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Commentary

Where Things go the other Way Around

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Lewis Carroll had a lot to say about what is real and what is not [1]. In *Through the Looking Glass*, he tells the reader that Alice was in the drawing room, curled up with her cat in the corner of a great armchair. She held a looking glass up to the cat and said, "I'll put you through into the Looking-glass House. How would you like that?" Alice explained to the cat that there is a room through the looking glass just like the drawing room, "only the things go the other way around." Then suddenly, the glass turned into a mist and melted away, and Alice jumped into the looking glass room. At first, the room seemed rather ordinary, much like the one she had left behind, but then the clock on the wall smiled at her, and she noticed chessmen walking about two by two and the White King and Red Queen sitting on the edge of a shovel and chatting.

When Alice peered into the looking glass, she saw the world from one point of view, and when she looked back into the drawing room from inside the looking glass, she saw things from a different point of view. From her new perspective, she saw a strange place where "the things go the other way around," a strange land where chessmen don't walk about two by two and don't even talk to one another.

Curiouser

After she suddenly grows to the size of a giant and scares the White Rabbit away, Alice asks, "Who in the world am I? ... Ah, that's the great puzzle." Another ALICE, A Large Ion Collider Experiment [2], part of one of the most ambitious scientific projects of all time, was designed to answer another grand question: What is the Universe made of? Both Alices peer deep into the abyss of the unknown, and the deeper they go, the curious the world seems.

Shortly after going into the looking glass, Alice saw a book lying on a table and she read aloud a poem called "Jabberwocky." The poem tells of fuming and furious creatures:

"Beware the Jabberwock, my son!

The jaws that bite, the claws that catch!

Beware the Jubjub bird and shun

The fruminous Bandersnatch!"

By the end of the poem, after "the vorpal blade went snicker-snack!" the Jabberwock lay dead. Alice was puzzled by what happened and told herself, "...somebody killed something: that's clear," and then she admitted, "It is rather hard to understand." Sometimes, like Alice, we all need to admit that we don't fully understand what we see or are told. I am an expert on the behavior and ecology of birds, and I am broadly trained in science and philosophy, but my knowledge of theoretical physics is thin. As best I understand, ALICE is a collaboration of thousands of scientists from 40 countries around the world, who are trying to create conditions like what the universe was like during the first partial microsecond after the Big Bang. They are doing this by colliding energetic particles, like accelerating nuclei of lead atoms, to generate temperatures 100,000 times hotter than the interior of our sun. As it was told to me, matter consists of protons and neutrons surrounded by clouds of electrons, but protons and neutrons are made from even smaller particles called quarks and gluons. These quarks and gluons are held so tightly together that they have rarely been seen, but they supposedly fly apart in a high-energy collision and allow observers a momentary glimpse of

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something called the *quark-gluon plasma*. After the collision, the plasma expands, cools down, and reverts to ordinary matter made of neutrons, electrons, and protons. Just as I think that I am beginning to understand what Alice and ALICE are saying, I am reminded of something Albert Einstein said:

"The existence of objects is...of a conceptual nature, and... depends wholly on their being connected (intuitively) with groups of elementary sense-experiences. This connection is the basis of the illusion which makes primitive experience appear to inform us directly about the relation of material bodies (which exist, after all, only as far as they are thought)" [3].

I have read about but have had no "elementary sense experience" with Jabberwocks, Jubjub birds, quarks, or gluons; do they only exist insofar as they are thought? I have also read about Napoleon Bonaparte, Madame Curry, little green men, and a giant Pooka named Harvey. Should I only believe things that I have experienced firsthand, and, if not, how do I pick and choose what to believe?

Jubjub birds and quarks

What is the difference between a belief in Jubjub birds and a belief in quarks? I am content to let Jubjub birds roam free in my mind because I do not expect them to exist outside of the shared imagination of Lewis Carroll and his many fans. I hold quarks to a higher standard. The concept of quarks is also a creation of the human mind, but quarks, unlike Jubjub birds, were imagined with the expectation that their existence would someday be verified by observation and experimentation.

