FIRST DRAFT

The Spatial Frame Model, Visualized

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Twenty chapters in six parts. Nine chapters carry drawings. Ten more mark where an illustration will go.

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Introduction

More than forty years ago Lewis Carroll Epstein wrote a short book called *Relativity Visualized*. It had almost no equations. It had drawings, jokes and puzzles, and it left its readers able to see why a moving clock runs slow. At the center of the book was one drawing. It showed that everything, you and I included, is always traveling at the same speed, and that the only choice anyone has is how much of that speed goes into moving through space and how much into moving through time. Epstein was careful to call this a myth: a story that gives the right answers without claiming to be what really happens.

This book begins with a question about that drawing. What if it is not a myth?

The Spatial Frame Model is an attempt to take the picture literally. It says three things. Space is a foam of tiny cells. The universe is a stack of complete snapshots of that foam, like the pages of a flipbook. Time is the number of pages that have passed through you. Everything else in the book is built from those three statements.

Here is what the picture buys.

It gives the results of relativity a cause. Clocks slow down and rulers shrink for reasons you can draw.

It takes seriously something the sky has been telling us for about half a century. Relativity says there is no universal now, and that is true of anything clocks and light signals can establish. But there is a universal frame. It is the one in which the afterglow of the early universe looks the same in every direction, and any astronomer can find it.

It gives gravity a picture as well: space flowing toward matter like a river, with falling objects carried along.

And it reaches toward things that are still unexplained, among them dark energy and the strange link between distant particles that physicists call entanglement.

A book that argues for a new model owes its readers a clear account of what is established and what is not. For every experiment done so far inside a laboratory, this model and Einstein's relativity give the same numbers. The model's picture of gravity reproduces the tested results, but its proposed cause of gravity is still a proposal. Some of the later chapters are speculation, and they say so. Every chapter carries a status line, and the last part of the book lists the ways the model could be shown wrong and the work that remains to be done.

You need no physics to read this book and no mathematics beyond the Pythagorean theorem. I spent my working life as a computer scientist, and I think in pictures. I have tried to write the book I would have wanted to read.

The book has six parts. Part I introduces the foam and the flipbook. Part II rebuilds special relativity from them. Part III does the same for gravity. Part IV describes the engine

that makes the foam and what it means for the cosmos. Part V goes to the quantum edge, where the footing is least sure. Part VI says how to prove all of it wrong.

Read it with a pencil. Argue with the drawings. If one of them is wrong, I would like to know.

Before you start

This book explains one model of space and time with pictures. The model is called the Spatial Frame Model. Its claim fits in a sentence: space is a foam of tiny cells, the universe is a stack of complete snapshots of that foam, and time is the count of snapshots that have passed through you.

From that one picture the book rebuilds the strange results of relativity: clocks that slow, rulers that shrink, light that bends. Then it goes past relativity into territory where the model makes its own claims.

Three house rules.

1. No algebra beyond the Pythagorean theorem. If a picture cannot carry an idea, the idea waits until I find the picture.

2. Every chapter ends with a puzzle. Try it before reading the answer. If the pictures have done their job, you can solve it.

3. Every chapter wears a status line. Some chapters reproduce physics that experiments have already confirmed. Some propose a mechanism that still needs its mathematics. Some are speculation. You should always know which kind you are reading.

PART I

The flipbook

CHAPTER 1

The Trouble with "Now"

STATUS Measured facts, and the question the book answers

Ask a physicist what is happening on a planet in the Andromeda galaxy right now and you will get a strange answer: the question has no meaning. Relativity says there is no universal now. Two observers moving past each other slice the universe into "same moment" differently, and no experiment with clocks and light beams can say which of them is right.

That part is well tested. Notice what it leaves out. There *is* a universal frame, and you can find it with a radio antenna.

The whole sky glows faintly in microwaves, light left over from the early universe. It is called the cosmic microwave background, or CMB. Its temperature is 2.7255 degrees above absolute zero and almost perfectly even. Almost. Roughly toward the constellation Leo the sky is warmer by about 3.4 thousandths of a degree, and in the opposite direction it is cooler by the same amount.

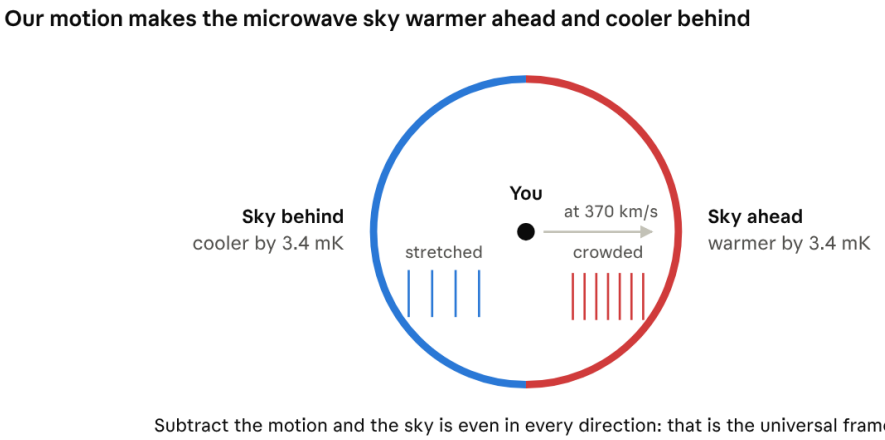


Figure 1.1. The CMB dipole: warmer ahead, cooler behind

The usual reading is a Doppler shift. We are moving toward the warm side at about 370 kilometers per second, which crowds the waves ahead of us and stretches the ones behind. Subtract that motion and you are left with a frame in which the sky looks the same in every direction. Any observer, in any galaxy, can make the same measurement and find that frame for themselves.

Standard relativity does not deny this frame exists. It says the laws of physics give it no special job. This book takes the other road. Suppose the frame is special because space is made of something, and that something is at rest there. Then "no universal

now” becomes a statement about what moving observers can measure with clocks and light, and the universal frame is where the real bookkeeping is done. The chapters ahead show that the familiar results of relativity fall out of this picture.

One loose end deserves mention. If our motion causes the warm and cool sides, distant quasars should also bunch up slightly ahead of us, by a matching amount. A 2021 quasar count found the bunching in roughly the right direction but more than twice as strong as expected. Later reanalysis shrinks the mismatch without removing it[1]. Nobody yet knows what that means.

Puzzle. You are in a sealed laboratory with no windows, drifting through space at a steady speed. Can you find your speed through the universal frame? Now you are allowed one small antenna on the roof. Can you find it?

Answer. Sealed in, no. Every experiment inside the lab gives the same result at any steady speed, and Chapter 10 shows why. With the antenna, yes: measure which side of the sky is warm. The frame hides from experiments done in a closed room. It does not hide from the sky.

[1] Source: https://arxiv.org/pdf/2511.00822v1

CHAPTER 2

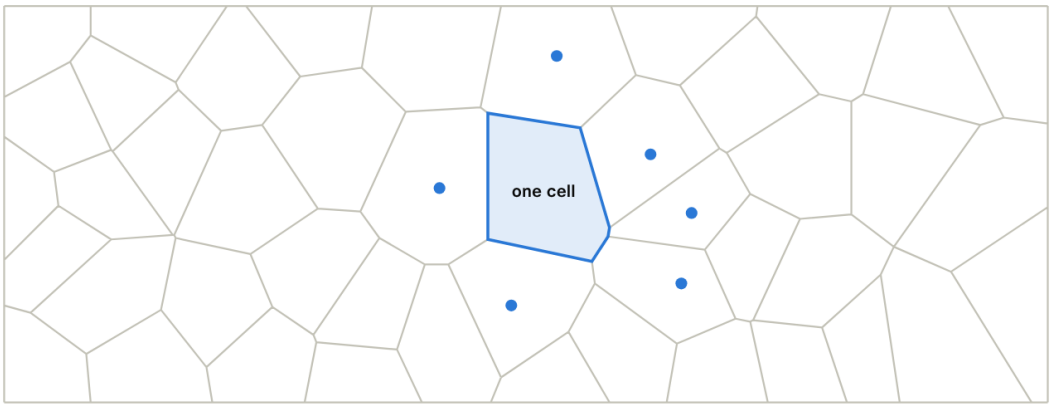
Space Made of Cells

STATUS The model's starting assumption

What is space made of? The usual answer is "nothing, it is just where things are." The answer in this book is that space is a foam.

Look at the suds in a kitchen sink. Every bubble is pressed against its neighbors, and its shape is whatever its neighbors leave it. No bubble has a shape of its own. In this model space is built the same way: a packing of cells, each about one Planck length across. That is small beyond picturing. It takes about 6 followed by 34 zeros of them, side by side, to span one meter. A single atom is roughly 6 followed by 24 zeros of cells wide.

