

# The Slipway

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Greg Egan

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Brian couldn't sleep, so as midnight approached he rose quietly and dressed in the dark. He did his best not to disturb Carol, but he knew that even if he woke her she'd pretend that he hadn't.

His binoculars were sitting on the table in the hall, and his boots were by the door. He put them on, wincing at the pain in his right knee, then he closed the door gently behind him and strode away from the farmhouse.

It was a perfect night, with no moon and no clouds. Scorpius had just risen in the east, Antares glinting as red as Mars, and from there the whole glorious band of the Milky Way stretched from horizon to horizon.

Brian stopped and sat on an old fencepost, a lone stump of wood that had been there since he was a child, though he had no memory of the larger structure it must once have belonged to. He raised the binoculars and swept them slowly across the dark dust clouds and bright clusters.

Three years before, on a night just like this, he'd spotted a comet no one else had yet seen. When the astronomers calculated its orbit, it had turned out to have a period of ninety thousand years. But no one could be sure that it wasn't making its one and only appearance; if it had been sent inward by a disturbance in the Oort cloud, it might well suffer another course change, robbing it of a second dalliance with the sun. Even his cosmic namesake might not outlive him as anything more than a frozen corpse.

One of the old dogs, Hera, came limping toward him, whining softly. Brian held out a hand to her, and she nuzzled it. It seemed obvious now that Hera had smelled the cancer in him before he was diagnosed, before he'd even noticed the symptoms. But at the time, he'd assumed that the dog's melancholy was a symptom of her own declining health.

Hera settled at his feet. Brian turned back to the sky, tracking the binoculars along the ecliptic. Every star and nebula seemed familiar, though he wondered how much detail he really did hold in his memory. The comet had been diffuse enough that there'd been no mistaking it for a star, but he might not have noticed an asteroid in exactly the same place.

He lowered the binoculars and stretched his shoulders. It was cold, and he had to drive to the hospital in the morning.

He stood and looked around, wanting to savor the whole glorious sky one more time before retreating to the warmth of his bed. The Southern Cross was high, a dagger hanging over the celestial pole, while the Small Magellanic Cloud was clipped by the trees along the farm's

boundary.

Some way left of the pole, a pale, steady dot hung in the sky, right above Nu Octantis, about level with Eta Pavonis, and a little brighter than both. Which was not to say much, except that Brian could not recall seeing a star in that position before.

He waited half a minute, expecting the thing to move, but it stayed put, so he lifted the binoculars. What he saw was not a satellite or an aircraft, but a small, tight cluster of stars: dozens at least, all contained within a neat, circular region.

He could have sworn there was no cluster like this in Octans. He'd have to check his *Norton's* once he was back in the house, but if this was new . . . what could it be? Dozens of supernovae, all in the same galaxy? All exploding within days of each other—or rather, in some even less likely sequence that brought their light-bursts to Earth in near-perfect synch?

Brian laughed, bemused. He spent a few minutes checking that he hadn't made some foolish error and ended up disoriented, but he wasn't mistaken about the location. Then he turned the binoculars on the cluster once more, just in case he'd missed some vital clue that might explain the stars' shared fate. But if anything, they only seemed more disparate than he'd realized, with none of the sibling resemblance that stars born together sometimes shared.

It was baffling. But he wasn't going to solve this himself, standing in a paddock getting chilled to the bone. "Come on girl," he said. "Time to spread the word and get some fresh eyes on this." Hera rose, and they set off together for the farmhouse.

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## 2

Fatima woke on the second ring and reacted in time to smother the third as she picked up the phone from her bedside table.

"Yes?" she whispered hoarsely, not waiting to check the caller on the screen. Salif hadn't stirred, but she turned away from him, sandwiching the phone between her ear and the pillow.

"Sorry to wake you, Dr. Benga." It was Gabrielle, one of her postdocs.

"No problem. What's happening?" Fatima didn't think Gabrielle was observing tonight, but she was on the roster for external alerts.

"There's some kind of transient," Gabrielle explained. "We really need to check it out. If we could get some time on the AAT—"

"Hang on, where's this coming from?"

"A farmer in New Zealand. He emailed the department."

"A farmer saw a light in the sky?"

Gabrielle said, "His name's Brian Farley. He discovered a comet a few years ago. He's not some crackpot who saw Venus in his rearview mirror and decided it was a UFO."

"Okay." Fatima remembered the comet. "So what's this transient?"

Gabrielle hesitated. "Multiple stellar-like sources, all in close angular proximity. I've taken a look myself through a thirty-centimeter instrument, but I have no idea what to make of it."

Salif rolled over, muttering incoherently.

"Hang on a sec." Fatima slipped out of bed and grabbed a robe, then walked into the hallway and headed for her study. "Have you put something on the Astronomer's Telegram?"

"Not yet. I don't know how I should describe it."

"Multiple sources?" Fatima was fully awake now, but that wasn't making any of this clearer.

"At least sixty. Across about eight arc-minutes. But there's no structure they could belong to in the catalogs, or on past plates."

"How bright?"

"Taken together, it's a naked eye object, about magnitude four."

Fatima booted up her desktop. How did sixty flashbulbs go off together in the same small patch of sky—too close to be any kind of coincidence, too far apart to share a common cause?

"Do you have an image you can mail me?"

"Yes."

When the file came through, it looked like some kind of collage. In the center of the frame, a circular region contained a modestly dense star field—nothing special in itself, but it seemed to

have been cut out of an image taken in the star-rich galactic plane, and then pasted into a different one with a substantially sparser background, as befitted the region's actual coordinates. A sudden shift in line-of-sight density like this could always arise by pure chance. But unless both Farley and Gabrielle were horribly confused, none of the stars in the center here had been present the last time anyone looked.

"I'm sure I can get you time on the AAT," she told Gabrielle. "We need to take some spectra, for a start."

"What do you think this is?"

Fatima stared at the image. "Maybe some kind of lensing event?" That didn't make much sense, though. A chance alignment between a black hole and a distant cluster of stars might magnify and brighten the cluster's image, but the scale and the geometry weren't really compatible with that: with this much brightening, whatever was magnified should also have been warped into a pair of arcs centered on the hole. "Put out a telegram just saying what you see; there's no need to try to interpret it. I'll make the booking straight away, and send you the details."

"Thank you."

Fatima was able to get an emergency slot starting at two A.M. At least Octans was so close to the pole that it never set over Siding Spring.

She emailed Gabrielle and went back to bed, but then she lay awake pondering the discovery, struggling to piece together some kind of viable hypothesis. What if the gravitational lens responsible was more complex than a single black hole? Maybe two or three foreground galaxies—too dim and distant to show up themselves—were working in concert to produce the image, partly correcting each other's distortion.

At four o'clock, Fatima got up and checked her emails, but Gabrielle hadn't sent her anything yet. She walked down to the study and called her.

"I'm still looking at the data," Gabrielle explained. "I don't want to make a fool of myself."

"But what do you have so far?" Fatima pressed her.

"No supernovae. They're just a whole lot of main sequence stars, with nothing special going on."

"What about red shift?"

"All less than ten to the minus four." Gabrielle sounded almost apologetic, as if the phenomenon's stubbornly inconsistent details were her fault.

