OFF THE BEAT

Physicists vs. Mathematicians: A Theory of Groups

To the casual leafer through the literature, mathematicians and physicists often look like similar breeds of cat. They use many of the same words. Their publications are full of similar arrays of arcane symbolism that often come in several layers and use up all the letters of the Latin and Greek alphabets and some of the Hebrew and Cyrillic as well. Mathematics is the language of physics, and every physicist must learn to speak it. Physical problems have often been the genesis of mathematical developments.

Yet the two species of feline are really basically different in attitude. Physicists are interested in material connections among phenomena and their physical description. Mathematicians are interested in the relations of numbers. Experiment is the physicist's ultimate judge; logic is the mathematician's only constraint. See what happens when one of them gets among the others.

The mathematician in this case is Irving E. Segal of the Massachusetts Institute of Technology, who came before a gathering of astrophysicists to attack dogma number one of their cosmology, the expanding-universe hypothesis. The expanding universe goes back to Edwin Hubble, and it arose from his observations of the redshifts of distant galaxies. One of its prime data supports is the so-called Hubble diagram, a graph of luminosity versus redshift. Hubble proposed that the farther a galaxy is from us, the greater should be its redshift. A law of optics says that the farther away a luminous object is, the dimmer it looks. So a diagram of apparent luminosity versus redshift should yield a straight linear relation between the two, the greater the redshift, the dimmer the galaxy.

In fact it does so only by arm twisting. The data points look very different from a straight line. The physicists say this is not because Hubble was wrong but because the galaxies so far recorded are not a truly representative sample. In other words, physicists will save their simple physical relationship even at the cost of manhandling the data somewhat.

The mathematician, Segal, says let's not do this finagling. He sees two sets of numbers that have a functional relationship to each other and asks himself what sort of function best fits the numbers. Statistical analysis leads him to a nonlinear, square relationship that makes hash out of the expanding universe.

The physicists jump all over him for this. Not that they hate statistics. They love statistics, use them all the time. But a physicist's statistics have ultimately to illustrate a physical connection, and the assembled astrophysicists find none behind Segal's square function. So they tell him he is using an unfair sample.

Sometimes the interdisciplinary tension is more fruitful. In a recent lecture, Raymond W. Hayward of the National Bureau of Standards, outlined some of the history of the unification of the theories of the weak interaction and the electromagnetic interaction, two classes of force that particle physicists have to deal with.

The theories of such interactions or parts of them are often written in terms of what mathematicians call group theory. A very important group in this instance is the intermediary particles that embody the forces of these interactions and carry them from place to place. In the older theories there were three such particles, one, the photon, for electromagnetism, and two, positively and negatively charged W particles for the weak interaction.

Mathematically these particles are members of a group that ought to have a fourth member. Mathematicians and mathematically minded physicists ached to complete the group. The characteristics of that fourth member made it to be a neutral intermediary for the weak interaction. Inclusion of this particle, usually designated B, was one of the things that made theoretical unification of the two interactions possible, but it demanded the existence of weak-interaction processes that had never been seen, the so-called neutral-current processes. Physicists thought the unified theory a beautiful accomplishment, but few of them would have staked their oath on it until experimenters, inspired by the mathematics, began to find the neutral-current processes.

Another example is so old it's in the textbooks. Maxwell's equations, which were published a hundred years ago, summarize classical electrodynamics. One of the things they predict is radio waves. Curiously, the equations for a transmitter radiating waves are symmetrical. In addition to waves radiating away from the transmitter, which are easy to understand physically, the equations predict infalling waves, arriving at the transmitter from an infinite distance. Physicists have no way to understand these infalling waves so they calmly throw them out as unphysical. When this is presented by a physics teacher to mathematics majors, they jump up and down and scream: "How can you throw away perfectly good solutions to perfectly good equations?" The physicist's reply is that you have to have some experience with your hands in the dirt to know what is physical and what is not.

Or do you?

The equations of special relativity yield solutions for particles that go faster than light. But the rest masses of such particles are represented by imaginary numbers. Nobody could see how an imaginary rest mass could be physical, so the solutions were ignored for a long time. Then some physicists began to point out that if these faster-than-light particles were always in motion and never at rest, it didn't matter what kind of number represented their rest mass since that quantity would never affect the actual physics. What mattered was that the energy and momentum of these particles (which were then dubbed "tachyons") were represented by real numbers and could therefore be physical. So now there are experimenters looking for tachyons.

You never know.

—Dietrick E. Thomsen

. . . Goddess

good health, good scores on school exams, a chance to visit distant relatives and just plain good luck are among the most common requests. Such petitions suggest the flexibility of mother worship, and show how thousands of years of tradition can remain valid in a modernizing society. For centuries people have prayed to the goddess for protection from disease, famine and flood. Now, with the stresses of modern life, they ask her for cash, material goods and opportunities for upward mobilility. Instead of a narrowing of the goddess's functions, as has happened with some religions, modernization may have widened them, says Preston.

He and others have also pointed out that profound changes are taking place within Hinduism all across India. The addition of a neon *Om* blinking above the gopuram (temple gateway) at one temple, the abandonment of blood sacrifices at others and the standardization of Hindu law through legislation are among the most obvious examples. Mother worship at the Chandi temple illustrates some of the more subtle changes that are taking place.

The goddess, Preston says, is part of a larger world view capable of integrating fragments of the past with new social relations between castes, classes and interest groups. She offers new forms of worship fitted to the urban climate, a sense of stability in the midst of change and a link to the past. The temple where the goddess is housed is no longer a quiet place for the pious, but a vibrant hub of city life where there is commercial activity. "Thus," concludes Preston, "as an agent of change the goddess emerges with a new dignity from her previous role as a tutelary deity of the raja. Chandi is tranformed into a goddess of the new India—commercialized, but still sacred—at once both modern and traditional." □