Space is a foam: each cell is shaped by its neighbors



The shaded cell has six neighbors (dots). Its shape is whatever they leave it.
No grid, no rows, no preferred direction: the seeds land at random.

Figure 2.1. A two-dimensional slice of the foam, 46 random seeds

Three things about the foam matter for everything that follows.

The cells are the space. They do not sit inside some larger emptiness the way suds sit in a sink. Where there are no cells there is no distance, no here or there.

The seeds are random. Each cell grows from a seed point, and a cell is simply the region closer to its own seed than to any other. The seeds land at random, so the foam has no rows, no columns, no grain like the grain in wood. You have seen this pattern before: on a giraffe, in cracked mud, in the wing of a dragonfly.

A cell knows only its neighbors. Nothing in this book reaches across the foam in one jump. Motion, light and gravity are all passed along from cell to neighboring cell.

Where do the cells come from? They are bubbles in the literal sense. Each one opens up out of a surrounding emptiness that has one more dimension than space does, the way vapor bubbles open up in water when the pressure drops. Engineers call that cavitation. Chapter 15 comes back to this engine. For now, take the foam as given.

Puzzle. A friend objects: "If space is made of cells, what is between the cells?" What do you tell him?

Answer. Nothing is between them, and "between" is the wrong word. Between means a place, and places are made of cells. It is like asking what lies north of the North Pole. The walls in the drawing are not gaps. They mark where one cell ends and the next begins.

CHAPTER 3

The Flipbook

STATUS The model's central picture

You have probably made a flipbook. You draw a stick figure on every page of a notepad, a little different each time, then riffle the pages with your thumb and the figure runs. No single page contains any motion. Each page is a complete, frozen drawing. The motion is in the difference between one page and the next.

In this model the universe is a flipbook. One page is called a frame. A frame is a complete snapshot of the entire foam, every cell in the universe at once. Nothing happens inside a frame. Things happen from one frame to the next.

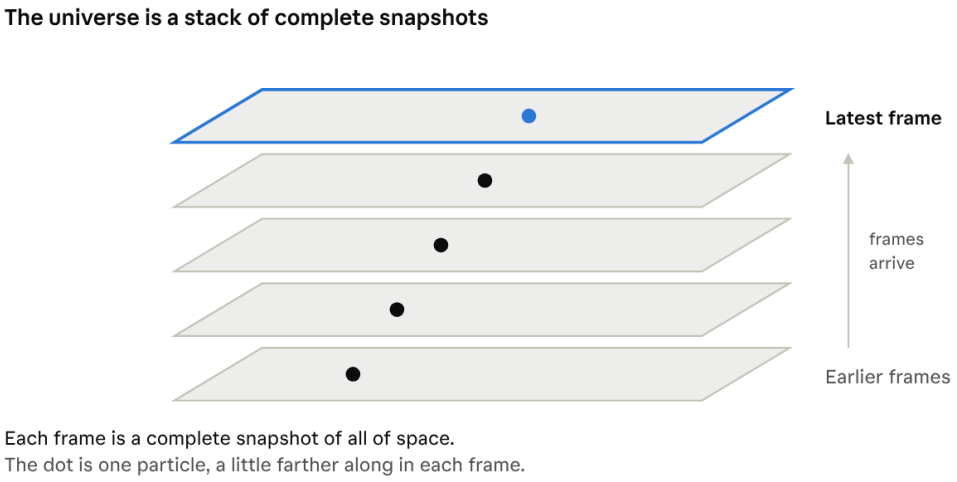


Figure 3.1. The flipbook: five frames and one particle

The pages turn fast. Roughly 2 followed by 43 zeros of frames go by every second.

Here the flipbook in your hand and the flipbook of the universe part ways. Nobody stands outside the universe riffling pages. So what is time?

Time is a count. Frames arrive one after another and pass through everything, and every piece of matter keeps a tally. The swing of a pendulum, the vibration of an atom, the beat of your heart are all built from small steps taken frame to frame. When we say one second has gone by, we mean that a certain number of frames have passed through the clock. Time does not flow. Frames arrive and get counted.

Two consequences will carry the rest of the book.

First, each frame is the whole universe in one snapshot. So relativity's "no universal now" cannot be the whole story. There is a universal frame, and each snapshot of it is

complete. Chapter 8 explains why moving observers still cannot agree on which distant events share a snapshot.

Second, clocks can disagree without time being elastic. If something makes a clock spend part of each frame's allowance on something other than ticking, that clock falls behind. Chapter 5 shows what that something is. It is motion.

Puzzle. Suppose every frame in the universe began arriving twice as fast. What would you notice?

Answer. Nothing at all. Your watch counts frames. So do your nerves, your heartbeat, and the light crossing the room. Everything you could use to notice the change is itself made of frame-to-frame steps. The count is the only time there is.

CHAPTER 4

Why Disorder Makes Spheres

STATUS Demonstrated in simulation

A model that builds space out of cells has an obvious way to fail. Think of a chessboard. A rook crosses it quickly along the rows, but the same trip along a diagonal takes many more moves. If space were a chessboard, a flash of light would spread out as a diamond, faster along the rows than across them. Real light does no such thing. It spreads at the same speed in every direction, and experiments have checked this to extraordinary precision. A cell model that cannot make a sphere is dead on arrival.

Disorder rescues it. Try the experiment yourself. Pick a cell and color it. Color all its neighbors. Then color all of their neighbors, and keep going. The colored patch is everything you can reach in a given number of steps.

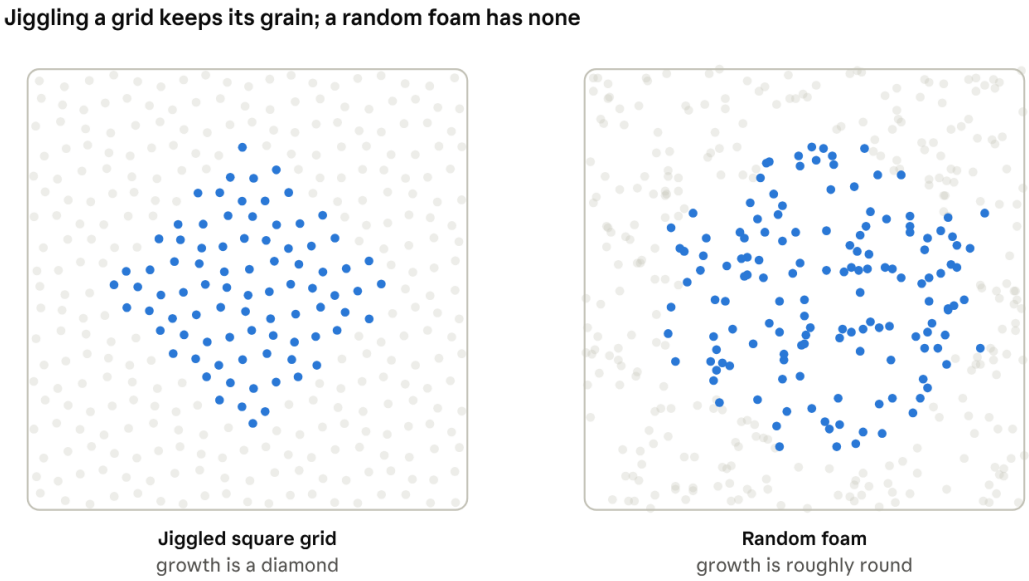


Figure 4.1. Cells reached from the center by stepping neighbor to neighbor

On a square grid the patch is a diamond. Now jiggle every point of the grid a little, so it no longer looks neat. The patch is still a diamond. Jiggling moves the points, but it does not change who is next to whom. Every point still has the same four neighbors, lined up in the same rows and columns. The grain is in the connections, and the connections survived.

On a random foam there are no rows or columns anywhere. One chain of neighbors runs a little long, the next a little short, and it averages out the same in every direction. The patch grows round.

This is why Chapter 2 insisted that the seeds land at random. The randomness is not a flaw to apologize for. It is what makes space the same in every direction. Mathematicians would say that the connection pattern carries the grain and the positions do not. Full three-dimensional simulations of the model show the same result: a jiggled lattice never grows a sphere, and the random foam does.

Author's note on the drawing: it is a two-dimensional toy computed for this draft, with 420 random seeds and five neighbor steps. Across 40 random foams the reach along the diagonals averaged 0.99 of the reach along the axes, give or take 0.07. A square grid gives 0.71. Replace it with output from the 3D simulation.

Puzzle. A honeycomb is more symmetric than a square grid. It has six directions where the grid has four. Would a honeycomb of cells grow a round patch?

Answer. Closer, but no. The patch is a hexagon, and a hexagon has corners. Any pattern that repeats has a short list of special directions, and growth remembers them. Only a pattern that never repeats has none.

