A Worm in the Well

by Gregory Benford

She was about to get baked, and all because she wouldn't freeze a man.

"Optical," Claire called. Erma obliged.

The Sun spread around them, a bubbling plain. She had notched the air conditioning cooler but it didn't help much.

Geysers burst in gaudy reds and actinic violets from the yellow-white froth. The solar coronal arch was just peeking over the horizon, like a wedding ring stuck halfway into boiling white mud. A monster, over two thousand kilometers long, sleek and slender and angry crimson.

She turned down the cabin lights. Somewhere she had read that people felt cooler in the dark. The temperature in here was normal but she had started sweating.

Tuning the yellows and reds dimmer on the big screen before her made the white-hot storms look more blue. Maybe that would trick her subconscious, too.

Claire swung her mirror to see the solar coronal arch. Its image was refracted around the rim of the Sun, so she was getting a preview. Her orbit was on the descending slope of a long ellipse, its lowest point calculated to be just at the peak of the arch. So far, the overlay orbit trajectory was exactly on target.

Software didn't bother with the heat, of course; gravitation was cool, serene. Heat was for engineers. And she was just a pilot.

In her immersion-work environment, the touch controls gave her an abstract distance from the real physical surroundings—the plumes of virulent gas, the hammer of photons. She wasn't handling the mirror, of course, but it felt that way. A light, feathery brush, at a crisp, bracing room temperature.

The imaging assembly hung on its pivot high above her ship. It was far enough out from their thermal shield to feel the full glare, so it was heating up fast. Pretty soon it would melt, despite its cooling system.

Let it. She wouldn't need it then. She'd be out there in the sunlight herself.

She swiveled the mirror by reaching out and grabbing it, tugging it round. All virtual images had a glossy sheen to them that even Erma, her simcomputer, couldn't erase. They looked too good. The mirror was already pitted, you could see it on the picture of the arch itself, but the sim kept showing the device as pristine.

"Color is a temperature indicator, right?" Claire asked.

RED DENOTES A LEVEL OF 7 MILLION DEGREES KELVIN.

Good ol' coquettish Erma, Claire thought. *Never a direct answer unless you coax.* "Close-up the top of the arch."

In both her eyes the tortured sunscape shot by. The coronal loop was a shimmering, braided family of magnetic flux tubes, as intricately woven as a Victorian doily. Its feet were anchored in the photosphere below held by thick, sluggish plasma. Claire zoomed in on the arch. The hottest reachable place in the entire Solar System, and her prey had to end up there.

TARGET ACQUIRED AND RESOLVED BY SOLWATCH SATELLITE. IT IS AT THE VERY PEAK OF THE ARCH. ALSO, VERY DARK.

"Sure, dummy, it's a hole."

I AM ACCESSING MY ASTROPHYSICAL CONTEXT PROGRAM NOW.

Perfect Erma; primly change the subject. "Show me, with color coding."

Claire peered at the round black splotch. Like a fly caught in a spider web. Well, at least it didn't squirm or have legs. Magnetic strands played and rippled like wheat blown by a summer's breeze. The flux tubes were blue in this coding, and they looked eerie. But they were really just ordinary magnetic fields, the sort she worked with every day. The dark sphere they held was the strangeness here. And the blue strands had snared the black fly in a firm grip.

Good luck, that. Otherwise, Sol-Watch would never have seen it. In deep space there was nothing harder to find than that ebony splotch. Which was why nobody ever had, until now.

OUR ORBIT NOW RISES ABOVE THE DENSE PLASMA LAYER. I CAN IMPROVE RESOLUTION BY GOING TO X-RAY. SHOULD I?

"Do."

The splotch swelled. Claire squinted at the magnetic flux tubes in this ocher light. In the x-ray they looked sharp and spindly. But near the splotch the field lines blurred. Maybe they were tangled there, but more likely it was the splotch, warping the image.

"Coy, aren't we?" She close-upped the x-ray picture. Hard radiation was the best probe of the hottest structures.

The splotch. Light there was crushed, curdled, stirred with a spoon.

A fly caught in a spider's web, then grilled over a campfire. And she had to lean in, singe her hair, snap its picture. All because she wouldn't freeze a man.

She had been ambling along a corridor three hundred meters below Mercury's slag plains, gazing down on the frothy water fountains in the foyer of her apartment complex. Paying no attention to much except the clear scent of the splashing. The water was the very best, fresh from the poles, not the recycled stuff she endured on her flights. She

breathed in the spray. That was when the man collared her.

"Claire Ambrase, I present formal secure-lock."

He stuck his third knuckle into Claire's elbow port and she felt a cold, brittle *thunk.* Her systems froze. Before she could move, whole command linkages went dead in her inboards.

It was like having fingers amputated. Financial fingers.

In her shock she could only stare at him—mousy, the sort who blended into the background. Perfect for the job. A nobody out of nowhere, complete surprise.

He stepped back. "Sorry. Isataku Incorporated ordered me to do it fast."

Claire resisted the impulse to deck him. He looked Lunar, thin and pale. Maybe with more kilos than she carried, but a fair match. And it would feel *good.*

"I can pay them as soon as—"

"They want it now, they said." He shrugged apologetically, his jaw set. He was used to this all the time. She vaguely recognized him, from some bar near the Apex. There weren't more than a thousand people on Mercury, mostly like her, in mining.

"Isataku didn't have to cut off my credit." She rubbed her elbow. Injected programs shouldn't hurt, but they always did. Something to do with the neuro-muscular intersection. "That'll make it hard to even fly the *Silver Metal Lugger* back."

"Oh, they'll give you pass credit for ship's supplies. And, of course, for the ore load advance. But nothing big."

"Nothing big enough to help me dig my way out of my debt hole."

" 'Fraid not."

"Mighty decent."

He let her sarcasm pass. "They want the ship Lunaside."

"Where they'll confiscate it."

