angular momentum of the Galaxy. A further interesting idea is that maybe WIMPs are basically antimatter and will explain the abundance of matter over antimatter in the universe.

Herzel Laor
Laor Optics IIc
Boulder, Colorado

Levi replies: When I wrote that weakly interacting massive particles (WIMPs) do not participate in the galactic rotation, I was not implying that WIMPs do not experience a gravitational field. They do. However, WIMPs move in more or less random orbits in a spherical volume, in contrast to the organized motion of the majority of stars in our Galaxy, which rotate in a flattened disk. The WIMPs are not likely to collapse into a disk, as most of the stars have; they collide so infrequently with one another (their mean free path is greater than the diameter of the Galaxy) that they have no mechanism for shedding energy and collapsing into the flattened pancake-shaped disk.

As for the question of whether WIMPs might be antimatter, we have several reasons for concluding that they are not: First, the amount of matter in WIMPs is much larger than the ordinary matter in the universe. Second, antimatter would exist in the form of antiprotons and positrons, and they would annihilate ordinary matter, with a spectacular and highly visible gamma-ray background. Finally, such antimatter would be charged, would interact with photons, and hence would not be "dark."

Barbara Goss Levi
(bgl@worldnet.att.net)
Physics Today
Santa Barbara, California

The Universe in a Glass of Beer

The mystery of the cosmological constant has been with us for a long time,[1] and has recently been said to be the most perplexing puzzle in contemporary physics.[2] Ever since it was introduced by Einstein in 1917, debate has continued as to whether it really exists or not; and if it does, why is it so small? Although Einstein and other theorists came to regard it as unnecessary, in the face of mounting evidence that the universe was expanding rather than stationary as was originally thought, the cosmological constant has been resurrected in recent years to help explain—along with the concept of "dark matter"—the apparent motion and structure of the universe. And although some theorists in modern times have tried to prove that it is either zero or extremely small (see, for example, ref. 3), recent evidence from high-redshift supernova studies strongly suggests that it not only exists but contributes at least twice as much as ordinary matter to the critical density required for a flat universe (see Physics Today, June 1998, page 17).

The question remains, however, as to why the constant is as small as it is rather than huge or even infinite as standard field theory would seem to indicate (Physics Today, March 1989, page 21). That is, if one assumes that it is due to the vacuum field that permeates all of space (Physics Today, July 1999, page 81) and sums the zero-point energies of all the field modes, the result would be an infinite energy density and the universe would have curled up upon itself long ago. Because this has not happened, it has been assumed that something either limits the number of field modes or causes them to largely cancel out. Attempts to impose limits, however, have still yielded results up to 120 orders of magnitude too large, while arguments that have been advanced for the field modes to cancel in some way have largely seemed untenable. Therefore, to help resolve this dilemma, I would like to put forth the following suggestion.

If we think of the vacuum as a fluid of uniform energy density, then a small "bubble" formed within it should "rise" toward the "surface" much like a bubble would in a glass of beer. If the bubble were to arise from a quantum fluctuation in the vacuum of space, it would move at an ever-increasing rate toward the boundary of the universe (if it is indeed bounded) due to the slightly unbalanced Casimir forces acting upon it (that is, the pressure of the vacuum). This suggests that a kind of cosmic Archimedes principle is at work in what might be called a Casimir-driven universe, causing space itself to expand at an ever-increasing rate. Whether the universe is finite and bounded as is a glass of beer is not yet known, but if it is, this model should account for the observed behavior of the expansion rate, at least in general terms. It may also lessen the need for "dark matter" (unless you're having a Guinness) and help achieve the "mass without mass" suggested recently by Frank Wilczek (Physics Today, November 1999, page 11; January, page 13) as a desirable consequence. In any case, it would not be the first time such a model has proven useful in physics (and probably not the last) and the thought that we live in a universe that is something like a light pilsner is not a bad thought at all.

References

1. L. Abbott, Sci. Am. **278** (5), 106 (1998).
2. L. M. Krauss, Sci. Am. **280** (1), 53 (1999)
3. S. W. Hawking, Phys. Lett. B **134**, 276 (1984).

Maurice T. Raiford
(mtr@physics.ucf.edu)
University of Central Florida
Orlando, Florida

Elegance: Keeping it Simple and Testable

N. David Mermin, in his recent Physics Today article (March, page 11), gave an interesting commentary on elegance in physics. I have to agree with his remarks—and perhaps we need to inquire further about why this strange concept has become so elevated in our discourse. Here I am guided, for one, by the statement of Einstein's in his little book on relativity, from 1916, which Mermin touches on. In translation, Einstein's original sentences read:

> "In the interest of clearness, it appeared to me inevitable that I should repeat myself frequently, without paying the slightest attention to the elegance of the presentation. I adhered scrupulously to the precept of that brilliant theoretical physicist L. Boltzmann, according to whom matters of elegance ought to be left to the tailor and the cobbler."

I think that Boltzmann's statement as quoted by Einstein casts this idea of elegance into a true light. It is, as Mermin suggests, largely a subjective judgement—and as Boltzmann implies, perhaps as changeable as the fashions behind our choice of clothing and shoes.

The fact is that we scientists really are not respected in society for our elegance, though we might have artistic aspirations. A doctor is respected and valued for saving lives, and that is all. A scientist is respected and valued for having a glimpse of truth, and that is all. We test the truth of scientific theory in experiment. If no experiment is possible, then the science is always uncertain.

Simplicity (which may seem elegant) is valued because it sometimes leads to truth. At least, if an assertion is simple, then testing it is a more straightforward procedure. I have to confess here that my philosophy of what is real science comes via Karl Popper, who is unfashionable. Even so, he was reliable in his understanding of good science.

