SEEDMAGAZINE.COM
AUGUST 27, 2016

TWO RIVAL SCIENTIFIC TEAMS ARE LOCKED IN A HIGH-STAKES RACE TO DISCOVER OTHER EARTH-LIKE WORLDS—AND FOREVER CHANGE OUR OWN.

The Long Shot
FEATURE BY **LEE BILLINGS** / MAY 19, 2009

CTIO. Courtesy of Tim Abbott and NOAO/AURA/NSF

From the Chilean seaside town of La Serena, it's a journey of 80 kilometers to the Cerro Tololo Inter-American Observatory (CTIO), through the Elqui River Valley, past huddled clusters of houses and lush fields of papayas, watermelons, and grapes, gradually dissolving into a sere alpine scrubland of cacti, stunted trees, and sun-warmed dust.

"Tololo" means "edge of the abyss" in the language of the Aymara tribe, indigenous to the region. The name presumably refers to the wide valley the peak overlooks from an altitude of more than 2 kilometers, but it could equally apply to the area's pristine night skies. Unspoiled by artificial light, the darkness overhead is a vast, enveloping void. On a moonless night, a careless glance upward can halt conversations mid-sentence as observers become lost in the radiant belt of the Milky Way, their shadows cast upon the ground by countless stars shining white, red, blue, and yellow.

A gauntlet of hairpin turns guards the last stretch of road up to CTIO, adding to the aura of hermetic isolation. Astronomers work here, not holy monks communing with God, but the scientists still seek something sacred: knowledge of humanity's place within creation. They just address such questions more empirically. I arrived in January, summertime in the southern hemisphere, and the housings of large telescopes shimmered in the heat like the domes of mosques. Bailahuen, a native shrub, sweetened the thin air with scents of lemongrass and balsam. The mountain seemed suited for pilgrimages.

I'd come to meet Debra Fischer, a professor at San Francisco State University. As a co-discoverer of more than 150 planets, nearly half the known total outside our solar system, she is a prominent figure in astronomy. Her work on this lonely mountaintop could propel her past that, though, into realms of myth and legend. Fischer is using a modest, neglected telescope at CTIO to search for Earth-like planets in Alpha Centauri, the nearest star system to our own. If they exist, she should find them in three to five years.

The implications would be timeless, echoing ancient questions of life's purpose, outlining futures distant yet possible. Against the certainty of another Earth circling one of the closest stars in the sky, the entirety of recorded history would abruptly seem the briefest prelude to an eternal denouement, a fire kindled to be passed on without end. Alpha Centauri could become a beacon illuminating and bringing significance to the accumulated toils of generations. Driven by the spectral hope of another living world unexplored, our own could profoundly change. Or Fischer's project could simply fail. Many astronomers assume it will.

We were scheduled for lunch in CTIO's cafeteria, but "lunch" meant "breakfast" there, as most of the mountain's tenants slept in after spending their nights at telescopes. Over their meals, they discussed their hopes for the next generation of world-class observatories, and the globe-gripping economic turmoil that cast all such plans into question. Giant cathedrals of glass and steel could soon sprout on the nearby peaks to wring deeper secrets from starlight, but only if the powers that be find the money and the drive to build them.

Fischer arrived late, yawning, in khaki capri pants and a t-shirt that said "Songs For Moms" (her daughter's band, she explained—Fischer is married, with three children). She's slim, with wispy shoulder-length blond hair and the gentle lines that accrue around eyes and mouth from years of smiles. Bernie Walp, an affable, bespectacled telescope technician from California's Mount Wilson Observatory who was helping set up Fischer's observations, accompanied her. Both are 55 years old.

After a quick meal, Fischer suggested the three of us go for a hike to discuss the project. She led us to what appeared to be a sheer drop-off that only revealed itself at its edge as a steep 60-degree escarpment, littered with piles of boulders between slurries of shattered rock. "You're here for a story, but I don't know what's going to happen," she casually mentioned as she clambered down the treacherous hillside. "We've been trying to fly under the radar with this project." There was no reason to make a possible failure highly visible, she said. "But it's gathered so much momentum now, people are starting to notice."

