

Two bits on qubits

I greatly enjoyed reading David Mermin's last two Reference Frame columns on factoring and quantum computing (PHYSICS TODAY, April 2007, page 8; October 2007, page 10). However, as the proud one-time owner of the California license plate QUBITS (which I had occasion to park beside a QUARKS license plate from New Mexico), I feel I must cheerfully disagree with Mermin's choice to denote quantum bits as qbits. His slander of the traditional shortened spelling of quantum bit as "the vulgar spelling *qubit*" lays down the gauntlet to the proud worldwide community of heterographic homophone lovers, many of whom I call friends.

Mermin's arguments are deceptively enticing:¹ that *qubit* violates the English rule that *qu* should be followed by a vowel, that no one would ever call the swab a Qutip, and that Paul Dirac with good reason called them q-numbers, not qunumbers. One reason might have been enough, but cube it and certainly no one will argue back at you.

Let us rebut those arguments one by one. First, if Mermin is serious about his respelling of the shortened form of quantum bits, then certainly he should choose q-bit instead of qbit, because the only word with a consonant following a *q* in the *Oxford English Dictionary* is the crippling child of circumstance, *qwerty*, to describe a keyboard. And, having settled on q-bit, one faces a dilemma. Writing "q-bit" immediately conjures up Q-tip and, worse for those of us from

the video game age, Q-Bert (or Q*Bert), the name of an addictive video game featuring an eponymous alien who hopped on a tricolored pyramidal staircase. Mermin may find no discomfort in hearing echoes of "Q-tip," but I think the majority of physicists—not to mention computer scientists—would prefer not to be reminded of either ear infections or hopping aliens when they transcribe their serious scientific work.

I note that q-number and Q-tip arose at the same time. (Originally called "Baby Gays," Q-tips were renamed in 1926. The Q stood for quality.) With no disrespect to Dirac, who seemed to have a thing for full-letter initials, history, as measured by the success of *q-number* versus the ubiquity of *Q-tip*, has clearly decided that the *q-* prefix works better for brand names than for scientific terms. In short: Let us keep the corporate branding of science off our beloved quantum bits.

Most importantly for the progress of science, the fact that *qubit* is an intentional homophone of *cubit* is not vulgar but rather a blessing in disguise. A cubit is an ancient unit of length, roughly equal to the length of a forearm. And that "roughly" should offend the heart of any physicist. Like the foot, the cubit is an imprecise unit whose lack of precision makes me think it deserves to die. Can you use *cubit* on your physics tests? No! And I can think of no better death than its replacement by *qubit*, a precise unit of quantum information.

As an addendum to the beauty of this homophone, one should not overlook the fact that the cubit is most often associated with lengths in biblical texts. And despite Mermin's claim to the contrary, *qu* followed by a consonant does appear in English words, albeit proper nouns, notably Qumran, the name of the settlement nearest where the Dead Sea scrolls were discovered.

Long live qubits. And may qbits and their dirty cousins Q-bits only rear their heads in a future quantum computing company or in a medical journal describing bits of cotton swab lodged in the ear.

Reference

1. N. D. Mermin, *Am. J. Phys.* **71**, 23 (2003).

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Mermin replies: The enticing arguments that Dave Bacon tries so well to refute were not in my Reference Frame columns, which I'm delighted he enjoyed. The point is put best in my new book,¹ where I also note that *q-bit* would indeed be better than *Qbit*, were it not that common expressions such as 2-*Qbit gate* fail to work when written in the form 2-*q-bit gate*. To solve the problem, I drop Dirac's hyphen but put Q in uppercase (which the *qbit* Bacon wrongly attributes to me does not) to emphasize that it functions as the name of a letter and not as part of another grotesquely spelled word.

Qbit for the quantum object parallels the equally important Cbit for the classical object (*clbit* would be ridiculous). The capitalization convention gives rise to the useful term *Bit*, which refers collectively to both kinds of physical objects, as opposed to *bit*, which refers only to a number that can be 0 or 1.

I agree with Bacon that *qubit* has achieved its current status because of its spurious resemblance to *cubit*,² but I do not agree that the foot deserves to die. It should be redefined 5 millimeters downward to a light nanosecond³ a couple of years after our backward nation finally goes metric, which I confidently expect to happen in a century or two.

