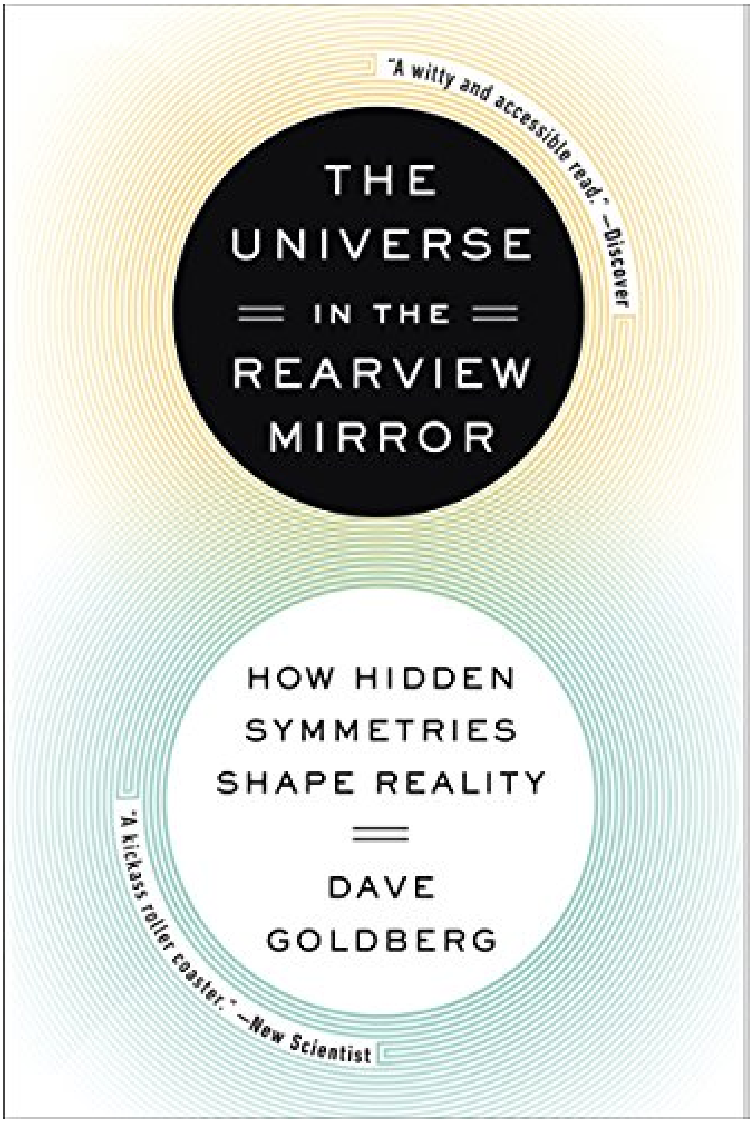
The Universe in the Rearview Mirror: How Hidden Symmetries Shape Reality



Par Dave Goldberg
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Par Dave Goldberg : The Universe in the Rearview Mirror: How Hidden Symmetries Shape Reality before purchasing it in order to gage whether or not it would be worth my time, and all praised The Universe in the Rearview Mirror: How Hidden Symmetries Shape Reality:

Description :

Prsentation de l'diteurA great read Goldberg is an excellent guide.Mario Livio, bestselling author of The Golden Ratio Physicist Dave Goldberg speeds across space, time and everything in between showing that our elegant universefrom the Higgs boson to antimatter to the most massive group of galaxiesis shaped by hidden symmetries that have driven all our recent discoveries about the universe and all the ones to come. Why is the sky dark at night? If there is anti-matter, can there be anti-people? Why are past, present, and future our only options? Saluting the brilliant but unsung female mathematician Emmy Noether as well as other giants of physics, Goldberg answers these questions and more, exuberantly demonstrating that symmetry is the big ideaand the key to what lies ahead.From the Trade Paperback edition.ExtraitIntroductionIn which I set everything up, so its probably best not to skip ahead Why is there something rather than nothing?Why is the future different from the past?Why are these questions a serious person should even ask?There is a gleeful skepticism of the orthodox in popular discussion of science. Reading some of the twittering, blogging chatter out there, you might suppose that relativity is nothing more than the ramblings of some dude at a party instead of one of the most successful physical theories ever, and one that has passed every observational and experimental test thrown at it for a century.To the uninitiated, physics can seem littered with a ridiculous number of rules and equations. Does it have to be so complicated?Physicists themselves sometimes bask in the aloof complexity of it all. A century ago when asked if it was true that only three people in the world understood Einsteins Theory of General Relativity, Sir Arthur Eddington thought for a few moments and casually replied, Im trying to think who the third person is. These days, relativity is considered part of the standard physicist toolkit, the sort of thing taught every day to students barely out of short pants. So lets put aside the highfalutin idea that you have to be a genius to understand the mysteries of the universe.The deep insights into our world have almost never been the result of simply coming up with a new equation, whether you are Eddington or Einstein. Instead, breakthroughs almost always come in realizing that things that appear different are, in fact, the same. To understand how things work, we need to understand symmetry.The great twentieth century Nobel laureate Richard Feynman likened the physical world as a game of chess. Chess is a game filled with symmetries. The board can be rotated half a turn and it will look just as it did before you started. The pieces on one side are (except for the color) a nearly perfect mirror reflection of the pieces on the other. Even the rules of the game have symmetries in them. As Feynman put it:The rule on the move of a bishop on a chessboard is that it moves only on the diagonal. One can deduce, no matter how many moves may be made, that a certain bishop will always be on a red square. . . . Of course, it will be, for a long time, until all of a sudden, we find that it is on a black square (what happened of course, is that in the meantime it was captured, another pawn crossed for queening, and it turned into a bishop on the black square). That is the way it works in physics. For a long time we will have a rule that works excellently in an over all way, even when we cannot follow the details, and then some time we may discover a new rule.Watch a few more games, and you might be struck by the insight that the reason a bishop always stays on the same color is that it always goes along a diagonal. The rule about conservation of color usually works, but the deeper law gives a deeper explanation.Symmetries show up just about everywhere in nature, even though they may seem unremarkable or even obvious. The wings of a butterfly are perfect reflections of one another. Their function is identical, but I would feel extremely sad for a butterfly with two right wings or two left ones as he pathetically flew around in circles. In nature, symmetry, and asymmetry generally need to play off one another. Symmetry, ultimately, is a tool that lets us not only figure out the rules but figure out why those rules work.Space and time, for instance, arent as different from one another as you might suppose. They are a bit like the left and right wings of a butterfly. The similarity between the two forms the basis