POST

What's "Q-Day"?

June 17, 2021

“Q-Day”

—"I can't wait." - Jed Anderson


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THE GREAT REHEARSAL
BASEBALL

Lots of concern with the federal government and institutions about”Q-Day” (https://r20.rs6.net/tn.jsp?f=001RmVZjHiDI6o9bGpblllh2G_DtvXrWqbw4S5A_ZoGiRvzN7Xm7WUqNl0hU61qj9zg4Ks3i3KC7BIr7Pc7H1CGnojZoIaVyLXOwtQPKvNNHSGVllJZWVnew5NxENEuMNMFo7opZ1iB2lizKtAGF3MIFCWZHHGfSPkToA2bA8AEQ3o9mJaIbNCi5yyOMwyQa3uUXdCyxR6xK-A_De8WZl9f457D6pnZevrvKKC1jKDmFfLj1NkyEMSUaQ==&c=&ch=)in the arena of encryption (https://r20.rs6.net/tn.jsp?f=001RmVZjHiDI6o9bGpblllh2G_DtvXrWqbw4S5A_ZoGiRvzN7Xm7

WUqNl0hU61qj9zgVaaYfO--00jx5mB_Ujz7LzNm4_pAlDdgCUmZabXNLrDVJpb5wdEVGFI6Bpg
KVhMukNnoz46--r_c0_qwkic60090GJLRCzjZ02BIb2ZIUdMbQACtx5q2rv4RLJ0tOFaM&c=&ch
=)for banks and national security.

—“I like to find the positive!”

Encryption … Decryption

Nature Decryption

Nature’s language will be decrypted. I can hardly wait.

PREPARE

Lots of focus on developing quantum computing, but not much on what questions we will be able to ask it and what environmental problems we will be able to solve when the language is decrypted.

Two more books that I'm holding in the picture above that I'm reading to help prepare EnviroAI that I would recommend reading:

1. "Helgoland: Making Sense of the Quantum Revolution (https://r20.rs6.net/tn.jsp?f=001RmVZjHiDI6o9bGpblllh2G_DtvXrWqbw4S5A_ZoGiRvzN7Xm7WUqNl0hU61qj9zgUYFvVw4WH6Dez1YpaAytUm4ps7OwadEE4xSd6ZRWMR6VS_0sVmSptOF0bLkMZLj0UOe4Rcp97IUrXdNjZHc185_quCuZGRyuNH7tHr6EHNjevCgd2aMZabFeOsOqbWB0Cp0dO-_aP-C9Sk5FZwOe9IVhrwhHHeLP&c=&ch=)"---Carlo Rovelli [Fascinating story---treeless island in the North Sea where Heisenberg came up with some of the basic tenets of quantum physics]
2. "Quantum Computing for Everyone (https://r20.rs6.net/tn.jsp?f=001RmVZjHiDI6o9bGpblllh2G_DtvXrWqbw4S5A_ZoGiRvzN7Xm7WUqNl0hU61qj9zgpsf8MMAkaEmO7Yc513hQG04SYNf49VzXs98F2n8_A0g4utjHurX6jbTEqOweGkZA5lxyo9bNOBcESwKTMJiKmEkDaUmxLOm_F7SNul8w7VbO97ASF7Oy6gphjJwWcOTrPWWB_U-MpJrBLbpSHmcLJA==&c=&ch=)"---Chris Bernhardt [Great introduction to the inner workings of quantum computing. It's got a bit too much linear algebra in it for my liking (see below)—but anyone with high school math can grasp it]

the concatenation of the two names. Though this is a rather weak play on words, it does help us to remember that, for this product, that the "bra" is to the left of the "ket."

In linear algebra this product is often called the *inner* product or the *dot* product, but the bra-ket notation is the one used in quantum mechanics, and it is the one that we will use throughout the book.

Now that we have defined the bra-ket product, let's see what we can do with it. We start by revisiting lengths.

