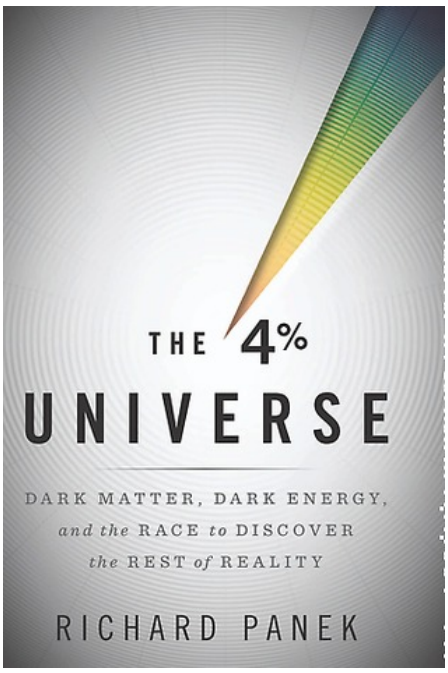

The 4 Percent Universe: Dark Matter, Dark Energy, and the Race to Discover the Rest of Reality

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The epic, behind-the-scenes story of an astounding gap in our scientific knowledge of the cosmos.

In the past few years, a handful of scientists have been in a race to explain a disturbing aspect of our universe: only 4 percent of it consists of the matter that makes up you, me, our books, and every planet, star, and galaxy. The rest—96 percent of the universe—is completely unknown.

Richard Panek tells the dramatic story of how scientists reached this conclusion, and what they're doing to find this "dark" matter and an even more bizarre substance called dark energy. Based on in-depth, on-site reporting and hundreds of interviews—with everyone from Berkeley's feisty Saul Perlmutter and Johns Hopkins's meticulous Adam Riess to the quietly revolutionary Vera Rubin—the book offers an intimate portrait of the bitter rivalries and fruitful collaborations, the eureka moments and blind alleys, that have fueled their search, redefined science, and reinvented the universe.

The 4 Percent Universe: Dark Matter, Dark Energy, and the Race to Discover the Rest of Reality Details

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From Reader Review The 4 Percent Universe: Dark Matter, Dark Energy, and the Race to Discover the Rest of Reality for online ebook

Paul Preuss says

For 20 years or so after the first Star Wars movie came out, most people who mentioned "dark" and "universe" in the same breath were talking about Darth Vader and the Dark Side. Doubtless some of the movie's fans were also astronomy fans who'd heard about the evidence for real dark matter -- not what it is (nobody yet knows what it is) but what it does, flattening galaxies, speeding up their rotation, and invisibly sculpting the structure of the visible night sky. Yet the import of that particular dark stuff had not yet excited a wider public.

Things started to change in 1998, when two teams of supernova collectors -- the Supernova Cosmology Project led by Saul Perlmutter, based at Lawrence Berkeley National Laboratory in California (Berkeley Lab), and the competing High-z Supernova Search Team, led by Brian Schmidt of the Mount Stromlo and Siding Springs Observatories in Australia -- announced they'd found strong evidence for a universe whose expansion wasn't slowing under the mutual gravitational attraction of matter, visible or dark, but instead was accelerating, propelled by something unknown. It couldn't be matter so presumably it was energy. Dark energy.

Within weeks, interest in the dark universe had accelerated beyond fans of astronomy and science fiction. Word swiftly got around: what we see, to the farthest reaches of the night, is a small fraction of the stuff that fills the universe. What we know is only four percent of what is.

Or, as Richard Panek puts it in the prologue of his extraordinary new book, "It's 1610 all over again." That was the year Galileo Galilei (physicist and master publicist) astounded Europe with his Starry Messenger, detailing the telescopic observations that proved Nicholas Copernicus's description of a sun-centered universe was more than just a mathematical convenience.

Panek set out to be a fiction writer, but he was bitten by the science-writing bug early on. He has produced quiet masterpieces, including Seeing and Believing: How the Telescope Opened Our Eyes and Minds to the Heavens (Viking, 1998). He knows a paradigm shift when he sees one, and in 2006 he began investigating how dark matter and dark energy had been dragged into the light.

Dark matter is the quiet backstory of his narrative. Part of Panek's gift is sketching distinctive personal qualities in a few words, as he does for the dark-matter pioneers. Vera Rubin "didn't like the controversy ... didn't like everyone challenging her on every number." Jim Peebles was "all angles ... elbows and knees ... a man of conflicting sensibilities." Panek lets the reader see how these utterly unquantifiable variables of character have shaped our rational understanding of the universe we live in.

The scientific exchanges over whether the shapes of galaxies and clusters of galaxies demand that there be some extra invisible matter in the universe were generally civil; over the decades there were arguments about dark matter, some even "virulent" and "rancorous" by Panek's account, but never a cut-throat competition, with one group of researchers trying to beat a competing group to the right answer by any means at hand.

