will be needed to determine whether the theory of Sundance Bilson-Thompson ("B-T"), on whom Gillespie relies for the many chapters of his explanation of the origin of matter, accounts for observed particle behavior quantitatively in addition to the combinatorial success that Gillespie highlights, in which B-T postulates two levels of simpler entities that combine in various ways to yield the quarks and leptons, the weak force bosons, and the Higgs particle of the Standard Model.

Although Gillespie does not mention it, the "Sundance Bilson-Thompson" Wikipedia article says that B-T also explains the three "colors" of quarks (the "red", "green", and "blue" "colors" being necessary in the theory to satisfy the Pauli exclusion principle, and put in scare quotes here to indicate that they have nothing to do with colors as perceived by the human eye, just as the "up", "down", "strange", "charm", "top" and "bottom" "flavors" have nothing to do with biological sensations of taste). However, it also says that he does not explain the gluons that in the Standard Model transmit the strong nuclear force (with "color" changes) between quarks in a way analogous to the transmission of electromagnetism by photons and the weak force by the three bosons that are included in the B-T model.

Obviously, having 6 types of gluon (one for each way to order each pair of distinct "colors" to implement all possible interactions) is even messier than what Gillespie describes, but they are a key aspect of the part of the Standard Model that describes the behavior of particles subject to the strong force, which because of the "colors" is called *quantum chromodynamics(QCD),* in analogy to the way that the theory of the behavior of electromagnetically interacting particles is called *quantum electrodynamics (QED)*. (Given that Gillespie quotes Richard Feynman frequently, it may be worth recalling here that Feynman's Nobel Prize in Physics (shared with Julian Schwinger and Sin-Itiro Tomonaga for work equivalent to Feynman's, though appearing very different) was for his theory of QED.) However, even if omitting the gluons is a deficiency in the B-T theory, much of Gillespie's discussion of space, time, and energy is independent of B-T, and hence can still be considered for possible experimental tests.

The situation for Gillespie now seems somewhat analogous to the situation for Einstein between his publication of general relativity in 1915 and Eddington's expedition in 1919: his work provides plausible reinterpretations of various previous observations, but it is so far in many respects from other theories that it opens up the possibility that some observation or experiment that would confirm his theory by matching its predictions would also be a strong counterexample for other theories; conversely, any large departure from his predictions would be a severe blow to, if not a conclusive disproof of, his theory.

It actually is not difficult to find a potentially testable contrast between Gillespie's ideas and conventional theory, since his expectations for black holes are as hugely different from previous ideas as anyone could want. In his chapter "The End" on pp. 430-434, he quotes the established calculation that the removal of energy from a black hole by an effect known as *Hawking radiation* (since it was predicted in 1974 by Stephen Hawking) is so slow that it would take some 10^{100} years to deplete the energy and mass of one of the black holes found at the centers of galaxies. However, he then asserts that the Flecks in a black hole would Fizzion fast enough to deplete it in only around 10^{12} years, noting explicitly that this is some 10^{88} times faster than the depletion by Hawking radiation. This estimated depletion rate evidently is necessary to explain the observed acceleration in the expansion of the universe in the past several billion years as the result of newly FizzionedFlecks tunneling out after they form in black holes. He expects relatively rapid Fizzion in black holes because theprobability that a Fleck will Fizzion increases with increasing energy contained in the Fleck, and compressing matter into a black hole should raise the energy content of the Flecks inside to levels matching those early in the history of the universe. (Thus, this concept eliminates the currently accepted need to postulate a previously unimagined and mysterious dark energy to explain the acceleration of the expansion.)

If Gillespie is correct about how fast black holes lose mass, it may be possible to detect mass loss from a supernova remnant black hole that is orbited by a pulsar. (Such binary astronomical objects are strongly believed to exist, although none has yet been observed.) This possibility follows from the following considerations.

Suppose, as seems plausible, that all or most of the Flecks in a black hole contain the same amount of energy, so that the probability of Fizzion is the same for all of them at each Tock. Then the number of new Flecks produced (hence the amount of mass lost) at each Tock is proportional to the mass in the black hole, so that the situation is described by a first-order differential equation for which the solution is an exponential function of time with a negative coefficient in the exponent to represent decay. Thus, once the black hole has depleted the supply of gas or other matter around it that could accrete to increase its mass, its mass should decline exponentially, like the decay of a radioactive element, with a characteristic time for losing half of the mass, analogous to a radioactive half-life. For brevity, let this time for a black hole be called the *half mass loss time (HMT)*. This implies that macroscopic black holes of all masses will display corresponding mass loss rates, whether they are supernova remnants or at galactic centers, down to the mass range at which Hawking radiation (for which the temperature varies inversely with the mass of the black hole) becomes dominant.

