

Bow Shock

By Gregory Benford

Ralph slid into the booth where Irene was already waiting, looking perky and sipping on a bottle of Snapple tea. "How'd it . . ." She let the rest slide away, seeing his face.

"Tell me something really awful, so it won't make today seem so bad."

She said carefully, "Yes sir, coming right up, sir. Um . . ." A wicked grin. "Once I had a pet bird that committed suicide by sticking his head between the cage bars."

"W-what . . .?"

"Okay, you maybe need worse? Can do." A flash of dazzling smile. "My sister forgot to feed her pet gerbils, so one died. Then, the one that was alive ate its dead friend."

Only then did he get that she was kidding, trying to josh him out of his mood. He laughed heartily. "Thanks, I sure needed that."

She smiled with relief and turned her head, swirling her dirty-blond hair around her head in a way that made him think of a momentary tornado. Without a word her face gave him sympathy, concern, inquiry, stiff-lipped support—all in a quick gush of expressions that skated across her face, her full, elegantly lipsticked red mouth collaborating with her eggshell blue eyes.

Her eyes followed him intently as he described the paper he had found that left his work in the dust.

"Astronomy is about getting there first?" she asked wonderingly.

"Sometimes. This time, anyway." After that he told her about the talk with the department chairman—the whole scene, right down to every line of dialog, which he would now remember forever, apparently—and she nodded.

"It's time to solicit letters of recommendation for me, but to who? My work's already out of date. I . . . don't know what to do now," he said. Not a great last line to a story, but the truth.

"What do you feel like doing?"

He sighed. "Redouble my efforts—"

"When you've lost sight of your goal?" It was, he recalled, a definition of fanaticism, from a movie.

"My goal is to be an astronomer," he said stiffly.

"That doesn't have to mean academic, though."

"Yeah, but NASA jobs are thin these days." An agency that took seven years to get to the moon the first time, from a standing start, was now spending far more dollars to do it again in fifteen years.

"You have a lot of skills, useful ones."

"I want to work on fundamental things, not applied."

She held up the cap of her Snapple iced tea and read from the inner side with a bright, comically forced voice, "Not a winner, but here's your Real Fact number two thirty-seven. The number of times a cricket chirps in fifteen seconds, plus thirty-seven, will give you the current air temperature."

"In Fahrenheit, I'll bet," he said, wondering where she was going with this.

"Lots of 'fundamental' scientific facts are just that impressive. Who cares?"

"Um, have we moved on to a discussion of the value of knowledge?"

"Valuable to *whom*, is my point."

If she was going to quote stuff, so could he. "Look, Mark Twain said that the wonder of science is the bounty of speculation that comes from a single hard fact."

"Can't see a whole lot of bounty from here." She gave him a wry smile, another hair toss. He had to admit, it worked very well on him.

"I *like* astronomy."

"Sure, it just doesn't seem to like you. Not as much, anyway."

"So I should . . .?" Let her fill in the answer, since she was full of them today. And he doubted the gerbil story.

"Maybe go into something that rewards your skills."

"Like . . .?"

"Computers. Math. Think big! Try to sign on with a hedge fund, do their analysis."

"Hedge funds . . ." He barely remembered what they did. "They look for short-term trading opportunities in the market?"

"Right, there's a lot of math in that. I read up on it online." She was sharp; that's what he liked about her. "That data analysis you're doing, it's waaay more complicated than what Herb Linzfield does."

"Herb . . .?"

"Guy I know, eats in the same Indian buffet place some of us go for lunch." Her eyes got veiled and he wondered what else she and Herb had talked about. Him? "He calculates hedges on bonds."

"Corporate or municipal?" Just to show he wasn't totally ignorant of things financial.

"Uh, I think corporate." Again the veiled eyes.

"I didn't put in six years in grad school and get a doctorate to—"

"I know, honey." Eyes suddenly warm "But you've given this a real solid try now."

"A *try*? I'm not done."

"Well, what I'm saying, you can do other things. If this doesn't . . . work out."

Thinking, he told her about the labyrinths of academic politics. The rest of the UC Irvine astro types did nearby galaxies, looking for details of stellar evolution, or else big scale cosmological stuff. He worked in between, peering at exotic beasts showing themselves in the radio and microwave regions of the spectrum. It was a competitive field and he felt it fit him. So he spelled out what he thought of as The Why. That is, why he had worked hard to get this far. For the sake of the inner music it gave him, he had set aside his personal life, letting affairs lapse and dodging any long-term relationship.

"So that's why you weren't . . . connected? . . . when you got here." She pursed her lips appraisingly.

"Yeah. Keep my options open, I figured."

"Open for . . .?"

"For this—" He swept a rueful, ironic hand in the air at his imaginary assets. For a coveted appointment, a heady way out of the gray postdoc grind—an Assistant Professorship at UC Irvine, smack on the absurdly pricey, sun-bleached coast of Orange County. He had beaten out over a hundred applicants. And why not? He was quick, sure, with fine-honed skills and good connections, plus a narrow-eyed intensity a lot of women found daunting, as if it whispered: *careerist, beware*. The skies had seemed to open to him, for sure . . .

But that was then.

He gave her a crinkled smile, rueful, and yet he felt it hardening. "I'm not quitting. Not now."

"Well, just think about it." She stroked his arm slowly and her eyes were sad now. "That's all I meant . . ."

"Sure." He knew the world she inhabited, had seen her working spreadsheets, reading biographies of the founding fathers and flipping through books on "leadership," seeking clues about rising in the buoyant atmosphere of business.

"Promise?" Oddly plaintive.

He grinned without mirth. "You know I will." But her words had hurt him, all the same. Mostly by slipping cool slivers of doubt into his own mind.

Later that night, he lay in her bed and replayed the scene. It now seemed to define the day, despite

Irene's strenuous efforts.

Damn, Ralph had thought. Scooped!

And by Andy Lakehurst, too. He had bit his lip and focused on the screen, where he had just gotten a freshly posted paper off the Los Alamos library web site, astro-ph.

The radio map was of Ralph's one claim to minor fame, G369.23-0.82. The actual observations were stunning. Brilliant, clear, detailed. Better than his work.

He had slammed his fist on his desk, upsetting his coffee. "Damn!" Then he sopped up the spill—it had splattered some of the problem sets he'd graded earlier.

Staring at the downloaded preprint, fuming, he saw that Andy and his team had gotten really detailed data on the—on *his*—hot new object, G369.23-0.82. They must have used a lot of observing time, and gotten it pronto.

Where? His eyes ran down the usual Observations section and—*Arecibo! He got observing time there?*

That took pull or else a lucky cancellation. Arecibo was the largest dish in the world, a whole scooped bowl set amid a tropical tangle, but fixed in position. You had to wait for time and then synchronize with dishes around the planet to make a map.

And good ol' ex-classmate Andy had done it. Andy had a straightforward, no-nonsense manner to him, eased by a ready smile that got him through doors and occasionally into bedrooms. Maybe he had connections to Beth Conway at Arecibo?

No, Ralph had thought, that's beneath me. He jumped on G369.23-0.82 and did the obvious next step, that's all.

Further, Andy was at Harvard, and that helped. Plenty. But it still galled. Ralph was still waiting to hear from Harkin at the Very Large Array about squeezing in some time there. Had been waiting for six weeks, yes.

And on top of it all, he then had his conference with the department chairman in five minutes. He glanced over Andy's paper again. It was excellent work. Unfortunately.

He sighed in the dark of Irene's apartment, recalling the crucial hour with the department chairman. This long day wouldn't be done until he had reviewed it, apparently.

He had started with a fixed smile. Albert Gossian was an avuncular sort, an old-fashioned chairman who wore a suit when he was doing official business. This unconscious signal did not bode well. Gossian gave him a quick, jowly smile and gestured Ralph into a seat.

"I've been looking at your Curriculum Vitae," Gossian said. He always used the full Latin, while others just said "CV." Slow shake of head. "You need to publish more, Ralph."

