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# *Epicycle*

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*A theory doesn't have to describe the real world to be true—and helpful!*

"Thar she blows! Hot and straight!"

I could hear Jenkins' reedy voice reverberate inside the control module, almost enough to restore the timbre muffled by his work helmet. No trick of acoustics could correct for his garbled slang, though. Kids these days weren't even taught that Connecticut once had thriving seaports—I guess you can't expect them to distinguish between the jargon of a whaler and a submariner.

It was the sailors who owned the stars in those days. If you don't believe me, take a look at a constellation map of the Southern Hemisphere. People bold enough to venture into strange waters didn't hesitate to write their words all over the sky. No ancient gods for them—the Clock and the Telescope helped them find their way. Sailors were a pretty good bunch, considering they were all men.

But now the NASA career types are starting to call themselves a navy (Congress already gave them the stars). Boys like Jenkins and Scott playing grownup. I hear the latest style at Skyhook is wearing one tiny gold earring, pirate fashion," and smoking tobacco. Machismo is alive and flourishing in orbit, my friends.

The Orbital Booster System was surely near burnout and separating rapidly. Even on attitude jets alone, those pigs could rack up a respectable delta-V in pretty short order. Not that I could see all this, mind you. Regulations required that control module ports be protected from pitting, whenever possible, during close maneuvers. You can bet my two little helpers would do all the "protecting" the law allowed.

They wouldn't even let me outside! My one and only trip into space, aborted before it really began, and those acned Tom Corbetts lacked the decency to let me stick my head out the hatch. Regulations again, of course. Let me tell you I'd had it up to here by then with NASA's damned regulations. I wanted to stomp my feet and bawl, but naturally I couldn't do either one.

The stomping was physically impossible, as you can well imagine; but the crying was equally forbidden, even though it violated no physical law. Gallant explorers of the spaceways never cry, you see. They are brave and tough. Men, that is. Manure.

Shuffling and clanging noises. One of the two was entering the lock. I assumed the fireworks were over, such as they were. Rockets aren't very impressive in vacuum—they just show a sort of pointy glow. Or so I'm told. Still, I wish I could

have watched.

The inner door swung open and a red-banded bubble head fluttered out. I recognized the species as a NASA lieutenant-I could tell it was Jenkins by his markings. He closed the hatch and started the cycle for Scott before unsuiting. I tried to look as if I hadn't been trying not to cry.

Frizzy hair tufting out in all directions, eyes somehow never quite in focus. Lieutenant Jenkins was the archetypal mathematician. Everything was right angles and planes in his young world. I'm certain he regarded the merciless vacuum around us as just a satisfyingly zero nothing. Me, I was a troublesome curvilinear boundary condition in his otherwise perfect world.

"OBS is disposed of, ma'm," he said, as if he suddenly remembered I was there. You'd think he'd just interrupted his homework to take out the garbage for mommy. I'd offered to compute a suitable disposal maneuver for the malfunctioning booster, in fact, but Jenkins had reacted with hurt pride and horror. That was man's work.

"Very good," I replied as offhandedly as I could muster. It was somehow necessary to keep up the pretense that I was commanding the mission, even though my wishes were overruled at every turn.

More clanging noises. The next time that lock cycled, I would be going through it into Skyhook. Two days from then I'd be swooping into Houston, leaving behind a hundred meters of unexposed film and a quarter century of wasted dreams. My eyes began to burn—something in the air—so I studied the communications console intently while Scott entered.

They had finished stowing their working gear by the time I looked up. Scott already had his comic book out. He was unbelievable. We used to joke about the illiterate engineers at school, but the truth was they could ace any liberal arts course they set their minds to, and we knew it. They just didn't have much truck with anything they couldn't apply.

But Scott, I think, was truly semi-literate. You could see his lips move slightly as the balloons and simple figures drifted by. The scan rate was set at MIN, of course, and he still keyed HOLD from time to time. Put a flattop on that blocky head and a varsity letter on his tunic and you could lose him in any of the old football factories.

In fact, I wish you would.

I resigned myself to twenty-five hours of inaction amid poor company. Once the bad news was in, that we'd have to ditch the OBS and return, I'd promptly computed a Hohmann transfer to the emergency backup booster orbiting at eighteen thousand kilometers. We could have left ten and a half hours after separation—why hang around with nothing to do but float and stare at each other? But NASA had to do it the company way, as usual, and burn computer time to verify my calculations.