Now a typical black hole at the center of a galaxy has a mass on the order of 10^8 times that of the sun, but some galaxies have been found with black holes of a little more than 10^{10} solar masses, so let this be the maximum mass in the calculation. In turn, the solar mass is about 300,000 times the mass of the earth, which is about 6 x 10^{21} tons, using the metric ton of 10^6 grams, so that a galactic black hole of 10^{10} solar masses has a mass of around 2 x 10^{37} tons. Now let the mass at which Hawking radiation becomes dominant (or the *Hawking radiation mass (HRM)*) be the mass of a black hole for which the

Hawking radiation “evaporation time” (the time for the radiation to completely destroy it) is equal to the HMT for a black hole of at least twice as much mass. The Wikipedia article on Hawking radiation states that the evaporation time for a black hole of 228 tons is 1 second, and that the evaporation time is proportional to the cube of the mass, so that the evaporation time for a black hole of 687,500 x 228 = 156,750,000 tons is $(687{,}500)^3$ seconds, or about 10.3 billion years.

Taking 156,750,000 tons as the HRM makes the mass of one of the largest galactic center black holes approximately 1.28×10^{29} times the HRM. Now 1.28×10^{29} is approximately 2^{97}, which is to say that the expected 10^{12}-year lifetime of one of the largest galactic center black holes is around 97 times the HMT, so that the HMT works out to approximately 10.3 billion years, the same as the evaporation time of the HRM, as desired. For a black hole well above the HRM, this corresponds to a loss rate of about 6.73×10^{-11} of the mass per year.

The reason for wanting a pulsar to be in orbit around the black hole is of course the extreme regularity of its pulsations, and the highly developed theory of the influences on a neutron star that affect the pulsation rate, providing the best available opportunity for detecting small changes in the orbit that could be the result of a loss of mass by the black hole.

The orbit of a neutron star around a black hole that is losing mass will be affected in two ways: as the gravity of the black hole weakens, the orbit of the neutron star will get bigger, which would require more time to complete if the speed of the neutron star at each point in the orbit stayed the same. However, the speed will decrease, as some of the neutron star’s kinetic energy is converted to potential energy as it gains altitude over the black hole, and correspondingly less speed is needed to maintain the same centrifugal force at each point in the orbit with a combination of higher altitude and weaker gravity. A preliminary analysis indicates that the combination of these effects on the orbital period should result in a fractional change of around twice the fractional change in the black hole’s mass, or about 1.35×10^{-10} per year. Given that a year is 60 x 60 x 24 x 365 = 31,536,000 seconds, the cumulative change in the orbital timing should be 1.35×10^{-10} of this, or a little more than 4 milliseconds per year.

Whether this would be detectable would depend on the extent to which other influences were present and could be accounted for. For example, gas inflow to the pulsar and the black hole obviously could be a disturbing influence. However, combining a recent paper by Claude-Andre´ Faucher-Gigu`ere and Abraham Loeb in the *Monthly Notices of the Royal Astronomical Society* with current observations suggests that this might not be as significant as two effects of general relativity if their predictions are correct.

They argue that the most promising place in the sky to search for pulsar-black hole systems is the region within a parsec (3.26 light years) of the massive black hole at the center of the Milky Way galaxy, the presence of which is now accepted as the only plausible explanation of the signals from the radio source Sagittarius A* (abbreviated as Sgr A*). According to the Wikipedia article on this object, observations since its discovery in February, 1974, show that “the accretion rate onto Sgr A* is unusually small for a black hole of its mass,” (a little more than 4 million times the mass of the Sun, according to the most recent estimates), indicating a low average gas density in the region around it. The accretion rate is likely to rise temporarily, since a gas cloud designated G2 is currently approaching Sgr A*, with its closest approach expected in the middle or latter part of 2013. However, G2 is small compared to the parsec around Sgr A, which is estimated to contain stars and stellar remnants totaling around a million times the mass of the Sun, so it and any other clouds like it would not be likely to affect a pulsar-black hole system.

Faucher-Gigu`ere and Loeb conclude that since this region has been estimated to contain around 25,000 stellar remnant black holes, and also many binary systems consisting of a white dwarf and a neutron star, the past few billion years should have seen many occasions when an encounter between a black hole and a white dwarf-neutron star system resulted in the neutron star being captured from the white dwarf by the black hole. They do their calculations for a plausible system in which the black hole has 10 times the mass of the Sun, and the neutron star (detectable as a pulsar if the Earth is within its radio beam sometime during its rotation) has 1.4 times the mass of the Sun, finding that the neutron star, after capture from a white dwarf with the mass of the Sun, should have a highly eccentric orbit, with an eccentricity ranging from less than 0.8 to greater than 0.9, and a semimajor axis in the range from 0.1 astronomical unit (AU, the mean distance from the Sun to the Earth, about 149.6 million kilometers) to around 3 AU or a little more.