"Okay." So the stars were not in a distant galaxy—and it was unlikely that even a single gravitational lens lay in front of them.

"There's something else."

"Go on."

Gabrielle said, "Between the first exposure I took and the latest, seven new stars appeared."

Fatima considered that. "Where, exactly?"

"On the edge of the central field."

If this was a lensing event, and the alignment was delicate enough, maybe the image could change in a matter of hours as the magnified region shifted. "And some stars disappeared on the other edge, right?" Fatima asked.

"No," Gabrielle replied. "The new stars appeared all around the edge. It's not shifting, it's growing larger."

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### 3

Fatima's computer chimed, then brought up a plot of the latest data from Chile: a time series giving each new star's angular distance from the center of the anomaly. "The growth looks close to linear," she mused. "About two thirds of an arc-minute per hour." But almost anything looked linear on a short enough time scale.

"So is the wormhole staying still and getting larger?" Gabrielle wondered. "Or is it a fixed size, but moving closer?"

"I've never believed in wormholes," Fatima confessed. "Take two in relative motion and

you've got a time machine. And I definitely don't believe in time machines."

"Maybe you can believe in just one wormhole at a time," Gabrielle replied, deadpan.

"There are schemes that could supposedly turn just one into a time machine," Fatima recalled. "But . . . never mind. Let's stick to what we can see."

She glanced out the window of her office; the late-morning sunshine bathing the campus felt jarring, as if she were jet-lagged. Neither she nor Gabrielle had had a chance to sleep before Cerro Tololo took over the observations and fresh data came flooding in, but there'd have to come a point where they worked out a roster that allowed them to take turns resting.

"Suppose this . . . whatever it is . . . has a fixed geometry, and it's just moving closer," Gabrielle proposed tentatively.

Fatima said, "Go ahead and try it out."

Gabrielle did the calculations. If the changes they'd seen were due entirely to the thing's motion, it should have been visible telescopically for months before Farley spotted it—but an automated wide-field survey had imaged the area three weeks before and found nothing out of the ordinary. More absurdly, though, pursuing the model into the future implied that whatever it was would arrive at the Earth *in about eighteen hours*—a prediction that lost its apocalyptic potency when Fatima realized that if the true growth was simply linear, it was now eighteen hours since the zero point . . . and however long after that moment they'd chosen to try matching Gabrielle's model to the data, the model would have forecast a collision an equal time later.

"I love it when the mathematics throws your assumptions back in your face," Gabrielle joked ruefully.

"So what if we assume this thing is growing from a fixed center?" Fatima suggested.

This time the verdict was more elusive. If the anomaly was a sphere expanding at a constant rate, then merely observing how fast its angular size was changing couldn't pin down both the distance to its center and the rate of growth. They could plug in any speed they liked and get a matching distance, or *vice versa*. But to make the distance suitably astronomical demanded a relativistic velocity for the sphere's border: at a mere twenty light-years, it would need to be expanding at 99.9 percent of light speed.

Fatima's phone rang. It was Daniel from the press office, nagging her again to draft a statement staking the university's claim over this epochal discovery.

"We don't even know what it is!" she insisted. "If we start putting out half-baked theories, we'll just make fools of ourselves."

"It's all over social media," Daniel warned her. "In an hour or so, when it hits the news outlets, whoever's on screen explaining exactly where this wormhole is and what it's doing will own the story."

"Own the story'? What's that supposed to mean?"

"They'll be the one that everyone comes to for the definitive answers."

"You mean the definitive answers that I just told you I don't have?"

Daniel tried a different tack. "You made the first observations. Who else should do the honors and explain to the public exactly where the current state of knowledge stands?"

"Brian Farley and Gabrielle Chan made the first observations."

"Is Ms. Chan with you?"

Fatima held the phone to her chest and whispered, "Do you want your thirty seconds of fame now?"

Gabrielle shook her head vehemently.

"Sorry," Fatima replied. "She was up all night, and I think she came down with the flu."

"Send me something," Daniel pleaded.

"I will, I will," Fatima promised him soothingly. She hung up. "As soon as I have the faintest clue what's going on."

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It was dusk when Fatima finally left the campus. As she waited for the bus she looked to the south, but the Pane—as people were now calling it—was still invisible against the pale sky.

She had to accept that there'd probably be no way to determine the Pane's true distance and motion until more data was in . . . but every time she tried to set one puzzling aspect of the thing aside, a different one resurfaced. She did not believe in wormholes, but if they existed at all she was pretty sure that they ought to bend light. If you arranged for incoming light rays to converge on one mouth of a spherical wormhole, like pins in a pin-cushion, they'd need to emerge from the other mouth in the same configuration, only now they'd be diverging—without having passed through a common central point, or the wormhole would be blocked by an untraversable bottleneck. So the light needed to make a kind of U-turn, even if the two halves of the U lay at different ends of the wormhole.

But the Pane was proving stubbornly unrefractive. Once a new star appeared within the growing circle, its location didn't shift at all; this window, which should have distorted the view like a thick concave lens, seemed more like an empty frame. There were toy models of cubical wormholes, and other polyhedra, where all the curvature was concentrated along the edges—but even if this wormhole was shaped more like a geodesic dome than a sphere, the images of the stars should have jumped as they crossed behind the dome's numerous edges.

When Fatima arrived home she could smell dinner cooking. “Now I remember why I married you!” she called out to Salif.

“Don't tempt fate,” he replied, as she entered the kitchen. “The minister's still threatening to relocate his whole department to some benighted country town in his electorate. Who'll cook for you then?”

“You'll quit and stay here with me, won't you?”

“I might check the weather in the new location first. There are only so many winters in Canberra I can take.”

He was smiling, but Fatima recalled the promise she'd made: five years here, then she'd move on. Her position at ANU had always been intended as a step along a path that ultimately took them, if not all the way back to Senegal, at least somewhere closer to home.

They sat down to eat, with the television on. The Pane was unavoidable, but Fatima tried not to wince at all the nonsense it was generating. “We're almost certainly catching our first glimpse of an alien transport network that crisscrosses the galaxy!” a celebrity string theorist from New York enthused.

“So what we're seeing is like . . . a new subway station under construction?” the interviewer asked.

“That's the perfect analogy! But as well as seeing the entrance to the station, we're seeing all the way through the tunnel to the destination at the other end! In this subway, every tunnel is much shorter than the distance between the stations it joins!”

Fatima could understand his boyish excitement, his yearning to believe that the Universe had been delivered to his doorstep. When she was eight years old, her teacher, Mrs. Ndoye, had broken the astonishing news to the class that astronomers had seen a star wobbling from the tug of a planet orbiting around it. Fatima had snuck out of her room that night and looked up into the sky, hoping to witness the stars trembling for herself.

But when she'd told Mrs. Ndoye that she planned to visit the new-found planet, her teacher had gently nudged her expectations a little closer to reality. “When you're older you might study this world, and a thousand others like it. But light itself takes years to cross these distances. How about leaving something for your grandchildren to do?”

Salif caught the look on her face. “So why isn't it you there, getting the facts right?”

“Because we don't have the facts.”

“None at all? You're not sure of even one thing?”