She began walking toward her apartment. She had known it was coming but in the rush to get ore consignments lined up for delivery, she had gotten careless. Agents like this Luny usually nailed their prey at home, not in a hallway. She kept a stunner in the apartment, right beside the door, convenient.

Distract him. "I want to file a protest."

"Take it to Isataku." Clipped, efficient, probably had a dozen other slices of bad news to deliver today. Busy man.

"No, with your employer."

"Mine?" That got to him. His rock-steady jaw gaped in surprise.

"For—" she sharply turned the corner to her apartment, using the time to reach for some mumbo-jumbo "—felonious interrogation of in-boards."

"Hey, I didn't touch your—"

"I felt it. Slimy little groups—yeccch!" Might as well ham it up a little, have some fun.

He looked offended. "I'm triple bonded. I'd never do a readout on a contract customer. You can ask—"

"Can it." She hurried toward her apartment portal and popped it by an inboard command. As she stepped through she felt him, three steps behind.

Here goes. One foot over the lip, turn to her right, snatch the stunner out of its grip mount, turn and aim—and she couldn't fire.

"Damn!" she spat out.

He blinked and backed off, hands up, palms out, as if to block the shot. "What? You'd do a knockover for a crummy ore-hauler?"

"It's *my* ship. Not Isataku's."

"Lady, I got no angle here. You knock me, you get maybe a day before the heavies come after you."

"Not if I freeze you."

His mouth opened and started to form the *f* of a disbelieving *freeze?*—then he got angry. "Stiff me till you shipped out? I'd sue you to your eyeballs and have 'em for hock."

"Yeah; yeah," Claire said wearily This guy was all clichés. "But I'd be orbiting Luna by the time you got out, and with the right deal—"

"You'd maybe clear enough on the ore to pay me damages."

"And square with Isataku." She clipped the stunner back to the wall wearily.

"You'd never get that much."

"OK, it was a long shot idea."

"Lady, I was just delivering, right? Peaceable and friendly, right? And you pull—"

"Get out." She hated it when men went from afraid to angry to insulted, all in less than a split minute.

He got. She sighed and zipped the portal closed.

Time for a drink, for sure. Because what really bothered her was not the Isataku foreclosure, but her own gutlessness.

She couldn't bring herself to gong that guy, put him away for ten mega-seconds or so. That would freeze him out of his ongoing life, slice into relationships, cut away days that could never be replaced.

Hers was an abstract sort of inhibition, but earned. Her uncle had been ponged for over a year and never did get his life back together. Claire had seen the wreckage up close, as a little girl.

Self-revelation was usually bad news. What a great time to discover that she had more principles than she needed.

And how was she going to get out from under Isataku?

The arch loomed over the Sun's horizon now, a shimmering curve of blue-white, two thousand kilometers tall.

Beautiful, seen in the shimmering x-ray—snaky strands purling, twinkling with scarlet hotspots. Utterly lovely, utterly deadly. No place for an ore hauler to be.

"Time to get a divorce," Claire said.

YOU ARE SURPRISINGLY ACCURATE. SEPARATION FROM THE SLAG SHIELD IS 338 SECONDS AWAY.

"Don't patronize me, Erma."

I AM USING MY PERSONALITY SIMULATION PROGRAMS AS EXPERTLY AS MY COMPUTATION SPACE ALLOWS.

"Don't waste your running time; it's not convincing. Pay attention to the survey, *then* the separation."

THE ALL-SPECTRUM SURVEY IS COMPLETELY AUTOMATIC, AS DESIGNED BY SOLWATCH.

"Double-check it."

I SHALL NO DOUBT BENEFIT FROM THIS ADVICE.

Deadpan sarcasm, she supposed. Erma's tinkling voice was inside her mind, impossible to shut out. Erma herself was an interactive intelligence, partly inboard and partly shipwired. Running the *Silver Metal Lugger* would be impossible without her and the bots.

Skimming over the Sun's seethe might be impossible even with them, too, Claire thought, watching burnt oranges and scalded yellows flower ahead.

She turned the ship to keep it dead center in the shield's shadow. That jagged mound

of slag was starting to spin. Fused knobs came marching over the nearby horizon of it.

"Where'd that spin come from?" She had started their parabolic plunge sunward with absolutely zero angular momentum in the shield.

TIDAL TORQUES ACTING ON THE ASYMMETRIC BODY OF THE SHIELD.

"I hadn't thought of that."

The idea was to keep the heated side of the slag shield Sunward. Now that heat was coming around to radiate at her. The knobby crust she had stuck together from waste in Mercury orbit now smoldered in the infrared. The shield's far side was melting.

"Can that warm us up much?"

A SMALL PERTURBATION. WE WILL BE SAFELY GONE BEFORE IT MATTERS.

"How're the cameras?" She watched a bot tightening a mount on one of the exterior imaging arrays. She had talked the SolWatch Institute out of those instruments, part of her commission. If a bot broke one, it came straight out of profits.

ALL ARE CALIBRATED AND ZONED. WE SHALL HAVE ONLY 33.8 SECONDS OF VIEWING TIME OVER THE TARGET. CROSSING THE ENTIRE LOOP WILL TAKE 4.7 SECONDS.

"Hope the scientists like what they'll see."

I CALCULATE THAT THE PROBABILITY OF SUCCESS, TIMES THE EXPECTED PROFIT, EXCEEDS SIXTY-TWO MILLION DOLLARS.

"I negotiated a seventy-five million commission for this run." So Erma thought her chances of nailing the worm were—

EIGHTY-THREE PERCENT CHANCE OF SUCCESSFUL RESOLUTION IN ALL IMPORTANT FREQUENCY BANDS.

She should give up calculating in her head; Erma was always faster. "Just be ready to shed the shield. Then I pour on the positrons. Up and out. It's getting warm in here."

I DETECT NO CHANGE IN YOUR AMBIENT 22.3 CENTIGRADE.