We spread out along the slope as we talked, scrambling between handholds and precariously balanced rubble. Fischer's foot dislodged a fist-sized breccia that fell clattering past me, and suddenly the ground beneath our feet shuddered to life, casting off growing cascades of rocks. A boulder as big as an oven tumbled with a low rumble of shifting stone down toward the distant valley floor until lost from view. We turned back.

As we retraced our steps up toward the observatory, I pressed Fischer on the feasibility of her scheme. She hesitated. "You know, this is a unique opportunity. I don't really take risks. I only do things when I think I've got a reasonable chance of success. It's like God is screaming at us to look at this system; Alpha Centauri is calling to us."

ALPHA CENTAURI IS TODAY what the Moon and Mars were to prior generations—something almost insurmountably far away, but still close enough to beckon the aspirational few who seek to dramatically extend the frontiers of human knowledge and achievement. For centuries, it has been a canonical target of the scientific quest to learn whether life and intelligence exist elsewhere. The history of that search is littered with cautionary tales of dreamers whose optimism blinded them to the humbling, frightful notion of a universe inscrutable, abandoned, and silent.

The 18th century astronomer William Herschel, like many of his contemporaries and forebears, believed life flourished throughout the solar system, even on the Sun and Moon. In the 1800s, respected scientists such as Percival Lowell and Camille Flammarion thought they saw canals on Mars, signs of an advanced civilization, but these were figments of their imagination. And in the 20th century the Dutch-American astronomer Peter van de Kamp spent decades of his life pursuing planets he was convinced orbited Barnard's Star, our next-nearest neighbor after Alpha Centauri. Van de Kamp's "planets" turned out to be aberrations in his instruments—and though his intuition that planets were common has since proved correct, he didn't live to experience vindication. Van de Kamp died in 1995, only months before the first confirmation of planets around other Sun-like stars.

Viewing Alpha Centauri is easy if you live in the southern hemisphere—it's the third-brightest star in the entire sky, a gleaming golden nail hammered into the foot of the constellation Centaurus, a few degrees away from the Southern Cross and the Coalsack Nebula. That point of light is actually two stars, Alpha Centauri A and B, both so close together they can only be individually resolved through telescopes. Each resembles our Sun; A is slightly larger and pale yellow, while B is slightly smaller and dusky orange. They're 4.39 light years from Earth, orbiting each other in a roughly 80-year period, with an average separation slightly greater than the distance between our Sun and Uranus. A third, much smaller red dwarf star, Proxima Centauri, drifts in the system's outskirts.

Alpha Centauri. Courtesy of ESO.

Fischer's observation program relies on a fact of Newtonian mechanics: Just as a star exerts a gravitational pull on its planets, the planets pull on the star, making it wobble in sync with the planets' orbits. These wobbles, or shifts in radial velocity (RV), are imperceptible to the eye, but can be detected by breaking up the star's light into a spectrum. In their revolutions, a star's planets play it like an instrument, producing a symphony of regularly shifting light we can see from Earth: As a planet pulls the star away from us, the light grows redder; as it pulls the star closer, the light grows bluer. By measuring the intervals and strengths of these shifts in the starlight's wavelength, astronomers can discern a planet's orbit and estimate its mass.

RV shifts are how the vast majority of extrasolar worlds have been discovered, but only because these planets, called "hot Jupiters," are extremely massive and in hellishly close orbits around their stars. Their stellar wobbles are measurable in meters per second; seeing the much smaller centimeters-per-second wobble of an Earth twin is orders of magnitude more difficult. For the Alpha Centauri system, the feat is akin to detecting a bacterium orbiting a meter from a sand grain—from a distance of 10 kilometers. But by devoting hundreds of nights of telescope time to collecting hundreds of thousands of individual observations of just these two stars, Fischer believes she can eventually distill the faint RV signal of any Earth-like planets. It's simply a matter of statistics and brute force. The planets wouldn't reveal themselves as images in a telescope, but as steadily strengthening probabilistic peaks.

