Remembering Zwicky

Fritz Zwicky–Scientific Eagle

An active and extraordinary scientist, still full of ideas and personal drive, Fritz Zwicky, professor of astrophysics emeritus, died suddenly on February 8. It is difficult to write a brief, conventional memoir about so unconventional a man. Fritz classified scientists into two categories, eagles and low-fliers; a low-flier like myself recognized clearly that Fritz was the high-flier. He pursued an extraordinary range of personal interests: international charities, city-planning, mountain climbing, new explosives, exploding stars, crystals and dying stars, and, especially galaxies. He always saw the Universe in his own original way; he loved the extraordinary objects it contained, and he explained them in his own fashion, sometimes wrong but never dull. He leaves, after nearly 50 years at Caltech, many loyal friends, scientists and public figures; his wife since 1947, Anna Margaritha; daughters Margrit and Barbara (of Berne and Pasadena) and a married daughter, Franziska Pfenninger (of Zurich).

Born in Varna, Bulgaria, a Swiss national all his life, he received his PhD from the Federal Institute of Technology in Zurich in 1922. He came to work at Caltech on the theoretical physics of crystals as a research fellow of the (Rockefeller) International Education Board, served as assistant and then associate professor of physics 1927-1941, and became a professor of astrophysics in 1942. He was a member of the staff of the Mount Wilson and Palomar Observatories till his retirement in 1968, and a pioneer observer on Palomar where he realized the importance of, and exploited, the wide-angle schmidt telescopes for discovery of unusual types of stars and galaxies.

Caltech graduates will remember his course in Analytical Mechanics, required for the PhD in physics.* Astronomers

*See *E&S*, February 1974, p. 29. I can vouch for a further part of the story—explosive events occurring in the Registrar's Office when Fritz wished to record his first perfect grade for a non-existent student.

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will remember his advanced seminar, which covered the Universe and admitted "only students, assistants, faculty and visiting research personnel . . . who have the time, inclination and ability to engage in active, constructive work. . . . " Faculty wives and secretaries will remember his charitable activities, including an annual display in our board room of children's knitwear destined for schools for war-orphaned children. Although Zwicky had few formal students in later years, he retained a strong influence on recent scientific developments.

He became one of the founders (with Theodore von Karman, Clark Millikan, and others) of Aerojet Engineering, where he served as director of research 1943-49; he was research consultant at Aerojet-General and Hycon till 1960. He held many patents on unusual concepts and devices in jet propulsion—air, water, and earth-borne. When he visited Japan and Germany for the U.S. Air Force, his strong interest in human causes led him to individual acts of charity long remembered. He had a strong interest in the Pestalozzi Foundation, was trustee and president of the American branch, and received its gold medal in 1955. He organized a lengthy project for reconstruction of war-stricken libraries; for years I struggled with Zwicky (always an administrator-baiter) to remove the many tons of books on their way to the Orient or Europe. For many technical services, and for his good works, he received the Medal for Freedom in 1949 from President Truman.

He was awarded the Gold Medal of the Royal Astronomical Society in 1973 for "his many distinguished contributions to the understanding of the constituents of the Galaxy and the Universe." The medal carries the motto *Quicquid Nitet Notandum* [Whatever shines is to be noticed], a phrase peculiarly suited to Zwicky's approach to astronomy. Zwicky's response was equally apt—"I heard as a boy that there will always be an England, a place where debatable gentlemen will be recognized. I hope you have not made a mistake this time."

Zwicky wrote over 300 articles, 10 books, and held 25 patents. From 1933 on he had a philosophical interest in morphological research, a systematic approach to science and technology; he was founder and president of the Society for Morphological Research, and recently a Zwicky Foundation was established in Glarus. He had a strong classical background in thermodynamics and statistical physics. These two threads, combined with a strong personality and bold mind, led him to contribute to astrophysics in a unique way. Lacking the repressions of many, he felt that if a "morphological box"—i.e., a possibility—existed, nature would have filled it and scientists should discover it. This characteristic pattern is found in many of his fields of study.

From 1921 to 1937 he studied secondary structure in crystals, cooperative phenomena, and the theory of cosmic rays; by 1928 he was interested in, and doubtful about, relativity; in 1934 he cooperated with Walter Baade of the Mount Wilson Observatory staff in the discovery of supernovae. He attempted to explain them as a collapse to the neutron-star state (1934), and as producing cosmic rays (1934). Both the discovery of the supernovae and the theoretical links to neutron stars (only two years after the neutron was discovered) are extraordinary feats. A supernova explosion releases energy close to what the sun radiates in 10^{10} years! Neutron-star physics was, in fact, put on a sound theoretical basis by 1937 by Oppenheimer and Volkoff. And rotating neutron stars probably do accelerate cosmic rays; the Baade-Zwicky mechanism used electrostatic fields. With many collaborators, Zwicky started a supernova patrol which discovered most of those now known, finding 100 himself. Baade and Rudolph Minkowski explored and classified their spectra, still an active topic of study and debate. Zwicky carried the idea of collapse under gravity much further, contemplating "pygmy stars" (which do not exist) and "object Hades" (black holes, which probably do exist). Several threads of his work thus appear—interest in extreme types of objects; speculative, approximate theory based largely on classical models; and willingness to undertake systematic, very large, and long observing programs.

