additional binding strength for T-cell activation with distinct dynamics[9]. We might expect the effect of CD8 to be to displace the threshold, or even qualitatively to influence the effects of some peptides more than others. The number of peptides sampled for these measurements is small, and consistent outliers, such as one reported for a TCR specific for a self-peptide bound to the MHC class I molecule H–2L^d (ref. 10), may be a warning for those who hold too firmly to such simple models. These affinity measurements are reported for purified molecules, expressed in *Drosophila* or *Pichia* cells (TCR) or in bacteria (H–2K^b), analysed in a binding system with three-dimensional freedom of diffusion: events that take place on cell membranes, constrained to diffusion in two dimensions, may be reflected only indirectly in such free-solution measurements[11]. Finally, although the TCR analysed in these studies has been tested in a transgenic system, and in fetal-thymic-organ culture, for its susceptibility to peptide-induced positive and negative selection, we should not overlook the artificial nature of the fully selected TCR expressed as a transgene.

Nonetheless, quantitative studies of the ligand/receptor interactions that regulate immune responses offer objective measurement of parameters that probably reflect molecular controls on the education, selection and function of T lymphocytes. We need only wait for all the right experiments. □

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SUPERCONDUCTIVITY

Counting the ten-year returns

Paul Grant

HOUSTON, oil capital of Texas, is not exactly New York City, and there was still a year remaining before the first decennial of that incredible rock concert of physics, the 1987 March Meeting of the American Physical Society, christened "another Woodstock" by the late Michael Schluter of AT&T Bell Labs. Why then, asked several journalists in attendance at a meeting in Texas earlier this year*, were we jumping the gun in both time and location? Well, actually the timing was spot on.

It was in the early months of 1986 that Georg Bednorz and K. Alex Müller of the IBM Zürich Research Laboratory caught the first glimpse of their great discovery: a startling drop in resistivity near 30 K in a mixed phase cuprate. As to location, the Houston venue was also eminently fitting, because soon after the appearance of the IBM paper, Paul Chu and his co-workers, both in their home Texas institution and in Alabama, embarked on the series of compositional variations that broke through the liquid nitrogen 'glass ceiling' and led to the subsequent sensational events.

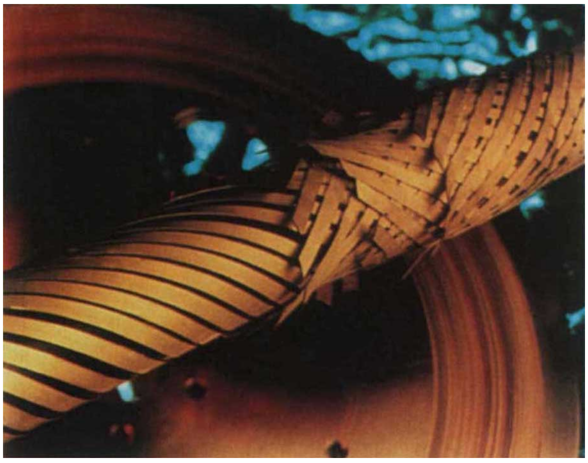
The plenary, invited and poster sessions addressed three primary topics in high-temperature superconductivity — pairing mechanisms (both theoretical and experimental aspects), materials and applications. I will concentrate on the third topic, emerging applications. What better tenth anniversary present to Bednorz, Müller and Chu?

The general tone was set in the plenary address by John Rowell, not known from his past presentations for giving an overly sanguine view of the commercial prospects of superconductivity, high- or low-T_c. This time, however, Rowell was quite upbeat, especially regarding high-temperature superconductor (HTSC) electronics, pointing out that a number of price/performance targets set by receiving industries had been met, especially in the case of passive radio frequency filters for cellular or 'personal communication' ground stations. The remaining challenge, in his view, was one of perception, not technology, especially regarding the requirement for refrigeration, which is seen by many potential customers as inherently expensive and unreliable. Education and packaging approaches are needed that will make users as comfortable with the presence of cryogenic devices as the general public is with household refrigerators. Rowell concluded that the next ten years will be "the decade of markets" for superconducting devices, with the prospect of billion-dollar revenues.