PART II

Special relativity from the flipbook

CHAPTER 5

One Budget for Motion

STATUS Reproduces tested physics

This is the chapter the rest of the book leans on. It has one rule and one drawing.

The rule: in every frame, every particle gets the same allowance of change. It can spend the allowance moving across the foam. It can spend it running its own inner clock. Or it can split it between the two. It cannot get more, and it cannot save any for later.

Light spends the whole allowance on moving. That is the speed of light, about one cell per frame, and it is the reason nothing travels faster. Nobody can spend more than everything. A particle at rest in the foam does the opposite. It goes nowhere and spends the whole allowance on its inner clock, which runs at full rate.

What about a particle moving at 60% of light speed? You might guess its clock gets the remaining 40%. That is how money works. It is not how the budget works, and experiments say plainly that the clock runs at 80%.

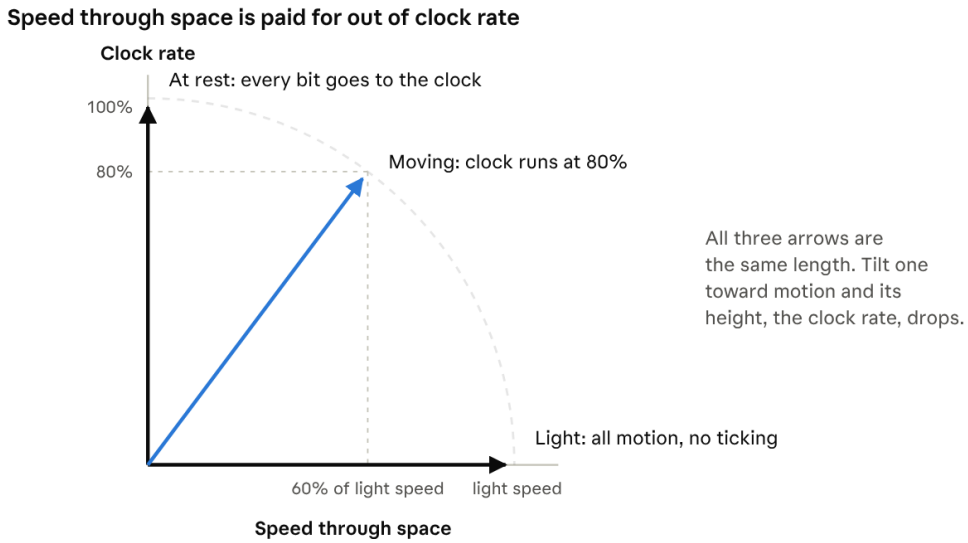


Figure 5.1. The budget triangle: at rest, at 60% of light speed, and light itself

The budget is an arrow of fixed length. Point it straight up and all of it is clock. Lay it flat and all of it is motion. Tilt it, and you read the speed off its reach to the right and the clock rate off its height. An arrow that reaches 60% of the way across stands 80% as tall, because 0.6 squared plus 0.8 squared equals 1. That is the Pythagorean theorem, the 3-4-5 triangle from school, and it is the only mathematics this book needs.

In the model this is a theorem about projections. The step a particle takes each frame has a fixed size. Its clock gets only the part of the step that does not point along its motion.

Author's note: the paragraph above is my paraphrase of the projection theorem. Check its wording against the paper.

Readers of Lewis Carroll Epstein's *Relativity Visualized* will recognize the drawing. Epstein offered it as a useful myth. In this model it is the mechanism.

One thing must be said about whose speed counts. The arrow's tilt is set by speed through the foam, measured in the universal frame. Chapter 10 shows why observers who are themselves moving still get consistent answers.

Puzzle. How fast must you travel for your clock to run at half its normal rate?

Answer. Draw an arrow that stands half as tall as it is long. That is the triangle you get by cutting an equilateral triangle in two, and its reach to the right is about 87% of its length. You need 87% of the speed of light.

CHAPTER 6

Slow Clocks

STATUS Reproduces tested physics

Build the simplest clock there is. Set two mirrors facing each other and let a flash of light bounce between them. Each round trip is one tick.

When the clock is at rest in the foam, the light goes straight up and straight back. Now slide the whole clock sideways at high speed. The light still has to get from the bottom mirror to the top one, but by the time it arrives the top mirror has moved. The light travels a slanted path, and a slanted path is longer. Light covers one cell per frame and no more, so each tick now takes more frames.

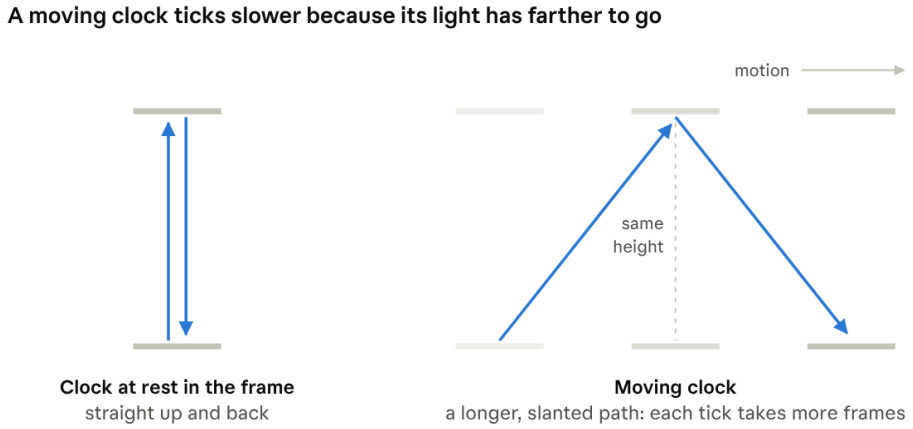


Figure 6.1. The light clock, at rest and moving

Look at the slanted path and you will see the budget triangle of Chapter 5 lying on its side. The light's path is the fixed-length arrow, the sideways run is the motion, and what remains for the up-and-down trip is the height. A clock moving at 60% of light speed ticks at 80% of the rate. No new idea is needed.

A clock made of mirrors is one thing. What about a wristwatch, or a heart? Every clock is built from the same frame-to-frame steps, so every clock slows by the same factor. If one kind did not, you could set it beside a light clock and read off your speed through the foam. Chapter 10 explains why that never works.

The check. Muons are unstable particles. At rest, a muon lasts about 2.2 millionths of a second on average. In the 1970s physicists at CERN sent muons around a storage ring at 99.94% of the speed of light. Those muons lasted about 64 millionths of a second, 29 times longer, which is the triangle's answer for that speed.

Notice that the muons went in circles. They ended each lap where they began it, yet their clocks ran slow the whole way around. Slowing does not depend on how far you end up from where you started. It depends on how fast you are moving through the foam in each frame, and the tally is kept frame by frame.

And us. The Earth moves through the universal frame at about 370 kilometers per second. That is about a tenth of one percent of light speed, so the arrow is tilted only a hair. Every clock on Earth runs slow by about one part in 1.3 million compared with a clock at rest in the frame. That is 24 seconds a year.

Puzzle. Turn the light clock on its side, so the mirrors face each other along the direction of motion. The light now chases the front mirror and then meets the rear one coming the other way. Does this clock tick at a different rate from the upright one?

Answer. It had better not, or you could measure your speed by comparing the two. But if you work it out with the mirrors the same distance apart, the sideways clock comes out slower still. Something else has to give, and it is the distance between the mirrors. That is the next chapter.

CHAPTER 7

Short Rulers

STATUS Reproduces tested physics

The sideways light clock at the end of the last chapter ticked too slowly. The repair is simple to state and hard to swallow: the moving clock is shorter. Everything that moves through the foam shrinks along its direction of motion, and by the same factor that slows its clock. At 60% of light speed a meter stick is 80 centimeters long.

This is not an illusion and not a trick of perspective. A ruler is a row of atoms. Each atom sits where the electric pull and push of its neighbors balance. Those pulls and pushes are passed along through the foam, cell to cell, at one cell per frame. When the whole ruler is moving, the influence from the atom behind has to chase the atom ahead, and the influence from the atom ahead meets the one behind coming toward it. The balance points move closer together. The ruler settles into a new, shorter length, the way a spring settles under a load.

George FitzGerald and Hendrik Lorentz proposed this in the 1890s, and Henri Poincaré built on it. Then Einstein showed you could get the same numbers without mentioning what the ruler moves through, and the physical picture fell out of fashion. This book picks it back up.

The effect is small at everyday speeds. The Earth, moving through the universal frame at 370 kilometers per second, is squashed by about ten meters along its direction of travel. Nobody notices, because every tape measure laid along that direction is squashed in the same proportion.