Despite her assurance that she doesn't take risks, the hazards in Fischer's project are considerable—some would say extreme. The RV precision and stability required to detect a planet like Earth is entirely unprecedented, perhaps impossible. If not undone by technical difficulties at the end, like Peter van de Kamp and so many other dreamers, Fischer may be thwarted by nature's apparent indifference to wishful thinking: There may be no planets around Alpha Centauri at all.

The person who convinced her to devote years to a search for Alpha Centauri's planets was her frequent collaborator Greg Laughlin, a 41-year-old multitalented theoretical astrophysicist at the University of California, Santa Cruz. In his spare time, Laughlin crafts software tools and observation programs for a global network of amateur planet-hunters, runs Monte Carlo simulations of the financial markets, and maintains a blog devoted to extrasolar planetology. Speaking to me from the air-conditioned comfort of his university office, he said the genesis of the project came on a quiet night in early July 2006.

"I was sitting at my kitchen table when I began thinking about the possibility of detecting any habitable planets around Alpha Centauri, doing some back-of-the-envelope calculations. B in particular looked promising, because it has lower mass and it's a very calm, quiet star," Laughlin said. "I couldn't shoot it down—finding planets [in Alpha Centauri] with a low-budget project seemed alarmingly feasible."

Alpha Centauri's brightness and visibility in southern skies for 10 months each year means an observation program can proceed relatively quickly with few disruptions. Further, the two stars offer a natural calibration: An identical signal in both of them would likely indicate a flaw in the observational equipment.

Discoveries of massive, close-in planets with the RV technique come quickly—just a handful of strong periodic signals are needed. So most RV surveys, hoping to rapidly harvest the low-hanging planetary fruit, have spread themselves thinly over a large number of stars. Laughlin realized that by focusing observations on a single promising star, the signatures of smaller planets should gradually emerge. “Your signal, the mass of a planet in a given orbit, scales with the square root of the number of observations,” he said. “With four times as many observations, in theory you can detect planets that are half as massive. If you’re willing to average over not hundreds, but hundreds of thousands of measurements, you can probably detect planets with masses equal to or less than that of Mars”—that is, a tenth the mass of Earth.

The more Laughlin thought about it, the more foreordained Alpha Centauri appeared for such an extreme search strategy. It began to seem somehow destined. On human timescales, the stars appear fixed in the sky, but as our Sun moves through its 250-million-year orbit around the galactic center, it brings us to new neighbors. Every few hundred thousand years, the list of our nearest neighboring stars must be made anew.

“If we were plopped down at some random point in the galaxy, there’s only a 1 percent chance we’d find ourselves near stars so optimal for detecting small rocky planets like our own,” Laughlin said. “The hand of fate has dealt us a very interesting situation that has not existed for at least 99.9 percent of Earth’s history. It’s remarkable that Alpha Centauri is right next door just as humans emerge and develop the ability to make these measurements. I’m enamored with that coincidence.”

Within a month of his late-night reverie, Laughlin had written several blog posts exploring the idea. Soon he began running computer simulations with his student, Javiera Guedes, to determine whether planets were likely to form in stable, habitable orbits in the Alpha Centauri system. Everything checked out: In the models, planets readily formed in the not-too-hot, not-too-cold regions around both A and B, where life-giving liquid water could exist. Laughlin broached the idea of an observational program to Fischer, who quickly jumped on board, bringing Howard Isaacson, her student, with her.

WALP CAME WITH FISCHER, TOO. Back at the observatory after our hike, Fischer returned to her room for a few moments, and Walp told me how he became involved with the project. The story resembles a random walk, with Walp borne toward CTIO by trajectories of coincidence. He dropped out of college to work in political consulting, but a midlife crisis sent him back to school to get a mathematics degree. Walp met Fischer in 1997, while working as a clerk in San Francisco State’s astronomy department.

“One night we were talking and I told her I wanted to do more science stuff,” Walp recalled. “I’ll go to my grave remembering her response: ‘Oh, well, let’s fix your job! Pack a bag, tomorrow night we’re going to Lick Observatory!’ I fell in love with the mountain, the telescopes, and the people—ended up applying for a job and working there.… Debra had not only fixed my job, she’d fixed my life.”