They couldn't admit I was right, even though it was common knowledge that I could practically do orbit calculations in my head. So they set up a flight plan for one synodic period later, muttering something about perturbation corrections. Result, we had to rot an extra fourteen-odd hours in synchronous orbit.

We really didn't have to abort. I mean the control module had a self-contained life-support system and enough juice in her jets to handle alignment maneuvers (more than enough, alas!). Skyhook could have let us do my experiment and come get us later. There was precedent for that.

But those damned regulations got me again. As long as a spacecraft has status critical and enough thrust to make it to safety, rules say it's gotta come home to poppa. Pronto. We could just make it to our backup on a minimum energy-transfer orbit inside (regulation) tolerances—provided we did no station-keeping maneuvers beforehand. So a perfectly viable experiment had to be scrubbed in the interest of "safety." Bah!

I couldn't argue with the "condition critical" designation. A stuck damper rod in an OBS pile can lead to a lot of radiation that I'd rather not have around, thank you. It wouldn't go boom, but in the six or seven days it spent slugging down, the pile would use up a year's supply of fissionables. And that makes for a lot of neutrons.

(Of course, all it needed was a well-placed kick to break the rod loose, and I knew exactly where to aim. The radiation hadn't built to an intolerable level yet. I won't repeat to you what Skyhook said when I offered to go back and fix it. My thesis adviser said something similar when I repaired a hundred kilovolt Cockroft Walton on the fly with a bobby pin at three a.m. one morning. When the data's coming in, a grad student will do anything to keep it coming.)

But we'd disposed of the damned booster and we'd already reached station—and the Comsat tender was due out in three weeks and could pick us up with very little extra fuel expenditure. Our life support was good for five weeks. It seemed only natural to save a ten-million-dollar investment and let me do my thing. Or so it seemed to me.

I reasoned and argued with Skyhook for three hours. I wheedled and pleaded. But I knew it was a losing battle. Being the first civilian woman to make it into space, I'd already used up all the good will I could scrounge. Those NASA cowboys weren't about to leave a lady in distress, even if she liked it there.

So there sat I within five meters of a lifelong goal, hamstrung by fate and a sexist bureaucracy. Jenkins was playing with the calculator—chess, it looked like—and Scott was still wrapped up in the adventures of Aquaman or some-such. Real fun people. I began to brood.

It all started when I was in college. Well anyway, that's when my plan crystallized; I'm sure you could trace it back to my toilet training if you tried hard enough. But that was when I started getting ready for space.

You see, I was always interested in astronomy. Daddy bought me a refractor when I was nine and I'd built my first Newtonian before I'd been kissed. A crisp, winter night would keep me enthralled for hours. Long after my brothers were driven in by the numbing cold, I'd be happily thumbing through Norton's for another binary star.

"Margo, are you still out there?" was my mother's standard midnight plea. And, "Don't you ever sleep?" when she caught me out before dawn. But she let me have my way, and I flourished under the stars.

I picked a college on the basis of its optics, two ten-inch reflectors and a sixteen-inch Cassegrain; but college came through with three delightful surprises—astrophysics, computers, and men. Those have been my principal loves ever since (though not always in that order), and wellsprings of endless joy and grief. But I'm forgetting about my plan.

Astrology was having a renaissance about then, and the charlatans were really cleaning up. One of the cuter of these frauds, an English major in real life, asked me to help him with his math (he couldn't read an ephemeris the same way twice to save his soul). So one thing led to another and I ended up writing a computer program to cast horoscopes.

Not the numerology garbage, mind you. I just placed the planets in the houses and left the interpretation up to him. I got ten bucks rakeoff from his twenty-five-dollar fee and kept a clear conscience. Writing the program was good exercise and besides, he really was cute.

(After twenty years of haggling with university and government committees, I have come to regret that early self-righteousness. I could have used the practice in duplicity and doubletalk, not to mention the extra fifteen dollars!)

But there I was at the computer console, one cloudy night, when the idea sprouted. Sooner or later the space program would have to open up to civilian researchers, much as the national labs did to help justify their continued existence. It would take a good reputation to get sent into orbit, plus an experiment that needed expert on-site tending. I've never been handicapped by false modesty, so I knew even then I could meet both those requirements in time.

Time was the dominant variable, as it so often is in astronomy. By guess and by golly I settled on the early 1980's as the politically ripest time. That would put me in my forties, but then most of the early astronauts were around that age. Physical condition would count for a lot, but I'd always kept pretty trim. I resolved then and there never to miss my daily session in the swimming pool—and except for a hiatus to bear two children I've kept that promise pretty well.