Unfortunately, these home truths about what is desirable in science play an ever-diminishing role in much of modern physics. When theory is totally divorced from experiment, as it so often is in current publications in our physics journals, how do we judge the value of what is contained therein? Hence the rise of this concept of elegance as a value judgment. We should be asking not "Is it elegant?" but "Is it true?" or "Is it falsifiable?"

Clever readers can surely judge for themselves how best to apply this criterion to contemporary fashions in theoretical physics, like string theory, or indeed as Mermin suggests, quantum computing. These subjects will contribute to science not their elegance, but rather only that part of them that is testable in real experiments. Like surgery, this is often messy, but it is certainly what we are about as physicists.

PETER DRUMMOND
(drummond@physics.uq.edu.au)
University of Queensland
Brisbane, Queensland, Australia

MERMIN REPLIES: I'm delighted to learn from Peter Drummond the reason why, as noted in the author blurb accompanying my column, Boltzmann's "Elegance is for tailors" is so often misattributed to Einstein. This is a spectacular example of the Matthew effect operating even among the giants of our profession. Who would have thought that the great Boltzmann could have been a victim? (My own low grade victimization was reported in PHYSICS TODAY, April 1981, page 53.) I'm also ashamed to have wasted months in a fruitless search for the true source of that quotation, when all along the answer lay unnoticed on my bookshelf in the preface to the very book by Einstein that inspired Bruno Latour's infamous essay on relativity, my commentary on which got me into so much hot water in these Letters pages just a few years ago (April, 1998, page 15).

N. DAVID MERMIN
Cornell University
Ithaca, New York

Proper Credit Given for Early Cancer Work

I was dismayed that your announcement (PHYSICS TODAY, May, page 9) of the very significant result achieved in our laboratory, demonstrating the ability of light scattering spectroscopy to find precancerous dysplastic lesions without removing tissue, failed to credit the creators of the work.

The idea was conceived by Lev Perelman, a principal research scientist, and Vadim Backman, a graduate student, in the Harvard–MIT Division of Health Sciences and Technology. Working closely with their principal clinical collaborator, gastroenterologist Michael Wallace, they demonstrated the validity of the concept by analyzing an extensive series of clinical measurements and comparing them with biopsies taken from the same areas.

For these reasons, their names appear first on each of the initial technical publications.[1,2,3] Working with other collaborators, they were able to demonstrate the applicability to many other organs.

It is true that the work involved many collaborators, and because of his position as director of the laboratory, Michael Feld played an important leadership role. However, we physicists make so few important breakthroughs in our working life that I feel it is important to get the credit right.

My role? I helped create the apparatus with which the data were taken, and have reviewed the progress of the project continuously from its inception.

References

1. L. T. Perelman, V. Backman, M. Wallace, G. Zonios, R. Manoharan, A. Nusrat, S. Shields, M. Seiler, C. Lima, T. Hamano, I. Itzkan, J. Van Dam, J. M. Crawford, M. S. Feld, Phys. Rev. Lett. **80**, 627 (1998).
2. V. Backman, R. Gurjar, K. Badizadegan, R. Dasari, I. Itzkan, L. T. Perelman, M. S. Feld, IEEE J. Sel. Top. Quantum Electron. **5**, 1019 (1999).
3. M. B. Wallace, L. T. Perelman, V. Backman, J. M. Crawford, M. Fitzmaurice, M. Seiler, K. Badizadegan, S. J. Shields, I. Itzkan, R. R. Dasari, J. Van Dam, M. S. Feld, Gastroenterology (in press).

IRVING ITZKAN
Massachusetts Institute of Technology
Cambridge, Massachusetts

The Neutrino Road Not Taken

This letter is in response to Allan Franklin's article, "The Road to the Neutrino" (PHYSICS TODAY, February, page 22). The hypothesis that a neutral particle is emitted in beta-decay processes, proposed by Wolfgang Pauli in 1930 (and later called the neutrino by Enrico Fermi), was made with two purposes: to save the principles of conservation of energy and momentum and to explain observed difficulties in relation to the statistics (Bose or Fermi) of nuclei and conservation of spin. In his article, Franklin refers, for a reason, to the former purpose, but unfortunately he does not even mention the latter.

LUCIANO N. BLANCO
(lnblanco@sigmaxi.org)
Institute for Theoretical Research
Coral Gables, Florida

FRANKLIN REPLIES: Luciano Blanco is correct that a neutrino in the nucleus model would solve the spin-statistics problem for nuclei. Such a model, however, would still require electrons in the nucleus, which would result in large unobserved nuclear magnetic moments. Perhaps this is why Pauli did not mention it in his letter that originally proposed the neutrino. The nuclear problem was soon solved by James Chadwick's discovery of the neutron.

ALLAN FRANKLIN
(allan.franklin@colorado.edu)
University of Colorado
Boulder, Colorado

Trouble for Quantized Hubble

The possible bunching of galactic redshifts that Maurice T. Raiford notes in his letter in the February issue of PHYSICS TODAY (page 75) could be important. However, the apparent numerical agreement between the putative quantum of recessional velocity, v = 72 km/s, and the Hubble constant results from the convention of writing that constant in units of kilometers per second per megaparsec instead of inverse seconds, and is without any deep significance. If H_0 is expressed as 2.3×10^{-18} s^{-1} instead of 71 km/(s Mpc) then there is nothing to suggest a direct proportionality between v and H_0.

GEORGE L. MURPHY
Trinity Lutheran Seminary
Columbus, Ohio