In my own speciality, power applications, we announced the successful construction and testing of a 50-metre underground a.c. transmission cable (Aldo Bolza, Pirelli Cavi, Milan). The conductor assembly contained more than six kilometres of lead-stabilized BSCCO tape (BSCCO is a cuprate perovskite structure joined to oxide complexes of bismuth, strontium and calcium). Immersed in liquid nitrogen, the flexible assembly carried a d.c. current of 1,800 A, which is more than twice its design target capacity and established a new record for HTSC current-times-length performance (the record has been broken again since the meeting). In my view, however, what is most important is that the tape was wound on its one-inch diameter hollow core by a standard cable-stranding tool, and not by a team of expensive PhD manual labourers.

An announcement containing a similar pleasant surprise came in the next paper. A collaboration has constructed and operated a 125-horsepower (93 kW) synchronous motor, whose rotor was wound with the same sort of BSCCO tape used in the cable conductor assembly (Dave Driscoll, Reliance Electric). But because the magnetic fields encountered in motor applications are much higher than in cables, the operating temperature had to be 27 K instead of 77 K to achieve the necessary current level. The good news is that the prototype actually produced 200 horsepower, a figure limited by the capacity of the test brake employed and not the intrinsic power of the motor, which is estimated at perhaps 400 horsepower.

Rapid and dramatic developments in BSCCO tape performance have occurred in the past five or six years to make these



Pirelli, EPRI, ASC & DOE

A record-breaking power cable. In March, this 50-metre superconducting assembly carried 1,800 A, almost twice as much as an ordinary copper conductor of similar diameter could.

**The 10th Anniversary HTS Workshop on Physics, Materials and Applications,* Houston, Texas, USA, 12–16 March 1996.

and other application prototypes possible (Alex Malozemoff, American Superconductor). American Superconductor can produce 10 km of multi-filament BSCCO tape per month, in 1,000-m lengths. Critical current density (J_c) in these tapes can now exceed 44,000 A cm^{-2}. Malozemoff noted that, since 1990, BSCCO wire performance has followed a consistently linear upward trend with time.

Where will it stop? Small regions of BSCCO embedded in the tape, especially near the silver-cladding interface, have been observed magneto-optically to have $J_c > 10^5$ A cm^{-2} at 77 K (David Larbalestier, Univ. Wisconsin). Beyond this limit, and especially to service high-magnetic-field applications at liquid-nitrogen temperatures, a new technology will be needed.

One is already on the horizon (see my earlier News and Views article, *Nature* **375,** 107–108; 1995). Workers from the Los Alamos and Oak Ridge National Laboratories revealed their latest results for biaxially oriented coatings of YBCO (yttrium–barium–copper oxide) on flexible metal tape substrates. The Los Alamos group produces substrate texturization with an auxiliary ion gun during deposition of a buffer film between the metal tape and the YBCO, whereas Oak Ridge directly textures the metal tape using a combination of metallurgical deformation techniques. Texturization is important in producing low-angle grain boundaries and thus good inter-grain coupling. Los Alamos has now observed critical currents of 200 A at liquid-nitrogen temperatures in 2-μm-thick YBCO in short lengths 1 cm wide, a J_c of 10^6 A cm^{-2}.

The Oak Ridge group principally described the textural properties of their method, which at the time of the Houston meeting had produced a J_c of only around 10^5 A cm^{-2}. But while writing this review, I've heard that portions of their samples now have $J_c \approx 5 \times 10^5$ A cm^{-2}, an important improvement given that metallurgical texturization may be scaled-up to manufacturing processes more easily than ion beam bombardment.

In the meantime, the improving performance of 'first generation' BSCCO wire seems certainly enough to satisfy a number of anticipated applications in the next five years, especially transmission cable. The principal uncertainties are cost and market acceptance of this new technology. The generally acknowledged commercial target for cost/performance is \$10 kA^{-1} m^{-1}, but the latter factor, acceptance, is by far the greater challenge. If the next decade is to see deployment of HTSC wire in power applications, as much attention, if not more, needs to be given to this area as to improving the technology itself.