When it comes to the story of dark energy, virulent and rancorous are mild adjectives. From its beginnings

there was head-butting opposition to the very existence of the Supernova Cosmology Project (SCP). The SCP was part of the program of the Center for Particle Astrophysics, jointly established by Berkeley Lab, a Department of Energy national laboratory, and the University of California at Berkeley. Although the center was supported by the National Science Foundation, its name gave away its genesis. Astronomers don't do particle astrophysics. Physicists do.

Nevertheless the center's founders thought it would be politic to include some people in the star-gazing business on its advisory board. One of those was Harvard's doyen of supernovae, Robert Kirshner, who opposed the Supernova Cosmology Project virtually from the moment he heard about it.

The physicists who started the SCP claimed they were going to weigh the universe, measure its shape, and learn its fate. "They used this giddy language in proposals to solicit funding," Panek writes, "they all told themselves that they were the ones who were finally going to solve some of the most profound mysteries of cosmology -- of civilization itself."

To do this they proposed to measure how fast the universe was expanding, or rather how quickly that expansion was slowing down. Expansion started with the big bang, and everyone assumed it was now slowing because of matter's mutual gravitational attraction. But would it finally stop and reverse, leading to a big crunch? Would it coast to a standstill? Or would the universe expand forever?

To answer these questions the SCP intended to use distant supernovae of a particular type, Type Ia, as standard candles -- objects whose distance could be calculated with confidence because they were bright enough to be seen across billions of light years and were also, or so the physicists believed, very similar in their brightness. Brightness was one measurement. Redshift was another.

How much the wavelength of light from these standard candles stretched before it reached Earth, shifting the identifying frequencies of cosmic objects toward the red end of the spectrum, indicated how much space itself had expanded and stretched since the light left the supernovae. So by comparing the brightness of Type Ia's to their redshifts, the SCP would be able to compare the present expansion of the universe to its expansion in the past.

In Robert Kirshner's opinion, the SCP didn't know what it was doing. At first, "Kirshner emphasized that the Berkeley search team hadn't yet found a supernova, needed to be careful about photometry [measuring brightness], couldn't account for dust [which reddened the light] -- and didn't know whether Type Ia supernovae were standard candles," Panek writes. When, after much tribulation, the SCP did find a distant supernova in 1992, "Kirshner complained that they still needed to be careful about photometry, still couldn't account for dust -- and still didn't know whether Type Ia supernovae were standard candles." Invited by the editors of Astrophysical Journal Letters to review the SCP's paper describing their first supernova, Kirshner delayed their paper on the grounds that "They hadn't yet learned anything about cosmology."

With an initial small sample the SCP did indeed make bad guesses about the universe's weight and shape. But in 1994 they started collecting Type Ia supernovae by the fistful, having developed and applied methods that should have been obvious -- particularly to doubting astronomers. A Type Ia supernova goes off in a typical galaxy perhaps once in a century. By photographing thousands of distant galaxies and then photographing the same batch some weeks later, a few supernovae are statistically certain to have gone off somewhere in that vast collection of stars. Sorting them out wasn't easy, but with the right detectors and computer programs it was inevitable; Type Ia supernovae could be had on demand.

The size of SCP's dataset began to multiply. Once the SCP and several other supernova hunters had shown

that distant Type Ia's could be used to do cosmology, and once the SCP proved they could be found on demand, competition to measure and weigh the universe quickly got organized.

Large datasets are a physicist's playground. Astronomers are content with fewer data but pride themselves on analyzing each with great discrimination. Brian Schmidt and Nicholas Suntzeff formed a team of astronomers that called itself the High-z Supernova Search Team (z stands for redshift). Ironically, many of its members were past or current students of Kirshner's, who was now enthusiastic about using Type Ia supernovae to do cosmology. When he offered to lead the new High-z team, however, its members declined.

What had begun as astronomers versus physicists took on the added flavor of East Coast versus West Coast. The SCP was a large group (including some astronomers, in fact) with many members from European and other institutions, but its core was at Berkeley Lab. The smaller High-z team was more randomly dispersed, but with some exceptions -- notably Adam Riess, a Kirshner graduate student who by 1997 was a postdoc at UC Berkeley – its center of gravity was in the East. Gradually that center coalesced around the Space Telescope Science Institute in Baltimore, which manages the Hubble Space Telescope -- and which Adam Riess would soon join.

A key episode related by Panek shows why what might have been a purely scientific race became tinged with bitterness. In 1996 Saul Perlmutter had approached Robert Williams, director of the Space Telescope Science Institute, to apply for Hubble Telescope time, which was much in demand and hard come by. Perlmutter argued that the SCP's ability to deliver supernovae on demand met the Hubble's high standards. The Hubble was needed to search for the most distant supernovae, in Panek's words, to "make a supernova pop out of its host galaxy."

