Amazing

Remarks by John Bahcall on receiving the Dan David Prize: 5/18/03.

I would like to tell you a story that amazes me.

In May 2001, scientists announced two important discoveries based on beautiful measurements made in a Canadian mine and in an underground laboratory in Japan.

The scientists used flashes of light in the bottom of a mine to determine the temperature in the center of the Sun and to establish the properties of exotic subatomic particles called neutrinos.

These discoveries, although recent, have their roots in the middle of the 19th century, when scientists first began to struggle with the question: How does the Sun shine?

In the last century and a half, there have been many essential steps in the struggle to figure out what supplies the energy radiated by the Sun and other stars. These steps include measuring the chemical composition of the Sun, discovering that four hydrogen atoms are heavier than a helium atom, developing the special theory of relativity, studying experimentally the nuclear reactions that produce the Sun's energy, and the invention of fast computers. Without all these developments, the underground experiments would not have been meaningful.

The mine experiments indirectly measure the nuclear reactions that cause the Sun to shine and make possible all life on Earth. These same nuclear reactions produce exotic particles, called neutrinos, that interact very little with matter, move essentially at the speed of light, have no electrical charge, and have almost no mass. They are strange indeed

Neutrinos are captured in the underground experiments. In order for the Canadian mine experiment to work properly, a detector as big as a ten story apartment building had to be constructed over a decade in an active mine with the accumulation of less than one teaspoon of dust in the detector. And the elusive neutrinos had to be observed in the mine through the faint flashes

of light that neutrinos cause when they occasionally strike electrons. It is hard to catch neutrinos; observing the flashes of light they cause is one of the few successful techniques.

The first important discovery announced in 2001 was that neutrinos, which come in different types, change their type, their personality, on their way to the Earth from the Sun. The second discovery was that the standard theoretical model of the Sun predicts correctly the total number of neutrinos of all types. These experiments with solar neutrinos show that we understand how stars shine and that we know the central temperature of the Sun to better than 1 percent.

I find it amazing, almost incredible, that the century and a half long chain of reasoning about how the Sun shines and how neutrinos get to us from the Sun could be tested on the basis of an experiment in the bottom of a mine.

I am amazed that so many people, speaking so many different languages and living at such different times, have collaborated in so many different ways to make it possible that flashes of light in the bottom of a mine could be used to determine the temperature in the interior of the Sun and the properties of exotic subatomic particles.

I am amazed that flashes of light in a mine, the temperature of the Sun, and the properties of neutrinos are linked in such a beautiful way.

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