Fang Lizhi: "Thinking" His Way to Freedom

China's most famous dissident consoled himself during a yearlong captivity by considering the large-scale structure of the universe

"IF WE LOSE THE PHYSICS, we feel unstable." Professor Fang Lizhi, astrophysicist and China's most famous dissident, was reflecting on science and survival, now that he's safe in the West a month after the People's Republic of China permitted him to leave the U.S. embassy in Peking and travel to England. In much of Fang's long, complex political history, physics seems to be what kept him going: "thinking, studying, imagining," he says.

Fang is currently a Royal Society Guest Research Professor at Cambridge University's Institute of Astronomy, his international star aglow again after a year in eclipse—a year spent confined in the U.S. compound in Peking. A little more than 12 months ago he was a leading light for the short-lived democratic uprising in China, having urged students and everyone else to "exercise all the rights citizens theoretically hold under the constitution."

In a recent interview with *Science*, Fang, who speaks very workable, if heavily accented, English, discussed his intertwined scientific and political careers. Sitting in his office in the low, tree-shaded Institute of Astronomy, he talked about his plans for future research, and dwelled on how, under conditions of severe political repression, he came to be interested in the grandest questions of theoretical astrophysics.

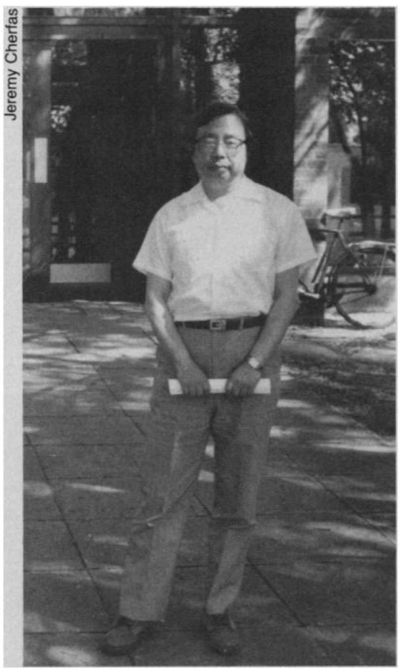
In the 1950s Fang studied nuclear physics at Peking University. After graduation, he worked on theoretical aspects of nuclear fission at China's first nuclear reactor, imported from the Soviet Union. At about the same time, Fang admits, he "first committed political trouble . . . campaigning, speaking out." As punishment he was expelled from the Communist Party and assigned to farm labor for a year.

Fang's combination of physics and dissidence is mirrored in his wife, Li Shuxian, a solid-state physicist. They met as undergraduates; after graduating, Li served as interpreter for physicists who came from the Soviet Union to teach in Peking. According to Fang, "she made more trouble than me." Li was therefore sent out to farm labor for an even longer term.

Back at Peking University in 1960, Fang turned to solid-state physics, studying magnetism and lasers. He was part of the team that built the first Chinese laser, 2 or 3 years after the first Western laser in 1960. Then, in 1966, came Mao's Cultural Revolution, and "everything stopped," especially research. At first Fang was sent to a farm again. Then he was "assigned to build a railway, to build a tunnel in the mountains." After that, it was down into the coal mines.

Between bouts of forced labor, Fang was allowed back to Peking University, but it was unlike any university in the West. Staff were forbidden to go home, were guarded by the Red Guard, and could read only Mao's quotations. Fortunately, Fang recalls, when the Red Guard came to take him to the university, he managed to smuggle along another book: a text by the brilliant Soviet physicist Lev Landau. "For about half a year, this was the only physics book I [had], so I read it carefully."

While the repression of the Cultural Revolution was at its height, Fang changed his scientific speciality again, from solid-state physics to astrophysics and cosmology. Political conditions had a role in that decision: "Only thinking was possible. If it needed a calculator, that was completely impossible." Cosmology, Fang says, with its emphasis on imagination, was both possible and intellectually satisfying.


Jeremy Cherfas

Astrophysicist at leisure. *Fang Lizhi, here at last, in Cambridge, England.*

The first task Fang set himself was to evaluate some of Einstein's rivals. "At that time," Fang said, "there were many theories of gravity, not just Einstein's." Fang used the newly discovered microwave background radiation to calculate an upper limit on a key parameter of one of the competitors, the Brans-Dicke theory. Along with several other efforts, Fang's work showed that general relativity provided the best account of gravitation.

As the Cultural Revolution wound down in 1971, Fang resumed teaching and research, but life was precarious. Association with foreign scientists was impossible: "If you had contact with a foreigner they were thinking you were maybe a spy." Reading the literature was tricky too, because discussing articles published in English was taboo. "We never speak," he said. "If the authorities know you can speak a little bit of foreign language, they say, 'Why you speak foreign language? You want contact with some spy?' "

In the 1980s, as reform provided breathing space, Fang caught up with some of Western astrophysics; lately he has specialized in large-scale structures in the universe. "Galaxies are still small scale," he explained. "One galaxy is like one molecule, and we're studying the diffusion of the molecules." Looking at the pattern of galaxies, he asks: "Why there are some filaments, why there are some voids, and some clumps?"

John Wheeler, the theoretical physicist regarded by many as the father of the black hole, remembers a seminar Fang gave at the University of Texas in Austin some 5 years ago at which Fang revived the idea that the universe could be smaller than we assumed. "The remote parts," Wheeler explained, "might be a more limited region reflected, as it were, in a mirror." The idea is not a new one—"it pops up from time to time," says Wheeler—but Fang, in his scientific isolation, had the idea independently.