Williams's response was to request a formal proposal and then, some months later, to convene a private meeting with Robert Kirshner, Nicholas Suntzeff, and Mark Phillips, all members of the High-z team, all of whom argued vigorously against giving the SCP any time at all on the Hubble.

Williams's position, according to those at the meeting, was that "This is really good science, and I [Williams] think the Space Telescope ought to do anything that's really good."

Panek continues, "at some point each of the High-z members at the meeting understood what Williams was really saying. If they asked for time, right then and there, they'd get it too."

In high-energy physics, proposals for the use of important resources were usually confidential. That was normally the case when astronomers applied for telescope time too. So from the West Coast perspective, says Panek, the dots were not hard to connect: "If you wanted to see evidence of an old boys' network, you didn't have to look very hard."

Both teams got Hubble time, and the suspense increased as both began to converge on an answer. Early in the fall of 1997, in data from 42 supernovae, SCP team member Gerson Goldhaber found evidence that only a small part of the universe is matter. High z team member Adam Riess soon reached the same conclusion. Early in 1998 both teams announced their findings that expansion isn't slowing at all; it's accelerating, because some three-quarters of the cosmos is made up of a "cosmological constant" or other form of what soon came to be called dark energy.

All agreed the universe is accelerating -- and they agreed that knowing why will require more data and new research methods. So the competition continues to this day, with opponents still grouped roughly as in the beginning, fielding different proposals for funding the space satellites and ground-based surveys that will be

needed to assess the nature of dark energy. Unless it's an illusion, a flaw in Einstein's theory of gravity -- and maybe even if it is -- dark energy is the most profound cosmological discovery since, well, 1610. It's the stuff of Nobel Prizes.

Talk about competition. To their credit many, if not all, of the scientists on both sides have tried hard to rise above the snide blogs and dueling press releases that marred the decade of rivalry following the 1998 announcements. (It's time to confess that this reviewer wrote many of those press releases on behalf of the SCP.)

Panek quotes Brian Schmidt speaking at a press conference the day before the bestowal of the prestigious Gruber Prize in Cosmology at Cambridge University in 2007, a prize shared between the leaders of the competing teams and also equally among the team members. "Our teams, certainly in the U.S., were known for sort of squabbling a bit," said Schmidt. "The accelerating universe was the first thing that our teams ever agreed on."

Panek writes, "The award ceremony at Cambridge wasn't only about posterity.... It was about history ... posterity in motion." He tells how Perlmutter and Schmidt, in the lecture that followed the ceremony, narrated "the history of modern cosmology, sometimes finishing each other's sentences," a modern history that began in 1965 with the discovery of the cosmic microwave background and brought with it a new way to do cosmology, opening new vistas on the possible. It was a time when "Perlmutter and Schmidt were themselves as young as the universe."

The most profound discoveries since Galileo deserve a chronicler whose passion for accuracy, love for the human story, and grace with words is the equal of the tale he tells. In Richard Panek, the scientific saga of dark matter, dark energy, and the other four-percent of the universe -- all that's left to us to see with our own eyes -- has found a spell-binding bard.

Steve says

This is a deeply frustrating book to read because Panek took no time to craft an overall meta-analysis to tie together all of the elements of his story. This is a subtle point and I will try to briefly explain what I mean below. I am all the more frustrated because the story of dark matter and dark energy, however the scientific understanding plays out in the future, is absolutely fascinating. But upon reflection, I have to issue what is perhaps the most damning verdict that can be passed on a book: after reading The 4% Universe, I could not tell a friend how the story of dark matter/dark energy hangs together. I will return to the “hang together” notion presently.

Just to make clear, while I am a layman in physics, I am a doctoral student in sociology with an interest in science and technology studies and organizations. That makes me a professional writer and I may be somewhat more sensitive to the weaknesses of Panek’s argument as a result.

When I say that Panek’s story does not “hang together”, I mean to say that the events that Panek presents come forth from the prose in a breathless way and there is a rush from event to event without anywhere near enough discussion of how to understand the event in question and how it relates to other events. (For an example of this sort of analysis in physics, I would refer you at the very least to Brian Greene’s work. In engineering, Henry Petroski does a very nice job of providing analysis.) What this means is that I don’t have

an overall sense of the story. When taking on a task like this, namely presenting a complicated argument in physics and cosmology to a lay audience, the writer must be an experienced and solicitous dance partner and have in mind both the overall pattern and structure of the dance as well as to be able to “cue” the reader/dance partner as to what is coming next.

Panek on the whole falls down on the “cue” part and as a result, I have no intellectual structure to tie the material in the book together in my head. In fact, the book reads like a long newspaper article rather than a book, and that is not a good thing. In a newspaper article, the lack of length is both a detriment and an advantage. The brevity of the format means the writer cannot supply much information but that same feature means that the article does not need the same type of narrative structure that holds a book together. The reader can be expected to fill in the missing structure and in any case because an article is short, the reader can re-read it a second or third time without too much of a time penalty.

