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LEONARDO THINKS

Editorial: The Neutrino and the Sydney Opera House

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The Neutrino and the Sydney Opera House Sounding like Aesop's fables, the combined tales of the neutrino and the Sydney Opera House have a moral about aesthetic patterns in science and in art. In each of two separate cases (one involving the discipline of physics; the other, architecture), aesthetic factors played a role in convincing theorists to believe in the reality of something that only existed in the mind-or perhaps better said, something that only existed "on paper." In telling these two stories, and in putting forward my proposition that they contain parallel themes, I do not wish to be misunderstood. I believe in the relative autonomy of art and science, and I trenchantly object to what I call "Zeitgeist historiography"-the belief that a necessary unity exists in all cultures such that a "spirit of the times" pervades all modes of thinking and acting [1]. The link between the neutrino and the Sydney Opera House is not some mystical connection that necessarily existed between the scientist who conceived of a new fundamental particle and the architect who designed a singular structure. Rather, the point is less mysterious: there are constraints in all aspects of human thought; these lead to similar patterns of thinking among theorists (independent of their areas of work); and aesthetic factors play a role in this interplay between constraints and patterns. One facet of the aesthetic dimension found in both art and science is revealed in the parallel stories of the neutrino and the Sydney Opera House.

THE STORY OF THE NEUTRINO

The idea of the neutrino was first conceived by Wolfgang Pauli in 1930 as a solution to a problem involving experimental results in beta decay-namely, the radioactive emission of beta rays (very fast moving electrons)-such that the Principle (or Law) of the Conservation of Energy seemed to be violated. In a now-famous letter that Pauli sent to a conference on radioactivity in Tiibingen (which he did not attend), he proposed what he called "a desperate way out" of this problem-the postulation of an as-yet-unknown particle that carried the necessary energy to balance the conservation equation. (Incidentally, at the time, only three elementary particles were known: the electron, the proton and

the photon.) The radical nature of Pauli's idea is revealed in part by the reaction of Niels Bohr, certainly no stranger to radical ideas in light of his landmark trilogy of papers in 1913 on the quantum explanation of the atom. Bohr was more comfortable abandoning the Conservation Law in nuclear processes than adding another particle to the world [2]!

Pauli's postulate came at a tumultuous time in his life, which may have been a factor in his "desperate" solution to beta decay. His mother had recently died, which had left him shaken; he was known to be drinking too much; and 5 days before penning the "neutrino" letter he divorced his first wife. Indeed, in a letter written 2 months before his death in 1958, Pauli recalled those days and spoke of the neutrino as "that foolish child of the crisis in my life" [3]. A perhaps tragicomic footnote to all this was Pauli's excuse for missing the Tiibingen meeting-he attended a ball in Zurich to which he said he was "indispensable" [4].

Ironically, Pauli originally named this particle a "neutron," but in 1932 the term was used when the "real" neutron was discovered. The term "neutrino" was coined by Enrico Fermi, from an Italian word for a "little neutral object." Little indeed: practically without mass, the neutrino was to have just enough energy to balance the equation for the Conservation Law; we know today in beta decay that as a neutron transforms into a proton and an electron, the neutrino is ejected. But the neutrino eluded detection for more than 2 decades. Its existence and eventual detection, however, was seldom doubted (despite Bohr's original qualms). In scientific publications from the 1930s to the 1950s the neutrino was treated as if it were real-whereas, in fact, it only existed on paper.

Then, on 14 June 1956, Fred Reines and Clyde Cowan (experimental physicists working on neutrino detection who subsequently won the Nobel Prize in physics for this work) sent the long-awaited message to Pauli. The telegram began, "We are happy to inform you that we have definitely detected neutrinos. . ." [5] It most certainly was comforting to Pauli and other scientists that the neutrino's reality was finally confirmed by experiment, but one also suspects that they probably felt this was inevitable. After all, the Conservation of Energy was a widely applied, fundamental law of nature. It also has an aesthetic appeal, as do all equations. Like Archimedes' law of the lever, it states that although the two "sides" entailed different entities, they could still balance if certain sums were equal. And the neutrino made them equal. There would be, in short, a harmony to nature if the neutrino existed.