For Walp, astrophysics is a communal embrace, not like the solitary work of mathematics or the faceless, overlarge collaborations of particle physics. “In astrophysics, even if you’re just a student, you’re encouraged to find new ways of doing things,” he said. “Build a piece of equipment, drive it to the observatory, bolt it on the telescope, get some data, write it up. I find that very attractive. In politics it was all turf, a zero-sum game. You just don’t have that in this environment. Everyone helps each other.”

He paused, eyes sparkling and fixed on something distant. When he spoke again his voice was soft, quiet. “My wife died kind of tragically last year.… I decided it was time for a change, and left Lick to go to Mount Wilson to be closer to my family. Debra needed help setting this up and invited me. I graciously accepted.”

Debra Fischer. Courtesy of Debra Fischer.

Walp is just one of a small army of friends and colleagues Fischer relied on to get the venture off the ground. It needed dedicated equipment—a telescope, a spectrometer, and a photon detector—all either custom-built or leased from existing facilities. It needed improvements to Fischer’s planet-hunting software, the computer code that extracts RV signals from massive influxes of data. Most of all, it needed funding. Fischer began methodically obtaining each piece of the puzzle, sometimes calling in old favors. In late 2007, along with Laughlin and another astronomer, Paul Butler, she applied for an NSF grant and received nearly $100,000 for a one-year “design study.” This was enough to pay for telescope time on a 1.5-meter telescope at CTIO that was on the verge of being mothballed. Andrei Tokovinin, an astronomer at the observatory, offered to refurbish a decommissioned spectrometer for Fischer and provided an old, outdated detector. The cutting-edge observations would take place on vintage equipment from the 1960s and ’70s.

“Andrei’s been a lifesaver,” Fischer said as we approached the 1.5-meter telescope’s white dome housing. “We don’t really have money for anything other than telescope time. We can’t afford a salary for me or stipends for my students. It’s like being in a sinking ship, throwing everything else overboard just to keep moving forward.” When the NSF funds run out in November, Fischer plans to ask for only one more year’s worth of money for what may be a project spanning several years; such a modest request may be more difficult to turn down. She’ll be relying on any promising, early signals in her data, hoping they strengthen from one year to the next to provide further incentive for financial support.

THE DOME'S INTERIOR was cavernous, cool, and dark, reverberant with hushed echoes. Walp turned on the lights in the control room, revealing the 1.5-meter as a hulking cylinder in an equatorial mount with a multi-ton, cast-iron counterweight, hovering in the center of the room above the corrugated metal floor. Fischer, laughing, said it's the smallest telescope she's worked with, and walked me through the tortuous path photons follow through the experiment.

Imagine a hundred photons leaving Alpha Centauri almost four and a half years before my January visit to CTIO. Back then, George W. Bush was winding down his first presidential term, the Summer Olympics were underway in Athens, the stock market was soaring, and the Cassini-Huygens mission had just arrived at Saturn. After years of continuous interstellar travel, that light entered the dome at CTIO. It bounced off the large primary mirror, back toward the sky, only to be reflected by a secondary mirror into a Cassegrain focus, a small hole in the primary mirror's center. For every 100 photons from Alpha Centauri that hit the primary mirror, 20 were lost en route to the focus. From the focus, the light entered a long, winding fiber-optic cable, stabilized by duct-tape, running into the spectrometer in the basement below. Another 20 out of 100 photons dropped out in the fiber. The light passed from the fiber through an iodine cell used for calibration, into the cryogenically cooled spectrometer, where a labyrinth of prisms, mirrors, and gratings scattered, split, and chopped the light into its constituent wavelengths. Of the 100 photons we've followed from Alpha Centauri, only one managed to navigate the obstacle course of the telescope, the fiber, and the spectrometer to strike the detector, where it was logged into Fischer's data.

From there, the rest of the work takes place on computers. For each one of the hundreds of thousands of observations, Fischer's custom-coded software must model and counteract the various transient distortions caused by the instruments, fluctuating weather and temperature, cosmic rays striking the detector, even the Earth's motion through space. The software compares the observed spectra of Alpha Centauri A and B to a spectrum from the calibrating iodine cell, then to a high-resolution spectrum of both stars taken through a larger telescope with a newer spectrometer. This comparison provides the wavelength shift, which is calculated and plotted for each observation. With enough time and sufficient numbers of observations, any planets around either star should manifest as tiny periodic shifts in the light's wavelength.