Fatima said, “I know we're seeing the light from stars that we weren't seeing a few days ago, and I know that the stars themselves show no signs that they've suddenly brightened. But I don't know where these stars are, or why we're seeing them now, or what we'll see tomorrow.”

Salif nodded soberly. “All right, I can be patient. I won't plan my trip around the Galaxy just yet.”

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"This has to tell us something!" Gabrielle declared. The Chilean team had just observed a blue supergiant—HD 183582, some four thousand light-years away—disappearing behind the Pane.

Fatima was trying to stay circumspect, but she could agree up to a point: having a new constraint like this ought to reinvalidate their analysis. Apart from setting a maximum distance, the event itself had been much like the appearance of a new star within the circle, in reverse. There had been no blurring, no bending of the light; the now hidden star had just winked out, as sharply as if it had gone behind the Moon.

"I'll bet you fifty dollars the next one gets occulted as well," Gabrielle proposed. HD 184039 was less than nine hundred light-years away, and they'd learn the result by noon the next day.

Fatima smiled. "Why would I take that bet? It'd be too much of a coincidence if the Pane was only just close enough to block the first star we could check."

Gabrielle seemed to like this answer, but she wanted to push it further. "So let's assume it could be even closer. Say . . . less than a light-year."

Fatima didn't protest. She'd entertain anything for the sake of the argument.

Gabrielle said, "What's the natural speed for a change in geometry to propagate through empty space?"

"Light speed."

"So what if the Pane is expanding that fast?"

"Ummm . . . it would have hit us before we saw it coming." Fatima scrutinized Gabrielle's face, wondering just how exhausted she was.

Gabrielle shook her head impatiently. "Suppose it's not spherical, though—suppose it's circular. If it's six-tenths of a light-year way, and its radius is growing at the speed of light, that would match the angular growth rate we're seeing."

Fatima could see the attraction of the idea. A growing sphere had to grow slower than light or it would have reached the Earth already, but the Pane as they saw it was expanding so rapidly that either the sphere's border was moving at some arbitrary but still enormous speed, or it would have to be even closer to the Earth than Gabrielle was now proposing.

"Wormhole mouths are spheres, not disks," she said.

"You don't believe in wormholes," Gabrielle retorted.

"I know." Fatima thought for a moment. "Maybe a disk would make more sense of the optical properties. If you're just cutting space-time along two flat surfaces and identifying the cuts, you don't have the same curvature effects . . . though the rim would still be singular, like a cosmic string under negative tension. It's hard to see how a structure like that could be expanding at the speed of light."

"I can't explain the dynamics," Gabrielle admitted. "And another catch is that we're seeing a circle, not an ellipse. What are the odds that a disk would be facing us head-on?"

"Maybe you should sleep on it," Fatima suggested. "I've got a class to teach. We can take this up tomorrow."

The class was meant to be on methods for observing exoplanets, but Fatima decided to cut her students some slack; even brain surgeons and ambulance drivers were probably debating their own theories of the Pane with their colleagues as they worked, so it would be cruel to expect a roomful of budding astronomers to resist the same urge. She gave them free rein to ask questions or just raise ideas, and did her best to keep anyone, herself included, from shouting down even the craziest suggestions.

"If the Pane actually hit us, would we survive passing through?" Leon asked.

"Do we get to take the Sun along, too?" Fatima joked.

"Why not? If the Pane were so tiny it could only fit the Earth, it would have to be so close that someone would have measured its diurnal parallax by now."

That was a fair point. Fatima said, "Given what we see with the starlight, the curvature doesn't look extreme—it's not on the scale of a solar mass black hole, say. But it wouldn't take that strong a gravitational field to disrupt the Earth's orbit."

"So . . . ?"

“We don’t know,” she said. “Maybe we could survive passing through, maybe not. But even if the Pane is big enough to swallow the Solar System, we have no real evidence to show that it’s moving at all, let alone heading straight toward us.”

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## 6

Fatima woke and lay still for a while, turning the problem over in her mind, then she rose and walked in the dark to her study.

She closed the door before switching on the light, then she sat at her desk and picked up a pen.

When Gabrielle had carried out her first calculations—trying to explain the apparent growth of the Pane by treating it as an unchanging object that was simply moving closer—she’d assumed that the size of the thing was negligible compared to its distance. Fatima had never thought to question that; it would have seemed as absurd as disputing the fact that the radius of Mars was much smaller than its distance from the Earth, when you could hide the whole planet behind a match-head held at arm’s length.

But if the Pane was a very large disk, and its center was actually much closer to the Earth than its rim, it could still *appear* small, covering a tiny circle in the sky, because of the extra time it took for light to travel from the rim. In the original calculations, Gabrielle had used the time lag for the distance from the observer to the center, not the rim, assuming that the two quantities were so close that it made no difference.

Fatima worked out the exact expression, then went back and checked it three times before attempting to connect it to the data.

It was impossible to solve for everything—the size, distance and speed of the Pane—all at once, but the simplest assumption would be that the thing was traveling at exactly the speed of light. If she extrapolated back in time to the moment when its apparent size would have been zero, five hours before Farley’s first sighting, that would be the moment it had reached the Earth. The observed rate of growth then implied a radius of about 450 light-days.

If all of that was true, the Pane was now a couple of light-days away, in the opposite direction to Octans—but the current picture in the sky reflected a time almost 140 years earlier, when the extra distance out to the rim made the hypotenuse of the 140-light-year triangle about two light-days longer than its side—so that starlight on the verge of being blocked by the disk would take two more days to reach Earth than the disk itself.

Fatima felt light-headed. She left her study and walked to the back door, then she stepped out into the courtyard. There was a streetlight nearby, but she found a place where it was hidden by a neighbor’s tree, then she stood there waiting for her eyes to adapt and the stars to come into view.

The Pane was twice as wide as a full moon now, still smaller than the Magellanic Clouds but far more eye-catching with its circular geometry. It really did look as if someone had taken a coin-sized piece of the Milky Way and slid it across the sky to a new position.

She heard the door open, and she turned to see Salif approaching. “Sorry I woke you,” she said.

“Don’t be sorry. I just want to know what’s troubling you.”

Fatima hesitated, as if speaking the words might be enough to make everything she’d imagined true, but holding her peace would see the possibility dissipate into the night like a dream.

But that wasn’t how the world worked.

“I think we’ve already gone through the Pane,” she said.

“Okay.” Salif rubbed his arms against the chill. “If you want me to say something sensible about that, I might need a bit more information.”

Fatima explained the geometry of the time lag. Salif frowned, but then he got it.

“So you’re telling me that *all of this*,” he gestured with a wide sweep of his hand that took in every part of the sky but the Pane, “is the view looking *back* through the portal at our old neighborhood?”

“Yes. Or you could say the view’s come with us. We’ve gone through, but enough light has

followed us that it still looks almost like home, for now.”

Salif was skeptical. “If we’re only seeing the Pane as it was 140 years ago, how can you be sure we really did pass through it? If it was off to the side a bit, just enough to miss us, would we even notice the difference?”

Fatima said, “If it was going to miss us, it would look like it was moving sideways as it grew bigger—enough that successive snapshots of the rim wouldn’t nest around each other; they’d intersect. But they do nest, almost concentrically. We might not have scored a bull’s eye, but we didn’t miss the dartboard entirely.”