ILLUSTRATION TO COME

Prompt for an image generator

A hand-drawn ink and watercolor diagram in the style of a 1980s popular physics paperback. Two wooden meter sticks, one above the other, against a faint background of irregular foam cells. The upper stick is at rest and labeled “100 cm, at rest in the foam”. The lower stick has motion lines trailing to the left and is visibly shorter, four fifths the length, labeled “80 cm, moving at 60% of light speed”. Inside each stick draw a row of beads for atoms joined by tiny springs. The beads in the lower stick are closer together along its length but the stick is the same thickness. White background, no other text.

Puzzle. Two identical rockets float one behind the other, joined by a thread pulled just taut. At the same moment both fire their engines and accelerate in exactly the same way, so the distance between them never changes. Does the thread break?

Answer. Yes. As the thread speeds up it tries to shrink, like any other object. The rockets hold its ends the same distance apart, so the thread is stretched tighter and tighter until it snaps. The physicist John Bell put this puzzle to his colleagues at CERN and found that

many of them got it wrong. If you think of shrinking as something that really happens to moving objects, the answer is obvious.

CHAPTER 8

The Tilted Now

STATUS Reproduces tested physics

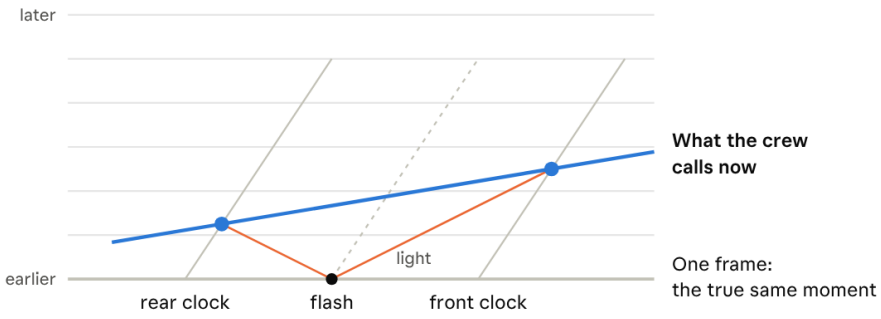
Chapter 3 said each frame is a complete snapshot of the universe. Two events that sit in the same frame happened at the same moment, full stop. So why does relativity say there is no universal now, and why does every experiment agree with relativity?

The answer lies in how clocks get set. To say that two distant events happened at the same time, you need a clock at each place, and the two clocks must agree. The standard way to make them agree is to set off a flash halfway between them and start each clock when the flash arrives.

If you are at rest in the foam, this works perfectly. The flash reaches both clocks in the same frame.

Now do it on a ship moving through the foam. The light still travels through the foam at one cell per frame, in both directions. But the rear clock is rushing to meet the flash and the front clock is running away from it. The flash reaches the rear clock first and the front clock some frames later. The crew, following the recipe faithfully, start each clock when the flash arrives.

Clocks set by light signals slice the flipbook at a tilt



The ship moves to the right. The flash reaches the rear clock first, because the rear is moving to meet it.

Figure 8.1. The flipbook seen edge-on: level lines are frames, the slanted line is the crew's now

From then on the ship's clocks are out of step, and the crew cannot tell. Whenever they say two things happened at the same time, they are pairing an event at the rear of the ship with a later event at the front. Their "now" is a tilted slice through the flipbook.

Could they catch the error by carrying a third clock slowly from the rear to the front? No. While it is being carried forward it moves through the foam a little faster than the

ship does, so it runs a little slower. It arrives behind by exactly the amount of the tilt and agrees with the front clock. Every method the crew can try gives the same tilted answer.

So relativity's claim that there is no universal now is correct about what clocks and light signals can establish. But there is a universal frame, and each snapshot of it is a true same moment. Moving observers cannot find it with the tools on board.

The tilt also explains the most famous fact in relativity. With their clocks set this way, the crew time a light beam from rear to front, then from front to rear, and get the same speed both ways. The uneven trips through the foam are exactly hidden by the uneven clocks. Everyone measures the same speed of light because the recipe for setting clocks guarantees it.

For scale: two clocks 3,940 kilometers apart, about New York to Los Angeles, lined up along the Earth's motion through the frame and set by light signals, would be out of true step by 16 millionths of a second.

Puzzle. Two ships pass each other, moving in opposite directions at equal speeds through the foam. Each crew says the other ship's clocks are out of step. Which crew has clocks that are truly in step?

Answer. Neither. Both sets of clocks are tilted, in opposite directions. Only a ship at rest in the foam has clocks that are truly in step, and its crew has no way to know they are the lucky ones except by looking at the sky.

CHAPTER 9

The Paradoxes Replayed

STATUS Reproduces tested physics

Relativity is famous for its paradoxes. Each one is a story in which two observers seem to contradict each other. With the flipbook in hand they stop being paradoxes, because there is one set of frames and you can simply point at them.

The twins. One twin stays home. The other flies to a distant star at 60% of light speed and comes straight back. When they meet again the traveler is younger. The textbook worry is that motion is relative, so each twin should be able to say the other one did the moving.

In the flipbook both twins pass through the very same frames. From the goodbye to the reunion, the same number of frames went through each of them. The difference is in how they spent them. The traveler's arrow was tilted far over for the whole trip, so her clock got only 80% of each frame's allowance. If ten years pass at home, she ages eight.

There is a subtlety, and it is better to face it than hide it. The stay-at-home twin is not at rest in the foam either. The Earth is moving at 370 kilometers per second. If you redo the bookkeeping with that included, both twins' arrows are tilted, by different amounts on the outbound and return legs, and the difference at the reunion comes out the same. The frames do the bookkeeping, but this experiment cannot tell you how fast the Earth is moving through them.

The pole and the barn. A runner carries a 10-meter pole at 60% of light speed toward a barn 8 meters deep with a door at each end. Take the barn to be at rest in the foam. The pole has shrunk to 8 meters, so for one instant it fits inside, and a farmer can slam both doors at once.

The runner tells it differently. By his measurements the pole is its full length, the barn is short, and the doors did not shut at the same time. There is no contradiction. The doors did shut in the same frame. The runner's clocks are tilted, as in Chapter 8, so he pairs the closing of the front door with a different moment at the back door. His account is consistent with all his own measurements, and so is the farmer's.

The train and the lightning. Lightning strikes both ends of a moving train. A woman on the embankment, midway between the strikes, sees both flashes together. A passenger at the middle of the train sees the flash from the front first and says the front was struck first.

Take the embankment to be at rest in the foam. Then the bolts struck in the same frame, and the passenger saw the front flash first because she was moving toward it. Her reasoning goes wrong at one step. She assumes light reaches her at the same speed from both directions. Measured with her own tilted clocks it does. Through the foam it does not.

In each story one observer was taken to be at rest in the foam. If the roles were swapped, so that the runner or the train was the one at rest, the same arguments would run with the labels exchanged. Nothing in these stories lets you find out which case you are in. That is the subject of the next chapter.

ILLUSTRATION TO COME

Prompt for an image generator

A hand-drawn ink and watercolor diagram in the style of a 1980s popular physics paperback. A side view of a tall stack of thin horizontal sheets, like the edge of a flipbook. Two lines climb through the stack from one shared starting dot at the bottom to one shared ending dot at the top. One line is straight and vertical, labeled “twin at home”. The other leans far to the right until halfway up, then leans back to the left, labeled “twin who traveled”. Beside each line draw a small clock face. The home twin’s clock reads 10 and the traveler’s reads 8. Caption under the stack: “Same frames, different counts”. White background.

Puzzle. The traveling twin makes the same trip at 80% of light speed, and again ten years pass at home. How much does she age?

Answer. Six years. An arrow that reaches 80% of the way across stands 60% as tall. It is the 3-4-5 triangle again, turned the other way.

CHAPTER 10

Why the Frame Hides

STATUS Reproduces tested physics

If the Earth is plowing through the foam at 370 kilometers per second, it ought to be possible to catch the foam streaming by. People have tried for well over a century. Every attempt made inside a laboratory has found nothing.

Michelson and Morley, 1887. They split a light beam in two, sent one half along the direction of the Earth's motion and the other half across it, bounced both off mirrors, and brought them back together. If the foam is streaming past, the two round trips should take slightly different times. They did not.

The flipbook says why. The beam that goes across the motion travels a slanted path, like the light clock in Chapter 6, and takes longer by the triangle factor. The beam that goes along the motion would take longer by that factor twice over, but the arm it travels along has shrunk by the same factor, as in Chapter 7. The two delays come out equal, and the beams return in step.

Kennedy and Thorndike, 1932. They repeated the experiment with arms of unequal length and watched for months while the Earth's speed changed around its orbit. Shrinking rulers alone would not hide the motion in this version. Slowing clocks are needed as well. Again nothing was seen.

Trading clock signals. Two ships moving through the foam can send each other timed pulses and compare notes. Each ship's clock is slowed, and each ship's sense of "now" is tilted. When they work out the exchange, the effects cancel, and what is left depends only on their speed relative to each other.