The same does not hold true of a book. A reader cannot be expected to read a book two or three times in one sitting. Consequently, the book author must take pains to supply an overall narrative structure – like a dance – and to supply cues to the reader to enable the reader to know what is coming next as well as to how it ties in with what has been said before. If this is not done, then the result is a chaos of information without structure. That is how I felt with respect to 4% Universe. Just as a measure of how much this book challenged me, in my time with social theory, I have read a fair amount of Marxism, a discipline (in)famous for the turgidity of its prose, and I have to say that Panek – for different reasons – was about as challenging.

There is much information that is useful in this book and I intend to retain it for two reasons. The first is that as a student of science and technology, there is a huge amount of evidence for how science is a social enterprise as well as being a search for the truth. But second, I keep it as a warning and a lesson for how not to write and for why a good narrative structure is absolutely essential in long-format writing. If you, the reader of this review, are looking for a general book that will educate you on dark matter/dark energy, then I would advise you to look elsewhere.

Becky says

I've been on something of a science kick lately. This is my third science-based audiobook this year, and it's only early April. I've enjoyed them all, even if I can't say that I understood everything in them. This book, though, felt like a desert triathlon compared to the other two leisurely strolls in the park. This book was exhausting. But I say that in the best way possible. I think.

First, let me just say that this book is seriously fascinating. I love astronomy and cosmology, so I'm fascinated with books and shows about what exists beyond our planet, as well as how it came to be. So books like this one are always going to strike my fancy. I just like to learn about what there is!

And this book definitely provided information about the cosmos, for sure. It's well researched and so very, very, very, very detailed. I don't know if all the details are accurate, because I think I only really understood 4% of this book (the real meaning of the title!), but that was not for lack of trying on Panek's part. Not only was this a science book about dark matter and dark energy and the universe's creation and make-up, but it's a history of the science along the way, as well as more than a little bit of the drama involved in the competitive arena of science.

And keeping all of these things straight in my head was exhausting. There were a ton of people involved, a whopping shit-ton of science and physics and astronomy and math and math and math for days, all of which was more than enough to make my brain cramp up, but then there was a whole lot of the bitchfighting between teams and specialties because everyone wanted to be first. Which I get, I do. Everyone wants their name marked down in the logs for posterity... but a little professionalism would be nice, gentlemen.

This is definitely a good read, but so technical that it was a bit overwhelming at times, especially in audio format, so I think I'd like to re-read this one day and maybe snag some additional understanding from the air above my head. Still, I can't blame the book for my lack of knowledge; that's a shortcoming on my part, because I lack even a single doctorate degree. Some of the INTERNS in this book were on their 3rd or 4th doctorate, so right away I knew that this was going to be over my head. I still really enjoyed the 4% I could understand though... so 4 stars.

Zanna says

This book has been hanging around on my shelf for a while, and I finally picked it up after having an amusing conversation about spherical cows which reminded me that I should really re-read The Black Hole War: My Battle with Stephen Hawking to Make the World Safe for Quantum Mechanics

Let there be dark. Let there be doubt

I have chosen this quote because it links contemporary cosmology with my current favourite book, The Left Hand of Darkness in which my favourite character ‘prays’ at night “praise now darkness and creation unfinished”. Indeed, let there be dark, doubt, and creation unfinished, futures unknowable because the timing of any particular interaction can by no means be predicted. Let there be deep knowledge and stirring mystery.

It’s me, not the author, but I was pretty disappointed with this book. The resonance of the glorious physics therein was muffled for me by three factors:

The absence of diagrams – even though there are innumerable references to graphs, curves on graphs, points on graphs, crucial data from images and so on. Please, SHOW ME THE DATA. I can’t think of any excuse for this

The absence of equations, although there are many references to equations. I understand that many people are put off by the sight of equations in a book, but if the aim is to write something that appeals to and can be understood by a wide audience, then it would be better to include at least the simpler equations and thoroughly explain them, or to at the very least put them in an appendix so those who would like to see them can have a look.

The excessive focus on the soap-opera of rivalry between teams of physicists and astronomers (who coalesce into cosmologists by the end of the story, perhaps?). This bored the hell out of me. I couldn’t care less who came up with a theory first or found the most supernovae. This stuff just gets in the way here. It’s not that I want a textbook - Leonard Susskind does a perfect job of dramatising the oppositing between himself and Stephen Hawking in *The Black Hole War* ,and I think it’s essential to have texts that reveal and remind that science is a human activity and has a sociology that affects what it produces. But I want more physics, less jockeying.

At times, the tone is comically overexcited which might be considered a noble effort to enliven the material:

> On this occasion, however, Alan Guth received a midnight visit from the Muse of Maths. The next morning he bicycled to his office at the Stanford Linear Accelerator Center (in the process establishing a new personal best of nine minutes and thirty-two seconds) and immediately sat down at his desk to summarize his long night's work
>
> "SPECTACULAR REALIZATION" he wrote near the top of a fresh page, and then he did something he'd never done before with a notebook entry. He drew two boxes around it.