Fischer wrote the code that makes the data analysis possible, but she still expressed amazement that the technique actually works. "Take our Sun. It's a quiet star, but look at it in ultraviolet, and you'll see all these flares boiling, wild coronal loops that break and spray out particles, plasma flowing across its surface at kilometers per second," she said. "We can measure the Sun's dynamical motion to a thousandth of that because, by some miracle, these surface motions average out over the disk. But at what point this stops, we don't know. The sensitivity floor for this technique is unknown."

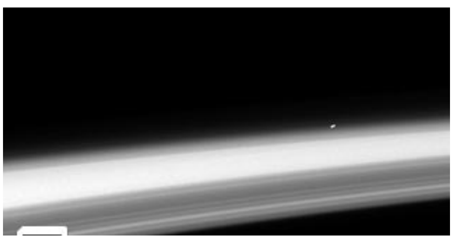
The afternoon was gone, eaten by the hike and discussing the experiment. Fischer decided to take a break. We emerged from the dome into a still evening awash in molten, honeyed light. Long purple shadows twisted like veins through the craggy valley below, and the russet pinpricks of sodium lamps from a small mining town sparkled in the distance. Beside a few battered pickup trucks in the asphalt parking lot, Christian Nitschelm, a jovial, frizzy-haired Franco-Chilean astronomer, was watching the Sun. He was waiting for the "green flash," the brief instant immediately before the Sun wholly disappears beneath the horizon, when its rays pass through so much atmosphere that they refract to a vivid emerald hue.

Nitschelm held an index card several centimeters in front of the eyepiece of a small hobby telescope, catching the Sun as a featureless, diminishing disk, judging when it would be safe to view directly. He chatted idly as he waited. "The Sun is quiet now. No one knows why. It should've already started its next cycle; sunspots should have appeared months ago. But I see none." After a moment he motioned me to the eyepiece—it was time. A green tint appeared around the upper edge of the Sun's wavering face, traveling inward until the entire final glimpse was the color of chlorophyll. Then we were in twilight.

LIKE PEOPLE, STARS ARE statistically predictable, but as individuals they often flout forecasts. The Sun's 11-year cycle of activity is inexplicably late this time around—we still have much to learn about our very own host star. Similar cycles with periods of months or years on Alpha Centauri A or B could scuttle Fischer's hopes for finding planets around either star. This possibility is what most worries Geoff Marcy, Fischer's mentor and a professor at the University of California, Berkeley. As one of the founders of RV planet discovery, Marcy is a de facto leader of the American planet-hunting effort.

"We have global circulation patterns on Earth," Marcy told me via telephone. "Trade winds, tropical winds, and so on. Similarly, our Sun and other stars have their own circulation patterns. These cyclic motions of a star's surface could easily masquerade as the motions caused by an Earth-like planet. Debra is one of the very rare astronomers capable of marshalling all the necessary resources for this project—telescope time, funding, and collaborators. But she can still be fooled. We could all be fooled!"

Or, Marcy fretted, a competing team of researchers could find Alpha Centauri's planets first.



Looking nearly due north through binoculars on a clear day at CTIO, you just may catch the glint from one of the telescopes at the European Southern Observatory's facilities on the peak of La Silla, another mountain some 60 kilometers away. Here, a Swiss team led by Michel Mayor and his protégé Stéphane Udry operates the High Accuracy Radial velocity Planet Searcher (HARPS). Thanks to the high precision of its spectroscopic equipment, running on a telescope more than twice the size of Fischer's, HARPS is the world's premier RV experiment. Since 2003, Mayor and his team have used HARPS to search for planets around Alpha Centauri B. Last August, they began observing the star every available night in a strategy similar to Fischer's.

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Alpha Centauri over the horizon of Saturn. Courtesy of NASA/JPL/Space Science Institute.

