Letters

Cool Policy

We at *Cool* would like to commend *Science* and its staff on Leslie Roberts' recent article "The rush to publish" (News & Comment, 18 Jan., p. 260). We agree that this is an issue of concern in the scientific community; however, we were disappointed to find no discussion of our publication guidelines. Under the time reversal policy™, we offer to authors the possibility of publishing their results before they actually do their experiments. This policy is specifically intended for only the coolest papers; clearly, rigorous fundamental papers have other, more appropriate and receptive outlets. Needless to say, we realize that it presents a number of ethical dilemmas, but given the competitive nature of the scientific enterprise and the fact that some of the coolest experiments are just too difficult to do, we feel that we are performing a "service" to the scientific community. Despite generally enthusiastic reviews of our debut issue (Briefings, 7 Sept., p. 1102), as a result of the advice of legal counsel (as well as a fair amount of pressure from our advisers to actually do some experiments), we intend to cease publication effective with our first issue.

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Explaining the Avocado Illusion

The avocado illusion described by Paul E. Sandorff (Letters, 21 Dec., p. 1646) is, indeed, of interest to experimental psychologists. If I may add spice to the guacamole and take a whack at the tennis ball illusion, my guess is that both are mediated by the same mechanisms that produce the moon illusion (Book Reviews, 28 Sept., p. 1590). There is little agreement, however, as to what those mechanisms are (*1*). I would explain them, as I did the moon illusion (*2*), by invoking the inherent activity of the eye-brain system. I proposed that this structure evolved to produce the perception of rigid objects moving in three dimensions whenever it is activated by an expanding or contracting retinal pattern. This constancy constraint is also activated by static stimuli such as avocado. In my view, the apparent size of the avocado, and that of the moon, is determined by the retinal size of the light reflected from them and by their relative apparent depth as determined by the context. In the case of the avocado, it is well known that depth perception is greatly impaired in leafy surrounds (*3*), and I would suggest that, like the moon on the horizon, the avocado appears to be closer than its actual distance. Because the retinal size is constant, the inherent constraint that normally produces size constancy when activated by a changing stimulus now produces the anomalous enlarged perceived size.

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REFERENCES

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High-Temperature Superconductivity Theory

David P. Hamilton's article "HTS theory: Where's the beef?" (Research News, 19 Oct., p. 375) contains a number of factually incorrect and misleading statements that I would like to address. First, he comments that the Bardeen-Cooper-Schrieffer (BCS) theory of superconductivity, while explaining low-temperature superconductivity, "didn't offer much predictive power." This statement overlooks several facts: (i) the theory was the basis for predicting the dramatic Josephson effects of fundamental scientific and technical importance; (ii) the theory accurately predicts the transition temperature of the low-temperature superconductors, provided the properties of the normal phase of these materials are known; and (iii) the theory predicts the form and temperature dependence of essentially all fundamental properties of low-temperature superconductors, including so-called strong coupling effects that go beyond the Fermi liquid theory of the normal phase.

Second, while I and many other theorists believe that the pairing condensation is essential in explaining high T_c superconductivity, the observed factor of 2 in the flux quantum is merely consistent with the BCS theory and is not a proof of its validity in these high-temperature materials.

Third, while high T_c theorists face many difficulties, one that is *not* likely to be serious is "a peculiar disorder that defies one of solid-state physicists' most cherished assumptions—periodic symmetry." As P. W. Anderson showed in the early 1960s, the BCS theory is, in essence, unaffected by scattering that breaks long-range translational order. Furthermore, most theories of superconductivity can rather easily include such symmetry breaking effects, as they are in no way of essence to the fundamentals of the theory, so long as the relevant order parameter is nonzero in all directions.

Missing from the article is a discussion of central issues of concern to the high T_c theorists of today. Fundamentally, the BCS theory has three ingredients: (i) the Fermi liquid description of the normal phase; (ii) the phenomenon of pairing condensation in the presence of very strong pair overlap and Pauli principle correlations; and (iii) the specific attraction mechanism causing this condensation. At present, most theorists are focusing on the nature of the normal phase. The cuprates have many features reminiscent of a Fermi liquid, but many other features are strange to those familiar with conventional solids (*1*). Another issue is whether the pairing theory holds for high T_c materials regardless of the nature of the attraction. I should be pleased by the comment that "Most physicists now agree that Cooper pairs lie at the heart of high temperature superconductivity." While I *believe* that this is the case, there is a difference in science between believing and proving; we have not proven the case at this point.

Finally, the nature of the attraction which causes the pairing condensation has received considerable attention, yet it is *not* the topic of primary theoretical interest in this field at present.