From this information one can calculate several further quantities that will be relevant for analyzing the radio signals if such a system is ever detected. A wide range of orbital periods will be possible for the pulsar, from around 107 per year for a semimajoraxis of 0.1 AU to only about one orbit every year and a half for a semimajor axis of 3 AU. General relativity predicts that, like the precession of the perihelion of Mercury, the *periastron* of the pulsar (the point of its closest approach to the black hole) willprecess in the plane of its orbit, at rates that are highly sensitive to the orbital parameters, from more than 4 degrees per year for an eccentricity of 0.9 and a semimajor axis of 0.1 AU, to only a few seconds of arc per year for an eccentricity of 0.8 and asemimajor axis of 3 AU. (The relevant formulas are accessible in the Wikipedia articles on “Elliptic orbit” and “Two-body problem in general relativity.”)

Most importantly, gravitational wave emission will remove orbital energy, counteracting the predicted effect of Fleck emission from the black hole by tending to shorten the pulsar’s orbital period. This effect is even more sensitive to the orbital parameters than the periastron precession is. Although a complete calculation of the energy loss per orbit would be laborious, since the power radiated in gravitational waves from a two-body system at any moment is inversely proportional to the fifth power of the distance between them at that moment, a useful preliminary assessment comes from comparing the power levels at periastron for different black hole-pulsar system orbits to the periastron power level for the *Hulse-Taylor binary pulsar* (more formally designated PSR B1913+16), for which the orbital period of 7.75 hours shortens by 76.5 microseconds per year, agreeing to within 0.2% with the general relativity prediction of its energy loss from emitting gravitational waves.

Evaluating the periastron power formula for various orbital parameters of black hole-pulsar systems gives a power level 6 times the corresponding Hulse-Taylor power level for a pulsar-black hole orbit with a semimajor axis of 0.1 AU and an eccentricity of 0.9, but only one fifth the Hulse-Taylor level for the same semimajor axis and an eccentricity of 0.8. For a semimajor axis of 0.5 AU and the same eccentricities, the corresponding power levels are approximately 1/500 and 1/15,000 the Hulse-Taylor power level, respectively, and for larger semimajor axes the power levels continue to decrease very rapidly. Also, of course, the total energy loss per year decreases because they have fewer orbits, hence fewer periastrons per year (107 per year, as noted above, for an 0.1 AU semimajor axis, but only about 9.6 per year for 0.5 AU). In short, this analysis indicates that only the smallest and most highly eccentric orbits should lose energy by gravitational wave emission fast enough to substantially counteract or to exceed the period-lengthening effect estimated for Gillespie's Fleck emission. (This paragraph relies on information from the Wikipedia articles on "PSR B1913+16" and "Gravitational wave.")

All of this would need to be considered much more precisely before one could be confident that Gillespie's rate of black hole mass loss would be detectable, but these calculations suggest that such an effort could be worth making. If black hole mass loss were successfully detected, then the result would be like Eddington's results from the eclipse: a successful prediction of a striking new observation instead of just a reinterpretation of things that were already known.

One other implication of Gillespie's black hole concept appears potentially observable under sufficiently favorable circumstances. It follows from considering where the new Flecks from a black hole might appear in relation to it, since he did not say anything about this, but only considered them in terms of their contribution to the expansion of the universe. It does not seem plausible to assume that they just tunnel out of the black hole's event horizon all around it, or maybe even appear far from it, but there is a natural candidate for where they emerge.

Matter accreting into a black hole at the center of a remote galaxy is the only explanation that has ever been found for the stupendous energy output observed from quasars, and the axial jets of a quasar are among its most prominent features. This is how, in a quasar that is close enough to be seen as a spiral radio galaxy, in most cases there are two lobes of ejected matter that are above and below the plane of the galaxy and are much larger than the galaxy, with most of the radio emission coming from these lobes. It has been generally assumed that the energy to accelerate the ejected matter to near the speed of light comes from some combination of the heat and pressure that develop as the infalling gas is compressed to the point of emitting a lot of energy in the far ultraviolet and x-ray regions of the spectrum, and perhaps also from kinetic energy transferred to the incoming matter from the black hole by the *frame dragging* effect, near the black hole's event horizon, by which the rotation of the black hole twists the space around it. However, the acceleration mechanism has not been considered to be fully understood, which is not surprising, since the distances to quasars range from hundreds of millions to billions of light-years, so the current and foreseeable angular resolution of the various types of telescopes is not sufficient to observe details of the environments around the black holes.

