PHYSICS
TODAY

Texans Triumph At Guess My Number

Bob Knauer; Andrew Steane; Wim van Dam

Physics Today **53** (7), 75–76 (2000);
https://doi.org/10.1063/1.1292496

hagen was presented here. I suggested that, having been a student of Carl von Weizsäcker, he might ask his former adviser about the visit. Weizsäcker had accompanied Heisenberg on his 1941 lecture tour of Denmark, but was not present at the Heisenberg–Bohr meeting. Here is an excerpt from Häfele's reply:

> I read the play and studied other available documents. Then I contacted Carl Friedrich von Weizsäcker. This is my description of the 1941 Copenhagen meeting as I understand it: Heisenberg did not want to build the bomb. You must realize the difficulties and dangers imposed by the ever-present Gestapo. A way of deflecting suspicion was to point to the extreme difficulties of the uranium-235 separation. Heisenberg was also plagued by the thought that the Americans and the British could develop the bomb. He strongly believed in the ethics of the brotherhood of physicists across borders and races. Von Weizsäcker threw in the idea of contacting Niels Bohr, and managed to organize a scientific event in Copenhagen with the help of the German Foreign Office . . . Heisenberg wanted to convey [to Bohr] the message that the German scientists would not develop the bomb, and that the others should not develop it either . . . Heisenberg and Bohr met. Afterward, Heisenberg came to von Weizsäcker in despair: Bohr had only heard and understood the hint that Heisenberg knew in principle how to build the bomb. The real point of Heisenberg's message did not come through at all.

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I enjoyed the enlightening and entertaining article by Andrew M. Steane and Wim van Dam, "Physicists Triumph At Guess My Number" (Physics Today, February, page 35), which relies on Greenberger, Horne, and Zeilinger (GHZ) quantum entanglement[1] to provide the extra bit of information needed to win the game every time. A few classically-unentangled computer engineers in Texas have devised a way to win every time using laptop computers of high enough quality that they can be synchronized just before the show and hold that synchronization to better than one-second accuracy for the duration of the show.

The contestants are Alice, a systems engineer from College Station; Bob (yours truly), a software engineer from Houston; and Charles, a hardware engineer from Austin. Programmed into Alice's and Bob's computers are two lookup tables, Table I and Table II. One of these tables appears concurrently on both computer screens during one fifteen-second time interval, and the other appears concurrently on both computer screens during the next fifteen-second interval. This procedure is repeated periodically.

Table I

	A	B	C
0	0	0	0
1	1	X	0

Table II

	A	B	C
0	0	X	0
1	0	1	0

A, B, and C represent Alice, Bob, and Charles respectively, with the 0 and 1 to the left of the tables representing the number of unpaired half-apples each party has in his or her holding. Note that it makes no difference how many half-apples Charles has, so his time synchronization is not important.

The result of a table lookup is a "half-apple parity" that can be one of three possibilities: even (0), odd (1), or no data (X). The meaning of "no data" will become clear below.

After the apples are distributed, the contestants calculate the parity of their whole-apple holdings, letting 0 represent even parity and 1 represent odd parity. As indicated in the tables, Charles sets his flag regardless of whether he has a half-apple or not, his arrow pointing up to indicate even parity or down to indicate odd parity. Bob waits for a particular table (I or II) to appear on his computer screen that does not have an "X" in the location where he gets his half-apple parity. If he gets an "X" from a particular table then he must wait for the next fifteen-second time interval when the other table is displayed. That is, he treats the "X" as "no data" and does not set his flag.

When the appropriate table does appear, he adds (mod 2) his whole-apple parity to the table's "half-apple parity" and immediately sets his flag accordingly, as did Charles above. Once both flags are set, the moderator must announce the settings to Alice during the same fifteen-second interval in which Bob sets his flag. Otherwise, Bob must unset his flag and wait for the next fifteen-second interval before resetting it.

Alice then adds (mod 2) the flag settings from Bob and Charles to her own whole-apple parity. Then she looks at the table currently displayed on her screen—the one that is in synchronism with Bob's table—and selects the appropriate "half-apple parity" based on her half-apple holding, adding it (mod 2) to the previous sum. From that result she announces the correct parity of the combined apple holdings for all three parties—and wins the game every time.

Some physicists might object to this classical sleight-of-hand, particularly because our scheme is so simple, but we counter with the following: Quantum entanglement experiments use time synchronicity in the form of coincidence measurements; therefore, we are free to use time synchronicity to create two temporal communication channels, one that carries the correct information and one that carries no (or incorrect) information.

In any event, we did manage to win every time—and that is what counts in the Guess My Number game. And we did so without complex, expensive, taxpayer-subsidized equipment. In fact, if we could have used the studio clock or two wristwatches as time references, we would not have needed computers at all.