Mayor's team can't devote the same amount of time to Alpha Centauri as Fischer; HARPS is simply too valuable to the astronomical community to be committed to a single star system. But even if they could, they don't want to. In a recent survey, the team showed that one-third of about 200 nearby Sun-like stars harbor rocky, terrestrial worlds several times more massive than Earth in short-period orbits. They're called "super-Earths."

"These objects aren't exactly like our Earth, but they may very well be habitable," Mayor said. "We're discovering them everywhere we look. So what lies below? What is the frequency of planets twice the size of Earth, or truly Earth-size? [Fischer's team] is focusing solely on one star system. Personally, I prefer to explore a larger sample."

Like several other rival teams, the Swiss are playing a numbers game, hoping that surveying a larger number of stars with a smaller number of observations from their superior instrument will net the first clearly habitable world outside our solar system. They're simply hedging their bets by observing Alpha Centauri B. If a super-Earth with three-to-five Earth-masses is there, the Swiss will probably detect it before Fischer.

"The borderline between where they'll get it and where we will would be a planet about 2.5 Earth-masses in the habitable zone," Laughlin said. "But even with hundreds of observations on HARPS, they won't be able to probe to Earth-mass planets in B's habitable zone like Debra will."

There are already firm constraints on what resides in Alpha Centauri. Previous searches have ruled out anything larger than Jupiter in close orbits around either star, and dynamical simulations clearly show that, for both stars, orbits beyond two to three astronomical units (one astronomical unit is the distance between the Earth and the Sun) are unstable. Past that boundary, the perturbative effect of the second star either ejects planets from the system or makes them fall inward, where they are engulfed and destroyed by their host star. The same perturbations could also have proved disastrous for the formation of planets, leaving nothing orbiting either star but sand.

This is the bleakest scenario for both Fischer's team and the Swiss, and precisely what Philippe Thébault, a young theoretician at the Paris Observatory, seems to have proved in a pair of papers he co-authored in 2007 and 2008. Using rigorous numerical simulations of the "standard model" of planet formation, he showed that planets could not form around Alpha Centauri A or B, refuting the work of Laughlin, Guedes, and several other researchers.

When we discussed his work, Thébault spoke impeccable English with a slight French accent, yet still apologized profusely for his "meager" grasp of the language. He was also contrite about his Alpha Centauri results.

"If you ask a doctor about a fatal diagnosis he makes for a cancer patient, of course he wishes he is wrong. It is the same for me. It appears to be very difficult to form planets around close binary stars. I don't wish for such a universe—I wish for another universe where planet formation is always very easy. I hope that Greg is right and that I'm wrong."

No one yet knows for certain precisely how planets form, but the process seems to be a complex chain reaction that is highly dependent upon initial conditions. It begins with the creation of a star, which forms from a gravitationally collapsing cloud of gas and dust. The leftovers flatten out, due to the conservation of angular momentum, forming a spinning disk of material. To create a rocky world like Earth, dust must condense in the disk to form grains, grains must settle to form pebbles and rocks, and rocks must collide to form planetesimals, kilometer-sized objects that can gravitationally attract each other. These planetesimals must collide to form embryos, Moon-sized objects that collide in turn to finally form a planet.

Laughlin and Guedes only accounted for this last stage in their simulation—investigating previous steps was too computationally intensive. Thébault, in contrast, used several simplifying assumptions to probe a step deeper, to the planetesimal-to-embryo stage within a stellar binary system. Embryo formation requires planetesimals colliding gently, so that they aren't shattered. Thébault's results showed that, in the Alpha Centauri system, the influence of one star would stir up the other star's disk of debris, increasing the relative velocities of planetesimals to such high speeds that they couldn't stick together to form embryos. The causal chain was broken; planet formation seemed impossible.

Fischer and Laughlin were so impressed with Thébault's work, they offered him a co-investigator position on their project, to help interpret any emerging signals. And though Thébault accepted, they still are skeptical of his conclusions.

"I take no issue with Philippe's calculations," Laughlin said. "If you start with his initial conditions, you'll end with no planets. I just believe the initial conditions were quite different than what he uses." Laughlin reeled off several possible ways planets could still emerge in Alpha Centauri, stretching back to the early history of the system, when the stars' orbital separations could have been greater, when their debris disks could have looked very different than the one that formed our own solar system. The list of planet-friendly possibilities is impressively long, but so filled with uncertainty that believing them remains largely a matter of faith.