So all right, I was headed for space; when to go was still the question. That was when I had my stroke of genius—I would cast my own horoscope, only in reverse. Forty minutes of eager dialogue with the number cruncher sealed my fate. I would be going into orbit in the spring of 1984.

It was mostly a matter of plotting the elongations of all the planets, that is, how far away from the sun they appear, as a function of time. The Messier objects, galaxies and such, are fairly sparse around Aries (that's where the sun is in late March—sorry if I keep forgetting that not everyone knows his zodiac). So I wanted a favorable arrangement of planets in the spring, if possible.

I hit the jackpot. In the spring of 1984, Venus would be just past greatest

elongation and swinging toward Earth. Mars would be in opposition, about as close as you could ask. All the outer planets would be far enough from conjunction for a good view, and even Mercury had a chance to be seen. So long as the sun didn't get too rowdy, sunspots and all that, I'd be home free.

They say the stars impel but do not compel. In my case that wasn't true. I'd spent the last twenty-five years enjoying life and growing, but I never once lost sight of my target. I won't tell you about all the little triumphs and near disasters along the way (well, maybe just a few). It was proof enough of my perseverance that I kissed my family good-bye and lifted off on schedule—a quarter-century after I set my goal.

And there I sat thirty-five thousand kilometers out in space, having done everything right along the way, thwarted by a damned stick of carbon.

Jenkins was beginning to tire of his chess match, and Scott had long since sacked out. Keeping up with Aquaman can be pretty grueling. I suppose I should have been lapping up the view through the ports, but it was such a poor second to what I really wanted that I didn't have the heart. I made an effort to be sociable.

"Is this your first trip out to synch orbit?" I opened. Most work is done below the Van Aliens, so it was a moderately intelligent question to ask.

"Oh no, ma'm," with a worldly air. Then, suspecting that I might know the truth, "Well, actually, it's my first *orbital* assignment this far out. But my sophomore outing was circumlunar. We got to do an out-and-back to drop off some repeaters." A little warmth had crept into his manner, for the first time since we'd met.

"They let me do the translunar injection," he said with pride, "and they didn't need any course corrections until halfway back."

So that was it. I wonder if he bothered to look down at the Moon as they swung around it.

"You did a pretty accurate job of putting us on station," I added. A little flattery never hurt. "I haven't detected any drift since we got here." Actually, we were fast by twelve kilometers per hour by my measurements, but what the hell.

"I always park on a dime," he preened. Then, in a conspiratorial whisper, "Scott is consistently three-quarters of a second fast on engine shutdown. He beats the automatics every time. Once you learn to correct for systematics like that, it's just a matter of careful navigation." We shared a chuckle.

"I guess engineers never learn to appreciate precision," I opined. Jenkins nodded sagely. "You know, back when I was in school, we used to tell engineer jokes—just like the British jokes people tell now." We also told mathematician jokes, but I didn't mention that.

"In fact, it's kind of funny. This crew, I mean. A mathematician, a physicist and an engineer all in the same situation. That was the format for a lot of the stories."

I hesitated, then decided to take a chance on offending the boy.

"Have you ever heard the theorem that all odd numbers are prime?"

He looked at me suspiciously.

"No, seriously," I hurried on. "If you were to ask a mathematician to test it he might say: 'Let me see, now. One is prime, three is prime, five is prime, seven is prime. Nine? Nine's not prime. Clearly the theorem is false.'"

"But a physicist is more pragmatic. She, I mean he," the slip was calculated, and had the usual effect on a male listener, "might say: 'Let me see, now. One is prime, three is prime, five is prime, seven is prime. Nine? That may be an experimental error—let's go on.'"

Jenkins smiled.

"Eleven is prime, thirteen is prime, fifteen is... Well, that's a lot of data points. The theorem is probably true."

He laughed outright.

"But if you ask an engineer to test the theorem, he might say: 'Let me see, now. One is prime, three is prime, five is prime, seven is prime, nine is prime, eleven is...'"

A guffaw interrupted my narrative, as it always does at that point. I had finally gotten through to part of my crew for the first time.

"That ain't so funny," Scott rumbled like a bear disturbed in mid-hibernation. The laughter must have awakened him. Oh well, win one, lose one. I was back to zero again.

But at least we were talking. I decided to borrow against Jenkins' good will and stick my neck out a little farther. What did I have to lose?

"There's also the story about the mathematician and the engineer who are put across the room from a pretty girl," I began. Both heads were perked. "A booming, hidden voice informs them that they may only cover half the remaining distance to the girl every ten seconds. Then he unleashes a spectacular, lightning bolt against the wall to show that he means business.

