Interview: "Creativity in Science"

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1. What is the essence of the contribution for which you received the Nobel Prize?

Until my discovery of the tau lepton, just two families of elementary particles were known. The first family consisting of the electron, the electron neutrino, the up quark and the down quark was already known. This first family makes up the ordinary matter of our world. The second elementary particle family, partially known, consists of the muon, the muon neutrino, the charm quark and the strange quark. But these second family particles are unstable, contributing indirectly to the behavior of ordinary matter.

I developed a theoretical idea, called sequential leptons, that postulated more families of elementary particles. I then went on to discover experimentally the tau lepton that is a member of the third family of elementary particles. This third family was eventually filled out with the later discovery by others of the tau neutrino, the top quark and the bottom quark.

Since my discovery of the tau lepton there have been many rigorous searches for similar, additional families of elementary particles. But none have been found. Only three families are known. There is no explanation of how it is that nature limits the elementary particles to three families. There are no theories, simple or exotic, that explain the number three, for example the much touted string theory models have no explanation. Therefore my discovery has led to a greater unsolved puzzle. I don't know the answer. Perhaps the answer will be found by a young Serbian physicist?

2. *What are the impacts of this contribution?*

My discovery introduced the existence of more elementary particle families. No more of the three types of elementary particle families have been found. But there are other possible types of particles. For example we know through astronomical observations that there is another type of matter called dark matter and we know that this dark matter does not consist of particles from the known three elementary particle families. Thus we may still be at the beginning of our knowledge of elementary particles.

By the way I am skeptical of the so-called super symmetric model of elementary particles in which it is postulated that every known particle has an unknown partner. There is no proof of this model and its parameters are forever shifting.

3. *What are the applications of your contribution that may change everyday life?*

There are no direct applications to everyday life of the discovery of the tau lepton and the third elementary particle family. But there are deep contributions to our understanding of our world

4. *Can you shed more light on the last answer?*

Our culture has many parts – literature, the visual arts, theology, horticulture, architecture, mathematics, philosophy, dance, crafts, music, sports and Science. The language of Science is universal. Science in culture studies all of nature. Science is in the stars. Scientific experiments can be beautiful. Science teaches humility and rationality. Science is full of dreams.

5. *We learned a lot from your lectures on Creativity, in Japan, Tokyo and Sendai. Can you tell us, what are the issues that we have to teach our kids, so they become creative when they finish studies?*

Creativity is sought everywhere: in the arts, entertainment, business, mathematics, engineering, medicine, the social sciences, and the physical sciences. Common elements of creativity are originality and imagination. Creativity is intertwined with the freedom to design, to invent and to dream. In engineering and science, however, creativity is useful only if it fits into the realities of the physical world. A creative idea in science or engineering must conform to the law of conservation of energy (including the mass energy mc^2). An inventor that thinks that she or he knows how to violate the conservation of energy will have to disprove a vast amount of laboratory measurements and accepted theory.

Creativity in science, engineering and computer science is constrained by feasibility and practicality. Consider the work in the US on a nuclear reactor powered airplane in the 1950's. Before the development of intercontinental missiles there was a desire to build a bomber that could fly around the world. There were three severe problems faced by the designers: the weight of the reactor and the shielding, the shielding of the crew from the reactor radiation, and the contamination of an area if the plane crashes. Tests went as far as connecting a nuclear reactor to an engine. But the plane was never built. This idea violated the constraint of feasibility.

Since the maturation of automobile technology and powered aircraft technology, inventors have dreamed of a flying car, a vehicle used by the public that could be driven on the road or flown. The vehicle would have easy convertibility between the two modes. There have been a few temporary successes but the concept does not meet the constraint of practicality. How is the airspace to be regulated? Where are the wings when the vehicle is used as an automobile. What is the cost of purchase and maintenance?

6. *What are the major things to keep in mind, when you form a team for a scientific experiment, or similar?*

I follow a two-part theorem that I always pass on to my graduate students and postdoctoral research associates: (1) Don't choose the most powerful experimental group or department—choose the group or department where you will have the most freedom; and (2) There is an advantage in working in a small or new group; you will get the credit for what you accomplish. When I received my Ph.D. in 1955, I had job offers from the physics departments at Yale, the University of Illinois, and the University of Michigan. At that time, Yale and Illinois had better reputations in elementary particle physics, so I deliberately went to Michigan.

7. *What are the people to avoid, when trying to generate a break-through achievement?*

The most important thing I learned from Isadore Rabi, my Ph. D. thesis professor, is to avoid fast talkers and fast thinkers. This is very important for young people. I try to avoid working with fast talkers. I don't mind working with fast thinkers if they say very little. And, the best thing of all is to work with people who are smarter than you, who thinker faster than you, but never say anything.

8. *What is your opinion about the impact of math?*

You don't have to be a mathematical genius. There are science fields where mathematics is secondary. Nonetheless, you must be competent in mathematics.

9. *When targeting a major breakthrough, how sensitive one has to be about the direct interests of tax-payers?*

In democracies such as Serbia and the United States, the tax-payer is the boss. Try to convince the citizenry of the wisdom of reasonable investment in applied and pure science and engineering.

10. *What is the major driving force that motivates a Nobel Laureate to continue to create and generate results after he-she receives the Nobel Prize?*

I am not young but I have three dreams. I would like to contribute to understanding the nature of dark matter. I would like to contribute to understanding the nature of dark energy. I would like to understand the nature of mass as exemplified by the mass spectrum of the electron, the muon and the tau. The so far hypothetical Higgs particle will not explain this mass spectrum even if it is discovered at the Large Hadron Collider.

11. *For small nations like Serbia, what is your advice, which road to take, when it comes to science?*

(a) Build on special strengths that are already developed in Serbia. Do not try to do many things in science in engineering. No nation can succeed in many areas in science and technology. For example the United States excels in medical research and technology but is way behind in automobile technology and storage batteries. The United States should copy Japan and other countries in automobile technology and storage batteries. It is much cheaper to pay royalties than to try to catch up in a well developed field.

(b) Develop cooperative projects and investigations with small or medium size countries.

(c) Serbia should stay out of grandiose science and new technology projects such as ITER, the international project being developed since 1985 to demonstrate net power production via controlled nuclear fusion.

12. *What road to take, when it comes to its general future development plans?*

Serbia has a distinguished scientific and technical history and tradition as exemplified by Nikola Tesla, Mileva Marić and Michael Pupin. (I did my Physics Ph. D. research in the Pupin Laboratory of Columbia University in New York City.

I don’t know enough about the specific interests and strengths of the present scientific and technical communities in Serbia to make suggestions.