"My grant funding's kept up, I—"

"Yes, yes, very nice. The NSF is putting effort into this field, most commendable—" A quick glance up from reading his notes, over the top of his glasses—"and that's why the department decided to hire in this area. But—can you keep the funding?"

"I'm two years in on the NSF grant, so next year's mandatory review is the crunch."

"I'm happy to say your teaching rating is high, and university service, but . . ." The drawn-out vowels seemed to be delivering a message independent of the actual sentences.

All Assistant Professors had a review every two years, tracking their progress toward the Holy Grail of tenure. Ralph had followed a trajectory typical for the early century: six years to get his doctorate, a postdoc at Harvard—where Andy Lakehurst was the rising star, eclipsing him and a lot of others. Ralph got out of there after a mutually destructive affair with a biologist at Tufts, fleeing as far as he could when he saw that UC Irvine was growing fast and wanted astrophysicists. UCI had a mediocre reputation in particle theory, but Fred Reines had won a Nobel there for showing that neutrinos existed

and using them to detect the spectacular 1987 supernova.

The plasma physics group was rated highest in the department and indeed they proved helpful when he arrived. They understood that 99% of the mass in the universe was roasted, electrons stripped away from the nuclei-plasma. It was a hot, rough universe. The big dramas played out there. Sure, life arose in the cool, calm planets, but the big action flared in their placid skies, telling stories that awed him.

But once at UCI, he had lost momentum. In the tightening federal budgets, proposals didn't get funded, so he could not add postdocs to get some help and leverage. His carefully teased-out observations gave new insights only grudgingly. Now five years along, he was three months short of the hard wall where tenure had to happen, or became impossible: the cutoff game.

Were the groves of academe best for him, really? He liked the teaching, fell asleep in the committee meetings, found the academic cant and paperwork boring. Life's sure erosions . . .

Studying fast-moving neutron stars had been fashionable a few years back, but in Gossian's careful phrasings he heard notes of skepticism. To the Chairman fell the task of conveying the senior faculty's sentiments.

Gossian seemed to savor the moment. "This fast-star fad—well, it is fading, some of your colleagues think."

He bit his lip. *Don't show anger.* "It's not a 'fad.' It's a set of discoveries."

"But where do they lead?"

"Too early to tell. We *think* they're ejected from supernova events, but maybe that's just the least imaginative option."

"One of the notes here says the first 'runaway pulsar,' called the Mouse, is now well understood. The other, recent ones will probably follow the same course."

"Too early to tell," Ralph persisted. "The field needs time—"

"But you do not have time."

There was the crux of it. Ralph was falling behind in paper count. Even in the small 'runaway pulsar' field, he was outclassed by others with more resources, better computers, more time. California was in a perpetual budget crisis, university resources were declining, so pressure was on to Bring In the (Federal) Bucks. Ralph's small program supported two graduate students, sure, but that was small potatoes.

"I'll take this under advisement," Ralph said. The utterly bland phrase did nothing to help his cause, as was clear from the chairman's face, but it got him out of that office.

He did not get much sleep that night. Irene had to leave early and he got a double coffee on the way into his office. Then he read Andy's paper carefully and thought, sipping.

Few astronomers had expected to find so many runaway neutron stars.

Their likely origin began with two young, big stars, born circling one another. One went supernova, leaving a neutron star still in orbit. Later, its companion went off, too, spitting the older neutron star out, free into interstellar space.

Ralph had begun his UCI work by making painstaking maps in the microwave frequency range. This took many observing runs on the big radio antennas, getting dish time where he could around the world. In these maps he found his first candidate, G369.23-0.82. It appeared as a faint finger in maps centered on the plane of the galaxy, just a dim scratch. A tight knot with a fuzzy tail.

He had found it with software that searched the maps, looking for anything that was much longer than it was wide. This retrieved quite a few of the jets that zoomed out of regions near black holes, and sometimes from the disks orbiting young stars. He spent months eliminating these false signatures, looking for the telltales of compact stellar runaways. He then got time on the Very Large Array—not much, but enough to pull G369.23-0.82 out of the noise a bit better. This was quite satisfying.

Ralph got more coffee and went back and studied his paper, published less than half a year ago. Until today, that was the best data anybody had. He had looked for signs of rotation in the point-like blob in front, but there were none. The first runaway seen, the Mouse, discovered many years before, was finally shown to be a rotating neutron star—a pulsar, beeping its right radio beams out at the cupped ears of radio telescopes.

Then he compared in detail with Andy's new map:

Clean, smooth, beautiful. He read the Conclusions section over again, mind jittery and racing.

We thus fail to confirm that G369.23-0.82 is a pulsar. Clearly it has a bow shock, creating a wind nebula, undoubtedly powered by a neutron star. Yet at highest sensitivity there is no trace of a pulsed signal in microwaves or optical, within the usual range of pulsar periods. The nebular bow shock cone angle implies that G369.23-0.82 is moving with a Mach number of about 80, suggesting a space velocity ? 120 km/s through a local gas of density ? 0.3 per cubic cm. We use the distance estimate of Eilek et.al. for the object, which is halfway across the galaxy. These dynamics and luminosity are consistent with a distant neutron star moving at a velocity driven by ejection from a supernova. If it is a pulsar, it is not beaming in our direction.

Beautiful work. Alas.

The bright region blazed forth, microwave emission from high energy electrons. The innermost circle was not the neutron star, just the unresolved zone too small for even Arecibo to see. At the presumed distance, that circle was still bigger than a solar system. The bow shock was a perfect, smooth curve. Behind that came the microwave emission of gas driven back, heated and caught up in what would become the wake. At the core was something that could shove aside the interstellar gas with brute momentum. A whole star, squeezed by gravity into a ball about as big as the San Francisco Bay area.

But how had Andy gotten such fine resolution?

Ralph worked through the numbers and found that this latest map had picked up much more signal than his earlier work. The object was brighter. Why? Maybe it was meeting denser gas, so had more radiating electrons to work with?

For a moment he just gazed at the beauty of it. He never lost his sense of awe at such wonders. That helped a bit to cool his disgruntlement. Just a bit.

There wasn't much time between Andy's paper popping up on the astro-ph web site and Ralph's big spring trip. Before leaving, he retraced his data and got ahead on his teaching.

He and Irene finessed their problems, or at least delayed them. He got through a week of classes, put in data-processing time with his three graduate students, and found nothing new in the radio maps they worked on.

Then came their big, long-planned excursion. Irene was excited, but he now dreaded it.

His start-up money had some travel funds left in it, and he had made the mistake of mentioning this to Irene. She jumped at the chance, even though it was a scientific conference in a small town—"But it's in France," she said, with a touch of round-eyed wonder he found endearing.

So off they jetted to the International Astronomical Union meeting in Briançon, a pleasant collection of stone buildings clinging to the French Alps. Off season, crouching beneath sharp snowy peaks in late May, it was charming and uncrowded and its delights went largely ignored by the astronomers. Some of the attendees went on hikes in the afternoon but Ralph stayed in town, talking, networking like the ambitious workaholic he was. Irene went shopping.

The shops were featuring what she called the Hot New Skanky Look, which she showed off for him in their cramped hotel room that evening. She flounced around in an off-the-shoulder pink blouse, artfully showing underwear and straps. Skanky certainly caught the flavor, but still he was distracted.

In their cramped hotel room, jet-lagged, she used some of her first-date skills, overcoming his distance. That way he got some sleep a few hours later. Good hours, they were.

The morning session was interesting, the afternoon a little slow. Irene did sit in on some papers. He couldn't tell if she was interested in the science itself, or just because it was part of his life. She lasted a few hours and went shopping again, saying, "It's my way of understanding their culture."

The conference put on a late afternoon tour of the vast, thick-walled castles that loomed at every sharp peak. At the banquet inside one of the cold, echoing fortresses they were treated to local specialties, a spicy polenta and fresh-caught trout. Irene surveyed the crowd, half of them still wearing shorts and T-shirts, and remarked, "Y'know, this is a quirky profession. A whole room of terribly smart people, and it never occurred to them to try to get by on their looks."