In studies of galaxies, which he began in 1929 with a note on the possibility of a gravitational drag on light, Zwicky combined a serious devotion to discovery and cataloging their properties with criticism of the expanding universe theory. He was constructively concerned about the applicability of the conventional definition of a galaxy as a large, closed system of a hundred billion stars—why not a billion or a million or ten stars? Why should not very dense galaxies exist? Could they be found? Look with the schmidt telescope! He studied interacting galaxies of strange shape, the forms of clusters of galaxies, searched for

intergalactic matter and intergalactic stars.

One important result was the six-volume catalog of galaxies and clusters of galaxies, prepared with collaborators, which will be of permanent importance to extragalactic astronomy. The "compact"—i.e., relatively dense, high-surface brightness—galaxies have become of special importance with the discovery by Sandage, Schmidt, and others of the quasars, and of their large redshift; Zwicky made lists of compact galaxies, published a large, useful catalog, and had another in preparation.

Violent events in the nuclei of galaxies (which may vary in light in a few days) and explosive phenomena in Seyfert nuclei have been a major concern of astronomers and observers of the last decade. The trend of recent studies of galactic nuclei has been to reinforce our knowledge of high-energy events of still mysterious nature. It is clear that Zwicky's intuition of the importance of implosion-explosion events was a valuable one. In a sense he was a pioneer of high-energy astrophysics. The strange shapes of interacting galaxies interested Zwicky in his search for intergalactic matter. Here, the recent discovery of X-rays from clusters of galaxies suggests that he had an early insight into still another important field.

With Milton Humason, he found the first "faint blue stars," 48 hot objects far from the galactic plane—objects on which I have worked, with pleasure, for many years. Closer to home, Zwicky was interested in research in space by 1946; he attempted to launch artificial meteors from a rocket, and claimed to have shot the first object out of the gravitational field of the earth; he helped found the International Academy of Astronautics and lectured on legal problems of the use of space.

Zwicky, as a young man, was a good mountain climber. He was an extraordinarily live person. He climbed many scientific mountains, some with great success, many for the first time.

—Jesse L. Greenstein
Lee A. DuBridge Professor of Astrophysics

Zwicky: Humanist and Philosopher

The great majority of Fritz Zwicky's publications were in the field of astronomy. Most of the remainder were about his researches in solid state physics and jet propulsion technology. But Zwicky himself always felt that his greatest contributions were in philosophy, specifically in epistemology—in the development of new methods of thought and action. He wrote in 1971: "I feel that I have finally found the philosopher's stone in what I call the *morphological outlook and method.*"

Giving us an insight into how he came to feel this way, Zwicky said in addressing the Pestalozzi Foundation of America, of which he served as president of the board of trustees: "After pursuing a dozen or so various activities ranging from mountain climbing and professional shorthand to physics, astronomy, engineering, languages, higher education, national and international politics, and mutual aid with fair success, I still did not feel satisfied. . . . It was difficult to account for the lack of satisfaction until it occurred to me . . . that no stereotype activity in the books of the past corresponds to my personal genius. Its nature is such that it could become fully alive only through the creation of a new profession—the morphologist."

This is not the occasion to review the details of the morphological method. Suffice it to say that the morphological approach sought to be integrative, systematic, and trans-scientific, pushing consciousness to the limits of the conceivable. Zwicky believed that if only we could free ourselves from our pedestrian patterns of thought and learn to think morphologically, the future could be shaped by our images—however bold—rather than by the inertias of existing institutions and investments. For Zwicky, the really revolutionary paradigm of morphology consisted in the replacement of *one* solution by *all* solutions, *one* path by *all* paths, *one* system by *all* systems. Only after the complete spectrum of possible solutions, theories, or systems is developed can the full energies of their mutual tensions become available to us.

Zwicky's "method of morphological construction" passed William James's test for great innovative ideas: "First the new idea is mocked as ridiculous and absurd, then it

is admitted to be valid but overrated and of no particular significance, finally it is decided that the idea had been known long ago and that everybody had thought of it himself." So it was with morphology.

Zwicky possessed that necessary concomitant of greatness, the generation in others of a strong positive or negative response. Very few people were merely indifferent to him. His evocation of bi-modal responses was in part due to his phenomenal percipience. Those who see further or deeper are not universally admired.

Another cause was Zwicky's frequent distrust of those in the upper echelons: "Unfortunately many people, and in particular professional men, are impressed only by specific accomplishments in science, engineering, finance, politics and so on, which lead to fame or to material and spiritual 'success' of one kind or another. Such men are a great obstacle to humanity in its march toward the realization of its inherent genius."

Zwicky felt that it was important to unhorse the pompous. He felt that all professors and executives should stay in touch with reality by periodically cleaning the wash rooms. He set the example by doing this himself. It would please Zwicky to say that "that bastard Chairman Mao" stole this aspect of the cultural revolution from him.