Salif laughed and shook his head. “I don’t know what to say! If you’re right, we just traveled thousands of light-years, *and no one even noticed?*”

“No one noticed because the short cut we took was over flat terrain. If we’d hit the rim, that might have been disastrous, but I think the Pane itself is just ordinary vacuum. So in a sense, nothing ‘happened’ to us—nothing that a purely local measurement could have detected. The topology around us just turned out to be different than we expected.”

“That’s got to be the understatement of the millennium.” Salif hugged himself; it really was getting cold. “So we’ve survived the journey, but are we in any danger now that we’ve arrived?”

“I don’t see why we would be,” Fatima replied. “There’s no reason to expect we would have ended up on the verge of colliding with anything. None of the new stars seem especially close, and to some extent the sheer size of the Pane means we’ve brought our old elbow room with us.”

“But you think this is a natural event? We haven’t been . . . caught in some alien butterfly net?”

Fatima wasn’t sure if he was gently mocking her, but she took the question at face value. “If the Pane is a topological defect, it could date back to the Big Bang. I can’t explain how it would have formed, but it’s even harder to believe it could be created artificially.”

“Okay.” Salif fell silent for a while, as if he was trying to put the whole picture together to his own satisfaction. Then he said, “How sure are you, of any of this?”

“Not sure at all,” Fatima conceded. “It fits what we’re seeing better than anything else I’ve heard, but that doesn’t mean much. I can make some predictions and see if they’re borne out over the next few months.”

“But sooner or later, you’re going to tell the world that we’ve already fallen through the looking glass?” Salif sounded more worried now than when they’d been discussing the event itself.

Fatima said, “That’s what I’m trying to decide. I don’t want to sow panic. But if I’m right, things are only going to get more frightening: the Pane will just keep growing bigger in the sky—and the more stars that vanish behind it, the closer it will seem to be. What better way to undercut the fear that hitting the Pane might destroy the Earth than announcing that we’ve already come through without a scratch?”

Salif remained apprehensive. “What if you’re wrong, though? What if this thing just fizzles out? Do you want to be remembered as the woman who claimed that while we were asleep one night, the sky fell down? And when people pointed out the familiar constellations—all still in place, exactly where they’d always been—she insisted that they were only a mirage?”

Fatima couldn’t help feeling wounded, but he was right to drag her back to Earth. “I’ll talk to my colleagues first,” she said. “Maybe Gabrielle can find some flaw in my reasoning, and prove that it’s all nonsense.”

Salif stepped forward and embraced her. “You know I trust you,” he said. “I just don’t want to see you get hurt.”

“I know.” Fatima extricated herself from his arms. “We’d better go inside, or we’re both going to freeze to death.”

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7

As Gabrielle listened, an expression of pure delight spread across her face—along with a hint of impatience as she joined the dots herself and waited for Fatima to stop talking.

“The geometry all makes sense now!” she proclaimed elatedly. “At light speed, the most symmetric shape is a disk moving perpendicular to itself; there is no rest frame in which it could be

spherical. And that explains why we're not seeing it at an angle—it's not like a frisbee or a man-hole cover that could approach us edge-on. To any observer, it's a circular disk moving perpendicular to itself at light speed."

Fatima had no argument with any of this, but it wasn't quite the response she'd expected. "You don't seem too unsettled by the thought that we might have . . ."

"Gone through already?" Gabrielle shrugged. "To be honest, I've had it at the back of my mind since yesterday, but I wasn't sure if you'd believe that the curvature could be so low that we wouldn't feel a thing."

"I see."

"Can I help you write the paper?" Gabrielle pleaded.

Fatima was taken aback. "Of course." So much for having her ideas torn to shreds, but maybe if they sat down together and worked through all the calculations carefully, they'd find a weak spot and the whole thing would unravel.

By early afternoon, they'd finished their first draft. The geometry itself was very simple, and they had enough data to fix the radius of the Pane to within a few percent. The only wiggle room that remained was in the impact parameter: the distance between the Earth and the axis of the cylinder the Pane had swept out. Without that, they could not make firm predictions for the way the Pane's apparent shape would evolve in the coming weeks, but they could at least constrain the possibilities for the progression of ellipses that ought to manifest as their off-center viewpoint finally made its mark.

"One more read-through, then we should post it on the arXiv," Gabrielle suggested.

"How long have you been up now?" Fatima asked.

"Eighteen hours."

"Maybe we should leave it till tomorrow."

Gabrielle was horrified. "What if someone beats us to it? They're not all trying to shoe-horn the Pane into standard wormhole models."

Fatima was torn, but it was true that anyone could stumble on the same insights at any moment. Whatever they did, the possibility that the planet had *relocated* was going to start seeping into the public conversation sooner or later. If she and Gabrielle published first, they'd own the story. Maybe if they put the right spin on it, they could soften the blow.

Still . . .

"What if we're wrong?" she replied. "This is a big claim to make, after less than three days' worth of observations."

Gabrielle said, "We still have a chance to falsify the theory."

"How?"

"You didn't check with Cerro Tololo yet, did you?"

"No." Fatima had completely forgotten about the impending event.

She brought up the website. While they'd been busy writing, HD 184039, nine hundred light-years away, had disappeared behind the Pane.

Gabrielle cheered. "Do you want to wait three months for Proxima Centauri?" she asked.

"No." Fatima still felt anxious, but she did not want to cede priority for the idea. And if she was wrong, she might not be in the best company, but she certainly wouldn't be alone. Seven hundred new papers had appeared on the arXiv in the last forty-eight hours—most of them positing exotic new physics to explain the Pane.

Gabrielle proofread the manuscript and corrected a couple of typos. Fatima posted it, though it wouldn't appear online for a few more hours.

"I'd better go home and grab some sleep," Gabrielle said. "No rest until we've answered the second question."

"The second question?" Fatima was a long way from letting go of the first.

"We're probably not in Kansas any more," Gabrielle replied. "So the question is: where exactly are we?"

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When Fatima emailed the draft press release to Daniel, he phoned her back in less than a minute. “Is this a joke?” he asked.

“Of course not.”

“The entire Solar System passed through a wormhole three days ago?”

“I don’t want to use the word ‘wormhole,’” Fatima insisted. “It has too many misleading connotations.”

Daniel said, “I think terminology is the least of your problems.”

“What I’ve described is just one of several competing theories,” she conceded. “And it might be a while before we know which one’s correct. But you wanted my take on the Pane as soon as possible, and this is it.”

Daniel sighed, resigned to the situation. “Are you willing to do interviews, defending this theory?”

“If I have to.”

“Here’s a tip, then: prepare some graphics illustrating what you’re saying, or the TV people will choose their own. Probably from some bad science fiction movie.”

Fatima made a short animation, showing how the light grazing the edge of the Pane would lag behind the Pane itself, determining its apparent size at any moment. She resisted the urge to add the Pythagorean formula, and just had the hypotenuse swing down across the diagram so its length could be visually compared with the distance to the center. Then she grabbed a passing undergraduate for an opinion.

“It’s kind of textbooky,” he complained. “You should show some actual stars.”