"What do they do then? Well, the mathematician just sits down in place, because he knows you must make an infinite number of moves to cross the room under the conditions stated." Jenkins gave a satisfied nod.

"But the 'engineer immediately sets off for the middle of the room. While he is waiting there for his next turn to move, the mathematician calls to him: 'Don't you know you can never get across a room if you're only allowed to cover half the remaining distance each time? Why are you wasting the effort?'

"And the engineer, replies cheerfully: 'Sure, I know I'll never get all the way there. But after a while I'll get close enough!'"

It was Scott's turn to gloat. Jenkins was abashed, but he took it well. This was more like it.

"Gee, it's too bad we have to abort," said Jenkins. "I mean, you must have

worked a long time to get ready for this mission." If only he knew.

"Maybe they'll be able to reschedule you soon, ma'm," Scott ventured. "I hear the waiting list is under two years now." Yes, but time and planets wait for no man. Or woman.

"Maybe," I said with a brave little smile. Actually, I knew I'd be lucky to make orbit ever again. I had to step on a lot of male, egos to get out this once. It was this time or bust, and I had gone bust.

Jenkins swung over to the situation display. "Radiation's down to forty millirems, ma'm," he reported, "and still dropping. At least, we won't be fried alive now that the booster's out of the way."

"There's that to be thankful for, I suppose." It was the most cheerful thing I could think of to say. But I couldn't help adding, "I wish I could have watched the sendoff."

Jenkins caught the reproach, but Scott was his usual thick-skinned self. Relentlessly, he charged in.

"Yeah, that was fun to watch." His eyes shone. "Old Jenkie dropped her straight down the pipe. The OBS was still pointed dead on Earth center even at burnout." Jenkins straightened with pride, ignoring my misery. It was time to change the subject.

A little vindictively, I began, "You know, I just thought of another of those stories we used to tell back in school." Again, my entertainment-starved audience was all ears.

"This is about a hotel, where a mathematician, a physicist and an engineer are spending the night in separate rooms. Late at night a fire breaks out and spreads rapidly to each of the rooms. What do you suppose they do?"

"Well, the engineer wakes up, smelling smoke. He sees the fire and quickly dashes out into the corridor, grabs a fire extinguisher off the wall, runs back to his room and drowns the flames. For safety, he then soaks the walls, ceiling, floor and mattress. Tossing the empty extinguisher aside, he climbs into his soggy bed to get what sleep he can.

"Then the physicist wakes up, smelling smoke. He sees the fire and quickly dashes out into the corridor, grabs a fire extinguisher off the wall, runs back to his room and makes a brief test blast. After a quick calculation, he aims a four-second blast at the base of the fire and puts it out. Setting the extinguisher next to his bed, he lies down to rest and watch for another outbreak."

That was my favorite part.

"Then the mathematician wakes up, smelling smoke. He sees the fire and quickly grabs a pad of paper and a pencil. He makes a number of calculations, glances at the fire, makes a few more. After a while, he wanders into the bathroom, turns on the tap and dabbles his fingers in the water. Looking back at the fire, he smiles and says: 'Aha! A solution exists!' Then he goes back to bed."

Stony silence.

"Well, I think I'll get some sleep," I interjected into, the void. To hell with them.

I hung in my bunk netting, wide awake and contrite. Revenge is fun at first, but it always leaves a bitter aftertaste. My mind automatically went back to my last petty victory, over General Walker.

He sat behind his large walnut desk in his dark paneled office. Leather upholstery and bronze plaques, a cigar humidor perched on one corner of the vast empty desktop. It was a real bastion of masculinity, a holdout in a changing world. I almost felt sorry for him, except that he was getting between me and where I wanted to go.

"But you must be reasonable about this, Mrs. Dixon," he said for the third time.

"My husband's surname is Sachs," I replied tersely. "So the form of address you're groping for is Mrs. Sachs. Professor Dixon is more suitable, however, in the present context. Dr. Dixon or Ms. Dixon are also acceptable.

"And I am being reasonable."

"But we have no facilities for women in space."

"What facilities do you think I'll need that are missing?" He blushed. He actually *blushed*. "I can assure you that there is nothing about the control module that will inconvenience me."

"You might require first aid. Accidents happen. It might be necessary to... to..."

"To undress me? I'm sure any of your men can handle that. And believe me, if I need first aid I'll welcome their assistance." Yeah, and what if I have to lift a heavy weight in zero gravity? Or what if I go home to a sick child from twenty-two thousand miles out?