The pattern is always the same. Whenever a moving observer tries to detect the foam going by, the rulers have shrunk, the clocks have slowed, and the synchronization has tilted by exactly the amounts needed to hide it. Poincaré thought this looked like a conspiracy of nature. In this model it is no conspiracy. Rulers, clocks and light beams are all made of the same cell-to-cell steps, so motion through the foam changes all of them together.

This has a consequence that should be said plainly. For every experiment done so far inside a laboratory, this model and Einstein's relativity predict the same numbers. Einstein's response to the hidden frame was to drop it: if it cannot be detected, do without it. This book keeps it, for three reasons. The sky shows that a universal frame exists. Keeping it gives a mechanism, an account of why clocks slow and rulers shrink. And it gives gravity a natural home, as Part III will show.

You are entitled to ask where the two pictures give different answers. Part VI is where that debt gets paid.

ILLUSTRATION TO COME

Prompt for an image generator

A hand-drawn ink and watercolor diagram in the style of a 1980s popular physics paperback, seen from directly above. A square stone slab floats in a round trough of mercury. On the slab: a lamp at the left edge, a half-silvered mirror at the center set at 45 degrees, a mirror at the right edge, a mirror at the top edge, and a small telescope at the bottom edge. Draw the two light paths as thin lines from the center mirror to each end mirror and back. Faint parallel streamlines drift across the whole picture from left to right, labeled "the foam going by, 370 km/s". Label the horizontal arm "along the motion: this arm is shortened" and the vertical arm "across the motion: the light takes a slanted path". White background.

Puzzle. Suppose moving rulers shrank but moving clocks did not slow down. Would Michelson and Morley still have seen nothing?

Answer. Yes. Their experiment compares one light trip against another, and no clock is involved. With equal arms, shrinking alone hides the motion. It takes the unequal arms of Kennedy and Thorndike to test whether clocks slow as well. That is why both experiments were needed.

PART III

Gravity

CHAPTER 11

Space Falls

STATUS Reproduces tested physics

Drop a ball and it falls. Newton said a force pulls it down. Einstein said space and time are curved and the ball follows the straightest path available. This model says something you can picture more easily: space itself is falling, and the ball is carried along.

Think of a canoe on a river. The paddler does nothing, and the canoe moves anyway, because the water it sits in is moving. Around every mass the foam flows inward like that river, from all directions at once.

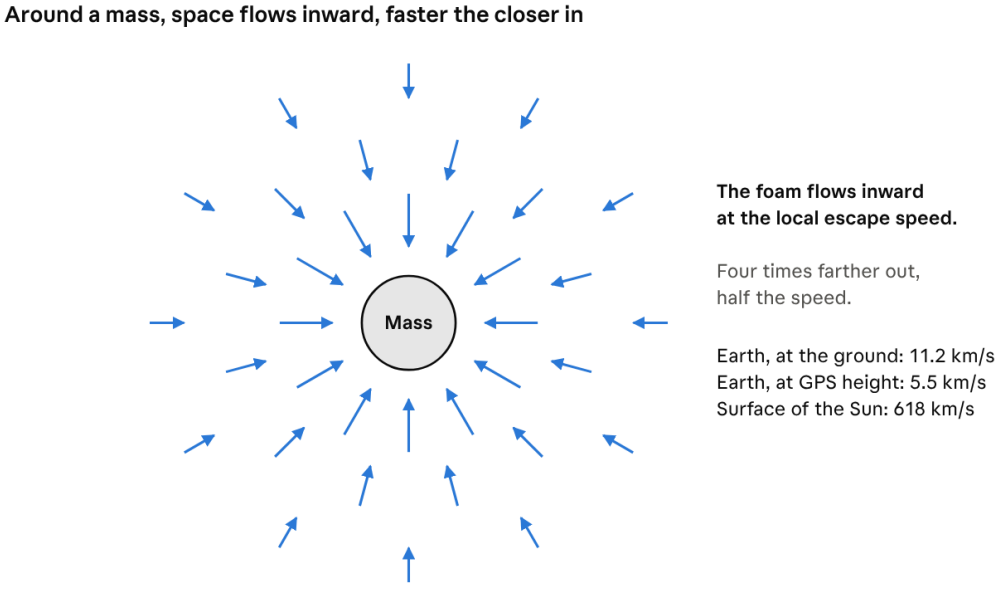


Figure 11.1. The river picture of gravity: arrow length shows flow speed

The flow follows one rule: at every point, the foam moves inward at the escape speed for that point. The escape speed is how fast you would have to throw something upward from there for it never to come back. At the surface of the Earth that is 11.2 kilometers per second. Farther out the flow is slower. Go four times as far from the center and it drops by half.

If space is pouring through you at 11 kilometers per second, why do you not feel a wind? For the same reason that nobody feels the Earth's motion through the universal frame. Chapter 10 showed that a steady drift through the foam cannot be detected. What you can feel is a change in the drift. The foam speeds up as it descends, so to stand still on the ground is to be held back against a current that is accelerating past you. The ground has to push up on your feet to do it. That push is what you call your weight.

Let go, and you drift with the current. You feel nothing at all. Einstein called this the happiest thought of his life: a person in free fall does not feel their own weight. In the river picture it is obvious. A canoe drifting with the current feels no current.

Physicists already know this picture. In 1921 and 1922 Paul Painlevé and Allvar Gullstrand each found that Einstein's equations for the space around a round mass can be written, exactly, as ordinary flat space flowing inward at the escape speed. In general relativity this is treated as one convenient way to label points. In this model the flow is real.

One question is left hanging. The foam cannot keep pouring toward the center of the Earth and piling up there. Something must be removing cells along the way. Chapter 14 offers a possible answer.

Puzzle. An astronaut floats weightless inside the space station. Is the foam flowing through the station?

Answer. Yes, and nearly as fast as at the ground, a little under 11 kilometers per second. The astronaut is weightless because she is falling with the flow, not because the flow is missing. The station is also moving sideways fast enough that it keeps missing the Earth as it falls.

CHAPTER 12

Gravity Slows Clocks

STATUS Reproduces tested physics

A clock on the ground is standing still while the foam streams through it at 11.2 kilometers per second. Go back to the budget of Chapter 5. The budget does not care whether the clock moves through the foam or the foam moves through the clock. Either way the arrow tilts, and the clock gets less than the full allowance.

So a clock held in place near a mass runs slow, and the rule is one line long: **a clock held still in the flow runs exactly as slow as a clock moving at the local escape speed.** The triangle of Chapter 5 does the rest. There is nothing new to learn, which is the best thing that can be said for a physical idea.

Gravity's slowing of clocks and motion's slowing of clocks are the same effect in this model. They have one cause, the speed of the clock through the foam.

The worked example: GPS. Every satellite in the Global Positioning System carries an atomic clock, and the system only works if those clocks are compared correctly with clocks on the ground.

Clock	Speed through the foam	Slow by, per day
On the ground	11.2 km/s of inflow	60 millionths of a second
At GPS height, held still	5.5 km/s of inflow	14 millionths of a second
Extra for the satellite's orbital speed	3.9 km/s sideways	7 millionths of a second

The satellite sits in a slower part of the river, so it gains 46 millionths of a second a day on the ground clock. Its orbital motion costs it 7 of those. The net result is that a GPS clock runs fast by about 38 millionths of a second every day. Engineers build that correction into the system. Without it, positions would drift by more than 11 kilometers a day.

Light climbing out. The same triangle explains why light loses energy climbing away from a mass. Its waves are made by a clock deep in the flow, which ticks slowly. Received high up, where clocks tick faster, the waves arrive stretched. Robert Pound and Glen Rebka measured this in 1960 using a tower 22.5 meters tall.

ILLUSTRATION TO COME

Prompt for an image generator

A hand-drawn ink and watercolor diagram in the style of a 1980s popular physics paperback. The curved edge of the Earth at the bottom, with a small clock tower standing on it. High above, a GPS satellite with solar panels and a clock face on its body. Blue streamlines pour down toward the Earth from all sides, drawn thick and closely spaced near the ground and thin and widely spaced near the satellite. Beside the ground clock draw a small right triangle with a strongly tilted arrow, labeled "fast flow, slower clock". Beside the satellite draw the same triangle with a nearly upright arrow, labeled "slow flow, faster clock". White background.

Puzzle. Which ages faster, your head or your feet?

Answer. Your head. It is farther from the center of the Earth, so the foam flows through it a little more slowly and its arrow is a little more upright. The difference is absurdly small, but it is real. In 2010 physicists at the National Institute of Standards and Technology measured it with two atomic clocks, one raised about a foot above the other.

CHAPTER 13

Bent Light and the Point of No Return

STATUS Reproduces tested physics

Light travels through the foam at one cell per frame. If the foam is itself moving, the light is carried with it, the way a swimmer crossing a river is carried downstream.