Fatima collected a sequence of exposures of the Pane, and then overlaid an expanding red circle showing her model’s prediction for the size of the effective window. The match was almost eerily perfect—as any linear fit to this linear data would have been.

She passed the animation on to Daniel, and he sent it out with the press release. Then she sat at her desk and waited, rereading the paper she’d written with Gabrielle, checking and rechecking every equation.

The first interview request came from local Canberra radio. The journalist was polite but a tad incredulous, and not a little confused; she seemed to think that if they’d already crossed through the Pane, but it looked as if they hadn’t, then at some point they must have traveled back in time. “We’re only *seeing* the past,” Fatima stressed. “That’s how it is, when you look into the sky. We’re always looking back in time.”

It was after five o’clock; Daniel had been clear that they’d probably missed the deadline for most Australian coverage. But Europe was just waking up, and a German breakfast TV program wanted to Skype her. “We’ll record the segment in English, then play it later with subtitles for your parts,” the producer explained.

“All right.”

Fatima was nervous, but the interviewer, Nora, seemed to have read the press release carefully, and she asked intelligent questions. “The other side of the Pane, the one we’ve emerged from, is now moving away from us at the speed of light?”

“Yes.”

“So if you’re right, we have no prospect of using it to get home? Not only have we passed through without warning, we can’t turn around and go back.”

“That’s true,” Fatima agreed. “You can’t see anything approaching at light speed, and you can’t catch anything retreating that fast.”

“Not a very convenient subway system, is it?” Nora joked.

“No,” Fatima agreed. “If this model bears out, I’d say it’s more unlikely than ever that the Pane could be part of any artificial transport network.”

The BBC was next, then an NPR station in Boston.

“I see from your university’s website that your specialty is exoplanets,” the NPR journalist noted.

“That’s right. It’s just luck that I got involved with the Pane.”

“So if we’ve suddenly changed neighborhoods, what happens to all your work on neighboring

planets?"

Fatima laughed. "To be honest, I hadn't really thought about that. But our techniques have improved so much over the last decade that it should be possible to catch up again pretty quickly. It might even be a boon, in one sense, because we'll potentially have a whole new population of stars and planets to observe."

\* \* \*

9

"I have 639 emails," Fatima told Salif. She hefted her phone up from the bedside table. "I think it actually weighs more than it used to."

She opened her inbox.

"Fan mail?" he asked.

"Not exactly." He leaned toward her, but she turned the phone away, then she climbed out of bed and headed for the kitchen. "I'll put the coffee on. You go first in the shower."

The first ten messages were wall-to-wall racist abuse, death threats, and rape threats. Fatima's chest tightened, and she could feel her heart racing and her mouth turn dry. She sat down on a stool and steadied herself, then she invoked the mail app's filter and fed it a few examples of the kind of thing she did not wish to see. It was smart enough to sweep up misspellings, deliberate or otherwise.

The inbox shrank to twenty-three messages, mostly from media outlets that wanted to follow up on the story. She said yes to five, and politely declined the rest; there were only so many hours in a day.

When Salif joined her, she tried to look cheerful, but he could read her face. "What is it with these animals?" he asked angrily.

Fatima shrugged. "They seem to think I've somehow harmed their chances for Elon to take them on a ride out to the wormhole, which the aliens are building in order to invite all the least pleasant people on Reddit and 4chan into their galactic empire."

When Gabrielle turned up at Fatima's office for her morning briefing, she seemed subdued.

"You got hate mail too?" Fatima asked.

Gabrielle winced sympathetically. "Only a little. I'm lucky: second author on the paper, no TV. It's the wormhole experts who are getting me down."

"How?"

Gabrielle showed her a few of the blog posts that had appeared in response to their paper. Andrew Jolliffe, a cosmologist at Princeton, had written, "While some of us are working hard to explain how the dynamics of an expanding wormhole can result in the unexpected optical properties we've seen, Benga and Chan sweep everything puzzling about the Pane into a massless cosmic string, and then make no effort to justify the existence of such an entity."

"That's true," Fatima conceded. They'd left the rim unexplained: a magical loop of who-knows-what possessing all the properties needed to make everything else work out. "But it doesn't mean we're wrong." The first step in understanding the Pane was to be clear what the observations implied about its structure, on an astronomical scale. Whatever exotic modifications to particle physics might or might not follow was a separate question.

Gabrielle said, "If we're right, no one else's predictions for the growth curve will match ours once it goes nonlinear. And no one else is predicting any departure from a circular window."

"Yeah." But the nonlinearity in the Pane's apparent growth would probably remain undetectable for five or six months, and any change in the shape would depend on how far they were off-axis. For now, all they could do was be patient, ride out the backlash . . . and get on with the rest of their work.

"How are things going on the second question?" Fatima asked.

"I'm building up a metallicity profile," Gabrielle replied. "So far, it looks comparable to the Milky Way. I've also spotted a few potential Cepheids, so we might have a chance to get some distances without having to wait for parallax measurements."

"Well done!"

When Gabrielle left, Fatima sat down and steeled herself for the five more interviews she'd

promised to do. They all turned out to be tougher than the earlier ones; the journalists had read the dismissive reactions from the experts.

“Your background isn’t in Einstein’s theory of general relativity, is it?” a reporter from Singapore asked pointedly.

“It’s not my area of research,” Fatima admitted. “I’m an astronomer; I’ve studied relativity, but I’m a planet hunter, not a cosmologist.”

“So how seriously should we treat your claim that we’ve all passed through a wormhole, when wormholes aren’t your area of expertise?”

The question stung a little, but it was not unreasonable. Or unanswerable.

Fatima said, “The simplest explanation for what we’re seeing isn’t a wormhole at all, in the usual sense; it’s a region of space-time that’s flat almost everywhere but connects up in an unexpected way. My coauthor and I don’t claim to have an account as to how this region formed in the first place, but that doesn’t change the fact that what we’re observing fits our model very well so far. Maybe that will continue to be true over the coming days and weeks, maybe it won’t. Only time will tell.”

\* \* \*

## 10

“We’re making plans to launch an ark that will preserve our civilization.”

Fatima’s heart sank as she heard the words, and she resolved to ignore them and keep loading the dishwasher, but Salif called out to her, “You’ve got to see this!”

Reluctantly, she joined him in the living room. A caption described the interviewee as George Fletcher, the director of a British think tank called the Institute for the Future.

“You don’t think that’s an alarmist response?” the interviewer asked.

“Not at all. The Pane continues to grow, and every chance it’s had to show itself to lie further away than some star, it’s turned out in fact to be closer. We’re now certain that it’s less than fifty light-years away, but that figure only keeps falling. Whether the Earth is at risk of being damaged or merely captured by some hostile entity is unclear, but we need to be prepared for the worst.”

“But what kind of spacecraft could we build at short notice? Where would we be sending it?”

Fletcher nodded gravely. “It’s a terrible thing to have reached this point, because even with the largest investment of resources we could hope to muster, we’ll only be able to send a robotic craft, carrying a digital library and some frozen genetic material. To outrace the Pane, we’ll launch it in a direction that will optimize its chance of escaping; once it’s achieved that goal, it will need to be able to carry out its own search for a potential new home.”