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1. An excellent source of information on this topic is Bertram Battlog's review in *The Los Alamos Symposium on High Temperature Superconductivity* [K. S. Bedell, Ed. (Addison-Wesley, Reading, MA, 1990), pp. 37–93].

Hamilton's article "HTS theory: Where's the beef?" trivializes the science in this field and ignores the content of the mainstream of scientific effort in favor of side issues. Contrary to statements in the article, the main issue for most mainstream theorists today is not what mediates pair bonding. The key question is actually the nature of the "normal" metallic state *above* T_c. Many of us feel that the solution of that problem will almost automatically solve the problem of T_c. A number of researchers believe that the normal state is a "Fermi liquid," which is the generalized version of a free, noninteracting electron gas. However, there is wide agreement that its properties are so unusual that the Fermi liquid picture must be strongly modified, as it is for the "heavy electron" in *f*-shell superconductors such as UPt_3. Others, such as the "anyon" proponents—a group at Bell Laboratories and Rutgers and another at Princeton—are sure that this system is not a Fermi liquid. At least two groups are at the stage of predicting experimental data and suggesting crucial experiments. These recent developments are not addressed in the article.

"Where's the beef?" is a derogatory, inappropriate remark to make about one of the most exciting and fruitful periods in history in the generation of ideas about what quantum theory has to say about complex systems such as high T_c superconductors. The excitement has drawn into the field numbers of particle theorists and mathematical physicists; there are analogies to important issues in particle theory, as well as a new kind of statistics and, possibly, a new state of matter. Superficial articles such as Hamilton's can have disastrous effects on the funding of this very exciting part of physics.

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I fear that *Science* readers may have gotten a wrong impression from Hamilton's article "HTS theory: Where's the beef?" and especially from its title. While to be sure there is at present no comprehensive theory of the properties of the high-temperature superconductors, the attempt to find such a theory has led to brilliant theoretical work.

Perhaps the most provocative new idea, briefly mentioned in the article, is that the quasiparticles in the high-temperature superconducting materials are anyons, that is, that they are characterized by quantum statistics intermediate between bosons and fermions. As pointed out by Robert Laughlin, this possibility entails a new mechanism for superfluidity and superconductivity that may or may not be operative in the currently known copper-oxide high-temperature superconductors, but it is hard to believe that nature does not employ it somewhere. In fact, anyon statistics are known to characterize quasiparticles in the fractional quantized Hall effect and in certain ordered states of spins (chiral spin liquids). Theoretical work on anyons, galvanized if not initiated by high-temperature superconductivity, has suggested new possibilities for magnetically ordered states in two-dimensional materials, and its potential is far from exhausted. I believe, for instance, that it allows a new quantitative approach to the classic problem of the superfluidity of liquid helium (in two dimensions) and suggests the existence of qualitatively new states of matter combining features of traditional superconductors and quantized Hall states.

Another example of important theoretical work inspired by high-temperature superconductivity not mentioned in the article is the prediction of qualitatively new features of vortex dynamics in these materials. Whereas in the old superconductors the vortices typically formed rigid lattices, in the new materials they can under certain circumstances form liquids or entangle into a highly viscous glass-like state. Understanding the dynamics of these vortices is crucial to many of the potential technological applications of the new materials.

Ordinarily scientists (certainly this one) are content to shrug off incomplete or superficial reports on research. However, some of us are especially sensitive at the moment because inadequate funding of basic materials research is making life difficult for many worthy colleagues. Basic research of any kind requires patience and sympathy. Progress is often fitful, and the value of a really new idea may take years to appreciate and may ultimately prove itself in totally unexpected ways. Inadequate funding of the "purest" of pure research (such as particle physics or cosmology) is a cultural tragedy and unworthy of a great and affluent nation. Inadequate funding of fundamental materials research is in addition foolish, even from the most hard-headed practical point of view, in the long run. I hope the rather flip treatment of an important subject in the article mentioned, which might tend to aggravate an already bad situation, will be repaired in the near future.

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Erratum: In the article "Exact solution of large assymmetric traveling salesman problems" by D. L. Miller and J. F. Pekny (15 Feb., p. 754), the first full paragraph on page 757 should have begun, "In order to determine whether G contains a Hamiltonian cycle, we use. . . ." On page 758, the last sentence of the sixth paragraph should have read, "The Hamiltonian cycle algorithm quickly does the same enumeration by using a bipartite matching algorithm on the admissible graph."

Erratum: In Albert B. Sabin's letter "Viral etiology of AIDS and the Gallo probe" (3 Aug., p. 465), reference 1 on page 466 should have read, "F. Barré-Sinoussi *et al.*, *Science* **220**, 868 (1983)."