I did stash away a couple of gems from Vera Rubin's biography for feminist history:

> When an admissions officer at Swarthmore College told her that because astronomy was her profession of choice and painting was one of her favourite hobbies, she might want to consider a career as a painter of astronomical scenes, she laughed and applied to rival Vasser. When she got a scholarship to Vasser and a teacher told her, "As long as you stay away from science, you should do OK," she shrugged and pursued a degree in astronomy (with a heavy load of philosophy of science on the side). When a Cornell professor told her that because she had a one-month-old son he would have to take her place at the Haverford AAS meeting and present her paper in his own name, she said, "Oh, I can go," and, nursing newborn and all, she went.

:)

Ilsa Bick says

This year, the 2011 Nobel Prize in physics went to three men--Saul Permutter, Brian Schmidt, and Adam Riess--for their discovery of what 96% of the universe is composed of: dark matter and the much more elusive, dark energy. Does anyone really know what these things/entities are? No, but they do make up the majority of the cosmos and dark energy appears to be responsible for the fact that our universe is neither static (as Einstein thought) nor are its boundaries beginning to collapse (as might be predicted by the inflationary/Big Bang model). Instead, the universe is expanding, and it is doing so at an ever-increasing rate as galaxies accelerate away from one another. Panek's book is not a scientific tome although there's a fair amount of easily understandable cosmology; you don't need to remember calculus to get what's going on here. Panek has instead focused on the race toward discovery: the personalities involved, the misjudgments, and--to be fair--some subterfuge and academic backbiting. Anyone who's involved in research will know whereof I speak; academics can be cunning, devious, ruthless, and egotistical. But many are dogged, and most are relentless in their drive to understand the universe's deepest mysteries. Some of this otherwise wonderful book is a slog; it bogs down a bit in the middle; but this is a book about personalities as much as it is about science. The fun comes as you realize that the jury's still out on exactly what 96% of the universe is made of.

Trevor says

This was another book that ended up being sold on false advertising. Now, you might be forgiven for thinking a book called the 4% universe is going to be about, well, cosmology or something crazy like that. This was mostly about the infighting between groups of cosmologists and as such it goes to prove that a physics degree is no protection from being a wanker. The cosmology, far too often, comes second.

That a tedious obsession with 'being first' and 'beating the other guy' is as bad for science as it is for, well, everything else in the world should hardly come as too much of a surprise. That it makes for tedious reading too should also hardly come as a surprise.

The best bits of this book where the bits where he discussed the cosmology, he is actually very good at this and incredibly clear. Now, it might just be that I find the sort of business school stuff so boring that I've exaggerated how much of this book seemed to be devoted to that rather than the science, but I don't think I have, to be honest. When the science is so infinitely interesting the idea you might spend any time at all talking about the all too human nonsense and fluff about whose name should go on which discovery or all of the back-biting and funding applications and whose name goes first on a paper – my eyes just glaze over, I'm sorry, but then, I have spent a lifetime in similar meetings wishing for sudden and painful deaths – either mine (sudden) or someone else's (painful) – so this generally isn't how I like to spend my recreation.

My favourite paradox which was explained in this book is the horizon problem. You look south into the night sky as far as you can see, then you look north into the night sky as far as you can and the universe is at exactly the same temperature and looks exactly the same – but the light that reaches you has taken the life of the universe to have travelled to you and the two distant and opposite parts of the universe have not had time to be in any contact with each other – so, how did they get to be quite so 'the same'? This is explained by inflation – and the idea of inflation is explained beautifully in this book.

What is also really interesting is how recent most of these discoveries are – as he points out, a young man getting shot in WW1 knew nearly as little about the universe as someone looking out from his cave 300,000 years before. Not quite true, obviously, but then given dark energy only became accepted in about 2006 the shocking recentness of this all is quite something. The idea there dark matter must be other than actual matter is something I hadn't quite realised previously either – that so much more of the universe needs to be something other than the stuff we see and eat and love and dream about, well, that's a tad disturbing.

A lot of this is written with a bad attitude, not quite Phillip Marlow, but heading down that path – again, it is a book with too much fluff so as to provide atmosphere and it really could have done without that as (and, again, it might just be me) but surely people would read pick up this book for the science, rather than the fluff. All the same, there is my favourite Australian expression included (when something is obvious it is said to 'stick out like dog's balls') – and it is an expression that needs further publicity. But this really could have done with someone attacking it with a red pen reading it before publication. Or it could have been subtitled, 'all is vanity'. Some warning would have been nice – as I had thought I was going to read a book on science.

(A better review of this book – and more forgiving of the fascination with the personal stories involved - is here http://www.goodreads.com/review/show/...)