"Surely there is someone else who can tend your remote gear. A subordinate perhaps." A man, you mean.

"Look, I plan to deploy the biggest interferometer ever sent into space. It's going to need constant tending just to keep it aligned within tolerances, not to mention watching for design bugs. That's not an off-the-shelf item, you know."

Walker started to speak, but I overrode him.

"And I've got three hundred hours of computer time committed at Livermore, just to process enough data in real time to do a meaningful scan. That's why I need to go out to synch orbit, to maintain a continuous wideband link with the big machine. Do you think I could leave that in the hands of an assistant?"

I knew the magnitude of the project didn't particularly impress him; everything that was done in space was grandiose on some scale. But I was sure he'd fall for the personal attention pitch. NASA was overburdened with college kids on work-study programs, passing themselves off as professionals. Government agencies haven't been the same since the Educational Relevance Act was passed.



"I see," said Walker in a tone that said he didn't see at all. "Perhaps this experiment has not been properly thought out, if it requires such delicate attention. It seems to me that a re-evaluation is in order. Perhaps at some later time..."

"General Walker," there were ice daggers in those two words, "this experiment has already been approved by the University Coop, by NASA and by the National Science Foundation. There is only one delicate component in the system and that is me. Your job is neither to approve nor disapprove, but to assist me in preparing for space, to get me there, and to bring me safely home. You are a bus driver."

We glared at each other for long seconds, then his scowl dissolved into a superior smile.

"I may be a bus driver in your eyes, *Professor* Dixon, but I'm a well paid one. And I'm paid, as you so aptly pointed out, to ensure the safety of my passengers. If I don't think you are physically or *psychologically* fit to endure the rigors of spaceflight, then I am empowered and duty-bound to bar you from space."

The old technical competence dodge, in a new guise: we're not really trying to keep her down, we just wouldn't want to see her overreach her capabilities and suffer failure. I stood up.

"Very well. I'm sure Senator Norwood will want to be informed of this change in policy as soon as possible. If you'll excuse me, I have a luncheon date with him."

Weary exasperation replaced the smirk. Walker must have names dropped all over his carpet every week, by everyone with a bone to pick with NASA. At least I had a name to drop that was too big to ignore.

"Now what makes you think there's been a change of policy, Professor Dixon?" He made some effort to sound soothing, anyway. "Perhaps you simply don't have a clear understanding of the terms of the Cooperative Space Research Effort."

Got him!

"And perhaps I do. Jimmy Norwood and I went to school together. I was one of his science advisers when he drafted the COSPARE bill." I started toward the door. "I suggest you reread it, before the Congressional hearings start. You should have no trouble recognizing the sections I wrote." My hand was on the doorknob. "I have a tendency to carelessly split infinitives," I said carefully.

"All right, you win." Just like that. I had to hand it to Walker, he knew when he was licked and didn't waste time bellyaching about it. By the time I'd turned around he had a medium-sized telephone book in his hands.

"You will report in at Houston at your earliest convenience for your pre-training physical." That meant right away, of course. "If you pass that, then you can begin the standard training course. And don't forget this." He shoved the phone book at me.

In one of those ugly U.S. Government Printing Office type fonts, the cover primly advertised, "Uniform Code of Operating Regulations for Civilian and Military Personnel in Space and Space-Related Activities. This manual is required reading for

all personnel." I flipped through it. The print was small.

"Since you will have an independent command, you will be expected to be reasonably familiar with these." His expression was bland as tapioca. "We'll make the OPREGS exam part of your pre-training certification, just to get it out of the way."

I don't remember what else we said, if anything. I came to about, twenty minutes later in the back of a cab, the phone book lying open on my lap. The preface informed me that the manual was the basic reference for a *one year* course in space law for academy seniors. I had four days at the outside to absorb it, and I didn't even have the tutorial text that went with it. Walker's revenge.

I thought about complaining to Jimmy Norwood, then changed my mind. It was one thing to go to him with a clear-cut case of obstructionism, but harassment was a harder thing to prove. I felt a little guilty about bringing his name into this in the first place—it was an act of desperation, employed only after all else had failed.

Not that I would have hesitated to ask Jimmy's help, if it came to that. We were pretty close in college and had remained good friends even after he left astronomy for law and politics. He and I had developed some delightful ways to keep warm in the observatory shack while waiting out time exposures. But that's another' story.

I learned that book. After the first fifty pages I began to detect the underlying philosophy. After the first hundred it was clear that the text was just going into variations on the same basic theme, as government manuals love to do. Once I rewrote it in Backus-Naur Form, the whole body of regulations could be written on two sides of a sheet of paper.