of Special Relativity and gives rise to the most famous equation in all of physics. The laws of physics seem to be unchanging over timea symmetry that gives rise to conservation of energy. Its a good thing too; its thanks to the conservation of energy that the giant battery that is the sun manages to power all life here on earth.To some peoples (okay, physicists) minds, the symmetries that have emerged from our study of the physical universe are as beautiful as that of diamonds or snowflakes or the idealized aesthetic of a perfectly symmetric human face.The mathematician Marcus Du Sautoy put it nicely:Only the fittest and healthiest individual plants have enough energy to spare to create a shape with balance. The superiority of the symmetrical flower is reflected in a greater production of nectar, and that nectar has a higher sugar content. Symmetry tastes sweet.Our minds enjoy the challenge of symmetries. In American style crosswords, typically the pattern of white and black squares look identical whether you rotate the entire puzzle a half a turn or view it in a mirror. Great works of art and architecture: the pyramids, the Eiffel tower, the Taj Mahal, are all built around symmetries.Search the deepest recesses of your brain, and you may be able to summon the five Platonic solids. The only regular three dimensional figures with identical sides are the tetrahedron (four sides), cube (six), octahedron (eight), dodecahedron (twelve), and the icosahedron (twenty). A nerd (e.g., me) will think back fondly to his early years and recognize these as the shapes of the main dice in a Dungeons Dragons set.Symmetry can simply refer to the way things match or reflect themselves in our daily casual chitchat, but of course it has a much more precise definition. The mathematician Hermann Weyl gave a definition thats going to serve us well throughout this book:A thing is symmetrical if there is something you can do to it sothat after you have finished doing it, it looks the same as before.Consider an equilateral triangle. There are all sorts of things that you do to a triangle to keep it exactly the same. You can rotate a third of a turn, and it will look as it did before. Or you could look at it in a mirror, and the reflection will look the same as the original.The circle is a symmetric object par excellence. Unlike triangles, which look the same only if you turn them a specific amount, you can rotate a circle by any amount and it looks the same. Not to belabor the obvious, but this is how wheels work.Long before we understood the motions of the planets, Aristotle assumed that orbits must be circular because of the perfection of the circle as a symmetric form. He was wrong, as it happens, as he was about most everything he said about the physical world.Its tempting to fall into the sense of sweet, smug satisfaction that comes from mocking the ancients, but Aristotle was right in a very important sense. Although planets actually travel in ellipses around the sun, the gravitational force toward the sun is the same in all directions. Gravity is symmetric. From this assumption, and a smart guess about how gravity weakens with distance, Newton correctly deduced the motions of planets. This is one of the many reasons you know his name. Something that doesnt look nearly as perfect as a circlethe elliptical orbits of the planetsis a consequence of a much deeper symmetry.Symmetries reveal important truths throughout nature. An understanding of how genetics really worked had to wait until Rosalind Franklins x ray imaging of DNA allowed James Watson and Francis Crick to unravel the double helix structure. This structure of two complementary spiral strands allowed us to understand the method of replication and inheritance.If you run in particularly geeky circles, you may have heard a scientist refer to a theory as natural or elegant. What this normally means is that an idea is based on assumptions so simple that they absolutely must be correct. Or to put it another way, that if you start with a very simple rule you could derive all sorts of complicated behavior like behavior of black holes or the fundamental laws of nature.This is a book about symmetry: how it shows up in nature, how it guides our intuition, and how it shows up in unexpected ways. The Nobel laureate Phil Anderson put it most succinctly:It is only slightly overstating the case to say that physics is the study of symmetry.Some symmetries will be so obvious as to seem to be completely trivial, but will produce some incredibly non-intuitive results. When you ride on a roller coaster, your body cant distinguish between being pushed into your seat by gravity or by the acceleration of your car; the two feel the same. When Einstein supposed that feels the same really means is the same, he derived how gravity really works, eventually leading to the proposal of black holes.Or the fact that you can swap two particles of identical type will lead, inexorably, toward