He laughed; she had a point. She was a butterfly among the astro-drones, turning heads, smiles blossoming in her wake. He felt enhanced to have her on his arm. Or maybe it was the wine, a *Vin Local* red that went straight to his head, with some help from the two kilometer altitude.

They milled around the high, arched reception room after the dessert. The crowd of over two hundred was too energized to go off to bed, so they had more wine. Ralph caught sight of Andy Lakehurst then. Irene noted his look and said, "Uh oh."

"Hey, he's an old friend."

"Oh? You're glaring at him."

"Okay, let's say there's some leftover baggage."

She gave him a veiled look, yawned, and said, "I'll wander off to the room, let you boys play."

Ralph nodded, barely listening. He eavesdropped carefully on the crowd gathered around lanky, broad-shouldered Andy. The man's booming voice carried well, over the heads of just about everybody in the room. Andy was going on about good ol' G369.23-0.82. Ralph edged closer.

"I figure maybe another, longer look at it, at G—"

"The Bullet," Ralph broke in.

"What?" Andy had a high forehead and it wrinkled as he stopped in mid-sentence.

"It looks like a bullet. Why not call it that, instead of that long code?"

"Well," Andy began brightly, "people might mistake—"

"There's even the smoke trailing behind it, the wake." Ralph said, grinning. "Use that, if you want it to get into *Scientific American*."

"Y'know, Ralph, you haven't changed."

"Poorer, is all."

"Hey, none of us went into this to get rich."

"Tenure would be nice."

"Damn right, buddy." Andy clapped him on the shoulder. "I'm going up for it this winter, y'know."

He hadn't, but covered with, "Well deserved. I'm sure you'll get it," and couldn't resist adding, "Harvard's a tough sell, though. Carl Sagan didn't make it there."

"Really?" Andy frowned, then covered with, "So, uh, you think we should call it the Rifle?"

"The Bullet," Ralph said again. "It's sure going fast, and we don't really know it's a neutron star."

"Hey, it's a long way off, hard to diagnose."

"Maybe it's distant, I kinda wonder—"

"And it fits the other parameters."

"Except you couldn't find a pulse, so maybe it's not a pulsar."

"Gotta be," Andy said casually, and someone interrupted with a point Ralph couldn't hear and Andy's gaze shifted to include the crowd again. That gave Ralph a chance to think while Andy worked the room.

There were nearly a thousand pulsars now known, rotating neutron stars that flashed their lighthouse

beams across the galaxy. Some spun a thousand times in a second, others were old and slow, all sweeping their beams out as they rotated. All such collapsed stars told their long tale of grinding decay; the slower were older. Some were ejected after their birth in bright, flashy supernovas, squashed by catastrophic compression in nuclear fire, all in a few minutes.

Here in Briancon, Ralph reflected, their company of smart, chattering chimpanzees—all evolved long after good ol' G369.23-0.82 had emerged from its stellar placenta—raptly studied the corpses of great calamities, the murder of stars by remorseless gravity.

Not that their primate eyes would ever witness these objects directly. They actually saw, with their football-field sized dishes, the brilliant emissions of fevered electrons, swirling in celestial concert around magnetic fields. Clouds of electrons cruised near the speed of light itself, squeezing out their waves—braying to the whole universe that they were alive and powerful and wanted everyone to know it. Passing gaudy advertisements, they were, really, for the vast powers wrecking silent violences in the slumbering night skies.

"We're out of its beam; that's got to be the answer," Andy said, turning back to Ralph and taking up their conversation again, his smile getting a little more rigid. "Not pointed at us."

Ralph blinked, taken unaware; he had been vaguely musing. "Uh, I'm thinking maybe we should consider every possibility, is all." Maybe he had taken one glass too many of the *Vin Local*.

"What else could it be?" Andy pressed his case, voice tightening. "It's compact, moving fast, bright at the leading edge, luminosity driven by its bow shock. A neutron star, charging on out of the galaxy."

"If it's as far away as we think. What if it isn't?"

"We don't know anything else that can put out emissions like that."

He could see nearby heads nodding. "We have to think . . ." grasping for something . . . "uh, outside the box." Probably the *Vin Local* talking.

Smiling, Andy leaned close and whispered through his tight, no-doubt-soon-to-be tenured lips, "Ol' buddy, you need an idea, to beat an idea."

Definitely the *Vin Local*, yes.

He awoke next morning with a traffic accident inside his skull. Only now did he remember that he had exchanged polite words with Harkin, the eminence gris of the Very Large Array, but there was no news about getting some observing time there. And he still had to give his paper.

It was a botch.

He had a gaudy Powerpoint presentation. And it even ran right on his laptop, a minor miracle. But the multicolored radio maps and graphics failed to conceal a poverty of ideas. If they could see a pulsed emission from it, they could date the age and then look back along the track of the runaway to see if a supernova remnant was there—a shell of expanding hot gas, a celestial bull's eye, confirming the whole theory.

He presented his results on good ol' G369.23-0.82. He had detailed microwave maps of it, plenty of calculations—but Andy had already given his talk, showing that it wasn't a pulsar. And G369.23-0.82—Ralph insisted on calling it the Bullet, but puzzled looks told him that nobody much liked the coinage—was the pivot of the talk, alas.

"There are enough puzzling aspects here," he said gamely, "to suspend judgment, I think. We have a habit of classifying objects because they superficially resemble others."

The rest was radio maps of various blobby radio-emitting clouds he had thought could be other runaways . . . but weren't. Using days of observing time at the VLA, and on other dish systems in the Netherlands and Bologna, Italy, he had racked up a lot of time.

And found . . . nothing. Sure, plenty of supernova remnants, some shredded fragments of lesser catastrophes, mysterious leftovers fading fast in the radio frequencies—but no runaways with the distinctive tails first found in the famous Mouse. He tried to cover the failure by riffing through quick images of these disappointments, implying without saying that these were open possibilities. The audience

seemed to like the swift, color-enhanced maps. It was a method his mother had taught him while playing bridge: finesse when you don't have all the tricks.

His talk came just before lunch and the audience looked hungry. He hoped he could get away with just a few questions. Andy rose at the back and asked innocently, "So why do you think the, uh, Bullet is *not* a neutron star?"

"Where's the supernova remnant it came from?" Ralph shot back. "There's nothing at all within many light years behind it."

"It's faded away, probably," Andy said.

A voice from the left, one of the Grand Old Men, said, "Remember, the, ah, Bullet is all the way across the galaxy. An old, faint remnant it might have escaped is hard to see at that distance. And—" a shrewd pursing of lips—"did you look at a sufficiently deep sensitivity?"

"I used all the observing time I had," Ralph answered, jumping his Powerpoint slides back to a mottled field view—random flecks, no structure obvious. "The region in the far wake of the Bullet is confusion limited."

Astronomers described a noisy background with that term, meaning that they could not tell signal from noise. But as he fielded a few more quick questions he thought that maybe the jargon was more right than they knew. Confusion limited what they could know, taking their mayfly snapshots.

Then Andy stood again and poked away at details of the data, a bit of tit for tat, and finishing with a jibe: "I don't understand your remark about not jumping to classify objects just because they superficially resemble other ones."

He really had no good reason, but he grinned and decided to joke his way through. "Well, the Bullet doesn't have the skewed shape of the Duck . . ."—which was another oddly shaped pulsar wake, lopsided fuzz left behind by a young pulsar Andy had discovered two years ago—"Astronomers forget that the public likes descriptive terms. They're easier to remember than, say, G369.23-0.82." Some laughter. "So I think it's important to keep our options open. And not succumb to the sweet temptation to go sensational, y'know—" He drew a deep breath and slipped into a falsetto trill he had practiced in his room. "*Runaway star! High speeds! It will escape our galaxy entirely!*"

—and it got a real laugh.

Andy's mouth twisted sourly and, too late, Ralph remembered that Andy had been interviewed by some flak and then featured in the supermarket tabloid *National Enquirer*, with wide-eyed headlines not much different.

Oops.