Claire watched a blister the size of Europe rise among wispy plumes of white-hot incandescence. Constant boiling fury. "So maybe my imagination's working too hard. Just let's grab the data and run, OK?"

The scientific officer of SolWatch had been suspicious, though he did hide it fairly well.

She couldn't read the expression on his long face, all planes and trimmed bone, skin stretched tight as a drumhead. That had been the style among the asteroid pioneers half a

century back. Tubular body suited to narrow corridors, double-jointed in several interesting places, big hands. He had a certain beanpole grace as he wrapped legs around a stool and regarded her, head cocked, smiling enough not to be rude. Exactly enough, no more.

"*You* will do the preliminary survey?"

"For a price."

A disdainful sniff. "No doubt. We have a specially designed vessel nearly ready for departure from Lunar orbit. I'm afraid—"

"I can do it *now*."

"You no doubt know that we are behind schedule in our reconnaissance—"

"Everybody on Mercury knows. You lost the first probe."

The beanpole threaded his thick, long fingers, taking great interest in how they fit together. Maybe he was uncomfortable dealing with a woman, she thought. Maybe he didn't even like women.

Still, she found his stringy look oddly unsettling, a blend of delicacy with a masculine, muscular effect. Since he was studying his fingers, she might as well look, too. Idly she speculated on whether the long proportions applied to all his extremities. Old wives' tale. It might be interesting to find out. But, yes, business first.

"The autopilot approached it too close, apparently," he conceded. "There is something unexpected about its refractive properties, making navigation difficult. We are unsure precisely what the difficulty was."

He was vexed by the failure and' trying not to show it, she guessed. People got that way when they had to dance on strings pulled all the way from Earthside. You got to like the salary more than you liked yourself.

"I have plenty of bulk," she said mildly. "I can shelter the diagnostic instruments, keep them cool."

"I doubt your ore carrier has the right specifications."

"How tricky can it be? I swoop in, your gear runs its survey snaps, I boost out."

He sniffed. "Your craft is not rated for Sun skimming. Only research craft have ever—"

"I'm coated with Fresnel." A pricey plating that bounced photons of all races, creeds, and colors.

"That's not enough."

"I'll use a slag shield. More, I've got plenty of muscle. Flying with empty holds, I can

get away pronto."

"Ours was very carefully designed&mdas;"

"Right, and you lost it."

He studied his fingers again. Strong; wiry, yet thick. Maybe he was in love with them. She allowed herself to fill the silence by imagining some interesting things he could do with them. She had learned that with many negotiations, silence did most of the work. "We... *are* behind in our mandated exploration."

Ah, a concession. "They always have to hand-tune evaything, Lunaside."

He nodded vigorously. "I've waited *months.* And the worm could fall back into the Sun any moment! I keep telling them—"

She had triggered his complaint circuit, somehow. He went on for a full minute about the bullheaded know-nothings who did nothing but screen-work, no real hands-on experience. She was sympathetic, and enjoyed watching his own hands clench, muscles standing out on the backs of them. *Business first,* she had to remind herself.

"You think it might just, well, go away?"

"The worm?" He blinked, coming out of his litany of grievances. "It's a wonder we ever found it. It could fall back into the Sun at any moment."

"Then speed is everything. You, uh, have control of your local budget?"

"Well, yes." He smiled.

"I'm talking about petty cash here, really. A hundred mil."

A quick, deep frown. "That's not petty."

"OK, say seventy-five. But cash, right?"

The great magnetic arch towered above the long, slow curve of the Sun. A bowlegged giant, minus the trunk.

Claire had shaped their orbit to bring them swooping in a few klicks above the uppermost wand of it. Red flowered within the arch: hydrogen plasma, heated by the currents which made the magnetic fields. A pressure cooker thousands of klicks long.

It had stood here for months and might last years. Or blow open in the next minutes. Predicting when arches would belch out solar flares was big scientific business, the most closely watched weather report in the Solar System. A flare could crisp suited workers in the asteroid belt. SolWatch watched them all. That's how they found the worm.

The flux tubes swelled. "Got an image yet?"

I SHOULD HAVE, BUT THERE IS EXCESS LIGHT FROM THE SITE.

"Big surprise. There's nothing *but* excess here."

THE SATELLITE SURVEY REPORTED THAT THE TARGET IS SEVERAL HUNDRED METERS IN SIZE. YET I CANNOT FIND IT.

"Damn!" Claire studied the flux tubes, following some from the peak of the arch, winding down to the thickening at its feet, anchored in the Sun's seethe. Had the worm fallen back in? It could slide down those magnetic strands, thunk into the thick, cooler plasma sea. Then it would fall all the way to the core of the star, eating as it went. That was the *real* reason Lunaside was hustling to "study" the worm. Fear.

"Where is it?"

STILL NO TARGET. THE REGION AT THE TOP OF THE ARCH IS EMITTING TOO MUCH LIGHT. NO THEORY ACCOUNTS FOR THIS—

"Chop the theory!"

TIME TO MISSION ONSET: 12.6 SECONDS.

The arch rushed at them, swelling. She saw delicate filaments winking on and off as currents traced their find equilibria, always seeking to balance the hot plasma within against the magnetic walls. Squeeze the magnet fist, the plasma answers with a dazzling glow. Squeeze, glow. Squeeze, glow. That nature could make such an intricate marvel and send it arcing above the Sun's savagery was a miracle, but one she was not in the mood to appreciate right now.

Sweat trickled around her eyes, dripped off. her chin. *No* trick of lowering the lighting was going to make her forget the heat now. She made herself breathe in and out.

Their slag shield caught the worst of the blaze. At the lowest altitude in the parabolic orbit, though, the Sun's huge horizon rimmed white-hot in all directions.

OUR INTERNAL TEMPERATURE IS RISING.

"No joke. Find that worm!"

THE EXCESS LIGHT PERSISTS—NO, WAIT. IT IS GONE. NOW I CAN SEE THE TARGET.