I'm still the only person who ever got a perfect score on the OPREGS final.

The Test of the certification was a breeze. I average a mile a day in the pool, so I have more stamina than most teenagers. The only thing that worried me was my vision - I'm 20/25, but I can fake 20/20 for a while by squinching up my eyes the least little bit. I made it all right. Still, it would have been a lot easier if I hadn't insulted Walker so much. I guess I'll never learn how to handle insecure men.

I hung in my bunk and tried to relax. Zero gravity was a novel sensation, an experience I had been looking forward to for a long time. I should have been savoring the feel, memorizing it with my entire body; but the dull ache of disappointment kept intruding.

I remembered all the cloudy nights, the missed conjunctions and transits. Almost as bad were the nights when the air was clear but the "seeing" was poor. I used to stare for hours at the shifting image of Mars, trying to pin down his squirming features, trying by sheer effort of will to still the turbulent soup of air overhead.

One of my earliest memories was of going to a parade with my father. Because we were several rows back from the edge of the crowd, he put me on his shoulders so that I might also have a view. But in front of us were taller fathers with children of their own aloft. Crane as I might I couldn't quite glimpse the clowns and the majorettes. I bawled and screamed in frustration. *I wanted to see.*

Just on the other side of that hull the stars shone hard and bright. No clouds, no air, no tall men to block my view. And I had lost my excuse for going outside.

I tried to console myself with the knowledge that I'd only lost an hour or two at best. I had expected my crew to be kept busy with attitude corrections to keep the beam aligned. That would leave only me available for the outside work.

But Jenkins was so damned precise that corrections would only have been needed once a day. As experienced vacuum workers, regulations required (you guessed it) that they relieve me of whatever outside duties their time permitted. It would have been a fight to get out the lock even once.

I hadn't counted on that when I first formed my plan back in school. Nor had I expected the feminist revolution to stop as short as it did. Nor, for that matter, would I have guessed that children like Jenkins and Scott would ever supersede mature adults in the exploration of space. I guess you really shouldn't try to plan your life decades at a time.

Still, things were better. Not so long ago, Jenkins might have died young in a Harlem slum before he even learned trigonometry. And I hadn't done all that bad. I had a good husband, two fine daughters, and a successful career. Few women are granted all that. And even if my career were dented a bit, and my daughters rather horrified at the antics of their elderly mother (there are no severer critics of one's social behavior than teenage daughters, believe me), still I had George.

I remember the night we met. General exams were over and I had passed. Beer flowed and music blared and I was letting it all hang out. There is a peculiar frenzy that sets in after weeks of study and tension, and I was in the full grip of it. To this day I can't remember who I was dancing with; but I know we cleared the floor and infected the band with our madness because they kept playing and playing and faces ringed us in on all sides.

It ended in an explosion of cymbals and applause and I was still floating when we got back to our table. I sort of knew George, but he was a theoretical physicist so we'd never crossed paths before. Anyway, there he was at our table, holding a beer in that precise way he has and scanning my sweaty body with his misty green eyes.

"Hey George," said a drunken voice, "what do you think of our Margo? Hey?"

He gave me another scan, as if to check his earlier findings, and said, "It's not obvious to me that you conserve momentum."

That was the sweetest thing anybody could possibly have said to me.

Before the night was out I had told him of my plan to get into space (I'd never told a soul before then). He confided that he wanted two children, and would probably need help since he was a man. I asked if he had any preferences on their sexes and he said no, just so long as they were happy. I allowed as how I could probably help, then, if he didn't mind the space business. He shrugged.

Eventually we got married.

George proved to be everything advertised, but I could never interest him in

astronomy. Too overrun, he said. Astrology turned him on, though. He worked out this beautiful variation on the classic interpretation, where you match the first derivatives of the attributes at the cusps, or something like that. I could never really be sure whether he was pulling my leg or not.

We both agreed that the Ptolemaic theory was a lot more fun than Kepler's laws. There was a baroque charm to the idea of crystal spheres rotating majestically about Mother Earth, each planet dutifully revolving about its assigned epicenter in its proper sphere.

I drifted off to sleep, circles whirling upon circles in my brain.

I came awake swinging. Those circles had turned ominous somewhere along the line and I was scared.

Jenkins and Scott were in their bunks and everything was quiet. I checked the consoles. No communications had been recorded, life-support systems were all in the green. Radiation from the Orbital Booster System had dropped to a mere ten times background; that couldn't be what was bothering me. Or could it?