Bent light. Starlight that skims past the edge of the Sun arrives from a slightly shifted direction. The shift is 1.75 seconds of arc, about the width of a small coin seen from two kilometers away. Astronomers first measured it during the solar eclipse of 1919.

If you treat light as a tiny bullet falling under Newton's gravity, you get half that, 0.87 seconds of arc. The river picture gets the full amount. Light is a wave moving at a fixed speed relative to the foam it is in. The flow carries the wave inward, and because the foam on the Sun's side of the beam is moving faster than the foam on the far side, the wave front also swings around toward the Sun, the way a line of marchers wheels when one end slows down. The two effects together give 1.75.

The flow also delays light. A radar pulse sent past the Sun to a planet and back returns a little late, because for part of the trip it is working against the current. Irwin Shapiro predicted the delay in 1964, and it has been measured many times since.

The point of no return. The closer you go to a mass, the faster the foam flows. Squeeze enough mass into a small enough ball and there will be a distance at which the inflow reaches the speed of light.

Picture a fish in a river that runs faster and faster toward a waterfall. Upstream, the fish can swim against the current and get away. At some point the water is moving as fast as the fish can swim, and the fish can only hold its place. Past that point, it goes over, no matter which way it points.

The place where the inflow reaches light speed is called the horizon, and what lies inside it is a black hole. Inside, a beam of light aimed straight outward is still carried inward. No rule is broken. The speed limit applies to motion through the foam. It does not apply to the foam.

A horizon is not a wall or a surface. It is a place in the current. Someone falling through it would notice nothing special at that moment.

How compact does an object have to be? The Sun would need to be squeezed into a ball 3 kilometers in radius. The Earth would need to be squeezed to 9 millimeters.

ILLUSTRATION TO COME

Prompt for an image generator

A hand-drawn ink and watercolor diagram in the style of a 1980s popular physics paperback. A wide river seen from the side flows from left to right and plunges over a waterfall at the right edge. The current is drawn with streamlines that grow longer and closer together toward the falls. Three fish all face upstream, to the left. The first, far upstream, is making headway, labeled “can escape”. The second, at a dotted vertical line labeled “horizon: the current equals the fastest possible swimming speed”, holds its place. The third, past the line, is being carried backward over the falls, labeled “carried in, even swimming outward at full speed”. White background.

Puzzle. A lamp is held just outside a horizon by powerful rockets, pointing outward. What does a distant observer see?

Answer. A dim, deep red, slow-motion lamp. The light does get out, because just outside the horizon the current is slightly slower than light. But the lamp’s clock is deep in fast flow and ticks very slowly, so its waves arrive stretched far toward the red, and its flashes arrive far apart.

CHAPTER 14

Why Mass Makes Space Flow

STATUS A possible cause. The mechanism is proposed and its mathematics is still being worked out

The last three chapters took the inflow as given and showed that gravity's known effects follow from it. This chapter asks the deeper question. Why would the foam flow toward matter at all? Here is a possible cause.

Start with how the foam renews itself. In every frame new cells open up all through the foam and crowd the cells already there. The most crowded cells pop. They vanish, and popping goes on until the foam holds as many cells as it did the frame before. Birth and popping balance, everywhere, all the time. In empty space the popping is spread evenly, with no direction favored, and nothing flows.

Now put a particle of matter into the foam. In this model a particle is a cell that has been energized. When new cells are born beside it, they inherit a share of what it has. Call these the descendant cells, and call the thing they inherit the carrier. Descendant cells have one important property: they are harder to pop than ordinary cells.

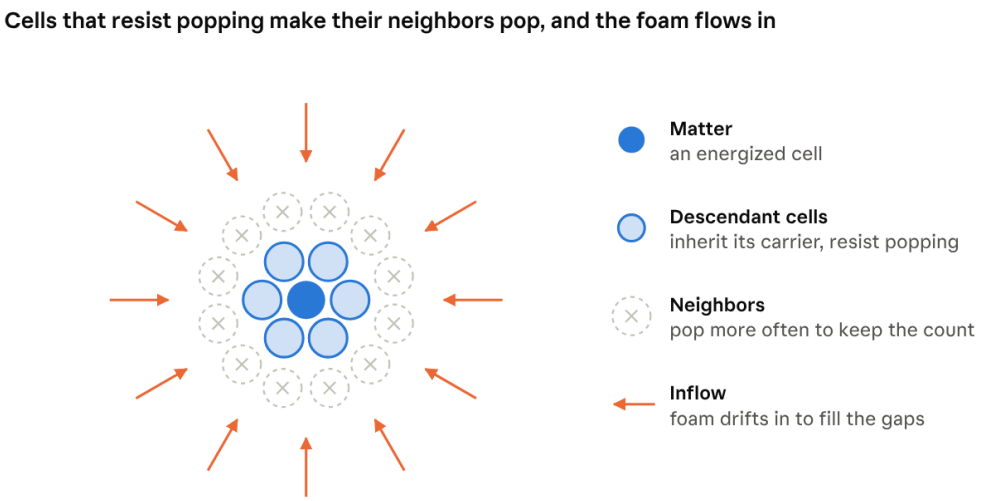


Figure 14.1. A possible cause of the inflow, in cartoon form

The count still has to come out even. If the descendant cells around a particle refuse to pop, their neighbors have to pop in their place. So every bit of matter is surrounded by a halo in which ordinary cells pop more often than they would in empty space.

Each pop leaves a gap, and the surrounding foam shifts to close it. Near matter the gaps open faster than they do far away. The foam therefore drifts steadily inward, from all

sides, toward the matter. That drift is the inflow of Chapter 11. On this account, it is what gravity is.

More matter means more descendant cells, more popping among the neighbors, and a faster flow. The halo thins out with distance. If the model is right, it must thin out in exactly the way that makes the foam arrive at the escape speed at every distance. Showing that from the rules for single cells is the main unfinished calculation, and Chapter 20 lists it first.

If this is the cause of gravity, two old puzzles get plain answers.

Why does everything fall at the same rate? Galileo found that a cannonball and a musket ball fall together. Here the reason is that falling is being carried by the flow, and the flow does not ask what it is carrying.

Why does gravity only pull? Electric charges attract and repel. Gravity never repels. In this picture matter can only make its neighbors pop more, never less, so the foam can only flow toward it.

Puzzle. Two particles sit near each other in the foam. Each has its own halo. Why do they drift together?

Answer. Each particle sits in the other's inflow. The foam around particle A is drifting toward B, and it carries A along. The foam around B is drifting toward A. Neither particle pulls on the other. Each one is riding the current the other one makes.

PART IV

The cosmos

CHAPTER 15

The Engine

STATUS Proposed mechanism

So far the foam and its frames have been taken as given. This chapter asks where they come from.

Spin a boat propeller fast enough and the water behind the blades tears open into bubbles of vapor. Nothing carries the bubbles in from outside. They open up out of the water itself, wherever the pressure drops low enough. Engineers call this cavitation.

In this model the cells of space are bubbles of that kind. They open up in a surrounding emptiness, which I will call the void. The void has four dimensions, one more than space has. A cell is a three-dimensional bubble in the void, in the way a soap film is a two-dimensional skin in a three-dimensional room.

The foam grows in two ways, and the difference between them is where time comes from.

Mode one: sideways. New cells open up beside the cells already there, and the foam spreads outward within its own three dimensions. This makes more space. It does not make a new frame, so no time passes while it happens. Sideways growth is timeless.

Mode two: stacking. Sideways growth cannot go on freely forever. The foam becomes crowded and pressure builds. When the pressure can no longer be relieved sideways, the foam is pushed out along the fourth direction, and a whole new layer of cells forms on top of the old one. That new layer is a frame. Each push adds one page to the flipbook. Time, in this model, is the foam being extruded one page after another.

Inside each frame. New cells open at the corners where existing cells meet. Left alone, that would double the number of cells with every frame. The foam cannot hold that many. The most crowded cells pop and return to the void, and the popping goes on until the frame holds as many cells as the one before it. Every frame is a burst of births followed by a burst of deaths, and the two nearly cancel.

Two later chapters hang on that word “nearly”. Chapter 14 already used the popping rule to offer a possible cause of gravity: matter shifts where the popping happens. Chapter 16 looks at what happens if the births and deaths do not cancel exactly.

Author’s note: this chapter is written from the outline of the two-mode picture. What triggers mode two, and whether doubling at the corners is still the current rule, should be checked against the paper.

ILLUSTRATION TO COME

Prompt for an image generator

A hand-drawn ink and watercolor diagram in the style of a 1980s popular physics paperback, in two panels. Left panel, labeled “Mode one: sideways”: a single flat sheet of irregular foam cells seen at an angle against a black background, with small new bubbles budding along its outer edge and arrows pointing outward within the plane of the sheet. Right panel, labeled “Mode two: stacking”: the same sheet now crowded, with a second identical sheet lifting off above it and a third above that, and one arrow pointing straight up labeled “each new sheet is one frame”. The black background is labeled “the void”. No other text.