Irene had been a hit at Briancon, though she was a bit too swift for some of his colleagues. She was kooky, or as some would say, annoying. But at her side he felt he had fully snapped to attention. Sometimes, she made it hard to concentrate; but he did. When he got back to UCI there was teaching to catch up on, students to coach, and many ideas to try out. He settled in.

Some thought that there were only two kinds of science: stamp collecting and physics. Ernest Rutherford had said that, but then, he also thought the atomic nucleus had no practical uses.

Most scientific work began with catalogs. Only later did the fine distinctions come to suggest greater, looming laws. Newton brought Galileo's stirrings into differential laws, ushering forth the modern world.

Astronomers were fated to mostly do astro-botany, finding varieties of deep space objects, framing them into categories, hoping to see if they had a common cause. Stamp collecting.

Once the theory boys decided, back in the 1970s, that pulsars were rotating neutron stars, they largely lost interest and moved onto quasars and jets and then to gamma-ray bursters, to dark energy—an onward marching through the botany, to find the more basic physics. Ralph didn't mind their blithe inattention. He liked the detective story aspects, always alive to the chance that just because things looked similar didn't mean they had to be the same.

So he prowled through all the data he had, comparing with other maps he had gotten at Briancon. There were plenty of long trails in the sky, jets galore—but no new candidates for runaway neutron stars. So he had to go back to the Bullet to make progress. For that he needed more observing time.

For him and Irene, a good date had large portions of honesty and alcohol. Their first night out after the French trip he came armed with attention span and appetite. He kept an open mind to chick flicks—rented and hauled back to her place, ideally—and even to restaurants that played soft romantic background music, which often did the same job as well as a chick flick.

He had returned to news, both good and bad. The department wasn't interested in delaying his tenure decision, as he had fleetingly asked (Irene's suggestion) before leaving. But: Harkin had rustled up some observing time for him on the VLA. "Wedges, in between the big runs," he told Irene.

"Can you get much with just slices of time?"

"In astronomy, looking hard and long is best. Choppy and short can do the same job, if you're lucky."

It was over a weekend, too, so he would not have to get someone to cover his classes.

So he was definitely up when they got to the restaurant. He always enjoyed squiring Irene around, seeing other guys' eyeballs follow them to their table—and telling her about it. She always got a round-eyed, raised eyebrow flash out of that. Plus, they both got to look at each other and eat. And if things went right this night, toward the dessert it might be like that scene in the *Tom Jones* movie.

They ordered: for her, the caramelized duck breasts, and for him, tender Latin chicken with plantains. "A yummy start," she said, eyeing the upscale patrons. The Golden Coast abounded with Masters of the Universe, with excellently cut hair and bodies that were slim, casually elegant, carefully muscled (don't want to look like a *laborer*), the women running from platinum blonde through strawberry. "Ummm, quite *soigne'*, Irene judged, trying out her new French vocabulary.

Ralph sensed some tension in her, so he took his time, glancing around at the noisy crowd. They carried themselves with that look not so much of energetic youth but rather of expert maintenance, like a Rolls with the oil religiously changed every 1500 miles. Walking in their wake made most working stiff feel just a touch shabby.

He said, "Livin' extra-large in OC," with a rueful smile, and wondered if she saw this, the American Dream Extreme, as he did. They lived among dun-colored hills covered by pseudo-Spanish stucco splendor, McMansions sprawled across tiny lots. "Affluenza," someone had called it, a disease of always wanting more: the local refrain was "It's all about you," where the homes around yacht-ringed harbors and coves shone like filigree around a gemstone. He respected people like her, in business, as the drivers who created the wealth that made his work possible. But just today he had dropped her at the Mercedes dealership to pick up her convertible, in for an oil change. Pausing, he saw that the place offered free drop-in car washes, and while you waited with your cinnamon-topped decaf cappuccino you could get a manicure, or else work on your putting at a green around the back. Being an academic scientist around here felt like being the poor country cousin.

He watched her examine all the flatware and polish it with her napkin. This was not routine; she was not a control freak who obsessed over the organization of her entire life, or who kept color-coded files, though, yes, she was a business MBA.

"That was a fun trip," Irene said in the pensive tones that meant she was being diplomatic. "Ah . . . do you want to hang out with those people all your life?"

"They're pretty sophisticated, I think," he said defensively, wondering where she was going with this.

"They—how to put this pleasantly?—work too damn hard."

"Scientists do."

"Business types, too—but they don't talk about nothing else."

"It was a specialists' conference. That's all they have in common."

"That, and being outrageously horny."

He grinned. "You never thought that was a flaw before."

"I keep remembering the M.I.T guy who believed he could wow me with"—she made the quote marks with her fingers—"a 'meaningful conversation' that included quoting *The Simpsons*, gangsta flicks, and some movie trilogy."

"That was Tolkein."

"Elves with swords. I thought you guys were scientists."

"We have . . . hobbies."

"Obsessions, seems like."

"Our work included?"

She spread her hands. "I respect that you're deeply involved in astronomy, sure." She rolled her eyes. "But it pays so little! And you're headed into a tough tenure decision. After all these years!"

"Careers take time."

"Lives do, too. Recall what today is?"

He kept his face impassive, the only sure way to not get the deer-in-headlights expression he was prone to. "Uh, no . . ."

"Six months ago."

"Oh, yes. We were going to discuss marriage again."

Her eyes glinted. "And you've been hiding behind your work . . . again."

"Hey, that's not fair—"

"I'm not waiting forever."

"I'm in a crunch here. Relationships don't have a 'sell-by' date stamped on them—"

"Time waits for no man. I don't either."

Bottom line time, then. He asked firmly, "So instead I should . . .?"

She handed him a business card.

"I should have known."

"Herb Linzfield. Give him a call."

"What inducement do I have?" He grinned to cover his concern.

She answered obliquely by ordering dessert, with a sideways glance and flickering little smile on her big, rich lips. On to *Tom Jones*.

To get to the VLA from UC Irvine means flying out of John Wayne airport—there's a huge, looming bronze statue of the Duke in cowboy duds that somehow captures the actor's trademarked gait—and through Phoenix to Albuquerque. Ralph did this with legs jammed up so he couldn't open his laptop, courtesy of Southwest Airlines—and then drove a Budget rental west through Socorro.

The crisp heat faded as he rose up the grade to the dry plateau, where the Array sprawls on railroad lines in its long valley. Along the Y-shaped rail line the big dishes could crawl, ears cupped toward the sky, as they reconfigured to best capture in their "equivalent eye" distant radiating agonies. The trip through four-lane blacktop edged with sagebrush took most of a day. When Ralph arrived Harkin had been observing a radio galaxy for eight hours.

"Plenty more useful than my last six hours," he said, and Harkin grinned.

Harkin wore jeans, a red wool shirt and boots and this was not an affectation. Locals described most of the astronomers as "all hat and no cattle," a laconic indictment of fake westerners. Harkin's face seemed to have been crumpled up and then partly smoothed out—the effect of twenty years out here.

The radio galaxy had an odd, contorted look. A cloud of radio emitting electrons wrapped around Harkin's target—a brilliant jet. Harkin was something of a bug about jets, maintaining that they had to be shaped by the magnetic fields they carried along. Fields and jets alike all were offhand products of the twirling disk far down in the galactic center. The black holes that caused all this energy release were hard

to discover, tiny and cloaked in gas. But the jets carried out to the universe striking advertisements, so they were the smoking gun. Tiny graveyards where mass died had managed to scrawl their signatures across the sky.

Ralph looked at the long, spindly jet in Harkin's radio images. It was like a black-and-white of an arrow. There was a lot of work here. Hot-bright images from deep down in the churning glory of the galactic core, then the long slow flaring as the jet moved above the galactic disk and met the intergalactic winds.

Still, it adamantly kept its direction, tightly arrowing out into the enveloping dark. It stretched out for many times the size of its host galaxy, announcing its presence with blaring radio emission. That came from the spiraling of high-energy electrons around magnetic field lines, Ralph knew, yet he always felt a thrill at the raw radio maps, the swirls and helical vortices bigger than swarms of stars, self-portraits etched by electrons alive with their mad energies.