Bra-kets and Lengths

If we have a ket denoted by $|a\rangle$, then the bra $\langle a|$ with the same name is defined in the obvious way. They both have exactly the same entries, but for $|a\rangle$ they are arranged vertically, and for $\langle a|$ horizontally.

$$|a\rangle = \begin{bmatrix} a_1 \\ a_2 \\ \vdots \\ a_n \end{bmatrix} \langle a| = [a_1 \quad a_2 \quad \cdots \quad a_n].$$

Consequently, $\langle a|a\rangle = a_1^2 + a_2^2 + \ldots + a_n^2$, and so the length of $|a\rangle$ can be written succinctly as $\||a\rangle\| = \sqrt{\langle a|a\rangle}$.

To illustrate, we return to the example where we found the length of $|a\rangle = \begin{bmatrix} 3 \\ 1 \end{bmatrix}$: $\langle a|a\rangle = [3 \quad 1]\begin{bmatrix} 3 \\ 1 \end{bmatrix} = 3^2 + 1^2 = 10$. Then we take the square root to obtain $\||a\rangle\| = \sqrt{10}$.

Unit vectors are going to become very important in our study. To see whether a vector is unit—has length 1—we will repeatedly use the fact that a ket $|a\rangle$ is a unit vector if and only if $\langle a|a\rangle = 1$.

Another important concept is orthogonality. The bra-ket product can also tell us when two vectors are orthogonal.

Bra-kets and Orthogonality

The key result is: Two kets $|a\rangle$ and $|b\rangle$ are orthogonal if and only if $\langle a|b\rangle = 0$. We will look at a couple of examples and then give an explanation of why this result is true.

Let $|a\rangle = \begin{bmatrix} 3 \\ 1 \end{bmatrix}$, $|b\rangle = \begin{bmatrix} 1 \\ 2 \end{bmatrix}$ and $|c\rangle = \begin{bmatrix} -2 \\ 6 \end{bmatrix}$. We calculate $\langle a|b\rangle$ and $\langle a|c\rangle$.

$$\langle a|b\rangle = [3 \quad 1]\begin{bmatrix} 1 \\ 2 \end{bmatrix} = 3 + 2 = 5$$

$$\langle a|c\rangle = [3 \quad 1]\begin{bmatrix} -2 \\ 6 \end{bmatrix} = -6 + 6 = 0$$

Since $\langle a|b\rangle \neq 0$, we know that $|a\rangle$ and $|b\rangle$ are not orthogonal. Since $\langle a|c\rangle = 0$, we know that $|a\rangle$ and $|c\rangle$ are orthogonal.

Why does this work? Here is an explanation for two-dimensional kets. Let $|a\rangle = \begin{bmatrix} a_1 \\ a_2 \end{bmatrix}$ and $|b\rangle = \begin{bmatrix} b_1 \\ b_2 \end{bmatrix}$, then $|a\rangle + |b\rangle = \begin{bmatrix} a_1 + b_1 \\ a_2 + b_2 \end{bmatrix}$. We calculate the square of the length of $|a\rangle + |b\rangle$.

$$\begin{aligned} \||a\rangle + |b\rangle\|^2 &= [a_1 + b_1 \quad a_2 + b_2]\begin{bmatrix} a_1 + b_1 \\ a_2 + b_2 \end{bmatrix} \\ &= (a_1 + b_1)^2 + (a_2 + b_2)^2 \\ &= (a_1^2 + 2a_1b_1 + b_1^2) + (a_2^2 + 2a_2b_2 + b_2^2) \\ &= (a_1^2 + a_2^2) + (b_1^2 + b_2^2) + 2(a_1b_1 + a_2b_2) \\ &= \||a\rangle\|^2 + \||b\rangle\|^2 + 2\langle a|b\rangle \end{aligned}$$

Clearly this number equals $\||a\rangle\|^2 + \||b\rangle\|^2$ if and only if $2\langle a|b\rangle = 0$. Now recall our observation that two vectors $|a\rangle$ and $|b\rangle$ are orthogonal if and only if $\||a\rangle\|^2 + \||b\rangle\|^2 = \||a+b\rangle\|^2$. We can restate this observation using our calculation for the square of the length of $|a\rangle + |b\rangle$ to say: Two vectors $|a\rangle$ and $|b\rangle$ are orthogonal if and only if $\langle a|b\rangle = 0$.