THE SYDNEY OPERA HOUSE

The competition for the design of the so-called Sydney Opera House (really a Center for Performing Arts and now the landmark of the city) was announced in September 1955. Submissions came from all corners of the world. Not long after the closing date of December 1956, the winner was announced: Jorn Utzon (b. 1918) of Denmark, who won for his exceptional design involving arching vaults that would appear as sails flying over the harbor site. The details of how and why Utzon won (apparently he was quite surprised) are lost-clouded in rumors, anecdotes and conflicting stories by participants. But one thing is clear: the winning model was controversial from the start [6]: Utzon had challenged the reigning architectural dogma of "functionalism." Those

arching vaults (Utzon called them "shells") seemed particularly frivolous and strangely placed; there was no obvious way of visualizing the interior space of the Opera House from its exterior. Moreover, the shells seemed to be randomly placed, thus barring the viewer from getting a visual grip on the solidarity of the structure itself. But, in fact, the shapes of the shells, as Utzon later explained and demonstrated, contain an underlying order-they are actually sections of a sphere. The Opera House was, as most critics eventually agreed, a fascinating idea for a work of architecture-if, that is, it could be constructed.

Ground was broken and construction began in 1959. The building of the Opera House is a long and complex story, with numerous delays and setbacks; several times it was almost terminated. In fact, in the spring of 1966 when the newly elected Australian government demanded major changes to Utzon's original plan, Utzon resigned and went back to Denmark. According to one account, he never returned [7]. Nevertheless, others stepped in and the Opera House was completed in late 1972 with the official opening in October 1973-almost 16 years after Utzon was announced the winner of the design contest.

Now, an event from my student days holds a key to the point of my discussion here. While studying art in the 1960s, I was puzzled by the fact that although many art books used the Sydney Opera House as an example of contemporary architecture, the published pictures of the building were always of either a drawing or a scale model; none were photographs of the building itself [8]. Of course, a little research 82 Editorial revealed why: to my surprise, I discovered the Sydney Opera House did not exist! It was still being constructed.

I found this fascinating. Why did this building appear in art books when, in fact, it did not exist? My guess at the time (which I still believe today) was that aesthetic factors prevailed. The structure is such a marvelous example of anti-functional contemporary architecture (among other things) that it must be included in discussions of architecture. That it only existed on paper at the time did not seem to inhibit authors.

So the parallel stories emerge: in both cases, theorists in their respective fields (physics, architecture) chose to treat conceptual entities (the neutrino, the Opera House) as if they really existed (over the periods of several decades for the neutrino, several years for the Opera House) for essentially the same reason (despite obvious differences between the Conservation Law and architectural rules of visual harmony): aesthetic factors gave credence to the need for treating the neutrino and Sydney Opera House as if they were realities before their time.

Endnotes

[1] David Topper, "On a Ghost of Historiography Past," *Leonardo* 21, No. 1, pp. 76-78 (1988).

[2] Laurie M. Brown, "The Idea of the Neutrino," *Physics Today* 31 (September 1978) pp. 23-27.

[3] Abraham Pais, *Inward Bound: Of Matter and Forces in the Physical World* (New York: Oxford, 1986), esp. pp. 314-315.

[4] Brown [2] p. 24.

[5] Christine Sutton, *Spaceship Earth* (Cambridge, U.K.: Cambridge Univ. Press, 1992) p. 44.

[6] John Yeomans, *The Other Taj Mahal: What Happened to the Sydney Opera House* (Victoria, Australia: Longmans, 1973).

[7] Frank C. Keil, "Godzilla vs. Mothra and the Sydney Opera House," *Mind and Language* 6, No. 3, 239-251 (1991).

[8] For example, see the photograph of a scale model in the Larousse *Encyclopedia of Modern Art*, Rene Huyghe, ed. (London: Paul Hamlyn, 1965; translated from the French edition of 1961) p. 306. Also Sigfried Giedion, in the 1967 edition of his classic Space, Time, and Architecture (Cambridge, MA: Harvard Univ. Press), devoted over 15 pages to the incomplete Sydney Opera House.

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