At the very end, where it met the intergalactic gas, the jet got brighter, saturating the images. "It's turned toward us, I figure," Harkin said. "Bouncing off some obstruction, maybe a molecular cloud."

"Big cloud," Ralph said.

"Yeah. Dunno what it could be."

Mysteries. Many of them would never be solved. In the murder of stars, only tattered clues survived.

Harkin was lean and sharp-nosed, of sturdy New England stock. Ralph thought Harkin looked a lot like the jets he studied. His bald head narrowed to a crest, shining as it caught the overhead fluorescents. Harkin was always moving from the control boards of the ganged dishes to the computer screens where images sharpened. Jets moved with their restless energies, but all astronomers got were snapshots. Black holes spewed out their advertisements for around a hundred million years, so Harkin's jet was as old as the dinosaurs. To be an astronomer was to realize one's mayfly nature.

"Hope I haven't gotten you to come all this way for nothing." Harkin brought up on a screen the total file on G369.23-0.82.

He recognized one image from the first observations a year before, when Feretti from Bologna had picked it up in the background of some jet observations. Over the last three years came others, Andy's and Ralph's extensive maps, polarization data files, the works. All digital; nobody kept much on paper anymore.

"Y'see here?" An observing schedule sheet. "The times when G369.23-0.82 is in the sky, I've only got three slices when we're reconfiguring the dishes. Each maybe half an hour long."

"Damn!" Ralph grimaced. "Not much."

"No." Harkin looked a bit sheepish. "When I made that promise to you, well, I thought better of it the next day. But you'd already left for your flight in Geneva."

"*Vin Local*," Ralph said. "It hit me pretty hard, too."

Harkin nodded at his feet, embarrassed. "Uh, okay, so about G369.23-0.82—"

"I call it the Bullet. Easier than G369.23-0.82."

"Oh yeah." Harkin shrugged. "You said that in Briancon."

But what could he do in half hour fragments? He was thinking this through when Harkin asked the same question.

"Andy pretty well showed there was no pulsar beam," Harkin said helpfully, "so . . .?"

Ralph thumbed through his notes. "Can I get good clarity at the front end? The Bullet's bow shock?"

Harkin shook his head, looking disappointed. "No way, with so little observing time. Look, you said you had some out of the box ideas."

Ralph thought furiously. "How about the Bullet's tail, then?"

Harkin looked doubtful, scribbled a few numbers on a yellow lined pad. "Nope. It's not that luminous. The wake dies off pretty fast behind. Confusion limited. You'd get nothing but noise."

Ralph pointed. "There's a star we can see at the edge of the Bullet."

Harkin nodded. "A foreground star. Might be useful in narrowing down how far away it is."

"The usual methods say it's a long way off, maybe halfway across the galaxy."

"Um. Okay, leave that for later."

Ralph searched his mind. "Andy looked for pulses in what range?" He flipped through his notes from Briancon. "Short ones, yes—and nothing slower than a ten-second period."

Harkin nodded. "This is a young neutron star. It'll be spinning fast."

Ralph hated looking like an amateur in Harkin's eyes, but he held his gaze firmly. "Maybe. Unless plowing through all that gas slows it faster."

Harkin raised his eyebrows skeptically. "The Mouse didn't slow down. It's spinning at about a tenth of a second period. Yusef-Zadeh and those guys say it's maybe twenty-five thousand years old."

Twenty-five thousand years was quite young for a pulsar. The Mouse pulsar was a sphere of nothing but neutrons, a solar mass packed into a ball as small as San Francisco, spinning around ten times a second. In the radio-telescope maps that lighthouse beam came, from a dot at the very tip of a snout, with a bulging body right behind, and a long, thin tail: mousy. The Mouse discovery had set the paradigm. But just being first didn't mean it was typical.

Ralph set his jaw, flying on instinct—"Let's see."

So in the half hours when the dish team, instructed by Harkin, was slewing the big white antennas around, chugging them along the railroad tracks to new positions, and getting them set for another hours-long observation—in those wedges, Ralph worked furiously. With Harkin overseeing the complex hand-offs, he could command two or three dishes. For best use of this squeezed schedule, he figured to operate in the medium microwave band, around 1 or 2 Ghz. They had been getting some interference the last few days, Harkin said, maybe from cell phone traffic, even out here in the middle of a high desert plateau—but that interference was down around 1 Ghz, safely far below in frequency. He need not worry about callers ringing each other up every few minutes and screwing up his data.

He took data carefully, in a way biased for looking at very long time fluctuations. In pulsar theory, a neutron star was in advanced old age by the time the period of its rotation, and so the sweeping of its lighthouse beam, was a second long. They harnessed their rotation to spew out their blaring radiation—live fast, die young. Teenage agonies. Only they didn't leave beautiful corpses—they *were* corpses. Pulsars should fade away for even slower rates; only a handful were known out in the two or three minute zone.

So this search was pretty hopeless. But it was all he could think of, given the half hour limit.

He was dragging by the time he got his third half hour. The dish team was crisp, efficient, but the long observing runs between his slices got tedious. So he used their ample computing resources to process his own data—big files of numbers that the VLA software devoured as he watched the screens. Harkin's software had fractured the Bullet signal into bins, looking for structure in time. It caressed every incoming microwave, looking for repeating patterns. The computers ran for hours.

Hash, most of it. But then . . .

"What's that?" He pointed to a blip that stuck up in the noisy field. The screen before him and Harkin was patchy, a blizzard of harmonics that met and clashed and faded. But as the Bullet data ran and filtered, a peak persisted.

Harkin frowned. "Some pattern repeating in the microwaves." He worked the data, peering at shifting patterns on the screen. "Period of . . . lessee . . . forty-seven seconds. Pretty long for a young pulsar."

"That's got to be wrong. Much too long."

In astronomy it paid to be a skeptic about your work. Everybody would be ready to pounce on an error. Joe Weber made some false detections of gravitational waves, using methods he invented. His reputation never fully recovered, despite being a brilliant, original scientist.

Harkin's face stiffened. "I don't care. That's what it is."

"Got to be wrong."

"Damn it, Ralph, I know my own codes."

"Let's look hard at this."

Another few hours showed that it wasn't wrong.

"Okay—funny, but it's real." Ralph thought, rubbing his eyes. "So let's look at the pulse itself."

Only there wasn't one. The pattern didn't spread over a broad frequency band. Instead, it was there in the 11 gigaHertz range, sharp and clear—and no other peaks at all.

"That's not a pulsar," Harkin said.

Ralph felt his pulse quicken. "A repeating brightness. From something peaking out of the noise and coming around to our point of view every forty-seven seconds."

"Damn funny." Harkin looked worried. "Hope it's not a defect in the codes."

Ralph hadn't thought of that. "But these are the best filter codes in the world."

Harkin grinned, brown face rumpling like leather. "More compliments like that and you'll turn my pretty little head."

So Harkin spent two hours in deep scrutiny of the VLA data processing software—and came up empty. Ralph didn't mind because it gave him to think. He took a break partway through—Harkin was not the sort to take breaks at all—and watched a Cubs game with some of the engineers in the Operations room. They had a dish down for repairs but it was good enough to tip toward the horizon and pick up the local broadcast from Chicago. The Cubs weren't on any national 'cast and two of the guys came from UC, where the C was for Chicago. The Cubs lost but they did it well, so when he went back Ralph felt relaxed. He had also had an idea. Or maybe half of one.

"What if it's lots bigger than a neutron star?" he asked Harkin, who hadn't moved from his swivel chair in front of the six-screen display.

"Then what's the energy source?"

"I dunno. Point is, maybe it's something more ordinary, but still moving fast."

"Like what?"

"Say, a white dwarf—but a really old, dead one."

"So we can't see it in the visible?" The Hubble telescope had already checked at the Bullet location and seen nothing.

"Ejected from some stellar system, moving fast, but not a neutron star—maybe?"

Harkin looked skeptical. "Um. Have to think about it. But . . . what makes the relativistic electrons, to give us the microwaves?"