Though we have shown this for two-dimensional kets, the same argument can be extended to kets of any size.

Orthonormal Bases

The word "orthonormal" has two parts; ortho from orthogonal, and normal from normalized which, in this instance, means unit. If we are working with two-dimensional kets, an orthonormal basis will consist of a set of two unit kets that are orthogonal to one another. In general, if we are working with n-dimensional kets, an orthonormal basis consists of a set of n unit kets that are mutually orthogonal to one another.

Harnessing Quantum Tech & Artificial Intelligence to Protect the Environment (click here) (https://r20.rs6.net/tn.jsp?f=001RmVZjHiDI609bGpblllh2G_DtvXrWqbw4S5A_ZoGiRvzN7Xm7WUqNiZ-__awvMzzKZ_5bBYLn8gfYkBUaLQWPpGuiwuZPhdhlWhJK_h98wuicHQkbvKYqyLruZP11mjf1_Q71kMILBaLAA2G2higEX6qzhKSmPalpmW4_P61d3qIUtoO4FxZUiIGVW1FhXqTW1lDUbmyYfq2jgbmcoxCnYpEyPg2pUVmqhl7_h6KaEo=&c=&ch=)

I again can recommend many books, lectures, and videos on quantum physics and quantum technologies, but I would start with these three: 1. Google/NASA (https://r20.rs6.net/tn.jsp?f=001RmVZjHiDI6o9bGpblllh2G_DtvXrWqbw4S5A_ZoGiRvzN7Xm7WUqNiZ-__awvMzzGg0DcsVy6mAH0PGF8ezCRbb9ABKb_ATKdQCGWmlCqhMiQ8cTb7S3YNSkDYJ5I5acxPBb1-BvQEtrAZxZznmj-i39qLT--41LMw08JeMpeZ7i9ZCAKFE_6w==&c=&ch=) Video (https://r20.rs6.net/tn.jsp?f=001RmVZjHiDI6o9bGpblllh2G_DtvXrWqbw4S5A_ZoGiRvzN7Xm7WUqNiZ-___awvMzzGg0DcsVy6mAH0PGF8ezCRbb9ABKb_ATKdQCGWmlCqhMiQ8cTb7S3YNSkDYJ5I5acxPBb1-BvQEtrAZxZznmj-i39qLT--41LMw08JeMpeZ7i9ZCAKFE_6w==&c=&ch=)2. Nova Video (https://r20.rs6.net/tn.jsp?f=001RmVZjHiDI6o9bGpblllh2G_DtvXrWqbw4S5A_ZoGiRvzN7Xm7WUqNoAk8DKPzsHaXWwJ_j8p3zAnFkhg5zSGh5AFWDzJUwpG287d-_oTtdFC24dyxNP6CWKL8Kgf8HBB6V8xspGm80An7H489QFcDLDLz54eXxhDw5Dtb3WoyQF4vws7f5ZK4D34y--V3kJAHL_KLGSQuRY=&c=&ch=) 3. PBS Video (https://r20.rs6.net/tn.jsp?f=001RmVZjHiDI6o9bGpblllh2G_DtvXrWqbw4S5A_ZoGiRvzN7Xm7WUqNipA1R72S3q3lbpSNcZHDW6X3RdvYWjpj0qxDjFVaQe7A2JqEwojYcHiKvPsRqIZxITJlsdQpj6GtZxCGg4VNJCnXpeakV5zpgrxvsZ5MV9-HAS--Nn2UsdZMXHamFHcFDdSOl7w_m9Eh4G3OCVKauFTPCBIzXekfw==&c=&ch=).

Original source: Constant Contact campaign

Markdown source: https://jedanderson.org/posts/whats-q-day.md (https://jedanderson.org/posts/whats-q-day.md)

Source on GitHub: /src/content/posts/whats-q-day.md (https://github.com/jedanderson432/jedanderson-site/blob/main/src/content/posts/whats-q-day.md)