an understanding of the fate of our sun and the mysterious Pauli Exclusion Principle, and ultimately to the functioning of neutron stars and all of chemistry.The flow of time, on the other hand, seems to be just as obviously not symmetric. The past is most definitely distinct from the future. Oddly, however, no one seems to have informed the laws of physics about the arrow of time. On the microscopic level, almost every experiment you can do looks equally good forward and backward.Its easy to overstate the case and assume that everything is symmetric. Without having met you, Im willing to make some outrageous assumptions. Back in college you had at least one stoner conversation along the lines of, What if our whole universe is just an atom in a way bigger universe, man?Have you grown up any since then? Admit it, you saw the perfectly decent Men in Black, or think back fondly to your childhood reading Horton Hears a Who!, and even now, you cant help but wonder if there is a miniature universe far beyond our perceptions.The answer, Smoky, is no, but the why is a somewhat deeper question.If you can make something bigger or smaller without changing it you are demonstrating a particular type of symmetry. Suppose a particularly malevolent intelligence decided to mess with humanity by firing a shrink ray at the nearby universe, squeezing everything down by a factor of ten. An engineer studying a bridge would notice that the bridges apparent tensile strength has somehow increased dramatically. Following the reduction, the bridge will be one tenth the length, one tenth the height and one tenth the width of the original size, and thus itll only be a piddling one thousandth of the original mass.For those of you whove read Gullivers Travels, you may recall that when we meet the Lilliputians, Jonathan Swift goes into excruciating detail explaining the consequence of the difference in height between Gulliver and the Lilliputians and, later, between Gulliver and the giant Brobdingnags. If youve never read the book, Swift really belabors the point, describing the ratios of everything from the size of a mans step to the number of local animals required to feed Gulliver.But even in Swifts time, it was pretty well established that the story wouldnt make physical sense (to say nothing of talking horses). A hundred years earlier, Galileo wrote his Two New Sciences, in which he probes the scientific plausibility of giants. After much deliberation, he concludes against the proposition, basically ruining everyones fun forever. The problem is that a bone that doubles in length becomes eight times heavier but has only four times the surface area. Eventually it would collapse under its own weight. As he puts it:An oak two hundred cubits high would not be able to sustain its own branches if they were distributed as in a tree of ordinary size; and that nature cannot produce a horse as large as twenty ordinary horses or a giant ten times taller than an ordinary man unless by miracle or by greatly altering the proportions of his limbs and especially his bones, which would have to be considerably enlarged over the ordinary.He obligingly sketches a giants bones for the benefit of the reader and concludes with the adorably disturbing imagery:Thus a small dog could probably carry on his back two or three dogs of his own size; but I believe that a horse could not carry even one of his own size.This is why Spider Man is such an ill conceived premise. Spidey wouldnt have the proportional strength of a spider. Hed be of such bulky construction that he wouldnt even need squashing. Gravity would do the trick for you. As the biologist J. B. S. Haldane puts it in his essay On Being the Right Size:An insect, therefore, is not afraid of gravity; it can fall without danger, and can cling to the ceiling with remarkably little trouble. . . . But there is a force which is as formidable to an insect as gravitation to a mammal. This is surface tension. . . . An insect going for a drink is in as great danger as a man leaning out over a precipice in search of food. If it once falls into the grip of the surface tension of the waterthat is to say, gets wetit is likely to remain so until it drowns.The problem goes much deeper than just the tensile strength of the bones of giants and the proportional strength of insects. Although things on the human scale seem to scale up or down finea 20 foot killbot seems like itd work twice as well and with the exact same design as a10 foot modelonce you get down to atomic scales all bets are off. The atomic world is also the quantum mechanical world, and that means that the concreteness of our macroscopic experience is suddenly replaced with uncertainty.Put another way, the act of scaling is not a symmetry of nature. A map of the cosmic web of galaxies kind of looks like a picture of neurons, but this isnt some grand symmetry of the universe. Its just a coincidence.I could go on describing