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Book Review

Fritz Zwicky: An Extraordinary Astrophysicist

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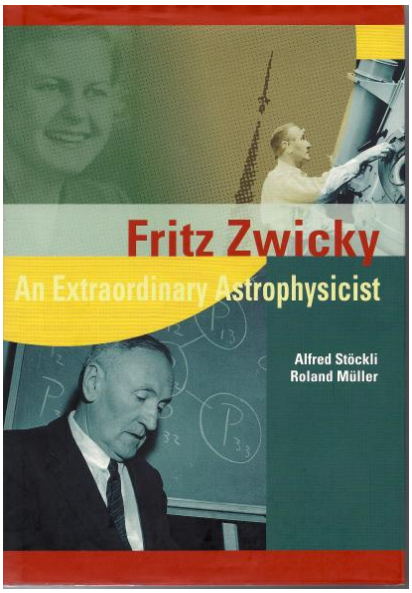
Alfred Stöckli & Roland Müller: *Fritz Zwicky – An Extraordinary Astrophysicist*. Cambridge Scientific Publishers, Cambridge, 2011. 248 pages. ISBN 978-1-904868-78-1



Finally! An English language biography of Fritz Zwicky, the Caltech based astrophysicist and aerospace scientist who pioneered the development of general morphological analysis.

This volume is a translation of the German edition *Fritz Zwicky: Genie mit Ecken und Kanten* (2008) by the same authors. Both authors are associated with The Swiss Federal Institute of Technology in Zurich (ETH, where Zwicky studied) and with the Fritz Zwicky Foundation in Glarus. Stöckli is President of the foundation.

Fritz Zwicky is not a household name in science today. He was not a superstar of the likes of Einstein or Hubble. Yet, as this book shows, his influence was significant; far more than his present-day lack of recognition would suggest. He was one of the broadest and most inventive scientists of his time, and combined "high-flyer" theoretical studies with eminently practical, humanitarian activities.

Background: Zwicky was born in Varna, Bulgaria, in 1898, the son of a Swiss merchant and sometimes diplomat. At the age of 6 he was sent to his father's ancestral district in Switzerland, Glarus, for schooling. (All the Zwickys in the world seem to have their common origin in Glarus!) Although expected to take up a career in commerce, Fritz' early bent for science 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. 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 was invited to study in the U.S. and ended up at the California Institute of Technology (Caltech) in Pasadena. There he initially worked with the great experimental physicist Robert Millikan (who once said that he kept Zwicky around because some of his hair-brained ideas might turn out to be right – which many of them did!).

From this point on, Zwicky more or less worked out of Pasadena, both as a faculty member of Caltech (1927-68) and research director/consultant for Aerojet Engineering Corporation (1943-61). 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 boundary conditions. This led him both to develop a method for systematically investigating multi-dimensional

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problem complexes and to formulating a number of hypotheses which represented significant breakthroughs in astronomy.

Zwicky and Caltech colleague 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-inch Palomar Schmidt -- in 1935. Schmidt's revolutionary new telescope made it possible to photograph large areas of the sky quickly, with little distortion. Zwicky used it to make the first rapid survey of the heavens, mapping out tens of thousands of galaxies (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 virial theorem 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-inch 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. 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. 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 1960's). In 1937 Zwicky proposed that galaxies could act as gravitational lenses.

Besides numerous other contributions to astrophysics, Zwicky was active in the aerospace industry. In the aftermath of WWII, he was appointed head of the U.S. Air Force teams that went to Germany and Japan to evaluate wartime research on jet and rocket propulsion. He was subsequently awarded the Medal of Freedom by President Truman for his work. He was also research director at Aerojet Engineering and was involved in the development of jet and rocket propulsion systems – for which he obtained a number of patents. And here is one for the Guinness Book of Records: He seems to have been responsible for the first man-made object being launched beyond earth orbit into interplanetary space. It was just a metal slug, but anyway....

This biography is a detailed chronicle of Zwicky's life (and loves) and describes all of his major accomplishments in astrophysics, jet and rocket propulsion science, general morphology, and as a polymath humanist and general "big idea man". Most interesting for me, of course, is Stöckli's chapter on "Zwicky's Morphology", which is that aspect of his work which is seldom presented (although Zwicky himself saw this as one of his major achievements – and called it his "philosopher's stone").

Zwicky has been described as a notorious maverick in science, both brilliant and insufferable. On the brilliant side, Zwicky was truly a "high flyer", an "outlier", who went his own way and formulated ideas and hypotheses that were ahead of their time. Some of them were wrong – many right. His triple hypothesis about the nature of supernovae, neutron stars and cosmic rays in the 1930's was scoffed at by many, but turned out to be completely correct – and, under better circumstances, might have earned him a Nobel Prize. He was also a great humanist, 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.

On the other side, the authors do not try to cover up the fact that Zwicky was, all too often, what we today would call a "difficult person". 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. "He's a bastard no matter which way you look at him!" His sometimes overbearing and belligerent manner irritated a lot of people, and this may well have contributed to his present day lack of recognition.

I have one minor bone to pick with the authors. In the section on "Morphological Research", Stöckli states:

> "Morphological Research for Zwicky means applying morphological methods in order to *predict future long-term developments*." [My emphasis]

He bases this assertion on text from the forward to Zwicky's original book in German: *Morphologische Forschung*:

> "Morphology as totality research actually discovers interrelationships which normal science is hardly able to deal with. Admittedly, classical science can make predictions about future events, which can be calculated from known peripheral or initial conditions, on the basis of physical laws. But so far, science has not been able to demonstrate with any degree of certainty any long term developments which relate to the nature of *as yet unknown laws of nature and new manifestations.*" [My emphasis]

This cited text does not warrant the assertion that Zwicky believed general morphological analysis (GMA) could "*predict future long-term developments".* He is stating that GMA will help you to discover new sets of *possible relationships*. Nowhere does he state that this will allow one to predict which of these possibilities will actually come about.

The principle difference between so-called "predictive analytics" and morphological modelling is that GMA is a *possibility generator*, not a (deterministic) predictive method or even a probability machine. Deterministic and probabilistic methods become useless (or "worse that useless", as is sometimes pointed out) beyond a certain time and complexity horizon – i.e. beyond the horizon of "as yet unknown laws of nature and new manifestations". Where this "horizon" *is*, we do not know with any certainty. If we did, then there would be no problem. Then we would simply use deterministic and probabilistic modelling methods up to their respective horizons, and from there on use possibility modelling – e.g. GMA.

One of the responsibilities of a book review is to give the reader the "bottom line" on the book being reviewed, so – here goes: This book will teach you nothing new about astrophysics, rocket science or general morphology. It is about Fritz Zwicky, and is of historical interest for people who are historically interested in Zwicky. I emphasise this because I am sometimes asked if reading Zwicky's original books about the morphological approach will help them to gain new insight into the method as such. The answer is: No. In fact, Zwicky's own (sometimes cryptic) descriptions and explanations concerning general morphology often only make sense if you already know all the details of how GMA actually works. In this context, modern computer-aided GMA has developed into something that Fritz could only dream about. However, he would have loved it!

Finally, I want to take this opportunity to thank Dr. Stöckli and Dr. Max Weber (Secretary) of the Fritz Zwicky Foundation for allowing me free access to the Zwicky archives on my visit to Mollis in 2006. A most wonderful experience.

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