The interviewer frowned slightly, but remained professional. “Is this a serious plan? Is NASA involved, or the ESA? China’s CNSA?”

Fletcher said, “So far, we have more than a dozen philanthropic backers, all people with considerable wealth. Of course we’d prefer to have the government space agencies on board, but if the politicians can’t be brought to their senses, we’re prepared to work solely with commercial launch partners.”

Fatima flopped down onto the sofa. Was this where the panic was going to start in earnest—with a cabal of gullible tech billionaires? Followed by everyone whose gametes wouldn’t be on board the life raft railing against the injustice of their own genetic annihilation? There might even be a frozen brain or two tucked away in the cargo, so the descendants could resurrect their benefactors after planet-fall . . . or maybe that would just be the rumor that helped drive the mobs to burn everything down.

“Turn it off,” she begged Salif. He clicked the remote.

“People ask me questions,” he said. “Colleagues, friends. Some of them are genuinely frightened. I tell them everything the way you explained it to me, but they still wonder if you might be wrong.”

“Of course I might be wrong,” Fatima replied. “But if the Pane is dangerous, and it’s about to hit us, our chances of building anything fast enough to get away from it are approximately zero. If it wasn’t moving at light speed, then it’s moving, or growing, so close to light speed as to make no difference when it comes to escaping. We’ll all go together if we go.”

She let Salif switch the TV back on, but the Pane wasn't finished with her yet. A religious leader in a town in rural India had managed to whip his followers into a frenzy over the supposed divine significance of the Pane, and nineteen people had died in the subsequent clash between rioters and police.

The last few times something similar had happened, Fatima had tried telling herself that if it wasn't this, the same zealots would have found a different pretext. But the Pane was unmissable in the sky for half the planet, and it was only going to grow more prominent. So long as there was no consensus about what it was, and what it might mean for the Earth, to hope people would ignore it and just get on with their lives was too much to ask.

"The truth will make itself known," Salif proclaimed earnestly.

"It will," she agreed. "But maybe not soon enough."

\* \* \*

## 11

As Fatima crossed the common room and approached the coffee machine, she had to force herself not to lower her gaze. None of her colleagues were staring at her; no one was whispering or laughing. Even if they thought she was foolhardy for taking a position on the Pane—and even if they viewed her own theory as deranged—she knew they'd be polite enough to ensure that they betrayed no sign of it in her presence.

As she carried her mug toward the nearest table, someone approached her. "Excuse me, Dr. Benga?"

She turned. It was Rob Bayer, from the galactic black hole group.

"I just wanted to say, I thought your paper made a lot of sense. Jolliffe's wrong; the Pane can't be spherical. This guy invents six new scalar fields before breakfast just to make his models work."

Fatima smiled. "Thanks for the vote of confidence."

Rob said, "I heard a group's using the Hubble to get a deep field between the stars."

"Between the . . . ?"

"Between the stars through the Pane. They've found a small region where they think they can see past the local stars, and get a background showing a patch of distant galaxies."

Fatima felt the skin on her forearms prickling; it was like the scene in a movie where the police were watching the video of a kidnap victim, and they spotted a reflection that let them look out through a window onto the street. "Which group?"

Rob hesitated. "I shouldn't really say. They haven't announced any results yet, and I heard about the whole thing third-hand. But I thought, if you had a heads-up, you might be able to use it."

"Thank you," Fatima replied, reflexively; she had no idea what he meant. But as he nodded and walked on, she understood. A correct prediction about the nature of this image, made before its actual contents were known, might win a lot of support for her model.

She sat down at the table. *How long did she have?* She thought of going after Rob to ask exactly when the results would be made public, but if he'd known that he would have told her. So she took a sip of coffee and tried to focus.

*Suppose Jolliffe was right, and the Pane was a spherical wormhole.* Since it wasn't accompanied by a haze of gamma rays from interstellar hydrogen converting to antimatter and annihilating, it seemed safe to assume that it was not transforming objects into their mirror image. But since light entering a wormhole was essentially reflected away from it—albeit at the other mouth—points on the two mouths needed to match up with each other via a process that also included a reflection, so the two reflections canceled and the handedness of any traveler remained intact.

For a spherical wormhole, that still allowed an infinite number of possibilities, but Fatima could imagine two especially natural choices. Each point on one mouth could match up with the antipodal point on the other—in which case, the view looking through the Pane would show the galaxies that used to be visible in Octans, but they'd be rotated 180 degrees around the center of the view. Or, if the mouths had been born together, they might be mirror images of

each other: reflections in the plane perpendicular to the axis along which they'd separated. The result would then depend on the relationship between the Earth, the Pane, and that unknown axis.

So, it would be hard for Jolliffe to predict the view. But how much did her own model change that? If the Earth really had passed through the Pane, they'd be seeing the distant galaxies directly, with nothing to distort or redirect the light—but by crossing through, the Earth itself could have been shifted into a new orientation.

If the two mouths of the Pane were disks traveling at light speed, the simplest account of their birth would involve them fleeing the scene in opposite directions. But if that was the case, the disks could *not* be matched to each other's mirror image in the axis of separation; that would imply that an object that passed through the leading face of one disk would emerge from the leading face of the other. Nothing could *emerge* from a portal that was traveling forward at the speed of light.

Fatima could see no other fix than to add in a rotation by 180 degrees: first reflect each disk, then turn it around, so the leading face was matched with the trailing face of the twin. But turn it around what axis? Anything perpendicular to the direction of travel would suffice . . . but how would nature have made that arbitrary choice?

The more she thought about it, the more troubling it seemed. It was true that she had no idea how these disks could have formed in the first place, so she had nothing more than a vague sense of symmetry to guide her. And the direction of travel would be arbitrary too, even if the pair of disks neatly canceled out each other's momentum. But the need for an extra choice, plucked out of the vacuum, still felt wrong.

She could announce half a prediction, regardless: that the view between the new stars would look backward, away from Octans. It was hard to see how that part could be wrong—and if she was right, for Jolliffe's model to explain the same result would require a blatant appeal to coincidence.

Fatima drained her mug and looked across the room. She had no doubt that people were discussing the Pane at every table, but for every supporter she had, and every detractor, she suspected there were ten others waiting for more evidence before they made up their minds. She'd started out just as cautious and agnostic, refusing to claim anything more than the observations showed. If she offered a prediction about the deep field now, it would just be a gamble—and if she was right, it would prove nothing more than that she'd made a lucky guess.

When she arrived home, the TV news showed no signs that the wormhole fever was subsiding. A fresh group of con artists were offering to "digitize" people and transmit them into space, which admittedly circumvented the problem of sluggish spacecraft escaping a relativistic threat, but didn't inspire much confidence in the content of the transmission, let alone the ultimate fate of the data. Minor cults with their own idiosyncratic messages about the Pane were blossoming across the world, but Fatima was more worried about the people who'd ignore all the faux-rationalist and faux-religious nonsense and just look into the sky in search of answers themselves. Before long, their guts would tell them—quite reasonably—that something huge was sweeping toward the planet.

Salif said, "Didn't everyone's ancestors freak out at a solar eclipse, at some point? But I've never heard a historian attribute a serious cultural setback to an eclipse."

Fatima took no comfort from that. "Eclipses only last a few hours. This could take a couple of years to resolve."