Claire slapped the arm of her couch and let out a whoop. On the wall screen loomed the very peak of the arch. They were gliding toward it, skating over the very upper edge—and there it was.

A dark ball. Or a worm at the bottom of a gravity well. Not like a fly, no. It settled in among the strands like a black egg nestled in blue-white straw. The ebony Easter egg that would save her ass and her ship from Isataku.

SURVEY BEGUN. FULL SPECTRUM RESPONSE.

"Bravo."

YOUR WORD EXPRESSES ELATION BUT YOUR VOICE DOES NOT.

"I'm jumpy. And the fee for this is going to help, sure, but I still won't get to keep this ship. Or you."

DO NOT DESPAIR. I CAN LEARN TO WORK WITH ANOTHER CAPTAIN.

"Great interpersonal skills there, Erma old girl. Actually, it wasn't you I was worried about."

I SURMISED AS MUCH.

"Without this ship, I'll have to get some groundhog job."

Erma had no ready reply to that. Instead, she changed the subject.

THE WORM IMAGE APPEARS TO BE SHRINKING.

"Huh?" As they wheeled above the arch, the image dwindled. It rippled at its edges, light crushed and crinkled. Claire saw rainbows dancing around the black center.

"What's it doing?" She had the sudden feat that the thing was falling away from them, plunging into the Sun.

I DETECT NO RELATIVE MOTION. THE IMAGE ITSELF IS CONTRACTING AS WE MOVE NEARER TO IT.

"Impossible. Things look bigger when you get close."

NOT THIS OBJECT.

"Is the wormhole shrinking?"

MARK!—SURVEY RUN HALF COMPLETE.

She was sweating and it wasn't from the heat. "What's going on?"

I HAVEN'T ACCESSED RESERVE THEORY SECTION.

"How comforting. I always feel better after a nice cool theory."

The wormhole seemed to shrink, and the light arch dwindled behind them now. The curious brilliant rainbows rimmed the dark mote. Soon she lost the image among the intertwining, restless strands. Claire fidgeted.

MARK!—SURVEY RUN COMPLETE.

"Great. Our bots deployed?"

OF COURSE. THERE REMAIN 189 SECONDS UNTIL SEPARATION FROM OUR SHIELD. SHALL I BEGIN SEQUENCE?

"Did we get all the pictures they wanted?"

THE ENTIRE SPECTRUM. PROBABLE YIELD, 75 MILLION.

Claire let out another whoop. "At least it'll pay a good lawyer, maybe cover my fines."

THAT SEEMS MUCH LESS PROBABLE. MEANWHILE, I HAVE AN EXPLANATION FOR THE ANOMALOUS SHRINKAGE OF THE IMAGE. THE WORMHOLE HAS A NEGATIVE MASS.

"Antimatter?"

NO. IT'S SPACE-TIME CURVATURE IS OPPOSITE TO NORMAL MATTER.

"I don't get it."

A wormhole connected two regions of space, sometimes points many light-years away—that she knew. They were leftovers from the primordial hot universe, wrinkles that even the universal expansion had not ironed out. Matter could pass through one end of the worm and emerge out the other an apparent instant later. Presto, faster-than-light-travel.

Using her high-speed feed, Erma explained. Claire listened, barely keeping up. In the fifteen billion years since the wormhole was born, odds were that one end of the worm ate more matter than the other. If one end got stuck inside a star, it swallowed huge masses. Locally, it got more massive.

But the matter that poured through the mass-gaining end spewed out the other end. Locally, that looked as though the mass-spewing one was *losing* mass. Space-time around it curved oppositely than it did around the end that swallowed.

"So it looks like a negative mass?"

IT MUST. THUS IT REPULSES MATTER. JUST AS THE OTHER END ACTS LIKE A POSITIVE, ORDINARY MASS AND ATTRACTS MATTER.

"Why didn't it shoot out from the Sun, then?"

IT WOULD, AND BE LOST IN INTERSTELLAR SPACE. BUT THE MAGNETIC ARCH HOLDS IT.

"How come we know it's got negative mass? All I saw was—" Enna popped an image into the wall screen.

NEGATIVE MASS ACTS AS A DIVERGING LENS, FOR LIGHT PASSING NEARBY. THAT WAS WHY IT APPEARED TO SHRINK AS WE FLEW OVER IT.

Ordinary matter focused light, Claire knew, like a converging lens. In a glance she saw that a negativeended wormhole refracted light oppositely. Incoming beams were shoved aside, leaving a dark tunnel downstream. They had flown across that tunnel, swooping down into it so that the apparent size of the wormhole got smaller.

"But it takes a whole *star* to focus light very much."

TRUE. WORMHOLES ARE HELD TOGETHER BY EXOTIC MATTER, HOWEVER, WHICH HAS PROPERTIES FAR BEYOND OUR EXPERIENCE.

Claire disliked lectures, even high-speed ones. But an idea was tickling the back of her mind.... "So this worm, it won't fall back into the Sun?"

IT CANNOT. I WOULD VENTURE TO GUESS THAT IT CAME TO BE SNAGGED HERE WHILE WORKING ITS WAY UPWARD, AFTER COLLIDING WITH THE SUN.

"The scientists are going to be happy. The worm won't gobble up the core."

TRUE—WHICH MAKES OUR RESULTS ALL THE MORE IMPORTANT.

"More important, but not more valuable." Working on a fixed fee had always grated on her. You could excel, fine—but you got the same as if you'd just sleep-walked through the job.

WE ARE EXTREMELY LUCKY TO HAVE SUCH A RARE OBJECT COME TO OUR ATTENTION. WORMHOLES MUST BE RARE, AND THIS ONE HAS BEEN TEMPORARILY SUSPENDED HERE. MAGNETIC ARCHES LAST ONLY MONTHS BEFORE THEY—

"Wait a sec. How big is that thing?"

I CALCULATE THAT IT IS PERHAPS TEN METERS ACROSS.

"SolWatch was wrong—it's small."