Puzzle. Before the first frame was stacked, the foam grew sideways. How long did that take?

Answer. The question has no answer, because it has no meaning. Time is the count of frames. Before there were frames there was nothing to count, so the sideways growth did not take a long time or a short time. It took no time.

CHAPTER 16

Dark Energy as a Leftover

STATUS Proposed, with one firm prediction

In 1998 two teams of astronomers measuring distant exploding stars found that the expansion of the universe is speeding up. Whatever is doing the pushing was named dark energy. The simplest description of it is a cosmological constant: a fixed push built into every bit of space, the same forever. Nobody knows why it should have the size it has.

In this model the push is not built in. It is a leftover.

Chapter 15 said that in each frame the births and deaths of cells nearly cancel. Suppose they miss by a hair, with slightly more births than deaths. Then space gains a tiny fraction of its volume with every frame, everywhere at once. From the inside that looks exactly like a gentle outward push built into space.

The hair is very fine. To match the expansion astronomers measure today, out of every 1 followed by 61 zeros of cells, births need to beat deaths by three or four per frame.

Think of a bank that takes in a trillion dollars every day and pays out a trillion dollars every day, and ends each day a few cents ahead. The few cents are not a kind of money. They are what is left when two enormous flows almost cancel. That is why the number is so small, and why it need not be a constant.

The prediction. As space grows, it takes more pressure to push the whole foam outward. More pressure means more crowding, more crowding means more popping, and the leftover shrinks. So in this model dark energy can hold steady or fade slowly. It cannot grow. A firm finding that dark energy is strengthening would count against the model.

Where the observations stand. In 2025 the Dark Energy Spectroscopic Instrument, which is mapping millions of galaxies, reported signs that dark energy is not constant and has been weakening for the last few billion years. The evidence ranges from 2.8 to 4.2 sigma depending on which other surveys are combined with it. Physicists ask for 5 sigma before calling something a discovery[1].

The fading is what this model allows. But the curve that best fits the data says something more. Before it began to fade, dark energy appears to have grown, reaching a peak about 4.5 billion years ago[2]. This model has no way to produce that rise.

So the scorecard is open. If better data keep the fading and lose the early rise, the model has passed a test it could have failed. If the early rise is confirmed, this chapter is wrong. More data are due over the next several years.

[1]Source: https://symmetrymagazine.org/article/new-desi-results-strengthen-hints-that-dark-energy-may-evolve

[2]Source: https://physicsworld.com/a/desi-delivers-a-cosmological-bombshell/

One gap should be admitted. The model cannot yet say how fast the fading should be. That needs the exact crowding at which a cell pops, which Chapter 20 lists among the things not yet known.

ILLUSTRATION TO COME

Prompt for an image generator

A hand-drawn ink and watercolor diagram in the style of a 1980s popular physics paperback. An old-fashioned balance scale. The left pan is heaped with a huge pile of small bubbles and labeled “cells born this frame”. The right pan holds an almost identical huge pile labeled “cells popped this frame”. The beam is tilted by the smallest visible amount toward the left. A magnifying glass held over the left pan shows three or four extra bubbles, labeled “the leftover: dark energy”. White background.

Puzzle. A bathtub has the tap running and the drain open. The water level is creeping up by a millimeter an hour. A plumber is allowed to measure only the level. What can she say about how fast the tap is running?

Answer. Almost nothing. A trickle from the tap with the drain nearly shut gives the same slow rise as a torrent from the tap with the drain wide open. The level tells her the difference between the two flows and nothing about their size. Dark energy is the level. The births and deaths of cells are the tap and the drain.

PART V

The quantum edge

CHAPTER 17

Entanglement Across Frames

STATUS Speculative

Quantum physics contains a fact so strange that Einstein refused to accept it. Make two particles together in the right way and send them far apart. Measure one, and the result is tied to what you find when you measure the other, more tightly than any pre-arranged plan could manage.

That last clause is the important one. In 1964 John Bell proved that if each particle simply carried its answers with it from the start, like a sealed envelope, the results could only be tied together up to a certain limit. Experiments beginning in the 1970s and 1980s, and closing the last loopholes in 2015, show the particles beating that limit. The 2022 Nobel Prize in physics went to this work. Whatever joins the two particles, it is not something each one carries along. The connection is live.

This sits badly with relativity. A live connection between distant places has to act at some moment, and relativity has no universal now for it to act in. Physicists have made an uneasy peace with that.

This model has a universal frame, so it has no such trouble. A connection can act across any distance within a single frame, and that is a perfectly definite thing to say.

The proposal. Entangled partners begin as two cells in direct contact in the same frame. Call them progenitor cells. Remember that every cell is a bubble in the four-dimensional void. Two cells born touching share a wall. The proposal is that they keep a connection through the void after they separate, and that this connection does not stretch as they move apart in space, because it does not run through space at all. When one partner is measured, the connection acts on the other in the same frame.

Two cautions keep this honest. First, a shared birth is not enough by itself. That would be the sealed envelope again, and Bell ruled it out. The connection has to stay active. Second, the connection cannot be used to send a message. Each observer alone sees only random results, and the tie shows up only when the two lists are laid side by side later. So even here the universal frame stays hidden from anyone trying to use it.

Author's note: the two families of link (side by side for opposite results, stacked for matching results) and the lock mechanism belong here once they are ready to present.

ILLUSTRATION TO COME

Prompt for an image generator

A hand-drawn ink and watercolor diagram in the style of a 1980s popular physics paperback. Three flat sheets of irregular foam cells are stacked with space between them, seen at an angle, against a dark background labeled “the void”. In the bottom sheet two neighboring cells are colored, one red and one blue, touching along a shared wall. In the middle sheet the red and blue cells are a little apart. In the top sheet they are at opposite edges. A thin glowing thread leaves each colored cell downward, dips beneath the sheet into the dark background, and joins the two, staying the same short length in every sheet. Label the thread “a link through the void, not through space”. White margins.

Puzzle. I put a red card in one envelope and a blue card in another, shuffle them, and mail one to Alice and one to Bob. Alice opens hers, sees red, and knows at once that Bob has blue. Is that entanglement?

Answer. No. That is the sealed-envelope scheme, and there is nothing mysterious in it. The cards had their colors all along. Bell’s discovery was that entangled particles produce patterns of agreement that no envelopes, however cleverly prepared, can copy.

CHAPTER 18

Speculations

STATUS Speculative, all three sections

Everything up to Chapter 13 reproduced physics that experiments have confirmed. Chapters 14 to 17 proposed mechanisms. The three ideas in this chapter go further out. Each is a guess about how the foam might account for something that is known to happen and is not yet understood. They are here because a model should say where it might lead, and because any one of them could turn out to be the place where it breaks. Each gets its own section so that it can stand or fall alone.

18.1 Pair creation

What is known. Matter can be made from light. When a gamma ray with enough energy passes close to an atomic nucleus, it can vanish and leave two particles in its place: an electron and a positron. The positron is the electron's antiparticle, the same in mass and opposite in charge. This was first photographed in the early 1930s, and it is routine in every particle accelerator today. The particles always come in pairs. Nobody has ever seen a lone electron appear from light.

The idea. In this model a particle is a cell that has been energized. The proposal is that the energy of the gamma ray does not go into one cell. It goes into two neighboring cells in the same frame, sharing a wall, and it sets them going in opposite senses. One becomes the electron and the other the positron.

That would explain why matter is always made in pairs and why the two members of a pair are opposites. It also connects to Chapter 17. Two cells energized together, touching, in one frame are exactly the progenitor cells of that chapter. Pairs made this way would be born entangled, and they are.

Author's note: this section is written from the outline. What "opposite senses" means for the two cells, and where the energy threshold comes from, need the details from the paper.

ILLUSTRATION TO COME

Prompt for an image generator

A hand-drawn ink and watercolor diagram in the style of a 1980s popular physics paperback, in two panels. Left panel, labeled "before": a patch of irregular foam cells with a wavy line arriving from the left, labeled "gamma ray", heading for two neighboring cells that share a wall. Right panel, labeled "after": the same patch, the wavy line gone, and the two cells now colored, one with a small curved arrow turning clockwise labeled "electron", the other with a curved arrow turning counterclockwise labeled "positron". White background.

18.2 The mirror antimatter universe

What is known. Every process ever observed that makes matter makes an equal amount of antimatter, as in the last section. Yet the universe we see is made almost entirely of matter. The stars, the gas between them and the distant galaxies are all matter, as far as anyone can tell. If matter and antimatter were made in equal amounts at the beginning, where did the antimatter go? The standard account supposes a slight imbalance arose very early, so that a little matter was left over after the rest annihilated. What caused the imbalance is not known.