The workshop was a major event for all of us in the high-T_c trade. As a Hollywood columnist might have put it, it was a bash where almost everybody who's anybody participated. The next great event will be the American Physical Society March Meeting in 1997 in Kansas City, bringing with it the tenth anniversary of our Woodstock. Unfortunately, this celebration will have to be held somewhere within the confines of a midwest convention centre, not in the Grand Ballroom of the New York Hilton where it all began. What a pity. □

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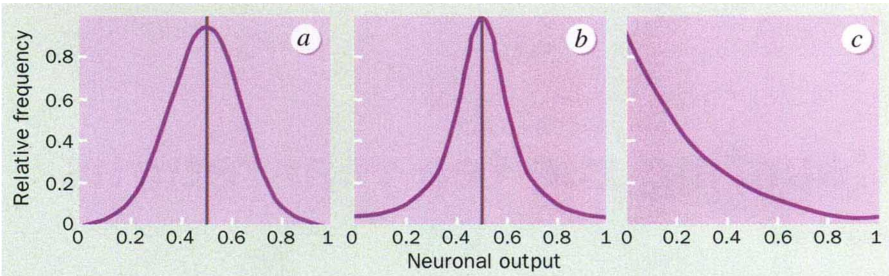
VISUAL PERCEPTION

An efficient code in V1?

Roland Baddeley

THE primary visual cortex (V1) is the first cortical area to receive visual input from the eyes. For over 30 years it has been known that the neurons in this part of the brain are sensitive to bars of light of various orientations and sizes[1,2], and this phenomenon constitutes a common, crucial stage of visual perception in mammals. What has been far less clear is why neurons in V1 show such selectivity.



What is a sparse representation? For a system with binary outputs, sparsity can be simply equated with a low average firing probability. For a system with continuous outputs, a definition is more difficult. But one method is to define a measure of how 'peaked' the distribution of outputs is around its mean. Consider the distribution of outputs from a single 'filter' when presented with a large collection of natural images. If the filter has random spatial weightings, then by the central limit theorem we would expect the distribution of outputs to be gaussian (*a*). If, on the other hand, the weightings of the filter matched some nonrandom structure in the images, we may find a non-gaussian output distribution. One simple way a filter's output distribution could differ from gaussian is to be more concentrated around its mean value (*b*), and a representation with an output distribution that resembles *b* rather than *a* is called 'sparse' (see the paper under discussion[3]). Another reason for having such filters is that they minimize the output entropy for a fixed output variance[3]. Given the more biologically plausible constraint on the average firing rate of the neuron (and hence metabolic cost), one particular sparse output distribution (*c*) maximizes output entropy.

neighbouring measurements. Therefore, by using such a code, efficient transmission is achieved because the intensity information is preserved while allowing the minimization of some measure of neuronal output capacity such as total variance.

Several researchers have explored this notion of efficiency. By using estimates of the correlation in image intensity in natural scenes as a function of distance, characterizing potential sources of noise, and formalizing efficiency (for example using information theory), predictions of the precise form of processing can be made. Such an approach has led to accurate quantitative predictions of contrast sensitivity[4,5], colour sensitivity[6] and the form of inhibition in fly retina[7].

On page 607 of this issue[3], Olshausen and Field describe some simulations that shed light on this question. They show that, for an appropriate definition of 'efficiency', the response properties of neurons in V1 qualitatively (and in some aspects quantitatively) resemble the most efficient linear representation of natural images possible.

Their definition of efficiency is probably best understood by reference to the coding performed by a more peripheral part of the visual system — the retinal ganglion cells that provide the output from the eye to the brain. Rather than simply signalling raw local image intensity, these cells appear to signal the difference between the intensity at a given location and that predicted from neighbouring locations. Image intensity in natural scenes is highly predictable from

Unfortunately, early attempts to apply the same notion to the coding performed by cells in the primary visual cortex have been less successful. One method that has had some popularity is a form of factor analysis, known as principal components analysis (PCA), which finds the linear combinations of image intensities (components) that capture as much of the variation in natural images using as few components as possible. Although there