The difficulty with such grand speculations is finding clear-cut evidence. If there were reflections, one would expect the universe to have a periodic structure. Fang isn't interested in becoming an observationalist, but he is interested in working with groups that do observation. For example, he's pleased by recent results from a group at Berkeley, which seem to show a repeated pattern. Fang asked the Berkeley astronomers to "check in another direction," as well, he says, because if the Universe is indeed "reflecting" it should also be patterned in other directions.

At present, Fang is most interested in what very massive, very fast-moving objects can reveal about the very early universe. Some objects, such as quasars, seem to be moving much more rapidly than their neighbors—violating assumptions about the homogeneity of the universe. While confined to the U.S. embassy, Fang calculated an upper limit of about 1000 kilometers per second for the so-called peculiar velocity of quasars. "That's not so different from the galaxies," he says, and will help to put limits on the size of the perturbations in the early universe.

"The large-scale structure today we observe comes from the seeds of the quite early universe," he says. Picturing the growth of those seeds excites him now. "I'm just beginning," he says. "I already have some solutions, now I need to find exact numerical solution." This, he thinks, is what will occupy him when he moves to the Institute for Advanced Study in Princeton, some 6 months from now, to work in a group led by astrophysicist John Bahcall.

Fang's most recent scientific work is a series of papers written during his year in the embassy. On the quality of that work, most researchers are quite guarded. The four papers he wrote, which will be published in *Astronomy and Astrophysics* and elsewhere, are, says Remo Ruffini, chair of theoretical physics at the University of Rome, "at the forefront of research. That makes it very difficult to give an assessment. It will have to be assessed by the whole community." Jerry Ostriker, another Princeton astronomer, concedes that Fang has "worked in isolation to some extent, and so is hard to evaluate."

While Fang was in the embassy working on those papers, he and Li became chips in protracted negotiations between China and the West. One complication had to do with Fang's sons; the younger, Fang Zhe, was an undergraduate studying—what else?—physics, at Peking University. On 25 June, Fang and his wife were allowed to leave on a U.S. military aircraft. Fang Zhe joined them in Cambridge a few days later, as did Fang Ke, the elder son, who is doing research on superconductors at Wayne State University in Detroit. Fang laughs as he considers his family: "All physics," he chortles, "all physics."

How long does Fang plan to stay in Princeton collaborating with Bahcall? "Not permanently," he says," but maybe for longer than here." Yet in spite of the greatly improved conditions he has found for his scientific work in the West, his heart is elsewhere. "I think there will be change in China in the future. Not the near future. Maybe several years. Then I will go back."

■ Jeremy Cherfas

The Ideal Scientist Described

What, exactly, is scientific misconduct? Fraud? Yes. Data fabrication? Plagiarism of someone else's scientific idea? Yes.

But what about interpreting data selectively, leaving out points that do not fit a hypothesis? What about failing to give credit to other researchers? Failing to share reagents? What about keeping sloppy notebooks or tossing away data? Are these instances of misconduct, or are they just bad manners?

The answers to questions such as these do not roll trippingly off the tongue. Yet they become vital in an era when the public and the Congress are studying scientific behavior almost as intently as scientists study unfamiliar organisms.

At the National Institutes of Health, a committee of peers has just completed "guidelines for the conduct of research" at NIH that can be read as scientists' own description of a researcher who achieves the Platonic ideal.


NIH

Use with care: *"If these guidelines become prescriptive, they'll do more harm than good."—Edward Korn.*

The scientists who crafted the five-page pamphlet describing what a scientist should be were led by Edward D. Korn, scientific director of the National Heart, Lung, and Blood Institute. The guidelines, which apply to scientists in NIH's intramural program, are meant to promote the "highest ethical standards." They are not, says Korn, "meant as a handbook for whistle-blowers. If these guidelines become prescriptive, they'll do more harm than good."

The document should be released soon, says Korn. And then what? Guidelines often have a way of undergoing metamorphosis and turning into rules to the surprise of their authors. In this instance, because current definitions of misconduct include a vague phrase about behavior that "deviates from accepted scientific practice," the odds of transformation seem especially high.

The ideal scientist, according to the guidelines, is a good mentor, a teacher who imparts to his or her students the ethos of a life in science, and "recognizes that the trainee is not simply an additional laboratory worker."

The ideal scientist knows the importance of hanging on to primary data and recording them in a way that makes them accessible to colleagues. "Scientific integrity is inseparable from meticulous attention to the acquisition and maintenance of research data," reads the new manifesto.

The ideal scientist publishes just the right amount—neither too much nor too little and, when possible, makes reagents and the like available to colleagues who want to follow up on published data. The guidelines call "timely publication" essential to scientific progress but oppose "fragmentary publication." People should be judged on the quality, not quantity, of their scientific output.

The ideal scientist is listed as an author of a paper only if he or she actually did some of the work. The guidelines describe authorship as a privilege that belongs only to those who make a "significant contribution to the conceptualization, design, execution, and/or interpretation of the research study." If you don't know enough about the study to be able to defend it scientifically, don't put your name on it, the guidelines add.

The ideal scientist never abuses peer review by taking a colleague's idea for his own. Nor does he tell anyone else about the substance of a paper or proposal under review—especially not in casual conversation.

And finally, if the ideal scientist is a physician, he or she carefully follows all the existing guidelines that are in place for the protection of patients.

■ Barbara J. Culliton