Glee says

A funny thing happened to me on the way to.... seriously, this book was given high marks by two friends. I tried listening to it, and abandoned the effort after 3 (out of 9) discs. A lot of the time, I could follow but then had no idea what it was that I had just heard. And sometimes I couldn't follow at all. And occaisionally (but not frequently enough), I understood it perfectly. So not a great experience.

However, (back to the "a funny thing....") over the next couple of weeks I kept hearing (radio) and reading (newspaper) stories about dark matter. And they were fascinating. And I could understand them.

I have to say if I hadn't made this attempt, I would have just skipped over the articles and podcasts, but now, having listened and read them, I have to admit I am richer for it.

That doesn't mean I understand quantum theory now. But I'm not afraid anymore....

Manny says

What a very strange book this is, and what a very strange guy Richard Panek seems to be. I know many autistic-spectrum people, and I wonder if he isn't a little autistic. One of the most characteristic things about autistic people is the unevenness in their range of abilities. They are usually extremely good at some things and staggeringly incompetent at others. Panek is definitely a bit in that direction.

Panek sets out to tell us about the most recent chapters in the exciting history of cosmology, the discovery of dark matter and dark energy. As everyone now knows, most of the universe is invisible. The 4% in the title is the part we can see: planets, stars, nebulae, things like that. Then there's about another 25% which is dark matter - we can't see it, but we can quite easily see the gravitational effects it causes - and the rest is dark energy, the evidence for which is considerably more indirect. The greater part of the book is about the discovery of dark energy during the 90s. Its presence is detectable by the fact that it acts to stretch the universe apart over time (you sometimes see it called "anti-gravity"), and finding proof that the stretching existed was very difficult. It involved accurately measuring the distances to galaxies which are many billions of light years away, obviously a challenging thing to do.

But scientists can be ingenious when there is a good reason for displaying ingenuity. The brightest things there are (simplifying a little) are the huge stellar explosions called supernovae, and it turns out that a certain type of supernova has predictable enough behavior that it can be used to carry out the accurate measurements that were needed. A supernova is so bright that you're able to see it more or less literally from the other end of the universe, and because their behavior is well understood you can also figure out from careful examination of the rate of change of intensity what their true brightness is. Comparing the true and apparent brightness gives you their distance. But the details are complicated.

So why are Panek and the book strange? Well, let me start with the good news. He is an incredibly dogged and hardworking journalist. He seems to have talked with virtually everyone who was involved in the story, he has read their papers, he has looked at their emails and PowerPoint slides, and he is certainly able to present you with some rather striking details. Where Vera Rubin was standing when she received a critical phone call; Alan Sandage's loss of his sense of balance causing him problems on the high telescope platform towards the end of his career; how the cosmology community reacted when they heard that David Schramm's private plane had crashed. He's got all the gossip, and, given that the discovery of dark energy was an acrimonious race between two teams, there's plenty to write about. On all of this, I can't fault him. He's booked you a ringside seat, and you can see the drops of blood flying every time someone lands a solid

punch.

Now for the middling news. Panek, alas, is not a particularly gifted writer. His prose is cliché-ridden and pedestrian. He is not good at sketching character. There are a bewildering number of people in the story, and it's frequently impossible to tell them apart. A lot of the time, you just have to remember that X is the person who's responsible for Y on the blue team, and Z is the person responsible for W on the red team. Luckily, a few people are such appalling assholes that their personalities shine through. (I hasten to add that there are also some truly admirable characters; the one I liked best was Vera Rubin). But they're the exceptions.

And finally for the bad. Oddly enough, for someone who's an award-winning science journalist, Panek seems to be rather sketchy on science. There are some remarkable bloopers. He says that the Casimir effect integrally involves gravity. He tells us that the hypothetical neutralino (important to dark matter theorists) is the supersymmetric partner of the neutrino. Most astonishingly of all, he misquotes Kepler's Third Law - something your average scientist learns in their early teens - and even gives some incorrect examples of how to apply it. So, unfortunately, when he's explaining something I don't already know, I'm never sure whether to trust him. I doubt I've spotted all the glitches.

To summarize, then, a mixed bag. But despite the weaknesses, I give him a clear thumbs-up. He's got an incredible story to tell you about how science actually gets done.

Todd Martin says

The 4-Percent Universe The 4-Percent Universe begins with the story of the discovery of cosmic microwave background radiation in 1964 by Bell Labs employees in Holmdel, New Jersey. This isn’t what I was expecting, but often science books set the stage with a little history as a prelude to the science. The next chapter? ... More history.

Unfortunately, and contrary to all expectations (I was expecting a science book), the entirety of the book is dedicated to a description of the people who made various discoveries that led to our current understanding of dark matter and dark energy (in other words ... this is a history book). While it’s possible that an insider would find the details of the individuals, teams, rivalries and the petty intrigues that make up the book to be of interest, I found it to be little more than standard office politics and about as appealing. While there is some cosmology scattered amongst the banalities, you really have to work for it.