Salif frowned. "And your nemesis has no qualms about spreading hysteria?"

"Jolliffe?" Fatima shook her head. "I can't put the blame on him. He's never claimed that the Pane will reach the Earth; all his calculations end up with the expansion slowing down and reversing. He believes that whatever's happening here has happened at random all over the Universe for the last thirteen billion years. His wormholes can't grow forever, or the whole place would be like Swiss cheese."

Fatima's phone rang. It was Gabrielle, and she sounded excited. "Did you hear about the deep field?"

“No.” Fatima felt a pang of guilt; she hadn’t shared the early tip-off with Gabrielle, telling herself it wasn’t fair to burden her with it. But she was a grown woman, she could have made her own choice.

Gabrielle explained the part Fatima already knew, but then she added the revelation that had prompted the call.

“What it shows is that the background’s unchanged! All the galaxies we can see are exactly where they were before the Pane appeared!”

\* \* \*

## 12

Fatima surrendered any hope of sleep. Salif offered to stay up and cook for her, to keep her energy from flagging while she worked, but she persuaded him to go to bed, leaving the house in silence.

Jolliffe’s model was mortally wounded. It wasn’t impossible for various aspects of the geometry he’d championed to conspire to yield an unchanged view, but no one could really argue for that with a straight face.

Nonetheless, her own theory still sat uneasily with the result. To explain it, she’d need the two disks to be traveling in the same direction. This scenario did avoid the awkward extra rotation, allowing the disks to be identified with nothing but a reflection—which canceled out the reflection at the boundary, and meant a traveler would pass through with their orientation entirely unchanged.

But how could two disks, born together, moving in the same direction at exactly the same speed, end up separated by thousands of light-years?

Not born together, then? But how had they become connected if they didn’t share a common origin?

Fatima put on a jacket and crept out into the courtyard, closing the back door as quietly as if she were sneaking out of her parents’ house for a forbidden night on the town.

The circle that everyone still called the Pane was wider than the Large Magellanic Cloud now, brighter overall but more visibly threaded with dust and gas. Above the crowded plane, just below the rim of the circle, the stars began to thin out; that was where the Hubble had found a place to peer into the background.

But even the foreground was more distant than the usual view: Gabrielle’s results had put all the Cepheids at least fifty thousand light-years away. As far as anyone could tell, there were no stars closer than that. If they were looking at a part of the Milky Way, they might well be looking at it from the outside.

But from where, exactly? If the two disks were sweeping through space on parallel tracks, what had set the two tracks apart?

Fatima pictured the cylinders the disks traced out in space-time. She shifted them back and forth in her mind, trying to imagine the perfect configuration—the one that nature would have chosen, because it could not have chosen differently. Were they side by side, keeping pace with each other? Or was one disk following the other, chasing it but never catching up?

For the rotation that she’d thought she’d needed to align the faces of the disks, there had been no right answer, no natural choice—because there’d been no rotation at all. But maybe she’d been wrong to think that the resolution there had left her with an entirely new problem. Maybe the answer was exactly the same as before.

She returned to her office and started collecting the software she needed. People had already written most of the modules she required; she just needed to fit them together. One piece of code mined the star catalogs from the Hipparcos and Gaia satellites, finding the most up-to-date measurements of current locations and proper motion. Another turned the mass of stellar data into a view from an arbitrary viewpoint, at any specified place and time. And a third module checked that synthetic view against the latest image of the stars from the Earth’s new vantage.

She took a guess to set the starting point for her extragalactic hunt, then she unleashed the search algorithm. It was not a fast process; each iteration had to find the best matches between millions of stars. But she’d narrowed down the degrees of freedom to a single parameter, and

over forty minutes, she watched the program converging on an answer.

When it halted, having done its best, the artificial image and the real one, though easily distinguishable by eye, were eerily close. Not every star had been cataloged and measured, and not every measurement was perfect. But by following the Pane along its trajectory into the future, the algorithm had found a viewpoint that more or less matched what Fatima now saw in the sky.

There was no need for a second disk, on a second, parallel track. If you passed through the leading face of the Pane, you emerged from the trailing face of the very same disk . . . *after a delay*. The past and future hyperfaces of the cylinder that the Pane traced out through space-time had somehow slipped along their shared boundary, so although they remained in intimate contact, they no longer matched up in the same way. It was less like any kind of bridge or tunnel than an ancient fault line, worn so smooth that you could cross it without ever noticing that the strata had ended up wildly misaligned.

Fatima shut down her computer, turned off the lights, and walked quietly to the bedroom. When she slid under the covers she put her arms around Salif and held him tightly, clinging to his warmth.

He stirred. "Did you get anywhere?" he asked.

"I did. I'll tell you all about it in the morning. Right now I need to catch some sleep."

"Good idea." He took her hand and covered it with his own. "Do you know what time it is?" Fatima said, "About 65,000 A.D."

\* \* \*

### 13

"I have an idea," Gabrielle announced. "I think there's a chance we can clinch the argument, once and for all. But it's going to need a coronagraph. In space."

Fatima said, "I'm listening."

The plan made sense to her, but they'd need time on the James Webb telescope. Fatima started sending out emails, trying to recruit supporters for the proposal, far from sure of her chances of success. Though everyone she knew in the exoplanet community had accepted her model of the Pane, that could only have increased their sense of urgency to use the Webb for its original purpose, in the short time that remained before its planetary targets all went out of range.

Jolliffe had gone quiet, but other wormhole proponents remained stubborn. The fact that they could gaze into the southern sky and see the Milky Way as it would appear 63,000 years into the future, from 63,000 light-years away, was not enough to convince them that they'd actually crossed that interval of distance and time themselves. Wormholes could be turned into time machines, so they might be looking at light streaming back to them from the future. The Slipway model explained the same observations without violating causality; stepping through the Pane carried you across a vast stretch of space and time, but you did not travel faster than light, and you could not turn around and step back into the time you'd come from.

As the days passed, a hint of eccentricity in the rim of the Pane continued to grow, in a manner consistent with the Earth lying some two hundred light-days off-axis. That left the proponents of perfectly spherical wormholes with nowhere to hide, but if the asymmetry of the looming form silenced some of her critics, that this lopsided rim would grow faster than a centered version gave Fatima no comfort, when the sight of *anything* growing in the sky still had the power to induce panic.

On the thirty-sixth day after the crossing, the notification came that they'd been granted a slot on the James Webb telescope, three days hence. Gabrielle seemed as excited as if she'd be rocketing out to the Lagrange point to operate the instrument in person.

"This is going to be tricky," Fatima stressed. "Don't take it too hard if it doesn't work."

"I won't."

Fatima's torrent of junk mail kept leaking past the filters she set; the latest correspondents weren't trying to threaten or abuse her, but it seemed they desperately needed to share their private theories about the Pane. Most of what they wrote was incoherent, but Fatima felt obliged to at least skim anything civil.

*We have been exiled*, she read. The sender hadn't included a name. *We were beginning to*

*reach out beyond the Earth, so those we reached toward flicked us away, much as a compassionate person might flick an encroaching insect off their picnic blanket, rather than crushing it.*

This scenario was not unthinkable, but Fatima was not convinced. A civilization with the power to create something like the Pane would not find humans threatening at all. But in any case, with luck they'd soon learn whether the thing that had carried them out of the Milky Way had a recent, proximate origin, or whether it had come a lot farther and carried more with it than she'd expect from a cosmic eviction tool created by a fastidious neighbor.