One of Zwicky's humanitarian activities was his organization of the Committee for Aid to War-Stricken Scientific Libraries. In order to establish closer scientific human relations, together with a small handful of volunteer assistants, Zwicky collected and distributed over a million dollars worth of scientific periodicals and books, sending them to university and other libraries that had been destroyed in the war—first to allied countries, later to former enemy countries. Zwicky devoted his weekends for several years to this task, personally carrying the heavy cartons of journals, cataloging, wrapping, and mailing.

But Zwicky had a second purpose in mind in organizing the Library Aid Committee. He said, "A common supposition is that activities of this kind require for their successful realization large organizations and considerable funds." Zwicky wanted to disprove this. He felt that the revitalization of democracy depended on "more initiative on the part of every individual as such." The book project was completed "without recourse to any funds except for a few dollars for wrapping paper, a card index, and some expenses for driving a car for the purposes of collecting the material."

Zwicky's point was that there are enough men and women of good will to make such projects a success if only they are pushed with determination. Availability of funds is not a prerequisite. He felt that such projects as the book distribution do more for establishing ties of confidence between different nations and races than can be achieved by speechmaking, legislation, or high-sounding efforts at international cooperation.

Zwicky was concerned with a second type of energy crisis, the drying up of spiritual energy: "There exists today no subject which would excite the imagination of men in a positive way, stimulating a constructive and happy life. The universal appeals of religion, art, political freedom, and science have faded to the vanishing point."

Zwicky's perception of the collapse of imaging power and its import for the Western World came two decades before other futurists finally woke up to its significance. In 1946, he wrote: "The world of today is in a state of disorder which is in conspicuous contrast to the avowed purposes of man . . . the teachings of science, of education, and of religion seem to have become lost in an elaborate system of hypocrisy in which there is little relation between words and actions."

This was one of the earliest recognitions of the corruption of our culture through the distortion of language.

If a single theme dominates Zwicky's humanistic writings, it is the importance of unfettered individual creativity and effort. This viewpoint may not be shared by those who feel everything worthwhile that remains to be discovered or developed will require sizable federal appropriations. Zwicky briefly went the grant and contract route but decided that the loss of the essence of creativity that was implicit in the federal funding system precluded its ever leading to any really basic discoveries. He returned to his original premise: The world's hopes lie in individual free agents, men and women of good will who can come together and work when the need be, but who form no permanent organizations or institutions.

One might wonder why a person of Zwicky's creative stature never attracted large numbers of followers. Discipleship was inconsistent with Zwicky's basic views. He held that everyone was a genius and that each person's life task was to find his own genius, not to follow some other genius. "Most individuals just never seem to realize that they possess unique potentialities and capabilities not to be matched by anybody else and that the penalty for not realizing one's genius is frustration and unhappiness."

Our present civilization is built on, and for, only a few types of geniuses. This is why so many are frustrated and unhappy. This malignancy will remain at the core of society until some way is found of restructuring so as to allow each person to discover his own innate genius.

Whether Zwicky's genius was to hear the beat of different drummers or whether it was the acuity to hear the fainter drummings of the same cosmic drummer that we all hear in part, his passing removes from our midst a creative source of great originality. With his departure the world becomes more homogenized and more mediocre; humankind loses a portion of its freedom and its dignity.

All who knew Zwicky would agree in the appropriateness of applying to him that eloquent eulogy first uttered by Winston Churchill on learning of the death of Rupert Brooke, which was later used at Churchill's own funeral: Certainly, *we shall not see his like again*, and these are times when this world has a desperate need for Zwicky's particular type of genius.

—Albert G. Wilson
Director
Society for Morphological Research

Zwicky on Zwicky

Theodore von Karman was not only a brilliant scientist; he was also a man who knew his Zwicky, as indicated in this brief excerpt from a 1971 interview with Zwicky by R. Cargill Hall, historian at the Jet Propulsion Laboratory.

I think I was instrumental in talking Millikan into getting Von Karman here permanently in 1931-32 or so, and we were really old friends. In all my attempts to get physics over into astronomy, engineering over into astronomy, and so on, he supported me heavily. While he was Director of the Scientific Advisory Board on the Air Force (on my standing with my colleagues I would have never been on that), he insisted that I too should be on it. So, he pushed that through, and I am indebted to him for that, and also later on for having pushed me into the International Academy of Astronautics, and so on. And it would have been quite impossible if all the hierarchy in power would have had their say, because they can not really admit a non-conformist like myself. On the other hand, he had his little jokes with me. He thought I was treating people too abruptly, too roughly, and it would be better not to be that rough; but to commemorate this abrasiveness, he said, "Now we have an occasion to get you into history, and we must devise a unit for the roughness of airplane wings, the surfaces of missiles, and so on. The proper thing will be to name this unit a Zwicky." But then on second thought, he said, "There is no such thing as a whole Zwicky except you—that's far too excessive—so the practical unit will be a micro-Zwicky!"