"Scott! Up and out!"

"Wh... what? What's going on?" He looked more like a bear than ever.

"What did you say before about the OBS, when it reached burnout?" He read the tenseness in my manner and stopped to think, for once.

"Why, uh. I said it was a perfect drop."

"You mean the delta-V was straight toward Earth?"

"Yeah. All the way."

"That's really great," I said in exasperation. "We'd better get the hell out of here, now!"

Jenkins stuck his head out of his netting. "What for? We made a good drop. At Skyhook we call that the garbage burn, and we've used it hundreds of times."

My exasperation deepened. "At Skyhook you had an atmosphere three hundred miles below you to eat your garbage on that trajectory. Think, man! We're thirty-five thousand kilometers out. You didn't drop that OBS down, you shot it straight up. And it's going to come crashing down on us all in, uh," I glanced at the chronometer, "twelve hours and seven minutes."

Jenkins still looked skeptical.

"Take a look at the radiation record," I said.

He scooted over to the situation display. "It's lower than ever," he retorted.

"Yes, but did you notice that it's stopped decreasing? And the source is in front of us now, not below. That OBS will begin closing on us again in just a few minutes, and even if it misses by a hundred miles we'll still get a pretty bad dose. The pile's really going to town now."

I thought about our alternatives. My transfer calculations were for a departure an hour and a half earlier, and I knew we didn't have the fuel to fly a reasonable catchup. The next Hohmann window would not be for another thirteen hours— that was NASA's flight plan. We would be fried long before then.

I wondered what idiot decided that an eighteen-thousand-kilometer orbit was halfway home from thirty-five thousand kilometers out. Angular momentum is the coin of the realm in orbit, not radial distance. A ten-hour orbit makes for a fourteen-and-a-half-hour synodic period at synch radius. With just enough fuel to make the cheapest possible transfer, a distressed control module could have to wait a dangerously long time before reaching safety. Why was I thinking in such abstract terms? We *were* in danger.

We would have to jump out of the way of that booster, and we couldn't jump anywhere that would do us any good. Whatever we did would leave us stranded. So it was a matter of picking a convenient place to jump to, where we could stay clear of the OBS and be easily picked up.

A beautiful white light exploded in my brain.

"All right. Battle stations, everybody. Scott, prepare to burn in three minutes." That would put us twelve hours on the button since separation. Beautiful.

"But, ma'm," Jenkins protested, "we have to get clearance from Skyhook."

"Not in an emergency, Buster. Section III, paragraph 17, part a." I could wield regulations with the best of them.

"But you haven't even computed an orbit yet." He waved his hand entreatingly toward the calculator.

"Oh yes I have." I was downright jaunty. "I used astrology. My horoscope says that we're going to go for a ride on an epicycle." Jenkins got that suspicious look again.

"Mr. Scott, what delta-V did you give the OBS?"

He looked at his crewmate, then back at me. I scowled.

"Uh, five thousand, ma'm."

"Fine. I want the same delta-V for us, along the same line. You fire in exactly one minute... mark! Is that understood?"

Scott squirmed, looked at Jenkins. "Well, uh..."

"Mr. Scott, I have issued you a direct order in an emergency situation. You disobey me at your peril. Is that clear?" I didn't think people spoke like that in real life. It was hard to believe that anybody with a lick of sense would really be scared.

"I repeat! Is that clear?" I had a tough time keeping a straight face.

"Uh. Yes, ma'm."

"Jenkins?"

"Yes, ma'm."

We strapped in and Scott set up the thruster controls. It was somehow anticlimactic when the rockets came on—first attitude correction, then main drive—and then went off. We could never rendezvous with the backup booster now.

Jenkins reached casually toward the communications console.

"Before you check in with your keepers," I interposed, "how would you like a brief lesson in orbit dynamics? Or are you quite prepared to defend your negligence and stupidity?"

He bridled. "What do you mean, stupidity?"

"It was negligent of you to try a garbage dump from synch orbit—if you'd thought at all you would have known it wouldn't work. But you were downright stupid to try it in the first place! What if you'd succeeded? Did you really want to dump a hundred kilograms of highly radioactive junk in the upper atmosphere? Why, the UN would have your hide for the fallout that could have produced."

Jenkins blanched.

"That book of regulations and Standard Operating Procedures you love to cite is great for intimidating uppity broads, but it's no substitute for thinking. Why, Ptolemy could have done a better job than you. Look."

I grabbed a pencil and pad.