That one was harder to figure. Elderly white dwarfs couldn't make the electrons, certainly. Ralph paused and said, "Look, I don't know. And I have to get back to UCI for classes. Can I get some more time wedged in between your reconfigs?"

Harkin looked skeptical. "I'll have to see."

"Can you just send the results to me, when you can find some time?"

"You can process it yourself?"

"Give me the software and, yeah, sure."

Harkin shrugged. "That forty-seven second thing is damn funny. So . . . okay, I suppose . . ."

"Great!" Ralph was tired but he at least had his hand in the game. Wherever it led.

Ralph spent hours the next day learning the filter codes, tip-toeing through the labyrinth of Harkin's methods. Many thought Harkin was the best big-dish observer in the world, playing the electronics like a violin.

Harkin was a good teacher because he did not know how to teach. Instead he just showed. With

the showing came stories and examples, some of them even jokes, and some puzzling until Harkin changed a viewing parameter or slid a new note into the song and it all came clear. This way Harkin showed him how to run the programs, to see their results skeptically. From the angular man he had learned to play a radio telescope as wide as a football field like a musical instrument, to know its quirks and deceptions, and to draw from it a truth it did not know. This was science, scrupulous and firm, but doing it was an art. In the end you had to justify every move, every conclusion, but the whole argument slid forward on intuition, like an ice cube skating on its own melt.

"Say, Andy," Ralph said casually into his cell phone, looking out the big windows at New Mexico scrub and the white radio dishes cupped toward the sky. "I'm trying to remember if you guys looked at long periods in your Bullet data. Remember? We talked about it at Briancon."

"Bullet? Oh, G369.23-0.82."

"Right, look, how far out did you go on period?"

A long pause. Ralph thought he could hear street noise. "Hey, catch you at a bad time?"

"No, just walking down Mass Ave., trying to remember. I think we went out to around thirty second periods. Didn't see a damn thing."

"Oh, great. I've been looking at the Bullet again and my preliminary data shows something that, well, I thought I'd check with you."

"Wow." Another pause. "Uh, how slow?"

Ralph said cautiously, "Very. Uh, we're still analyzing the data."

"A really old pulsar, then. I didn't think they could still radiate when they were old."

"I didn't, either. They're not supposed to." Ralph reminded himself to check with the theorists.

"Then no wonder we couldn't find its supernova remnant. That's faded, or far away."

"Funny, isn't it, that we can pick up such weak signals from a pulsar that's halfway across the galaxy? Though it has been getting brighter, I noticed."

Andy sounded puzzled. "Yeah, funny. Brighter, um. I wonder if it shows up in any earlier survey."

"Yeah, well I thought I'd let you know."

Andy said slowly, "You know, I may have glimpsed something, but will get back to you."

They exchanged a few personal phrases and Ralph signed off.

Harkin was working the screens but turned with eyebrows raised.

Ralph said, "Bingo."

As soon as Irene came into the coffee shop and they kissed in greeting, he could see the curiosity in her eyes. She was stunning in her clingy blue dress, while he strutted in his natty suit. He had told her to dress up and she blinked rapidly, expectant. "Where are we going tonight?"

He said, not even sitting down, "Y'know, the only place where I can sing and people don't throw rotten fruit at me is church."

Irene looked startled. "I didn't think you were religious."

"Hey, it's a metaphor. I pay for a place to dance, too, so—let's go. To the Ritz."

Her eyebrows arched in surprise. "What an oblique invitation. Puttin' on the Ritz?"

As they danced on the patio overlooking sunset surfers, he pulled a loose strand of hair aside for her, tucking it behind her ear. She was full of chatter about work. He told her about his work on the Bullet and she was genuinely interested, asking questions. Then she went back to tales of her office intrigues. Sometimes she seemed like a woman who could survive on gossip alone. He let it run down a bit and then said, as the band struck up "Begin the Beguine," "I need more time."

She stiffened. "To contemplate the abyss of the M word?"

"Yes. I'm hot on the trail of something."

"You didn't call Herb Linzfield, either, did you." Not a question.

"No."

"Oh, fine."

He pulled back and gazed at her lips. Lush, as always, but twisted askew and scrunched. He knew the tone. *Fine. Yeah, okay, right. Fine. Go. Leave. See. If. I. Care.*

He settled into it then, the rhythm: of thickets of detail, and of beauty coming at you, unannounced. You had to get inside the drumroll of data, hearing the software symphonies, shaped so that human eyes could make some hominid sense of it. These color-coded encrustations showed what was unseeable by the mere human eye—the colors of the microwaves. Dry numbers cloaked this beauty, hid the ferocious glory.

When you thought about it, he thought, the wavelengths they were "seeing" with, through the enormous dish eyes, were the size of their fingers. The waves came oscillating across the blunt light years, messages out of ancient time. They slapped down on the hard metal of a radio dish and excited electrons that had been waiting there to be invited into the dance. The billions of electrons trembled and sang and their answering oscillations called forth capturing echoes in the circuits erected by men and women. More electrons joined the rising currents, fashioned by the zeros and ones of computers into something no one had ever seen: pictures for eyes the size of mountains. These visions had never existed in the universe. They were implied by the waves, but it took intelligence to pull them out of the vagrant sizzle of radio waves, the passing microwave blizzard all life lived in but had never seen. Stories, really, or so their chimpanzee minds made of it all. Snapshots. But filling in the plot was up to them.

In the long hours he realized that, when you narrow your search techniques tuned to pick up exactly what you're looking for, there's a danger. The phrase astronomers use for that is, "I wouldn't have seen it if I hadn't believed it."

The paper on the astro-ph web site was brief, quick, three pages.

Ralph stared at it, open-mouthed, for minutes. He read it over twice. Then he called Harkin. "Andy's group is claiming a forty-seven second peak in their data."

"Damn."

"He said before that they didn't look out that far in period."

"So he went back and looked again."

"This is stealing." Ralph was still reeling, wondering where to go with this.

"You can pull a lot out of the noise when you know what to look for."

Whoosh— He exhaled, still stunned. "Yeah, I guess."

"He scooped us," Harkin said flatly.

"He's up for tenure."

Harkin laughed dryly. "That's Harvard for you." A long pause, then he rasped, "But what *is* the goddamn thing?"

The knock on his apartment door took him by surprise. It was Irene, eyes intent and mouth askew. "It's like I'm off your radar screen in one swift sweep."

"I'm . . ."

"Working. Too much—for what you get."

"Y'know," he managed, "art and science aren't a lot different. Sometimes. Takes concentration."

"Art," she said, "is answers to which there are no questions."

He blinked. "That sounds like a quotation."

"No, that was *me*."

"Uh, oh."

"So you want a quick slam bam, thank you Sam?"

"Well, since you put it that way."

An hour later she leaned up on an elbow and said, "News."

He blinked at her sleepily "Uh . . . what?"

"I'm late. Two weeks."

"Uh. Oh." An anvil out of a clear blue sky.

"We should talk about—"

"Hoo boy."

"—what to do."

"Is that unusual for you?" First, get some data.

"One week is tops for me." She shaped her mouth into an astonished O. "Was."

"You were using . . . we were . . ."

"The pill has a small failure rate, but . . ."

"Not zero. And you didn't forget one?"

"No."

Long silence. "How do you feel about it?" Always a good way to buy time while your mind swirled around.

"I'm thirty-two. It's getting to be time."

"And then there's us."

"Us." She gave him a long, soulful look and flopped back down, staring at the ceiling, blinking.

He ventured, "How do you feel about . . ."

"Abortion?"

She had seen it coming. "Yes."

"I'm easy, if it's necessary." Back up on the elbow, looking at him "Is it?"

"Look, I could use some time to think about this."

She nodded, mouth aslant. "So could I."

Ralph had asked the Bologna group—through his old friends, the two Fantis—to take a scan of the location. They put the Italian 'scopes on the region and processed the data and sent it by Internet. It was waiting the next morning, forty-seven megs as a zipped attachment. He opened the attachment with a skittering anxiety. The Bologna group was first rate, their work solid.