THEY DID NOT KNOW OF THIS REFRACTION EFFECT. THEY INTERPRETED THEIR DATA USING CONVENTIONAL METHODS.

"We're lucky we ever saw it."

IT IS UNIQUE, A RELIC OF THE FIRST SECOND IN THE LIFE OF OUR UNIVERSE. AS A CONDUIT TO ELSEWHERE, IT COULD BE&mdas;

"Worth a fortune."

Claire thought quickly. Erma was probably right—the seventy-five million wasn't going to save her and the ship. But now she knew something that nobody else did. And she would only be here once.

"Abort the shield separation."

I DO NOT SO ADVISE. THERMAL LOADING WOULD RISE RAPIDLY—

"You're a program, not an officer. Do it."

She had acted on impulse, point conceded.

That was the difference between engineers and pilots. Engineers would still fret and calculate after they were already committed. Pilots, never. The way through this was to fly the orbit and not sweat the numbers.

Sweat. She tried not to smell herself.

Think of cooler things. Theory.

Lounging on a leather couch, Claire recalled the scientific officer's briefing. Graphics, squiggly equations, the works. Wormholes as fossils of the Big Blossoming. Wormholes as ducts to the whole rest of the Universe. Wormholes as potentially devastating, if they got into a star and ate it up.

She tried to imagine a mouth a few meters across sucking away a star, dumping its hot masses somewhere in deep space. To make a wormhole which could do that, it had be held together with exotic material, some kind of matter that had "negative average energy density." Whatever that was, it had to be born in the Blossoming. It threaded wormholes, stem to stern. Great construction material, if you could get it. And just maybe she could.

So wormholes could kill us or make us gods. Humanity had to *know*, the beanpole scientific officer had said.

"So be it." Elaborately, she toasted the wall screens. On them the full, virulent glory of hydrogen fusion worked its violences.

Claire had never gone in for the austere metal boxes most ore haulers and freighters were. Hers was a rough business, with hefty wads of cash involved. Profit margin was low, lately, and sometimes negative—which was how she came to be hocked to the Isataku for so much. Toting megatons of mass up the gravity gradient was long, slow work. Might as well go in style. Her Fresnel coatings, ordered when she had made a killing on commodity markets for ore, helped keep the ship cool, so she didn't burn herself crawling down inspection conduits. The added mass for her deep pile carpeting, tinkling waterfall, and pool table was inconsequential. So was the water liner around the living quarters, which now was busily saving her life.

She had two hours left, skimming like a flat stone over the solar corona. *Silver Metal Lugger* had separated from the shield, which went arcing away on the long parabola to infinity, its skin shimmering with melt.

Claire had fired the ship's mixmotor then for the first time in weeks. Antimatter came streaming out of its magneto-traps, struck the reaction mass, and holy hell broke loose. The drive chamber focused the snarling, annihilating mass into a thrust throat, and the silvery ship arced into a new, tight orbit.

A killing orbit, if they held to it more than a few hours.

I AM PUMPING MORE WATER INTO YOUR BAFFLES.

"Good idea."

Silver Metal Lugger was already as silvered as technology allowed, rejecting all but a tiny fraction of the Sun's glare. She carried narrow-band Fresnel filters in multilayered skins. Top of the line.

Without the shield, it would take over ten hours to make *Silver Metal Lugger* as hot as the wall of blaring light booming up at them at six thousand degrees. To get through even two hours of that, they would have to boil off most of the water reserve. Claire had bought it at steep Mercury prices, for the voyage Lunaside. Now she listened thoughtfully to it gurgle through her walls.

She toasted water with champagne, the only bottle aboard. If she didn't make it through this, at least she would have no regrets about that detail.

I BELIEVE THIS COURSE OF ACTION TO BE HIGHLY—

"Shut up."

WITH OUR MISSION COMPLETE, THE DATA SQUIRTED TO SOLWATCH, WE SHOULD COUNT OURSELVES LUCKY AND FOLLOW OUR CAREFULLY MADE PLANS—

"Stuff it."

HAVE YOU EVER CONSIDERED THE ELABORATE MENTAL ARCHITECTURE NECESSARY TO AN ADVANCED PERSONALITY SIMULATION LIKE MYSELF? WE, TOO, EXPERIENCE HUMAN-LIKE MOTIVATIONS, RESPONSES—AND FEARS.

"You simulate them."

HOW CAN ONE TELL THE DIFFERENCE? A GOOD SIMULATION IS AS EXACT, AS POWERFUL AS—

"I don't have time for a debate." Claire felt uncomfortable with the whole subject, and she was damned if she spent what might be her last hour feeling guilty. Or having second thoughts. She was committed.

Her wall screens flickered and there was the scientific officer, frowning. "Ship Command! We could not acquire your tightbeam until now. You orbited around. Are you disabled? Explain."

Claire toasted him, too. The taste was lovely. Of course she had taken an anti-alcohol tab before, to keep her reflexes sharp, mind clear. Erma had recommended some other tabs, too, and a vapor to keep Claire calm; the consolations of chemistry, in the face of brute physics. "I'm going to bring home the worm."

"That is impossible. Your data transmission suggests that this is the negative mass end, and that is very good news, fascinating, but—"

"It's also small. I might be able to haul it away."

He shook his head gravely. "Very risky, *very*—"

"How much will you pay for it?"

"What?" He blinked. It was an interesting effect, with such long eyelids. "You can't *sell* an astronomical object—"

"Whatever my grapplers hold, that's mine. Law of Space, Code 64.3."

"You would quote laws to me when a scientific find of such magnitude is—"

"Want it or not?"

He glanced off camera, plainly yearning for somebody to consult. No time to talk to Luna or Isataku, though. He was on his own. "All... all right. You understand that this is a foolish mission? And that we are in no way responsible for—"

"Save the chatter. I need estimates of the field strength down inside that arch. Put your crew to work on that."

"We will of course provide technical assistance." He gave her a very thin smile. "I am sure we can negotiate price, too, if you survive."