Instead of dark matter, we are subjected to details of a competitor’s underhanded dealings to publish a paper ahead of a rival ... Oooh burn!
Rather than dark energy we are treated to excruciating detail of the minutia that goes into real science … hours spent in a computer room debugging code?!? ... I’m on the edge of my seat!

The reality is that the process of doing science is tedious and boring. It’s full of false starts, hard work, mistakes, corrections and endless hours of drudgery. The reward for this effort, if all goes well, is that a small slice of the world becomes slightly less fuzzy. What Panek misses is that it is the revelations revealed by this process that are fascinating. The process by which we come by them is not, except perhaps to those individuals who are directly involved.

Atila Iamarino says

Que livro gostoso de ler. Panek explica da concepção da ideia de Big Bang à descoberta recente de matéria escura e energia escura. O livro é bem compreensivo e bem explicado, daqueles que expõe as perguntas e ideias que levam à formulação de uma nova teoria, além dos testes feitos depois que corroboram ela. Com uma explicação bem detalhada das descobertas de constantes.

Explicações como "segundo esta hipótese do Big Bang, o Universo ainda estaria a 1-4K de temperatura [...] confirmaram a temperatura" e outras do tipo deixam muito claro o valor das ideias cientificas, como foram formuladas e porque foram consideradas válidas. Ele deixa muito claro o processo todo de como mudamos radicalmente nosso entendimento do Universo ao longo do Século XX e porque estamos mais perdidos do que nunca – o que é muito legal. :)

Saiu em português como De que é feito o Universo? e recomendo demais. Ele só perdeu o Nobel de Física de 2011 para os propositores da expansão com energia escura, mas não está muito desatualizado. Li um trecho para o episódio de Fim do Universo e a melhor coisa que fiz foi resolver ouvir todo.

John says

This is an attempt to tell the human story behind the discoveries that led to our modern conception of the universe being made up mostly of dark energy, plus about 25% dark matter, and finally about 4% in the form of the matter and energy that we can directly detect, including ourselves. In addition, Panek goes some distance toward explaining in simple terms some pretty abstruse cosmological concepts.

So far, so good. I read the book for relaxation as much as anything else, and at that level I very much enjoyed it -- although I did have difficulty keeping track of all the names and the acronyms/contractions.

But I was a tad alarmed to trip over odd little errors. On page 85 there's an error in the units for the Hubble "constant" (there's a crucially omitted "per second"). On page 188, discussing primordial and current levels of deuterium and helium-3 in the universe, Panek has his "most" and his "least" back to front. (The explanation on that page is also, I'd suggest, a bit oversimplified, but I don't offer that as a criticism: it's always hard to know where to draw the line between oversimplification and opacity.) On a page that I can now no longer find there's a false explanation of Kepler's third law. That sort of thing.

These instances got me worried: how many *other* slips might there be that I *wasn't* spotting? Was it possible that some of the insights I thought I was gaining were misleading me?

The 4% Universe is a great read, and can be thoroughly recommended at that level. I'm not sure that it tells the story behind dark matter and dark energy so much as it tells the stor*ies*, in the plural -- at the end I didn't feel everything had been pulled together, although perhaps that's inevitable when the science itself is still a work in progress. Hum ho.

Sam Webster says

I don't consider the two star review a qualitative measure of "4 Percent Universe", so much as an indication that it failed to deliver what I expected. It is exceptional as a series of biographies of the scientists involved in the search for dark matter, dark energy, and supernovae; it is passable as a layman's course on modern cosmology and the techniques that are being employed; but it falls far short of being a useful study on dark matter and dark energy themselves. These concepts don't even show up until about halfway through the book, and modern theories are only discussed tangentially. The quality of the book, therefore, depends a great deal on what you expect from it.

Riku Sayuj says

Now *this* is how an honest-to-goodness popular science book ought to be like. The book basically tracks the same story as A Universe from Nothing by Lawrence M. Krauss and even has Lawrence as a character every now and then. Because I was familiar with the story and its ending, this time around I could concentrate on the telling of the story more than the actual events themselves and I was struck by the high contrast of how Richard Panek handles the material and how Krauss had presented it in his book.

Krauss comes at it with a vehemence and a rejoicing attitude as if science has finally solved the big problems with the confirmation of the 'dunkel stuff' and from the extension of the flatness of the universe to how it was possible for it to have come from nothing. Throughout the book, the language is forceful and the story is convincing. The scientists know what they are doing and they are finally getting things right was the sonorous message. 'No doubts entertained' was Krauss's attitude and the percentages and the fractions were thrown at us as if there was no contention on those measurements whatsoever. I was convinced and I accepted them. After all, they were coming from a respected scientist who was part of these very breakthroughs. So with a few reservations about how Krauss had not really closed the door with the book, I had concluded my review.