Gillespie's concept of black holes makes it reasonable to imagine that the matter in the jets from quasar black holes could to some extent be riding along in streams of new Flecks tunneling out of the black hole along its axis of rotation. This raises the question whether he did not mention this possibility because he did not think about axial jets in this context, or because the concept would have been too detailed or esoteric for his story and the narrator he created. However, there appears to be an analogy here between the idea of matter riding along in a stream of new space from the black hole and the description in the book of distant galaxies as not moving through space, as usually thought, but riding along as space expanded at the time when the light by which we see them was emitted, billions of years ago.

From this viewpoint, it seems significant that jets believed to be generated by the conditions in accretion disks have been observed around not only supernova remnant black holes, but around at least some neutron stars. The effect around neutron stars would have to be due solely to the accretion disk, but for supernova remnant black holes the acceleration could also have a component of Fleck outflow.

Further consideration suggests that even in the absence of detectable jets of matter an axial outflow of Flecks would lead to asymmetric gravitational lensing around a black hole (in contrast to the uniformly converging effect around the sun), with convergence around the equator, where an accretion disk would be if it were present, and weaker convergence or even divergence at the poles. If a more systematic analysis gave a quantitative prediction of the asymmetric gravitational lensing, it would be a notable theoretical consequence of Gillespie's vision.

For an isolated black hole the probability that it would align closely enough with a distant radio source for gravitational lensing to be detected is undoubtedly far too small to justify the effort of looking for such a situation. However, Faucher-Gigu`ereand Loeb note that if the orbit of a pulsar around a black hole were nearly edge-on, as viewed from Earth, so that the pulsar passed behind the black hole, or very nearly so, then gravitational lensing would be detectable in the radio signals from the pulsar. They mention the possibility of using this to determine the orientation and spin of the black hole, which would follow from asymmetric gravitational lensing resulting from the rotation's frame dragging.

However, if the orbit of the pulsar allowed its radio signals to pass near the poles of the black hole then asymmetry due to Fleck outflow might also be detectable. A pulsar orbital plane that would take it to high latitudes of the black hole is possible in the situation imagined by Faucher-Gigu`ere and Loeb, since the process that they expect predicts that the plane of the orbit of a captured pulsar would be randomly oriented with respect to the equatorial plane (and hence the axis) of the black hole. On the other hand, for the same reason the plane of the orbit probably would not be nearly edge-on as viewed from Earth, so the chance of finding a pulsar-black hole system with detectable gravitational lensing seems small. Nevertheless, if gravitational lensing indicating Fleck outflow asymmetry were ever observed, it would provide support for the concept of Fizzion in black holes that would be complementary to any observations of black hole mass loss, and would be an important confirmation for Gillespie.

Doubtless there would be other interesting and possibly significant conclusions from a more thorough and quantitative development of the ideas in *Time One*, but it seems unlikely that Gillespie will do this. He has the fictional detective imagined by his narrator say in the "Farewell to Arms" chapter (p. 436), about making the new concepts into a theory, "It will need a lot of work." Then he has the narrator say (presumably speaking here for himself) that he will not be the one to do this work. This is understandable, since Gillespie is now about 70 years old (the biographical information available on his website, www.colingillespie.com, gives no birthdate, but says he received his B. Sc. degree in 1961; anyone who has read *Time One* does not need to be told, as is said in the Amazon listing for the ebook version, that he has an “off-the-charts IQ,” so he probably moved through his precollege and undergraduate studies several years faster than most people).

Furthermore, the page after the title page of *Time One* assures the reader that it is “BOOK ONE OF THREE,” so he evidently expects to publish two more books, perhaps of comparable magnitude and complexity. The dust jacket of *Time One* says that his most recent previous book (published in December, according to Amazon) was titled *This Changes Everything: New views on the physics, philosophy, and religious thinking that matter to us all*, so it seems reasonable to guess that it was a kind of preview of the three books of which *Time One* is the first, implying that Book Two will offer his ideas on philosophy and Book Three will be about religion.

What he will do after the completion of those books is unpredictable, but in view of the social activism expressed in many of his legal cases, he may well consider that it is more important to develop and present philosophical or religious ideas that are more directly applicable to human concerns than further development of his physics ideas would be.

Or perhaps he will turn to economics. On p. 437 he has the narrator comment, “We are far past [the tipping point] for passing on a viable economy, a train that left the station some time back.” A little further down the page he approaches the end of the “Farewell to Arms” chapter by wishing that the new understanding of the Beginning would produce “ideas of such potency as might lead to a new economy as inconceivable as cellphones, CPUs, genetic codes and googling were a hundred years ago.” He thinks that coming generations will need such an economic transformation, or at least the prospect that it will come, to have hope, and then in reference to this possibility he ends by nearly echoing the fictional detective: “It needs a lot of work.”

Even if he does not write any more about the origin of the universe, in this book Colin Gillespie has given people interested in physics and cosmology much to think about.