On an Internet visual phone call he asked, "Roberto, what's this? It can't be the object I'm studying. It's a mess."

On-screen, Roberto looked puzzled, forehead creased. "We wondered about that, yes. I can improve the resolution in a few days. We could very well clear up features with more observing time."

"Yes, could you? This has got to be wrong."

A head-bob. "We will look again, yes."

Forty-seven seconds . . .

The chairman kept talking but Ralph was looking out his window at the eucalyptus weaving in the vagrant coastal winds. Gossian was listing hurdles to meet before Ralph would be "close to tenure"—two federal grants, placing his Ph.D. students in good jobs, more papers. All to get done in a few months. The words ran by, he could hear them, but he had gone into that place he knew and always welcomed, where his own faith dwelled. The excitement came up in him, first stirrings, the instinct burning, his own interior state of grace. The idea swarmed up thick in his nostrils, he blinked—

"Ralph? You listening?"

"Oh, uh, yeah." *But not to you, no.*

He came into the physics building, folding his umbrella from a passing rain storm, distracted. There were black umbrellas stacked around like a covey of drunken crows. His cell phone cawed.

Harkin said, "Thought I'd let you know there's not much time I can use coming up. There's an older image, but I haven't cleaned it up yet."

"I'd appreciate anything at all."

"I can maybe try for a new image tomorrow, but I'm pretty damn busy. There's a little slot of time while the Array reconfigures."

"I sent you the Fantis' map—"

"Yeah, gotta be wrong. No source can change that much so fast."

Ralph agreed but added, "Uh, but we should still check. The Fantis are very good."

"If I have time," Harkin said edgily.

Between classes and committees and the long hours running the filter codes, he completely forgot about their dinner date. So at 9 P.M. his office phone rang and it was Irene. He made his apologies, distracted, fretting. He knew he looked tired, his forehead gray and lined, and he asked, "No . . . change?"

"No."

They sat in silence and finally he told her about the Fanti map.

She brightened audibly, glad to have some distraction. "These things can change, can't they?"

"Sure, but so fast! They're big, the whole tail alone is maybe light years long."

"But you said the map is all different, blurred."

"The whole object, yes."

"So maybe it's just a mistake?"

"Could be, but the Fantis are really good . . ."

"Could we get together later?"

He sighed. "I want to look at this some more." To her silence he added more apologies, ending with, "I don't want to lose you."

"Then remember where you put me."

The night wore on.

Wouldn't have seen it if I hadn't believed it.

The error, he saw, might well lie in their assumptions. In his.

It had to be a runaway neutron star. It had to be a long way off, halfway across the galaxy. They knew that because the fraying of the signal said there was a lot of plasma in the way.

His assumptions, yes. It had to be.

Perfectly reasonable. Perfectly wrong?

He had used up a lot of his choppy VLA time studying the oblong shroud of a once-proud star, seen through the edge of the Bullet. It was fuzzy with the debris of gas it threw off, a dying sun. In turn, he could look at the obscuration—how much the emission lines were absorbed and scattered by intervening dust, gas and plasma. Such telltales were the only reliable way to tell if a radio image came from far away or nearby. It was tricky, using such wobbly images, glimpsed through an interstellar fog.

What if there was a lot more than they thought, of the dense plasma in between their big-eyed dishes and the object?

Then they would get the distance wrong. Just a like a thick cloud between you and the sun. Dispersing the image, blurring it beyond recognition—but the sun was, on the interstellar scale, still quite

close.

Maybe this thing was nearer, much nearer.

Then it would have to be surrounded by an unusually dense plasma—the cloud of ionized particles that it made, pushing on hard through the interstellar night. Could it have ionized much more of the gas it moved through, than the usual calculations said? How? Why?

But what *was* the goddamn thing?

He blinked at the digital arrays he had summoned up, through a thicket of image and spectral processors. The blurred outlines of the old star were a few pixels, and nearby was an old, tattered curve of a supernova remnant—an ancient spherical tombstone of a dead sun. The lines had suffered a lot of loss on their way through the tail of the Bullet. From this he could estimate the total plasma density near the Bullet itself.

Working through the calculation, he felt a cold sensation creep into him, banishing all background noise. He turned the idea over, feeling its shape, probing it. Excitement came, tingling but laced with caution.

Andy had said, *I wonder if it shows up in any earlier survey.*

So Ralph looked. On an Italian radio map of the region done eleven years before there was a slight scratch very near the Bullet location. But it was faint, an order of magnitude below the luminosity he was seeing now. Maybe some error in calibration? But a detection, yes.

He had found it because it was bright now. Hitting a lot of interstellar plasma, maybe, lighting up?

Ralph called Harkin to fill him in on this and the Fanti map, but got an answering machine. He summed up briefly and went off to teach a mechanics class.

Harkin said on his voice mail, "Ralph, I just sent you that map I made two days ago, while I had some side time on a four point eight GHz observation."

"Great, thanks!" he called out before he realized Harkin couldn't hear him. So he called and when Harkin picked up, without even a hello, he said, "Is it like the Fanti map?"

"Not at all."

"Their work was pretty recent."

"Yeah, and what I'm sending you is earlier than theirs. I figure they screwed up their processing."

"They're pretty careful . . ."

"This one I'm sending, it sure looks some different from what we got before. Kinda pregnant with possibility."

The word, *pregnant*, stopped him for a heartbeat. When his attention returned, Harkin's voice was saying, "—I tried that forty-seven second period filter and it didn't work. No signal this time. Ran it twice. Don't know what's going on here."

The E-mail attachment map was still more odd.

Low in detail, because Harkin had not much observing time, but clear enough. The Bullet was frayed, longer, with new features. Plunging on, the Bullet was meeting a fresh environment, perhaps.

But this was from two days ago.

The Bologna map was only 14 hours old.

He looked back at the messy Bologna view and wondered how this older picture could possibly fit with the 4.8 GHz map. Had the Fantis made some mistake?

"Can you get me a snapshot right now?" Ralph asked. "It's important."

He listened to the silence for a long moment before Harkin said, "I've got a long run on right now. Can't it wait?"

"The Fantis at Bologna, they're standing by that different looking map. Pretty strange."

"Ummm, well . . ."

"Can you get me just a few minutes? Maybe in the download interval—"

"Hey, buddy, I'll try, but—"

"I'll understand," but Ralph knew he wouldn't.

His home voice mail from Irene said, fast and with rising voice tone, "Do onto others, right? So, if you're not that into me, I can stop returning your calls, E-mails—not that there are any—and anyway, blocking is so dodge ball in sixth grade, right? I'll initiate the phase-out, you'll get the lead-footed hint, and that way, you can assume the worst of me and still feel good about yourself. You can think, hey, she's not over her past. Social climber. Shallow business mind. Workaholic, maybe. Oh, no, that's you, right? And you'll have a wonderful imitation life."

A long pause, time's nearly up, and she gasped, paused, then: "Okay, so maybe this isn't the best idea."

He sat, deer in the headlights, and played it over.

They were close, she was wonderful, yes.

He loved her, sure, and he had always believed that was all it took.

But he might not have a job here inside a year.

And he couldn't think of anything but the Bullet.

While she was wondering if she was going to be a mother.

Though, he realized, she had not really said what she thought about it all.

He had no idea what to say. At a talk last year about Einstein, the speaker quoted Einstein's wife's laconic comment, that sometimes when the great man was working on a problem he would not speak to anyone for days. She had left him, of course. But now Ralph could feel a certain kinship with that legendary genius. Then he told himself he was being fatuous, equating this experience . . .

Still, he let it all slide for now.

His eighth cup of coffee tasted bitter. He bit into a donut for a sugar jolt. When had he eaten last?

He took a deep breath and let it out to clear his head.

He was sure of his work now, the process—but still confused.

The earlier dispersion measure was wrong. That was clear from the broadening of the pulses he had just measured. Andy and everybody else had used the usual interstellar density numbers to get the Bullet's distance. That had worked out to about five thousand light years away.