The idea. The antimatter is not missing. It is in a mirror universe, a twin of ours that came from the same beginning and is made of antimatter where ours is made of matter. On this view the universe did what an energetic gamma ray does. It was born as one of a pair.

The books then balance at the largest scale. Matter and antimatter were made in equal amounts after all. We see only matter because we live in one of the two halves.

This is not as far from mainstream physics as it may sound. In 2018 Latham Boyle, Kieran Finn and Neil Turok proposed that our universe has a mirror partner on the far side of the Big Bang, with matter and antimatter exchanged. Their reasons were different from the ones given here, but the picture is a close relative.

Author's note: this section is written from the outline. Where the mirror universe sits in the model (in the void, or as a second stack of frames extruded the opposite way) and whether anything in our universe could reveal it need the details from the paper.

ILLUSTRATION TO COME

Prompt for an image generator

A hand-drawn ink and watercolor diagram in the style of a 1980s popular physics paperback. A central bright point on a dark background labeled "the beginning". From it two stacks of thin foam sheets fan out in opposite directions, like two flipbooks set back to back. The stack on the right is tinted blue and labeled "our universe: matter". The stack on the left is tinted red and labeled "mirror universe: antimatter". The two stacks are exact mirror images of each other. White margins.

18.3 The zero-point ledger

What is known. According to quantum physics, empty space is never still. Every possible vibration of every field keeps a minimum of energy that cannot be taken away, called zero-point energy. Its effects have been measured in the laboratory. The trouble starts when you add it all up. The straightforward sum gives empty space an energy about 1 followed by 123 zeros times larger than the dark energy astronomers actually find. It has been called the worst prediction in the history of physics.

There is a second, quieter fact. The zero-point energy is spread across frequencies in one particular pattern, rising as the cube of the frequency. The physicist Timothy Boyer

showed that this is the only pattern that looks the same to every observer in steady motion. Any other pattern would let you measure your speed through empty space.

The idea. Keep a ledger for the foam. On one side enter every cell born in a frame. On the other side enter every cell that pops. Chapter 15 said the two columns are enormous, and Chapter 16 said they nearly cancel.

The proposal is that the zero-point energy and the dark energy are the same account read two ways. Zero-point energy is the turnover, the total activity of the foam, and it is huge. Dark energy is the balance at the bottom of the page, and it is tiny. The worst prediction in physics came from reading the turnover and expecting to see it on the bottom line.

Author's note: this section is written from the outline. How the ledger produces the cube-of-frequency pattern, and how the numbers work out, need the details from the paper.

ILLUSTRATION TO COME

Prompt for an image generator

A hand-drawn ink and watercolor drawing in the style of a 1980s popular physics paperback. An open accountant's ledger on a wooden desk. The left page is headed "cells born" and the right page "cells popped", and both are crammed with long columns of enormous numbers. At the foot of the right page, circled in red ink, is a single very small figure labeled "balance: dark energy". A bracket spanning both full columns is labeled "turnover: zero-point energy". White background.

Puzzle. In section 18.1 the electron and the positron start out as neighboring cells sharing a wall. What does Chapter 17 lead you to expect when the two are measured later, far apart?

Answer. Their results should be tied together more tightly than any sealed-envelope scheme allows. Two cells energized together, touching, in one frame are progenitor cells, so the pair should be entangled from birth. Pairs of particles created together are in fact entangled. That is a point in the idea's favor, though not a proof, since standard quantum theory expects the same thing.

PART VI

Putting it at risk

CHAPTER 19

How to Prove This Wrong

STATUS The tests

A theory that cannot be wrong is not physics. This chapter lists the places where the model sticks its neck out, starting with the place where it does not.

Inside a laboratory: no test. Chapter 10 showed that for experiments done in a closed room, this model gives the same numbers as Einstein's relativity. No bench-top experiment of the kinds done so far can choose between them. If that were the whole story, the universal frame would be a matter of taste. The tests have to come from elsewhere.

One version is already dead. The simplest way to build a theory with a special frame is to let the frame show up directly in one-way timing. That version makes a loud prediction. As the Earth circles the Sun, the pulses from distant pulsars, the most regular clocks in the sky, should arrive early and late by about six tenths of a second over the year. Pulsar timing leaves room for a hidden signal of perhaps ten millionths of a second. The simple version fails by a factor of about 60,000. The model survives only in the form given in Part II, where the frame hides.

The grain of the foam. Space made of cells is not perfectly smooth. At the very smallest scales the foam might treat light of different energies slightly differently, or favor some directions. Astronomers have looked for such effects in light that has crossed billions of light-years, where a tiny difference would have had time to build up, and have found none to remarkable precision. Chapter 4 argued that the randomness of the foam is what protects it. That argument has to hold at every level of precision anyone can reach. A direction-dependent effect that the random foam cannot hide would end the model.

The inflow law. Part III needs the foam to arrive at exactly the escape speed at every distance from a mass. The measurements of the solar system are too precise to allow anything else. Chapter 14 offered a possible cause of the inflow. When the calculation from the cell rules is finished, it either gives the escape-speed law or it does not. If it does not, that cause of gravity is wrong.

Dark energy cannot grow. Chapter 16 made a prediction that surveys now under way can check. Dark energy may fade but may not strengthen. The current data show a recent fading, which fits, and hint at an earlier rise, which does not. This is the test most likely to be settled soon.

One-way timing in the sky. Experiments on Earth send light out and back, and the round trip hides the frame. Pulsars offer something different: clocks so far away that their pulses can only be timed one way. The proposal is to time the same pulsars from probes moving in different directions through the universal frame and compare.

Author's note: state here exactly what the model predicts the probes will record and what relativity predicts, in numbers. The annual pulsar residuals from the timing paper belong in this chapter only if their interpretation is settled by publication.

ILLUSTRATION TO COME

Prompt for an image generator

A hand-drawn ink and watercolor diagram in the style of a 1980s popular physics paperback. At the top, a small spinning star with two lighthouse beams, labeled "pulsar: a clock in the sky". Evenly spaced curved wave fronts spread down from it. Near the bottom, two small space probes travel in opposite directions, one to the left and one to the right, each with a little clock face. A long faint arrow across the whole picture is labeled "motion through the universal frame, 370 km/s". Caption: "Same pulses, timed one way, by clocks moving differently through the frame". White background.

Puzzle. Someone offers you a theory that agrees with every experiment ever done and predicts nothing new. Is it wrong?

Answer. It is not wrong, and it is not yet worth much. A theory earns its keep by forbidding something that could turn out to happen. Part II of this book, taken alone, is in that position. Parts III to V are where the model forbids things: a different inflow law, a grain in space, dark energy that grows.

CHAPTER 20

What We Don't Know

STATUS The open questions

A book like this one can leave the impression that everything fits. It does not, yet. Here is the unfinished work in one place, roughly in order of importance.

1. **The inflow law from the cell rules.** Chapter 14 proposed that cells which resist popping make their neighbors pop, and that the foam flows in to fill the gaps. Nobody has yet shown that this gives inflow at exactly the escape speed. The halo of extra popping has to thin out with distance in one particular way, and that has to come out of the rules instead of being put in by hand.
2. **Gravity in general.** The river picture in this book describes a single round mass sitting still. A complete account has to handle masses that move, spin and orbit one another, and it has to do so in a form that every observer can use.
3. **Why the budget is an arrow.** Chapter 5 stated that a particle's allowance splits between motion and clock rate the way an arrow splits between its reach and its height. That rule should follow from what single cells do from one frame to the next. Deriving it is work in progress.
4. **When a cell pops.** The model says the most crowded cells pop. It does not yet say exactly how crowded is too crowded. That number controls how fast dark energy should fade, and matter's resistance to popping complicates it.
5. **What particles are.** Matter has been described as energized cells, and that is only a beginning. Mass, charge, spin and momentum all need an account in terms of cells. These ideas are at an early stage.
6. **What the link is.** Chapter 17 proposed a connection through the void between cells that were born touching. How it works, and why it cannot carry a message, is not worked out.
7. **What the void is.** The foam opens up in a four-dimensional emptiness. The model uses the void and does not explain it.

None of this is hidden in the fine print, and none of it is unusual. Every physical theory began with a picture and a list like this one. The picture in this book is that space is a foam, the universe is a flipbook, and time is a count. The list is the work that will decide whether the picture is right.

Puzzle. Which item on the list, if it failed, would do the most damage to the rest of the book?

Answer. The third. Parts II and III both rest on the budget arrow. Gravity's slowing of clocks in Chapter 12 is the same arrow tilted by the inflow. If the arrow cannot be derived from the cells, the model still matches experiment, but it has lost its claim to explain why.