symmetry after symmetry, but I trust Ive made the point. Some changes matter and some dont. My approach in this book is to focus each chapter on a specific question that will turn out to be answered, however indirectly, by fundamental symmetries in the universe.On the other hand, that other hand isnt perfectly symmetric. One of the most important puzzles humans can ever ponder is that, in some sense, the universe isnt symmetric. Your heart is on the left side of your chest; the future is different from the past; you are made of matter and not antimatter.So this is also, or perhaps more fundamentally, a book about broken and imperfect symmetries. Theres a proverb: A Persian rug is perfectly imperfect, and precisely imprecise. Traditional rugs have a small imperfection, a break in the symmetry that gives the whole thing more character. So too will it be with the laws of nature, and a good thing because a perfectly symmetric universe would be staggeringly boring. Our universe is anything but.The universe in the rearview mirror is closer than it appearsand that makes all of the difference in the world. But lets not look back; were on a tour of the universe. Symmetry will guide our way, but symmetry breaking will make our tour something to write home about.Revue de presse"Mathematical symmetries lie at the heart of the answers, but Goldberg offers math-free guideposts along the way in this witty and accessible read. Tip: Don't skip the copious footnotes, packed with geek humor." - Discover An informative, math-free, and completely entertaining look at the concept of symmetry in physicsThroughout his fascinating discussion, Goldbergs writing remains accessible and full of humorSeasoning his expos with pop culture references that range from Doctor Who to Lewis Carroll to Angry Birds, Goldberg succeeds in making complex topics clear with a winning style. - Publisher's Weekly "Goldberg delivers relentlessly cheerful but comprehensible explanations of a dozen profound features of the universe." - Kirkus "Most physics books can't really be described as 'rollicking,' but most physics books aren't written by Dave Goldberg. This is fun, irreverent, and enjoyable, but also very truthful and illuminating. Buy it for your friend who was always scared of physics, especially if that friend is yourself." - Sean Carroll, theoretical physicist at Caltech, author of The Particle at the End of the Universe"This is a fun and fascinating examination of core physics concepts-and which even includes a look at one of physics' unsung heroines, a giant upon whose shoulders many physicists have stood: Emmy Noether!" - Danica McKellar, actress and author of Math Doesn't Suck"Unputdownable! This book is tremendous fun for any reader curious about our bizarre and beautiful universe. If only the profound concepts and laws of physics were presented in schools in the clear and fun way Dave Goldberg has in this book, we would attract many more people to science early." - Priyamvada Natarajan, Departments of Astronomy Physics, Chair, Women Faculty Forum, Yale University"The scope of this book is almost as vast as the physical universe it does a most impressive job of describing. Perhaps more importantly, Goldberg limns the under-appreciated work of Emmy Noether. Her principle that every symmetry gives rise to a conserved quantity unifies much of physics and Goldberg makes clear why and how." - John Allen Paulos, Professor of Mathematics, Temple

University, author of Innumeracy"Dave Goldberg's masterful explanations of how symmetry shapes the universe are a delight to read. From kaon koans to Antworld, to all the fuss about the Higgs boson, you will be enthralled and enlightened." - J. Richard Gott, Professor of Astrophysics, Princeton University"Reading this book is like taking a class with the most awesome science professor ever. Goldberg answers the physics questions you secretly want to ask, like whether you'll ever have a TARDIS and what would happen if Earth were sucked into a black hole. A must read for anybody who wants to understand the nature of the universe - with jokes." - Annalee Newitz, editor and time distortion field operator: i09.com"Dave Goldberg offers a funhouse of fascinating curiosities, mind-bending paradoxes, and clever humor...Magnificently elucidate the importance of symmetry in physics, astronomy, and math. A powerful reflection on the power of reflection!" - Paul Halpern, author of Edge of the Universe Who knew symmetry could be so brilliantly entertaining? Physicist Dave Goldberg slings the reader straight in at the deep end of this big physics concept, but with enough masterly wit to keep you afloat. - NatureThroughout his fascinating discussion, Goldbergs writing remains accessible and full of humorSeasoning his expos with pop culture references that range from Doctor Who to Lewis Carroll to Angry Birds, Goldberg succeeds in making complex topics clear with a winning style.Publishers Weekly