From his pulse measurements he could show that the Bullet was much closer, about thirty light years away. They were seeing it through the ionized and compressed plasma ahead and around the . . . what? *Was* it a neutron star at all?

And a further consequence—if the Bullet was so close, it was also much smaller, and less intrinsically luminous.

While the plume was huge, the Bullet itself—the unresolved circle at the center of it all, in Andy's high-resolution map—need only be a few hundred kilometers long. Or much less; that was just an upper limit.

Suppose that was the answer, that it was much closer. Then its energy output—judging that it was about equal to the radiated power—was much less, too. He jotted down some numbers. The object was emitting power comparable to a nation's on Earth. Ten gigaWatts or so.

Far, far below the usual radiated energies for runaway neutron stars.

He stared into space, mind whirling.

And the forty-seven second period . . .

He worked out that if the object was rotating and had an acceleration of half an Earth gravity at its edge, it was about thirty meters across.

Reasonable.

But why was the shape of its radio image changing so quickly? In days, not the years typical of big astronomical objects. *Days*.

Apprehensively he opened the E-mail from Irene.

You're off the hook!

So am I.

Got my period. False alarm.

Taught us a lot, though. Me, anyway. I learned the thoroughly useful information (data, to you) that you're an asshole. Bye.

He sat back and let the relief flood through him.

You're off the hook. Great.

False alarm. Whoosh!

And asshole. Um.

But . . .

Was he about to do the same thing she had done? Get excited about nothing much?

Ralph came into his office, tossed his lecture notes onto the messy desk, and slumped in his chair. The lecture had not gone well. He couldn't seem to focus. Should he keep his distance from Irene for a while, let her cool off? What did he really want, there?

Too much happening at once. The phone rang.

Harkin said, without even a hello, "I squeezed in some extra observing time. The image is on the way by E-mail."

"You sound kind of tired."

"More like . . . confused." He hung up.

It was there in the E-mail.

Ralph stared at the image a long time. It was much brighter than before, a huge outpouring of energy.

His mind seethed. The Fanti result, and now this. Harkin's 4.8 Ghz map was earlier than either of these, so it didn't contradict either the Fantis or this. A time sequence of something changing fast—in days, in hours.

This was no neutron star.

It was smaller, nearer, and they had watched it go to hell.

He leaned over his desk, letting the ideas flood over him. *Whoosh*.

Irene looked dazed. "You're kidding."

"No. I know we've got a lot to talk through, but—"

"You bet."

"I didn't send you that E-mail just to get you to meet me." Ralph bit his lip and felt the room whirl around.

"What you wrote," she said wonderingly. "It's a . . . star ship?"

"Was. It got into trouble of some kind these last few days. That's why the wake behind it—" he tapped the Fantis' image "—got longer. Then, hours later, it got turbulent, and—it exploded."

She sipped her coffee. "This is . . . was . . . light years away?"

"Yes, and headed somewhere else. It was sending out a regular beamed transmission, one that swept around as the ship rotated, every forty-seven seconds."

Her eyes widened. "You're sure?"

"Let's say it's a working hypothesis."

"Look, you're tired, maybe put this aside before jumping to conclusions."

He gazed at her and saw the lines tightened around her mouth. "You've been through a lot yourself. I'm sorry."

She managed a brave, thin smile. "It tore me up. I do want a child."

He held his breath, then went ahead. "So . . . so do I."

"Really?" They had discussed this before but her eyelids fluttered in surprise.

"Yes." He paused, sucked in a long breath, and said, "With you."

"Really?" She closed her eyes a long time. "I . . . always imagined this."

He grinned. "Me too. Time to do it."

"Yes?"

"Yes." *Whoosh.*

They talked on for some moments, ordered drinks to celebrate. Smiles, goofy eyes, minds whirling.

Then, without saying anything, they somehow knew that they had said enough for now. Some things should not be pestered, just let be.

They sat smiling at each other and in a soft sigh she said, "You're worried. About . . ."

Ralph nodded. How to tell her that this seemed pretty clear to him and to Harkin, but it was big, gaudy trouble in the making. "It violates a basic assumption we always make, that everything in the night sky is natural."

"Yeah, so?"

"The astronomy community isn't like Hollywood, y'know. It's more like . . . a priesthood."

He sipped his coffee and stared out the window. An airplane's wing lights winked as it coasted down in the distance toward the airport. Everybody had seen airplanes, so seeing them in the sky meant nothing. Not so for the ramscoop ship implied by his radio maps.

There would be rampant skepticism. Science's standards were austere, and who would have it differently? The angles of attack lived in his hands, and he now faced the long labor of calling forth data and calculations. To advance the idea would take strict logic, entertaining all other ideas fairly. Take two steps forward, one back, comparing and weighing and contrasting—the data always leading the skeptical mind. It was the grand dance, the gavotte of reason, ever-mindful of the eternal possibility that one was wrong.

Still . . . When serendipity strikes . . . let it. Then seize it.

"You need some sleep." Her eyes crinkled with concern. "Come home with me."

He felt a gush of warm happiness. She was here with him and together they could face the long battle to come.

"Y'know, this is going to get nasty. Look what happened to Carl Sagan when he just argued there *might* be intelligent life elsewhere."

"You think it will be that hard to convince people?"

"Look at it this way. Facing up to the limits of our knowledge, to the enormity of our ignorance, is

an acquired skill—to put it mildly. People want certainty."

He thought, *If we don't realize where the shoreline of reasonably well established scientific theory ends, and where the titanic sea of undiscovered truth begins, how can we possibly hope to measure our progress?*

Irene frowned. Somehow, after long knowledge of her, he saw that she was glad of this chance to talk about something larger than themselves. She said slowly, "But . . . why is it that your greatest geniuses—the ones you talk about, Hawking, Feynman, Newton—humbly concede how pitifully limited our reach is?"

"That's why they're great," he said wryly. *And the smaller spirits noisily proclaim the certainty of their conclusions. Well, here comes a lot of dissent, doubt, and skepticism.*

"And now that ship is gone. We learned about them by watching them die."

She stared at him. "I wonder . . . how many?"

"It was a big, powerful ship. It probably made the plasma ahead of it somehow. Then with magnetic fields it scooped up that plasma and cooked it for energy. Then shot it out the back for propulsion. Think of it as like a jet plane, a ramscoop. Maybe it was braking, using magnetic fields—I dunno."

"Carrying passengers?"

"I . . . hadn't thought of that."

"How big is it? . . . was it?"

"Maybe like . . . the *Titanic*."

She blinked. "That many people."

"Something like people. Going to a new home."

"Maybe to . . . here?"

He blinked, his mind cottony. "No, it was in the plane of the sky. Otherwise we'd have seen it as a blob, head on, no tail. Headed somewhere fairly near, though."

She sat back, gazing at him with an expression he had not seen before. "This will be in the papers, won't it." Not a question.

"Afraid so." He managed a rueful smile. "Maybe I'll even get more space in *National Enquirer* than Andy did."

She laughed, a tinkling sound he liked so much.

But then the weight of it all descended on him. *So much to do . . .* "I'll have to look at your idea, that they were headed here. At least we can maybe backtrack, find where they came from."

"And look at the earlier maps, data?" she ventured, her lip trembling. "From before . . ."

"They cracked up. All that life, gone." Then he understood her pale, tenuous look. *Things living, then not.* She nodded, said nothing.

He reached out and took her hand. A long moment passed and he had no way to end it but went on anyway. "The SETI people could jump on this. Backtrack this ship. They can listen to the home star's emissions . . ."

Irene smiled without humor. "And we can send them a message. Condolences."

"Yeah." The room had stopped whirling and she reached out to take his hand.

"Come on."

As he got up wearily, Ralph saw that he was going to have to fight for this version of events. There would always be Andys who would triangulate their way to advantage. And the chairman, Gossian . . .

Trying for tenure—supposedly a cool, analytic process—in the shouting match of a heated, public dispute, a howling media firestorm—that was almost a contradiction in terms. But this, too, was what science was about. His career might survive all that was to come, and it might not—but did that matter, standing here on the shores of the titanic ocean he had peered across?