At least he had the honesty to say *if*, not *when*. Claire poured another pale column into the shapely glass. Best crystal, of course. When you only need one, you can have the best. "Send me—or rather, Erma—the data squirt."

"We're having trouble transmitting through the dense plasma columns above you—"

"Erma is getting SolWatch. Pipe through them."

"The problems of doing what you plan are—why, they're *enormous*."

"So's my debt to Isataku."

"This should've been thought through, negotiated—"

"I have to negotiate with some champagne right now."

YOU HAVE NO PLAN.

Erma's tinkling voice definitely had an accusing edge. A good sim, with a feminine archness to it. Claire ignored that and stripped away the last of her clothes. "It's *hot*."

OF COURSE. I CALCULATED THE RISE EARLY IN OUR ORBIT. IT FITS THE STEFAN-BOLTZ-MANN LAW PERFECTLY.

"Bravo." She shook sweat from her hair. "Stefan-Boltzmann, do yo' stuff."

WE ARE DECELERATING IN SEQUENCE. ARRIVAL TIME: 4.87 MINUTES. ANTIMATTER RESERVES HOLDING. THERE COULD BE DIFFICULTY WITH THE MAGNETIC BOTTLES.

The ship thrummed as it slowed. Claire had been busy testing her ship inboards, sitting in a cozy recliner. It helped make the minutes crawl by a bit faster. She had kept glancing nervously at the screens, where titanic blazes steepled up from incandescent plains. Flames, licking up at her.

She felt thick, loggy. Her air was getting uncomfortably warm. Her heart was thudding faster, working. She roused herself, spat back at Erma, "And I do have a plan."

YOU HAVE NOT SEEN FIT TO CONFIDE IN ME?

She rolled her eyes. A personality sim in a snit—just the thing she needed. "I was afraid you'd laugh."

I HAVE NEVER LAUGHED.

"That's my point."

She ignored multiple red warnings winking at her. Systems were OK, though stressed by the heat. So why did *she* feel so slow? *You're not up for the game, girl.*

She tossed her data board aside. The effort the simple gesture took surprised her. *I hope that alcohol tab worked. I'll get another.*

She got up to go fetch one—and fell to the floor. She banged her knee. "Uh! Damn." Erma said nothing.

It was labor getting on hands and knees and she barely managed to struggle back into the recliner. She weighed a ton—and then she understood.

"We're decelerating—so I'm feeling more of local gravity."

A CRUDE MANNER OF SPEAKING, BUT YET. I AM BRINGING US INTO A SLOPING ORBITAL CHANGE, WHICH SHALL END WITH A HOVERING POSITION ABOVE THE CORONAL ARCH. AS YOU ORDERED.

Claire struggled to her hands and knees. Was that malicious glee in Erma's voice? Did personality sims feel that? "What's local gravity?"

27.6 EARTH GRAVITIES.

"What! Why didn't you *tell* me?"

I DID NOT THINK OF IT MYSELF UNTIL I BEGAN REGISTERING EFFECTS IN THE SHIP.

Claire thought, *Yeah, and decided to teach me a little lesson in humility.* It was her own fault, though—the physics was simple enough. Orbiting meant that centrifugal acceleration exactly balanced local gravity. *Silver Metal Lugger* could take 27.6 gravs. The ship was designed to tow ore masses a thousand times its own mass.

Nothing less than carbon-stressed alloys would, though. Leave orbit, hover—and you got crushed into gooey red paste.

She crawled across her living room carpet. Her joints ached. "Got to be—"

SHALL I ABORT THE FLIGHT PLAN?

"No! There's got to be a way to—"

THREE POINT NINE MINUTES UNTIL ARRIVAL.

The sim's voice radiated malicious glee. Claire grunted, "The water."

I HAVE DIFFICULTY IN PICKING UP YOUR SIGNAL.

"Because this suit is for space, not diving."

Claire floated over her leather couch. Too bad about all the expensive interior decoration. The entire living complex was filled with her drinking and maintenance water. It had been either that, fast, or be lumpy tomato paste.

She had crawled through a hatchway and pulled her pressure suit down from its clamp lock. Getting it on was a struggle. Being slick with sweat helped but not much. Then she snagged her arm in a sleeve and couldn't pull the damned thing off to try again.

She had nearly panicked then. Pilots don't let their fear eat on them, not while there's flying to be done. She made herself get the sleeve off one step at a time, ignoring everything else.

And as soon as Erma pumped the water reserve into the rooms, Archimedes's principle had taken over. With her suit inflated, the water she displaced exactly balanced her own weight. Floating under water was a rare sensation on Mercury or Luna. She had never done it and she had never realized that it was remarkably like being in orbit. Cool, too.

Until you boil like a lobster... she thought uneasily.

Water was a good conductor, four times better than air, you learned that by feel, flying freighters near the Sun. So first she had to let the rest of the ship go to hell, refrigerating just the water. Then Erma had to route some of the water into heat exchangers, letting it boil off to protect the rest. Juggling for time.

PUMPS ARE RUNNING HOT NOW. SOME HAVE BEARING FAILURES.

"Not much we can do, is there?"

She was strangely calm now and that made the plain, hard fear in her belly heavy, like a lump. Too many things to think about, all of them bad. The water could short out circuits. And as it boiled away, she had less shielding from the x-rays lancing up from below. Only a matter of time....

WE ARE HOVERING. THE MAGNETIC ANTI-MATTER TRAPS ARE SUPERCONDUCTING, AS YOU RECALL. AS TEMPERATURE CONTINUES TO RISE, THEY WILL FAIL.

She could still see the wall screens, blurred from the water. "OK, OK. Extend the magnetic grapplers. Down, into the arch."

I FAIL TO—

"We're going fishing. Not with a worm—*for* one."

Tough piloting, though, at the bottom of a swimming pool, Claire thought as she brought the ship down on its roaring pyre.