Fischer preferred to assault Thébault's claims with an inconvenient truth. "Here's my problem with those papers: HD196885 is another binary star system, one almost exactly like Alpha Centauri, and we know it has a gas giant planet, orbiting at 3.5 astronomical units. I asked Philippe, 'Can you explain this with your models?' He said, 'I can't…. It shouldn't be there.'"

ONE CAN WHIMSICALLY SHOW that essentially any occurrence, any circumstance, is a virtual impossibility. Simply trace its origins back through time until the accumulated serendipities within that chain of chance overwhelm logic and reason. This game applies to everything, from the formation of the Earth and life upon it, to your birth or your first love. All that occurs and exists is but the thinnest sliver of light, bookended by the infinite, muted depths of what will never be. Call it luck, call it destiny, but this intangible something seems the only arbiter between being and nothingness.

Thus, the Alpha Centauri project should not exist—numerous unlikely midwives have coaxed it into being. It should not succeed, since it relies on scarce funding for outdated equipment to provide unprecedentedly precise observations of uncertain stellar behavior, seeking planets that by standard estimations should not be there. But of course, the project does exist, and it may somehow succeed. It's a long shot, cast outward into a distant, hazy region where our understanding dwindles, where probabilities coalesce to create reality.

For Laughlin, the potential rewards outweigh the risks; betting on planets in Alpha Centauri is a gamble he can't help but make. "From a strictly monetary point of view, I think the discovery of habitable planets around Alpha Centauri would be worth a billion dollars, and ultimately perhaps far more," he speculated. "Whereas Debra's project, the price tag is running in the hundreds of thousands, maybe a million. Given a strict probabilistic analysis, that means if there is a one-in-a-thousand chance there's something there, it's worthwhile to spend a million dollars because of that expectation of coming out ahead, and I think the odds are much better than that. The payoff could be enormous."

The discovery of habitable worlds around any star would be front-page news, but finding them around our next-door neighbors would catalyze a scientific and cultural revolution, an immense rising wave of effort to learn whether our sister stars' habitable planets were in fact inhabited. The ripples would spread beyond science to touch and change our literature and art, our politics and religion, perhaps even aiding our struggles to unite, survive, and expand as a species. The chain of chance that brought us into existence would swing to point outward to the stars, strengthening our resolve to someday reach them.

"If planets are found around Alpha Centauri, it's very clear to me what will happen," Marcy said. "NASA will immediately convene a committee of its most thoughtful space propulsion experts, and they'll attempt to ascertain whether they can get a probe there, something scarcely more than a digital camera, at let's say a tenth the speed of light. They'll plan the first-ever mission to the stars."

In fact, planning is already underway. In their scant spare time, Fischer and Laughlin are examining the propulsion requirements and orbital mechanics for a robotic interstellar mission and determining how to reliably transmit any collected information back to Earth. Traveling at 10 percent light-speed, a probe would take more than 40 years to reach Alpha Centauri, and its data wouldn't come back for more than another four. Fischer and Laughlin are both middle-aged. Even if such a mission launched within the next decade, it seems unlikely either would live to see its returns; for them, any planets found there will probably be, at best, flickering dots in an image from a space telescope. Their work is sacrificial, sustained by dreams of future generations escaping Earth's cradle, of a universe made less lonesome and senseless.

DUSK HAD GIVEN WAY to darkness at CTIO, and though the stars blazed above the windswept summit, no one was there to see them except for Fischer and me; Walp and the other astronomers had retreated to their domes and control rooms to watch the skies through telescopes and computer screens. The gravel crunched beneath our feet as we walked to the edge of the abyss, and Fischer gestured to the spot on the sky where, in a few hours, Alpha Centauri would rise above the mountains. "I wonder every time I point it out, whether there's someone there, pointing back at me," she said. It was getting late, and there was much to do. Waving goodbye, Fischer turned and walked back to the telescope to prepare for that night's many hours of observations. My visit was at an end, but her long shot had only just begun.