"We started out with everything going around in a circle together." I drew a circle, put a tiny Earth at its center. "When you fired the booster, you put it on an elliptical orbit that passes closer to the Earth at first, then farther away." I drew an ellipse that snaked in and out of the big circle.

"How do you know that's how the orbit looks?" asked Jenkins. "Kepler's laws aren't that easy to integrate."

"They certainly aren't. But we physicists are shifty. We do things the easy way whenever possible. In this case I used a little applied astrology." That look again.

"O.K., I'll do it just using Kepler's laws—but I still don't have to integrate them.

"Once its jets shut down, the OBS was in free fall around the Earth, right? That means it was following a closed orbit from then on and so must return to that same spot in space one period later.

"But what is its period? Kepler's third law says the period is determined solely by the length of the orbit's semi-major axis. When you blasted straight toward Earth, you made no change in the booster's angular momentum. So its equilibrium orbit is still the circle we were on, and the booster must oscillate inside and outside our old path, keeping essentially the same semi-major axis length."

Scott was listening intently. My opinion of him went up about ten points.

"That's just another way of saying that the period of small oscillations about a circular orbit is the same as the orbit period. Ergo, our booster has pretty much the same orbital period as we did, near as no matter. If we had not moved, we would have rejoined our unwelcome OBS almost exactly twenty-four hours after we kissed

it goodbye."

Scott whistled.

"Then why do they use that orbit for disposal at Skyhook?" he ventured.

"Probably because the Earth looms so large that 'down' is psychologically obvious. At Skyhook you can afford such mistaken notions because the upper atmosphere will drag stuff down from nearly any variant orbit before even one revolution.

"A better disposal orbit would be to burn back along the orbit line, because it gives you the greatest drop, or narrowest ellipse, for a given amount of thrust. And it shortens the period markedly enough that your trash is not likely to come back to plague you, even if it takes several periods to decay."

I let that sink in.

"But there's an easier way of thinking about orbits, which is why I knew which way we should jump." I keyed ERASE on the pad and redrew my big circle. "An ellipse can be generated by a circle moving around another circle. The Greeks called the big circle the deferent, and the little circle, centered on the rim of the big one, the epicycle. If you go once around the epicycle while the deferent rotates once, you trace out the ellipse."

"I thought that stuff was proved wrong," said Jenkins a little huffily.

"Not wrong, just not as elegant as Newton's theory, which explained Kepler's laws and planetary motions with a minimum of fuss. But any *description* that gives the right answer is equally valid, even if you don't believe in the mechanism implied. In fact, Ptolemy wins in our case, because his description is easier to work with. Watch."

I drew a little circle with its center lying on the rim of the big one.

"You put that booster on an epicycle, like so. Ptolemy would say that we were on its deferent, though that isn't important. What counts is that we know both periods are around twenty-four hours.

"So where is the best place to hide from our OBS, assuming we can't leave the neighborhood in time? Why, on the opposite side of the epicycle, of course. That's where we just climbed on. Until we're picked up by the Comsat tender, we'll stay comfortably far from the radiation."

Now for the fun part.

"And we're also still essentially synchronous, so we can keep in touch with Livermore and do my experiment. Of course, we'll be wiggling back and forth relative to the Earth's surface, so you two will have to tend the radio link continuously, I'm afraid. I figure we can work in overlapping sixteen-hour shifts—I'll have to handle most of the outside work." I put my face in neutral.

Jenkins and Scott looked at each other, back at me, then at each other again. But they couldn't think of a single regulation to get them out of this one. Everyone works

overtime in orbit, when necessary.

"Now, why don't you check in with Skyhook and tell them our latest situation. Scott, I can use a hand outside unpacking the interferometer array." Then to Jenkins, "Oh, yes, and tell Livermore we'll be ready for checkout in six hours."

It was good to be in command.

I felt a brief twinge of guilt about some of my actions. There might have been an intermediate orbit, for instance, from which we could still have reached the backup booster without coming too near the hot OBS. We had a few hours to spare, enough time to use Skyhook's computers to advantage. I pointedly avoided contacting them for that very reason. My simple-minded orbit calculations carried much more weight that way.

And the broadband link was programmed to track a very eccentric orbit, if necessary. I had prepared for the worst, not counting on the nit-picking likes of Jenkins. But why tell them? It would give them something to do and keep them out of mischief.

I put those troublesome thoughts quickly aside. Tucked away with the interferometer was a twelve-inch, f4 Newtonian telescope—made with loving care and fitted with all the accouterments twenty-five years of dreaming could envision. I had pictures to take and planets to see.

And there wasn't a cloud in the sky.