Chapter 9
About Fritz Zwicky

Fritz Zwicky is not a household name in science today. He was not a super star of the likes of Einstein, Hubble or Oppenheimer. Yet his influence was significant – far more than his present-day lack of fame would suggest. He was one of the broadest and most inventive scientists of his time, and combined theoretical studies with eminently practical, humanitarian activities.

Zwicky was born in Varna, Bulgaria, in 1898, the son of a Swiss merchant. At the age of 6 he was sent to his father's ancestral district in Switzerland, Glarus, for schooling. Although expected to take up a career in commerce, Fritz' early bent for science apparently persuaded his father to allow him to study engineering instead.

In 1914 he moved to Zürich where he subsequently enrolled in the Swiss Federal Institute of Technology. There he switched to mathematics and experimental physics, wrote his examination essay for no one less than Herman Weyl, and in 1922 took his doctorate with a dissertation on ionic crystals. Three years later he moved to the California Institute of Technology in Pasadena to work with, among others, the great experimental physicist Robert Millikan.

From this point on, Zwicky more or less worked out of Pasadena, both as a faculty member of Caltech (1927–1968) and research director/consultant for Aerojet Engineering Corporation (1943–1961). He became Professor of Astrophysics at Caltech in 1942 and was a member of the staff of Mount Wilson and Palomar Observatories until his retirement in 1968.

Zwicky is primarily known for his work in astrophysics, and especially his comprehensive galaxy surveys. However, he thrived on investigating and theorizing about extreme phenomena and the boundary conditions. This led him both to develop a method for systematically investigating multi-dimensional problem complexes and to formulating a number of hypotheses which represented significant breakthroughs in astronomy.

Zwicky and Walter Baade were the driving forces behind acquiring and installing the first Schmidt telescope to be used in a mountain-top observatory – the famous 18-in. Palomar Schmidt – in 1935. Schmidt's revolutionary new telescope made it possible to photograph large areas of the sky quickly, with little

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distortion. Zwicky used it to make the first rapid survey of the heavens, mapping out hundreds of thousands of galaxies (now called the Zwicky Galaxy Database).

As a result of this, Zwicky discovered that galaxies tended to cluster, opening up a new chapter in the history of astronomy and cosmology. At the same time, he applied the so-called virial theorem[1] to the Coma cluster of galaxies and obtained evidence of unseen (or "missing") mass, thus starting off the debate on what is now called *dark matter* (The 18-in. Schmidt was later used by Gene and Carolyn Schumacher to discover the comet Schumacher-Levy 9, which smashed into Jupiter in July 1994).

Pursuing the idea that "bright novae" were of fundamental interest for determining the distance to far-off galaxies, he and Walter Baade coined the term supernova (Baade & Zwicky, 1934a). These, Zwicky proposed, marked the transition from ordinary stars to neutron stars – which he was the first to hypothesize – and were the origin of cosmic rays (Baade & Zwicky, 1934b). This was an amazing (and correct) triple hypothesis and was an important step in the still on-going project to determine the size and age of the (visible) universe. (Zwicky's neutron-star-hypothesis entered mainstream astronomy in the 1960s). In 1937 Zwicky proposed that galaxies could act as gravitational lenses.[2]

Besides numerous other contributions to astrophysics, Zwicky was active in the aerospace industry. Just after WWII, he was appointed head of the U.S. Air Force teams that went to Germany and Japan to evaluate wartime research on jet propulsion. He was subsequently awarded the Medal of Freedom by President Truman for his work. He was also director of research at Aerojet Engineering and was involved in the development of jet and rocket propulsion systems – for which he obtained a number of patents. He is credited by some as being the "father" of the modern jet engine.

He was also vice president of the International Academy of Astronautics and founder of the Society for Morphological Research, where he enthusiastically advanced "General Morphology" for some 30 years – between the 1940s until his death in 1974.

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[1] "The virial theorem states that, for a stable, self-gravitating, spherical distribution of equal mass objects (stars, galaxies, etc), the total kinetic energy of the objects is equal to minus 1/2 times the total gravitational potential energy. In other words, the potential energy must equal the kinetic energy, within a factor of two." See http://www.astro.cornell.edu/academics/courses/astro2201/vt.html

[2] Einstein had originally calculated that stars could act as gravitational lenses, but that the focal point would be too short for the effect to be observed from earth. According to a news report in the Los Angeles Times in the 1930s (which I found in Zwicky's family scrapbook at the Fritz Zwicky Foundation in Glarus, Switzerland) the idea that *galaxies* could act as gravitational lenses was first conceived by a Los Angeles "dish washer" and amateur physicist. He allegedly contacted a physicist acquaintance at CalTech, who in turn contacted Einstein and Zwicky. According to the story, Einstein never answered, but Zwicky did the calculations, found it valid, and got the credit. I have no idea about the veracity of this story. However, it was also the Los Angeles Times, on January 19, 1934, that (ignorantly) lampooned Zwicky's neutron star hypothesis with a cartoon entitled "Be Scientific with Ol' Doc Dabble". Was there bad blood between Zwicky and the L.A. times? Was the "dish washer" story concocted?

Zwicky has been described as a notorious maverick in science, both brilliant and insufferable. There are scores of anecdotes about his deeds and manners, his "salty" attitude and abusive statements (no doubt embellished over time). He is "credited" with coining the term a *spherical bastard*, i.e. "a bastard no matter which way you look at him". There is also a rap poem written about him – "The Dark Matter Rap" by the astronomer David Weinberg (1996). It begins:

> My name is Fritz Zwicky,
> I can be kind of prickly,
> This song had better start
> by giving me priority.
> Whatever anybody says,
> I said in 1933.
> Observe the Coma cluster,
> the red-shifts of the galaxies
> imply some big velocities.
> They're moving so fast,
> there must be missing mass!
> DARK MATTER!

However, despite his ascribed abrasive nature, Zwicky was in fact a great humanist. He was engaged in a number of charitable activities, including years of work to help rebuild scientific libraries destroyed during the Second World War and participating in the Pestalozzi Foundation's program to establish war orphan villages. In 1949, he was awarded the Presidential Medal of Freedom by Truman for his work on rocket propulsion during World War II.

The two Principal works in English by Zwicky on General Morphological Analysis are:

Zwicky, F. (1969). *Discovery, invention, research – through the morphological approach*. Toronto: The Macmillan Company.
Zwicky, F., & Wilson A. (Eds.) (1967). *New methods of thought and procedure: Contributions to the symposium on methodologies*. Berlin: Springer.

There are also two short biographical sketches in English:

Remembering Zwicky by Greenstein, J. (1964). *Engineering and Science, 37*, 15–19. (Available at: http://calteches.library.caltech.edu/354/2/zwicky.pdf)
Idea Man by Stephan M. Maurer, at Beamline: http://www.slac.stanford.edu/pubs/beamline/31/1/31-1-maurer.pdf