I would like to thank one of the authors, Wim van Dam, for comments on quantum entanglement and communication complexity.[2] I also would like to acknowledge the lucid explanations of the GHZ and EPR experiments provided by N. David Mermin.[3]

References:

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Steane and van Dam reply: The essence of Knauer's idea is to use timing as a means of classical communication, so that, using the standard definitions of information theory, Bob now sends two bits of classical information to Alice, not one bit.

Obviously this does not succeed in breaking the lower bound for the classical communication complexity (which is in any case a mathematically provable result). Timing is a very commonly used form of communication—as for example in comedy and irony. In the precise definitions of information science, however, we quantify it along with all other forms of communication, by counting the number of different eventualities that might arise. In Knauer's scheme there are four eventualities in Bob's message to Alice: flag up in 1st time period; flag down in 1st time period; flag up in 2nd time period; flag down in 2nd time period. Hence, if the timing is adhered to, a single message carries two classical bits.

As far as the "Guess My Number" game show is concerned, of course the information scientists employed by the television company pointed out the danger of this form of sneakiness, so the hostess is under strict instructions not to have any particular pattern of timing when she conveys messages to Alice. Indeed, they often have a review of the score just before the hostess announces one of Bob and Charles's messages to Alice, ostensibly to keep up the element of suspense, but really to close this type of classical communication avenue.

Finally, Knauer is mistaken in thinking that quantum entanglement observations require coincidence measurements—no particular timing of measurements is needed when using entangled states of things like atoms, which can be held in one place. See, for example, C. A. Sackett *et al.*, Nature **404**, 256 (2000).

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Digital TV: Artificial Obsolescence?

This letter is in response to the article by Louis A. Bloomfield, entitled "Television Goes Digital" (PHYSICS TODAY, November 1999, page 42). Hidden in the article is the assumption that digital television is a done deal. This is far from evident; advertisers (the driving force behind TV) are not going to use the medium unless citizens have the equipment to receive signals. Consumers are demonstrating widespread opposition to being forced to buy all new (and very expensive) TVs, VCRs, and other hardware.

The article's comparison of the two types of television is fully consistent with standard advertising ethics; the older rival analog is smaller, dimmer, "out of it." However, the fact is that the difference in picture quality is not great for the general run of pictures.

But the aspect of difference that is a lead-pipe certainty is that consumers would be forced to spend thousands of dollars in yet another artificial obsolescence scam. The waste of resources involved in junking 50 million television sets and replacing them with the "newer technology" hardware will certainly give pause to all of us concerned with the environment.

There are several engines driving this latest attack on consumers. But a prominent one is evident—market saturation (overproduction) of electronic equipment. We have seen the response over and over again: in music, AM, FM, vinyl, 78s and 33s, eight-track, cassettes, CDs, and now digital. Mainstream television has, of course, also seen several rounds of forced obsolescence.

Enough already.

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BLOOMFIELD REPLIES: I agree with much of what William Meecham writes. I am not a lover of television and don't look forward to watching marketers of new digital technology manipulate owners of existing analog equipment. I already feel sad seeing people of limited means rolling new big-screen analog televisions and VCRs through store parking lots, knowing that in a few years they'll probably regret those purchases.

However, unlike Meecham, I fully expect digital TV to replace analog TV. I don't necessarily expect it to go according to schedule, but it's going to happen. Digital really is better and the fact that the transition will make enormous amounts of equipment obsolete won't stop it. Previous revolutions in television brought everyone along: Black and white televisions still work, and UHF and cable adapters allow even antique sets to receive modern analog transmissions. But the transition to digital is going to be far more disruptive. Adapters that convert digital signals to analog and perhaps vice versa will be everywhere but they won't solve all the problems. Among the casualties will be VCRs, video games, camcorders, videotapes (including home movies), and televisions with picture-in-a-picture. It will be a good time to read more books.

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Calculating buckyballs and nanotubes

It is a sad feature of our times that in spite of the powerful tools that are available to search the literature, few comprehensive searches are made. The result is misinformation such as that given by Jerzy Bernholc in his letter in PHYSICS TODAY, (February, page 76), that carbon nanotubes are exceptionally strong. The article cites a breaking strain of "at least 5%." But, more than 60 years ago, breaking strains of 25% were reported for silica fibers,[1] and strains as large as 13% were observed in sizable silica rods.[2] Also in silicon micromechanical structures breaking strains of at least 8% are observed. Even humble oriented-polyethylene breaks at 17% strain.[3] Thus, the statement of Bernholc that nanotubes are "the 'strongest' material known!" is quite hollow.

References

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In his Reference Frame article (PHYSICS TODAY, September 1999, page 11), Philip W. Anderson makes the statement that "computational physics" should be considered an oxymoron. Yet his comment is challenged a few pages later by the article of Jerzy Bernholc (page 30), which describes the role of computational materials science by giving three examples: superconductivity in the fullerene compounds, polycrystalline silicon, and magnetism in low-symmetry systems. The last two examples seem reasonable to me, but I am not an expert in those fields. The fullerene case, however, is misleading and sets an example for Anderson's point of view. Bernholc's article gives the impression that *ab*