Setting aside the fact that transliterations of foreign proper nouns notoriously violate all kinds of rules, I note that *Qumran* is pronounced *k'mran*. This class of examples would require *qubit* to be pronounced *k'bit*.

It may be quixotic (but certainly not *Qxotic*) to try to correct the spelling of an entire community, but I owe it my best shot. What else is retirement good for?

References

1. N. D. Mermin, *Quantum Computer Science: An Introduction*, Cambridge U. Press, New York (2007), p. 3.
2. Ref. 1, p. 4.

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3. N. D. Mermin, *It's About Time: Understanding Einstein's Relativity*, Princeton U. Press, Princeton, NJ (2005), p. 22.

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Cool shades for hurricanes?

Kerry Emanuel's Quick Study of hurricane formation (PHYSICS TODAY, August 2006, page 74) inevitably lends itself to thoughts about the disruption of those storms. Weakening, as opposed to outright dissipation, might be easier to achieve and ultimately preferable, so that the energy involved can be released in a semicontrolled manner, as opposed to its being shunted elsewhere. Past ideas such as reducing evaporation or artificial upwelling of cold ocean water in the path of a hurricane would be case-by-case, resource-intensive operations that may well reduce storm intensity.

As a more far-fetched thought, have any calculations been undertaken to model a large, space-based sun shade to cut off the solar energy input to a storm system? If the Moon, approximately 3470 km in diameter and orbiting at around 384 500 km from Earth, can cast a shadow some 200 km wide during a solar eclipse, wouldn't a much smaller structure orbiting closer to Earth be sufficient to completely shade the eye of a typical Atlantic hurricane? Or perhaps more effectively, it could shade the early stages of storm formation farther out in the ocean. Using these approximate eclipse values to determine a working relationship between shade structure size, orbital height, and desired ground shadow yields roughly a 65-km-wide structure in Earth orbit at 3200 km. A real-world test of that relationship might be possible if there exist historic wind measurements observed during the timely intersection of hurricane and solar eclipse paths.

Granted, boosting the appropriately sized shade into orbit would be costly, but it could be used on numerous storms. Composed of ultrathin sections, each rigged with narrow, inflatable spars to create rigidity, a circular structure could be unfurled like an umbrella while a square structure could be unrolled. As with any space structure, the shade would wear with time, but even punctures from micrometeors or space junk would not necessarily degrade performance. Each section could be replaceable, and the spars self-sealing. Given the current state of materials sci-

ence, this idea does not seem out of the realm of possibility. However, total weight might be problematic and necessitate multiple launches. Once it is deployed, common satellite systems could maintain it in geosynchronous orbit and allow for steering and tilting for variable storm tracks. A geostationary orbit might be optimal but unlikely due to limited real estate in that orbit and to the size of the shade.

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Emanuel replies: Michael Binkley advances an interesting idea to deprive tropical cyclones of their power source. In principle, it would work, if one could cool a strip of ocean roughly 100 km wide along the path of the cyclone. For average conditions in the tropics, a cooling of 2.5 °C would eliminate the necessary thermodynamic disequilibrium altogether, so even a 1 °C cooling would have a noticeable effect.

The technical difficulty here is one of time scale. The upper tropical ocean is typically well mixed by turbulence, through a depth of roughly 50 meters. To cool that layer by 2.5 °C, one would need to shut off sunlight for about 30 days, and roughly a week to achieve a 1 °C cooling. That is far longer than the time scales over which storm tracks can be predicted, and so one would be forced to cool a vast region of the tropical Atlantic Ocean. That would no doubt have unforeseen and probably undesirable consequences.

Given the high toll that hurricanes extract in human suffering, it is certainly worth contemplating means by which they might be tamed.

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Difficult deterrence decisions

The problem with Sidney Drell's rekindling the vision of Reykjavík in "The Challenge of Nuclear Weapons" (PHYSICS TODAY, June 2007, page 54) is that the steps advocated by George Shultz, William Perry, Henry Kissinger, and Sam Nunn cannot be carried out unilaterally or bilaterally. Even if the US and Russia were willing to abide by the program developed at the Hoover Institution, there is little indication that more volatile nuclear states, such as

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