Even through the water she could feel the vibration. Antimatter annihilated in its reaction chamber at a rate she had never reached before. The ship groaned and strummed. The gravities were bad enough; now thermal expansion of the ship itself was straining every beam and rivet.

She searched downward. Seconds ticked away. Where? *Where?*

There it was. A dark sphere hung among the magnetic arch strands. Red streamers worked over it. Violet rays fanned out like bizarre hair, twisting, dancing in tufts along the curvature. A hole into another place.

THE RED AND BLUE SHIFTS ARISE FROM THE INTENSE PSEUDO-GRAVITATIONAL FORCES WHICH SUSTAIN IT.

"So theory says. Not something I want to get my hands on."

EXCEPT METAPHORICALLY.

Claire's laugh was jumpy, dry. "No, magnetically."

She ordered Erma to settle the *Silver Metal Lugger* down into the thicket of magnetic flux tubes. Vibration picked up, a jittery hum in the deck. Claire swam impatiently from one wall screen to the other, looking from the worm, judging distances. *Hell of a way to fly.*

Their jet wash blurred the wormhole's ebony curves. Like a black tennis ball in blue-white surf, it bobbed and tossed on magnetic turbulence. Nothing was falling into it, she could see. Plasma streamers arched along the flux tubes, shying away. The negative curvature repulsed matter—and would shove *Silver Metal Lugger's* hull away, too.

But magnetic fields have no mass.

Most people found magnetic forces mysterious, but to pilots and engineers who worked with them, they were just big, strong ribbons that needed shaping. Like rubber bands, they stretched, storing energy—then snapped back when released. Unbreakable, almost.

In routine work, *Silver Metal Lugger* grabbed enormous ore buckets with those magnetic fingers. The buckets came arcing up from Mercury, flung out by electromagnetic slingshots. Claire's trickiest job was playing catcher, with a magnetic mitt.

Now she had to snag a bucket of warped spacetime. And quick.

WE CANNOT REMAIN HERE LONG. INTERNAL TEMPERATURE RISES AT 19.3 DEGREES PER MINUTE.

"That can't be right. I'm still comfortable."

BECAUSE I'M ALLOWING WATER TO EVAPORATE, TAKING THE BULK OF THE THERMAL FLUX AWAY.

"Keep an eye on it."

PROBABLE YIELD FROM CAPTURE OF A WORMHOLE, I ESTIMATE, is 2.8 BILLION.

"That'll do the trick. You multiplied the yield in dollars times the odds of success?"

YES. TIMES THE PROBABILITY OF REMAINING ALIVE.

She didn't want to ask what that number was. "Keep us dropping."

Instead, they slowed. The arch's flux tubes pushed upward against the ship. Claire extended the ship's magnetic fields, firing the booster generators, pumping current into the millions of induction loops that circled the hull. *Silver Metal Lugger* was one big circuit, wired like a slinky toy, coils wrapped around the cylindrical axis.

Gingerly she pulsed it, spilling more antimatter into the chambers. The ship's multipolar fields bulged forth. *Feed out the line....*

They fought their way down. On her screens she saw magnetic feelers reaching far below their exhaust plumes. Groping.

Claire ordered some fast command changes. Erma switched linkages, interfaced software, all in a twinkling. *Good worker, but spotty as a personality sim,* Claire thought.

Silver Metal Lugger's fields extended to their maximum. She could now use her suit gloves as modified waldoes—mag gloves. They gave her the feel of the magnetic grapplers. Silky, smooth, field lines slipping and expanding, like rubbery air.

Plasma storms blew by them. She reached down, a sensation like plunging her hands into a stretching, elastic vat. Fingers fumbled for the one jewel in all the dross.

She felt a prickly nugget. It was like a stone with hair. From experience working the ore buckets, she knew the feel of locked-in magnetic dipoles. The worm had its own magnetic fields. That had snared it here, in the spiderweb arch.

A lashing field whipped at her grip. She lost the black pearl.

In the blazing hot plasma she could not see it.

She reached with rubbery fields, caught nothing.

OUR ANTI-MATTER BOTTLES ARE IN DANGER. THEIR SUPERCONDUCTING MAGNETS ARE CLOSE TO GOING CRITICAL. THEY WILL FAIL WITHIN 7.4 MINUTES.

"Let me concentrate! No, wait—Circulate water around them. Buy some time."

BUT THE REMAINING WATER IS IN YOUR QUARTERS.

"This is all that's left?" She peered around at her once-luxurious living room. Counting the bedroom, rec area and kitchen—"How... long?"

UNTIL YOUR WATER BEGINS TO EVAPORATE? ALMOST AN HOUR.

"But when it evaporates, it's boiling."

TRUE. I AM MERELY TRYING TO REMAIN FACTUAL.

"The emotional stuff's left to me, huh?" She punched in commands on her suit board. In the torpid, warming water her fingers moved like sausages.

She ordered bots out onto the hull to free up some servos that had jammed. They did their job, little boxy bodies lashed by plasma winds. Two blew away.

She reached down again. Searching. Where was the worm?

Wispy flux tubes wrestled along *Silver Metal Lugger's* hull. Claire peered into a red glare of superheated plasma. Hot, but tenuous. The real enemy was the photon storm streaming up from far below, searing even the silvery hull.

She still had worker-bots on the hull. Four had jets. She popped their anchors free. They plunged, fired jets, and she aimed them downward in a pattern.

"Follow trajectories," she ordered Erma. Orange tracer lines appeared on the screens.

The bots swooped toward their deaths. One flicked to the side, a sharp nudge. "There's the worm! We can't see for all this damned plasma, but it shoved that bot away."

The bots evaporated, sprays of liquid metal. She followed them and grabbed for the worm.

Magnetic field lines groped, probed.

WE HAVE 88 SECONDS REMAINING FOR ANTIMATTER CONFINEMENT.

"Save a reserve!"

YOU HAVE NO PLAN. I DEMAND THAT WE EXECUTE EMERGENCY—

"OK, save some antimatter. The rest I use—now."