Scientific hypotheses often begin in the imagination, having an idea that might explain some of what we have already observed, and the more the hypothesis explains the better, but the strongest evidence supporting a hypothesis is not how much it explains of what we already know, it is instead how well it predicts things we have never before observed. American theoretical physicist Gell Murray hypothesized the existence of quarks in 1964 to explain properties of the strong force that holds protons and neutrons together to form the nucleus of an atom. According to what is now known as the *Standard Model*, there are six kinds of quarks, and they have been named *up, down, charm, strange, top,* and *bottom*. There is a problem with testing the Standard Model: we cannot directly observe quarks. The strong force is so strong that quarks cannot be separated from the nucleus and directly observed. Their existence has to be verified by predicting and measuring their effects on their surroundings.

You can't see the quarks themselves, but you can see tell-tale particles left behind when a proton or neutron is smashed in an accelerator. Quarks come in matched pairs, and by the 1970s, two pairs (up-down and charm-strange) had been verified, but only the bottom half of the top-bottom pair had been found. The top quark was more elusive and not verified until 1995, more than 30 years after its existence had been predicted.

Point of view: Does the moon exist?

Einstein is said to have asked a friend, fellow physicist Abraham Pais, "Do you believe that the moon only exists if you look at it?" Pais gave a nuanced answer that represented a common view among physicists and philosophers of the time, and likely is still the opinion of many. Pais said, "The existence of anything in the absence of an observer is a conjecture that can neither be proven nor disproven [4]." Consider the old question: if a tree falls in the woods, is there no sound if no one is there to hear it? An 1884 note in *Scientific American* addressed a very similar question, stating: "Sound is vibration, transmitted to our senses through the mechanism of the ear, and recognized as sound only at our nerve centers. The falling of the tree or any other disturbance will produce vibration in the air. If there be no ears to hear, there will be no sound." I have a different point of view and have come to a different conclusion.

Physicists and philosophers have had ample opportunity to comment on Professor Pais' statement that *the existence of anything in the absence of an observer is a conjecture.* I'd like to present a more ecological point of view. First, specifically regarding the tree falling when no one is there to hear it, are human ears the only ones that count? What about all the animals with ears; did not the falling tree make a sound for birds and mice? But even if there were no animal ears, ears are not the only things that vibrate, nor the only things altered by vibration. If a dewdrop falls to the ground because of the vibration of the air, and the dewdrop nourishes a parched seed, the state of the forest may be irreversibly changed by a sound that was not heard by a single ear. Are we to suppose that because there were no ears to hear the sound, the forest was not altered; indeed, if no one heard the Big Bang, does the universe not exist?

In our minds, we imagine that there are two ways to verify that something you predicted happened: 1) it can be verified directly by seeing it happen, or 2) it can be verified indirectly, by predicting how it will affect its surroundings, and then observing the predicted effect. It sounds like a strange idea, knowing that something happened even though you didn't see it happen, but actually, we do it frequently. You don't have to see your kid eating a jelly doughnut; you can tell that he ate it by observing the powdered sugar and strawberry jam around his mouth.

I often find more clarity and wisdom in the simple words of great poets than in the equations and writings of the greatest scientists. I think that Oscar Wilde was spot on when he said that "it is in the brain that the poppy is red, that the apple is odorous, that the skylark sings." We do not experience a falling tree or anything else directly; we experience everything indirectly by experiencing the effect of what happens, like the effect of a falling tree on the vibration of air and, in turn, the effect of a sound wave on our sensory cells.

Finally, I am reminded of the wisdom of English author and humorist Douglas Adams, who wrote in the Hitchhiker's Guide to the Galaxy [5], "anything that is happening, causes itself

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to happen again, happens again." To which, I can only add "anything that, in happening, causes something else to happen, changes the future and, therefore, must have happened."

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