\* \* \*

#### 14

"Okay, I'm logged on," Gabrielle said. "I hope I don't break anything."

"Just don't press the self-destruct button, and you'll be fine." Fatima hesitated. "Do you want me to leave?" They were in her office, but she wasn't sure that Gabrielle would welcome having someone hovering by her shoulder.

"No! I might need your help."

The interface to the telescope was clean and simple, and Gabrielle had operated automated instruments before. But Fatima was glad she wouldn't have to spend the time pacing outside the door.

Gabrielle entered the coordinates and verified them, then waited for the telescope to turn toward Octans. When the first trial exposure came through, it showed a crowded, dazzling star field, with one bright star at the center of the field that they especially did *not* want to see.

Choosing and aligning the coronagraph mask was a matter of trial and error. Step by step, the unwelcome glare fell away.

Beside the vanquished star, a small dot emerged: a single lit pixel. Not the light from a planet, but the light from a much dimmer star that merely happened to share the line of sight.

Gabrielle exhaled. "Now we try to get the spectrum," she muttered.

The dwarf star was more or less where they'd expected to find it, but Fatima knew that could still be a coincidence. This could easily be one of the "new" stars that they couldn't trace back to any particular, cataloged predecessor.

Once Gabrielle had initiated the process, there was nothing to do but wait. Fatima thought: *Maybe it wouldn't be so bad to be wrong.* Maybe the Universe really was full of magic wormholes sending images back in time, built by friendly aliens who weren't trying to toss the Earth away, but just wanted to share their latest galactic selfies.

A trace appeared at the top of the screen, plotting the dwarf star's luminosity across the near-infrared band. Gabrielle saved the image to disk and then opened it beside the cataloged spectrum. Every peak and dip was the same.

When the Pane had occulted the blue supergiant HD 183582, four thousand light-years away, people had stopped bothering trying to look for this dwarf star, much dimmer and more than twice as distant. Surely it would have vanished the instant the rim passed across it—and it was so close to the center of the disk that this ought to have happened before Farley had made his first sighting of the Pane.

But it hadn't vanished. It had just been drowned in the glare of a bright star that had suddenly appeared *behind* it—when the disk of the Pane swept over it and transported it 63,000 light-years. This dwarf star was their fellow traveler, carried along on exactly the same ride eight thousand years earlier. There was no other way to explain its presence.

Fatima started sobbing. Gabrielle turned to her, perplexed. "What's wrong? This is the proof we needed! This settles it!"

"I didn't want it to be true," Fatima confessed. "I didn't want us to be out in the dark, looking back. What do we have to look forward to, now?"

Gabrielle said nothing. Fatima composed herself and gestured at the pair of matching spectra. "You should announce this as soon as possible. People need to know."

"Will you help me write it up?"

"It was your idea, your discovery." Fatima smiled. "Just make sure you get a good junk mail

filter.”

\* \* \*

## 15

Carol Farley was quiet as she drove Fatima and Salif back to the farmhouse. She'd insisted on putting them up for the night rather than letting them stay in a hotel.

“It was a beautiful ceremony,” Salif said.

“Thank you,” Carol replied. There'd been no religious service, but about a hundred people had gathered in the town hall to reminisce about their departed friend.

Beside the picture of Brian there'd been a poster of Comet Farley, which one of his grandchildren had made for the occasion. Fatima had formed the impression that his relatives still considered it the more noteworthy of his two discoveries, but perhaps it was just the fact that only the comet bore his name. All credit where it was due, but no one was going to rename the whole Milky Way in his honor—even if he might have been the first human being to see it from the outside.

The sky was growing dark as the truck rattled over the gravel road. Fatima had almost declined the invitation to attend the funeral; she had exchanged a handful of emails with Farley after she'd sent him a copy of her paper, but that hardly made her a close friend. Still, the request had seemed sincere, and she hadn't wanted to offend his widow. She wasn't sure what it meant that the tiny parts of their respective stories that had ended up entwined would be the ones that outlived them both, but it would have felt ungrateful not to come here and acknowledge her debt.

When they reached the farmhouse, Fatima heard dogs barking. Carol shouted out some sharp rebukes, but told her guests, “Don't worry, they're sweethearts.” Fatima steeled herself, but as she stepped down from the cabin the dogs just paced back and forth in front of her, keeping their distance.

Carol switched off the headlights, leaving the farmhouse and the surrounding buildings in darkness. Fatima took a few steps away from the truck and looked into the sky.

To the south, the Galaxy sprawled across the horizon, not quite edge-on. She could see part of one spiral arm, but the view would be much clearer when it rose a little more. To the north, a larger ellipse full of the old stars poked one end toward the south, where the light from the farthest part of the rim was taking longer to arrive.

“I never really cared much about the sky,” Carol admitted. She gestured toward the Milky Way. “But that's quite a sight.”

“It looks close enough to touch,” Fatima replied.

Inside, Carol showed them to their room. “I'll be up for a while yet, so if you need anything, just ask.”

“This is very kind of you,” Salif said.

“It was good of you both to come.” Carol was about to leave, then she turned back to them. “I wrote the WiFi password and left it on the table there, if you need it.”

When she left, Salif sat on the bed and loosened his tie. He picked up the piece of paper with the password and held it out to Fatima. “Go on, you know you want it.”

“You're evil.” But she didn't refuse.

She'd told most of her friends and colleagues about the trip, so she only had half a dozen messages. The last was from the INSU in Paris.

Fatima read it through twice, then sat on the bed beside Salif. “What would you think if I took a new job, in France?”

He scowled. “You mean, we'd have to speak to our colleagues in our second language, not our fourth? And we'd be forced to spend only a quarter of the time traveling whenever we flew home?”

“You do know Paris gets colder than Canberra?”

Salif shrugged. “Is it a job you want?”

Fatima described the project. A team was being assembled to design and operate a new satellite, purpose built to study the retreating rim of the Pane. Every time it crossed a source of X-rays or gamma rays, the occultation would be recorded, gathering information about the nature of the

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phenomenon at the highest available energies.

She said, “Either I stay with exoplanets, and try to improve the techniques so we can keep mapping them from this distance, or I jump ship and spend the last twenty years of my career doing something new.”

Salif pondered that. “The Milky Way isn’t going anywhere. We hope. But the Pane certainly is.”

“That’s what I was thinking,” Fatima replied.

She was done with mourning the old sky, and mourning her old dreams. But she would not accept that this exile was permanent, any more than she’d ever accepted the gulf to the stars as eternally uncrossable.

She said, “If the Slipway was artificial, one day we’ll build our own. But if it was natural, it can’t be all that rare; there must be others to be found. Either way, if we ever want to take the same kind of ride again—by choice, instead of by accident—we’d better learn to understand what’s in front of us before it’s gone.”

Salif smiled at the audacity of her words. “I can’t imagine anything harder.”

Fatima said, “Nor can I. But this is where we are now, and there’s only one way back.”