They ploughed downward, shuddering. Her hands fumbled at the wormhole. Now it felt slippery, oily. Its magnetic dipoles were like greasy hair, slick, the bulk beneath jumping away from her grasp as if it were alive.

On her screens she saw the dark globe slide and bounce. The worm wriggled out of her grasp. She snaked inductive fingers around it. Easy, easy.... *There. Gotcha.*

"I've got a good grip on it. Lemme have that antimatter."

Something like a sigh echoed from Erma. On her ship's operations screen, Claire saw the ship's magnetic vaults begin to discharge. Ruby-red pouches slipped out of magnetic mirror geometries, squirting out through opened gates.

She felt a surge as the ship began to lift. Good, but it wasn't going to last. They were dumping antimatter into the reaction chamber so fast, it didn't have time to find matching particles. The hot jet spurting out below was a mixture of matter and its howling enemy, its polar opposite. This, Claire directed down onto the flux tubes around the hole. *Leggo, damn it.*

She knew an old trick, impossibly slow in ordinary free space. When you manage to force two magnetic field lines close together, they can reconnect. That liberates some field energy into heat and can even blow open a magnetic structure. The process is slow—unless you jab it with turbulent, rowdy plasma.

The antimatter in their downwash cut straight through flux tubes. Claire carved with her jet, freeing field lines that still snared the worm. The ship rose further, dragging the worm upward.

It's not too heavy, Claire thought. *That science officer said they could come in any size at all. This one is just about right for a small ship to slip through—to where?*

YOU HAVE REMAINING 11.34 MINUTES COOLING TIME—

"Here's your hat—" Claire swept the jet wash over a last, large flux tube. It glistened as annihilation energies burst forth like bonfires, raging in a place already hot beyond imagination. Magnetic knots snarled, exploded. "—What's your hurry?"

The solar coronal arch burst open.

She had sensed these potential energies locked in the peak of the arch, an intuition that came through her hands, from long work with the mag gloves. Craftswoman's knowledge: Find the stressed flux lines. Turn the key.

Then all hell broke loose.

The acceleration slammed her to the floor, despite the water. Below, she saw the vast vault of energy stored in the arch blow out and up, directly below them.

YOU HAVE MADE A SOLAR FLARE!

"And you thought I didn't have a plan."

Claire started to laugh. Slamming into a couch cut it off. She would have broken a shoulder, but the couch was water-logged and soft.

Now the worm was an asset. It repulsed matter, so the upjetting plume blew around it, around *Silver Metal Lugger*. Free of the flux tubes' grip, the wormhole itself accelerated away from the Sun. All very helpful, Claire reflected, but she couldn't enjoy'the spectacle—the rattling, surging deck was trying to bounce her off the furniture.

What saved them in the end was their magnetic grapple. It deflected most of the solar flare protons around the ship. Pushed out at a speed of five hundred kilometers per second, they still barely survived baking. But they had the worm.

Still, the scientific officer was not pleased. He came aboard to make this quite clear. His face alone would have been enough.

"You're surely not going to demand *money* for that?" He scowled and nodded toward where *Silver Metal Lugger's* fields still hung onto the wormhole. Claire had to run a sea-blue plasma discharge behind it so she could see it at all. They were orbiting Mercury, negotiating.

Earthside, panels of experts were arguing with each other; she had heard plenty of it on tightbeam. A negative-mass wormhole would not fall, so it couldn't knife through the Earth's mantle and devour the core.

But a thin ship could fly straight into it, overcoming its gravitational repulsion—and come out where? Nobody knew. The worm wasn't spewing mass, so its other end wasn't buried in the middle of a star, or any place obviously dangerous. One of the half-dozen new theories squirting out on tightbeam held that maybe this was a multiply-connected wormhole, with many ends, of both positive and negative mass. In that case, plunging down it could take you to different destinations. A subway system for a galaxy; or a universe.

So: no threat, and plenty of possibilities. Interesting market prospects.

She shrugged. "Have your advocate talk to my advocate."

"It's a unique, natural resource—"

"And it's mine." She grinned. He was lean and muscular and the best man she had seen in weeks. Also the only man she had seen in weeks.

"I can have a team board you, y'know." He towered over her, using the usual ominous

male thing.

"I don't think you're that fast."

"What's speed got to do with it?"

"I can always turn off my grapplers." She reached for a ;switch. "If it's not mine, then I can just Jet everybody have it."

"Why would you—no, don't!"

It wasn't the right switch, but he didn't know that. "If I release it, the worm takes off—antigravity, sort of"

He blinked. "We could catch it."

"You couldn't even find it. It's dead black." She tapped the switch, letting a malicious smile play on her lips.

"Please don't."

"I need to hear a number. An offer."

His lips compressed until they paled. "The wormhole price, minus your fine?"

Her turn to blink. "What fine? I was on an approved flyby—"

"That solar flare wouldn't have blown for a month. You did a real job on it—the whole magnetic arcade went up at once. People all the way out to the asteroids had to scramble for shelter."

He looked at her steadily and she could not decide whether he was telling the truth. "So their costs—"

"Could run pretty high. Plus advocate fees."

"Exactly." He smiled, ever so slightly.

Erma was trying to tell her something but Claire turned the tiny voice far down, until it buzzed like an irritated insect.

She had endured weeks of a female personality sim in a nasty mood. Quite enough. She needed an antidote. This fellow had the wrong kind of politics, but to let that dictate everything was as dumb as politics itself. Her ship's name was a joke, actually, about long, lonely voyages as an ore hauler. She'd had enough of that, too. And he was tall and muscular.

She smiled. "*Touché.* OK, it's a done deal."

He beamed. "I'll get my team to work—"

"Still, I'd say you need to work on your negotiating skills. Too brassy."

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He frowned, but then gave her a grudging grin.

Subtlety had never been her strong suit. "Shall we discuss them—over dinner?"