The 4% Universe - ***4% science... 96% stories*.**

Panek on the other hand has shown me the human version of what happened behind the scenes. Those astronomers and observers who found the standard candles and made the measurements, those theorists who made the elegant theories and the physicists who ran the accelerators in patient search of extreme particles, they were not really all that, exactly. They were mostly guessing and fumbling and playing scattergun. They had no idea whether Type Ia supernovae would really be standard candles, they had no clue why lambda should be non zero or for that matter, what dark matter or dark energy really *is*.

These uncertainties of the scientific procedure too should be captured when science is written or commented upon and Panek has done that in wonderful fashion. At times his obsession with detail and the pages and pages of detail about the letters exchanged and the worries of each group member of the High-z team and the SCP team does get tedious when the reader already knows the outcome of this famous spat and Panek doesn't quite manage to achieve the suspense that he tries so hard to build up. But what the detail does provide is an insight into the insecurities and the many mistakes of these Nobel laureates and exposes how almost everything they thought of the universe was wrong and that the Nobel they got was mostly for proving themselves and almost everyone else so completely wrong.

Let There Be Dark

That said, anyone who approaches the book to get answers to the big questions will quickly realize that the book is not about providing answers but about how circuitous the route to finding answers can be. The first half of the book details the work of astronomers discovering in steps, starting from Galileo, that there is more to the universe than what meets the eye. The astronomers progress to seeing the planets, the moon, then the stars and then even the galaxy and then, horror of horrors, other galaxies and clusters of galaxies. The theorists could not keep pace with the speed at which discovery was progressing, lockstep with technology and the theorists lagged far behind, still in the armchair with Newton and Einstein. Meanwhile, the astronomers were going ahead and finding out weirder and weirder things about the universe - they found that the Big Bang was real and had proof in the form of CMBR, they found that the universe is expanding, then that the expansion is accelerating. Then they found that the galaxies rotate too and that the rotation does not slow down towards the edges. The only way they could explain this was to posit a huge amount of 'dark matter' on the edges, stabilizing the rotation, only to be derided for reincarnating the discredited 'ether' of old days. But, evidence gathered and soon it was accepted. Weird thing, that. It was accepted purely because it solved problems, not because anyone could explain why it was there or what it was doing there, a trend that was soon going to dominate cosmology.

The next step was to come from the laggard theorists. Out of nowhere came the breakthrough idea of an 'Inflationary universe' - now this solved even more problems and also made acceptable a few arbitrary assumptions that the cosmologists had made about the universe such as homogeneity and isotropy. Who could resist that? It was soon standard truth. Now that universe was inflationary and the current state of the universe was satisfactorily explained, the question was how will it end, what is its future? The answer was to find out if the universe was 'flat'. The mathematics seemed to indicate that it indeed was. But for this, with the existing dark matter and matter put together, there still had to be much more energy (many orders of magnitude) than what the universe we can measure contains. Dark Energy was born, at least on paper. So there we have it, the universe we know, perhaps the universe we can ever know (baryonic matter) is just 4.56% (?) of the real thing.

They had to accept now that there might be *less* to the universe than what meets the eye. Of course, the theorists and the physicists are still devising new theories to explain away or to prove these unseen problems and millions are spent every month in remote corners with hopes of detecting these elusive stuff, the stuff of the universe.

The best response then, from scientists as well as from those of us trying to make sense of all this, should be humility and a willingness to entertain and rigorously examine the wildest ideas - they seem to have made a habit of coming true.

Eric Rasmussen says

I have a lot of respect for this book, but after reading it (and rereading large portions of it), I was unable to retain anything from it. First, it is primarily the story of the scientists behind the recent advances in cosmology and the search for dark matter and energy, and without the benefit of any character development, I was unable to keep anyone straight. I could not recount any of the story of discovery, the teams involved, or the people that won the awards, as there is not much establishment of these characters as people; instead,

they are simply names. Second, there is actually very little focus on the explanation of the science behind cosmology and dark matter; instead, this book is clearly geared towards those with a much stronger background in physics and astronomy than I have.

Although this certainly earns me the derision of the "real" scientists out there, I need a pop-science, science for dummies, Bill Bryson style approach to topics like this, especially ones as incomprehensible as cosmology. Give me some metaphors. Walk me through the math. After finishing the book, I cannot recount the story of the people involved, nor can really discuss what dark matter is. So why did I read it?

As a pretty smart dude, I hate to admit that this book went right over my head. But, then again, it wasn't meant for me.

David says

This is really an enjoyable, easy-to-read book on the recent history of cosmology. Read this book and you will understand the big questions in cosmology--there are no answers yet. I especially appreciate the descriptions of recent advances in astronomical observation techniques, and the telescopes (optical and radio) that are used. I thought that a bit too much of the book is devoted to the competition to find and measure supernovae, and the squabbles that ensued.
