theory and experiment remains. Theorists are focusing on uncovering new algorithms that may benefit from quantum logic and investigating the limits of quantum error correction. For their part, experimentalists exploring entangled quantum states and mesoscopic "Schrödinger's cat"–like states are investigating "how big" and "how entangled" they can prepare their systems using quantum logic. Although we heartily agree with Haroche and Raimond that this research may shed light upon fundamental issues of quantum measurement and decoherence, these experiments may also lead to useful applications such as quantum computation, whose feasibility is unresolved and whose limits have not yet been determined.

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HAROCHE AND RAIMOND REPLY: Christopher Monroe and David Wineland find too pessimistic a view of quantum computing that, needless to say, is not only ours.[1] Of course, we may be proved wrong if some unforeseen technology emerges one day to break through the quantum/classical boundary and make it possible to build large systems in coherent superpositions of quantum states. That would be great news indeed, a true revolution going far beyond computing. But such an event is unpredictable, and our discussion must be restricted to reasonable extrapolations from present knowledge.

Monroe and Wineland think that quantum computing could be achieved by improving on today's technology. They qualify the difficulties they will encounter in scaling up their beautiful ion trap experiment to large number of gates and operations as merely "technical, not fundamental," and herein lies our basic conceptual disagreement with them. We remain convinced that, in the context of presently known physics, the fundamental phenomenon of quantum decoherence, whose probability increases exponentially with the system size, will make it impossible to "push back" far enough the quantum/classical boundary. Note that the magnitude of the decoherence problem for quantum computing had already been stressed theoretically before our paper appeared.[2] Recently, working with atoms in cavities, our group has observed decoherence effects on "Schrödinger's cat"–like systems and demonstrated the fragility of mesoscopic quantum coherences in a well-controlled environment.[3]

Error correcting codes, on which Monroe and Wineland place big hopes, are very important for the light they shed on fundamental aspects of decoherence. However, we do not believe that they could make large-scale quantum computing feasible, in that they are prone to adding their own detection errors[1] and impose a tremendous overload on already very challenging experiments.

Ultimately, time will be the referee of this friendly dispute, although it may take a decade. Meanwhile, to end on a bright note, we are convinced that, whoever is vindicated, science will be the winner because outstanding physics—even if not a quantum computer—is bound to emerge from the beautiful theoretical and experimental studies being pursued in this field.

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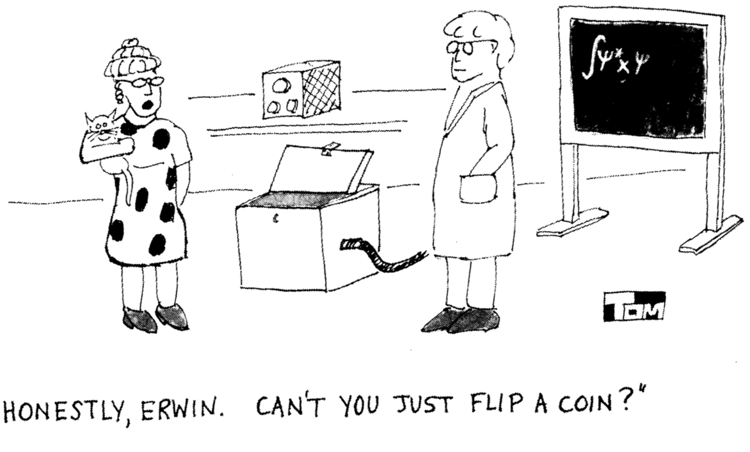

" HONESTLY, ERWIN. CAN'T YOU JUST FLIP A COIN?"

Physics Ties to Cuba Should Be Personal, Not Institutional

Jean Kumagai's "Physics Community" story (April, page 53) on US scientists' ties with Cuban colleagues needs some amplification. As a strong believer in the importance of person-to-person communication and as a former physics professor at the University of Havana (1950–60), I support strengthening personal relations between US and Cuban physicists. There are many good physicists in Cuba, most of them trained in the former Soviet Union, and they would benefit from exchanges with US physicists. In recent years, for example, I have maintained a correspondence with a few Cuban physicists.

However, I oppose relations with Cuba at the institutional level, because such links imply support for a dictatorial government that exerts tight controls on all of the country's institutions, as well as individual scientists. In Cuba, there are no private institutions or organizations, including the Cuban Physics Society. For a Cuban scientist to hold an academic position, he or she has to be politically correct—that is, express support for the Communist Party of Cuba or even be a party member. Otherwise his or her professional opportunities are severely limited. Those who dare to express their opposition to the regime are demoted or put in prison, and there are many examples of this having happened. Furthermore, Cuban scientists are not free to travel abroad, and may do so only by obtaining special permission from the Cuban government; even then, they are not allowed to take their families with them.

For these reasons, I urge those well-intentioned scientists in the US who want to help their colleagues in Cuba to be extremely cautious, making sure that any support they provide goes to individual scientists, not institutions, and does not contribute to the further abridgment of the human and professional rights of those scientists. I also encourage the American Physical Society to find ways of increasing exchanges with individual Cuban physicists while abiding by these principles.

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Brain Researchers Differ on MEG's Role in Getting Ahead

Sam Williamson's review of my book, *Neocortical Dynamics and Human EEG Rhythms* (April, page 57), touches on several issues likely to engage physicists with an interest in brain research. Three obvious dichotomies involving complementary approaches to large-scale brain dynamics are theory versus experiment, electroencephalography (EEG) versus magnetoencephalography (MEG) and local function versus global function.

Since Sam and I tend to be at opposite ends of each of these categories, it is perhaps not surprising that he bemoans my very brief treatment of MEG, which, thus far, has been used mainly to study local brain function. He is quite correct that MEG has shown value in medical evaluation of the subclass of epilepsy patients with seizures starting in small regions of tissue that may be surgically removed, perhaps after being located through the use of a combination of MEG and EEG data.

However, most normal and abnormal brain states (including many of the epilepsies, cognitive disorders and neuropsychiatric illnesses) are best characterized by neural sources that are distributed over large fractions of neocortical surface. My book emphasizes that brains seem to like combinations of functional segregation and integration modulated by chemical neurotransmitters that may alter neural control parameters. Theoretical work in neuroscience suggests that extreme global behavior may result in standing waves of synaptic action that compete with local circuits, as described by multiple branches of dispersion relations. Solid-state physicists may appreciate a partial analogy to localized/extended wavefunction states in disordered solids. In my book, the