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## Viewpoint
# Created Computed Universe

*Computing crosses cosmology and makes the case for agnosticism.*

IN 1956, JUST a few years after the birth of computing, Isaac Asimov published a story called the "Last Question."[1] In the story, he envisions a computer-based superintelligence will eventually emerge. The story's highlight is its brilliant ending, in which computing crosses into cosmology, philosophy, and the atheism-creationism debates. Starting from Asimov's story, this Viewpoint discusses how speculation about the future of computing reshapes our perspective on the nature of reality, makes a strong case for agnosticism, and elevates mind and computing into primary cosmological forces.

In Asimov's story, in the year 2150 humanity has solved its energy problems by efficiently harvesting solar energy. A supercomputer, named AC, is the key enabler of this solar energy technology. But two technicians of AC still worry that humanity will eventually die, when the sun and all other energy sources finally exhaust themselves. Since AC has plenty of spare computing cycles it is given the question: How can we keep humanity alive forever? AC replies "INSUFFICIENT DATA FOR MEANINGFUL ANSWER" but keeps thinking on it. Centuries pass and AC becomes a vast superintelligent mind that occupies the mass of whole planets. Still no answer. Myriad years pass, AC becomes a vast superintelligent mind. Every human's mind is uploaded on it. Millions of years pass and AC's
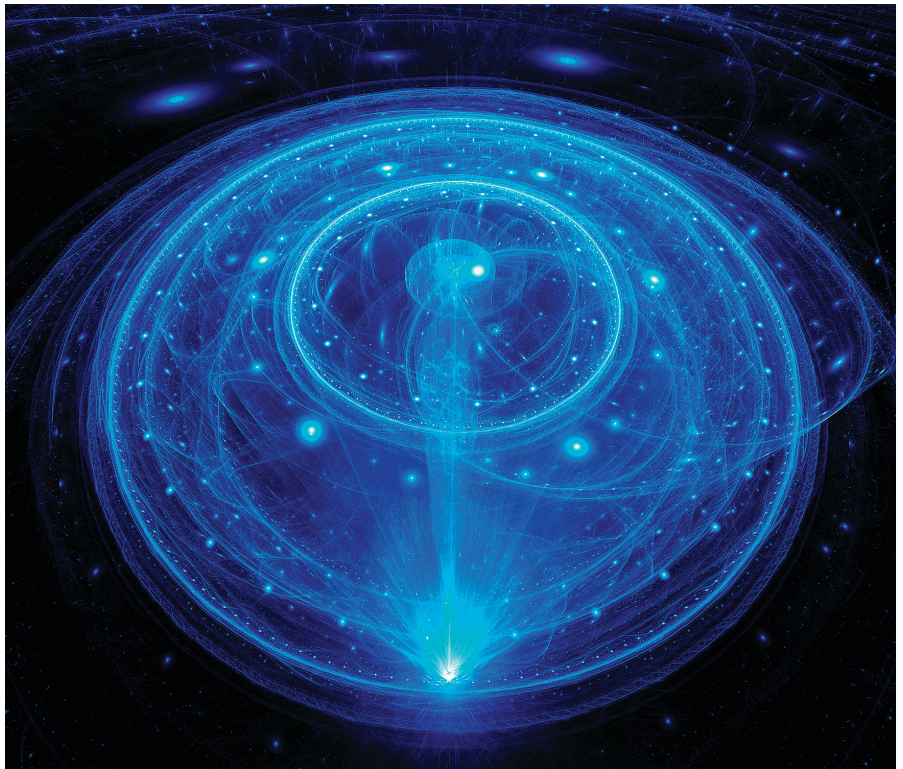


computation is a pattern of energy spread out in the whole space, much alike the alien race in Arthur Clarke's *2001: A Space Odyssey* and in the spirit of Ray Kurzweil's prediction[11] that it is the fate of humanity to produce a superintelligent mind, whose computation will eventually consume the matter and energy of vast areas of the universe. Still no answer.

Billions of years pass, AC has thought everything that was worthy of being thought, and there is only this last question remaining. Finally, AC comes up with the answer: *"Let there be light."*

AC becomes the creator of a computed universe. It runs a universe in its computer mind. Had Asimov continued his story, AC's universe would evolve, obtain lands, life, and eventually obtain sentient beings that create their own civilization. The beings would also (re-)invent computing. Indeed, some of these beings might read Viewpoint columns in a magazine plausibly called *Communications of the ACM*.

Is it possible AC has already happened? Could you be one of the sentient beings in AC's created computed universe?

## Created Computed Universes

In 1964, the novel *Simulacron 3*,[8] described a universe that is an elaborate computer simulation, yet it includes conscious beings. After abstracting away these stories' details (such as AC's reason for creating a universe) a plausible *Created Computed Universe* (*CCU*) cosmological hypothesis emerges. Mind and computing play a key role in this cosmology, which unfolds in the following three steps: First, we know that mind happens in the cosmos, since we have already seen it happening in our universe. Second, we reasonably speculate that computing technology will enable mind to create CCUs. Then mind can happen in the CCUs as well.[a] Therefore our own universe may be a CCU, created by mind from its parent universe. Note, the physics of a CCU (as perceived by the minds that inhabit it) may be different from the physics of its parent universe. Indeed, any parent universe physics is possible, as long as it enables the emergence of mind.

In 1998, the blockbuster science-fiction movie *The Matrix* brought the CCU idea to the mainstream. In 2003, philosopher Nick Bostrom's simulation argument[2] posited that future civilizations may create CCUs that are simulating the times of their ancestors. Bostrom argued that one must accept one of the following three outcomes:

▸ Virtually *all* intelligent civilizations (self)destruct before becoming able to launch a simulated universe.

▸ Virtually *all* intelligent civilizations that can launch a simulated universe, choose not to.

▸ Almost definitely our universe is simulated, since a primary, non-simulated, intelligent universe can produce a vast number of created universes.

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a In a variant, AC designs a physical universe, whose essence is not part of AC's mind. The differences between such a *Created Physical Universe* (*CPU*) hypothesis and the CCU hypothesis do not affect the main conclusions.

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## Could you be one of the sentient beings in a created computed universe?

### CCU, Plato, and Descartes

Is the CCU hypothesis just the computing era's adaptation of a 2,500-year-long series of *skeptical* thought experiments on the nature of reality?[b] Plato's Cave first suggested the true nature of reality may be much different than the perceived reality. 500 years ago Descartes, when he was not busy inventing Cartesian coordinates, was worried about an *Evil Genius*. Descartes writes in the "Meditations on First Philosophy": What do I really know about the nature of reality? My senses could be systematically deceived by an Evil Genius. What I see and what I hear may not be real but just what the Evil Genius feeds to my senses.[c] Some centuries later, the Matrix would become the computerized version of the Evil Genius.

So, the CCU hypothesis appears similar to Plato's Cave and Descartes' Evil Genius: They all suggest there may be a deeper reality below the one we perceive. But there is also a key difference, which is due to the CCU's computing aspect: While until 1950 we would not assign a significant probability to the existence of the Evil Genius (how did the Evil Genius happen?), we now must assign a significant probability to being in a CCU since it appears technologically possible.

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b Plato's Cave and Descartes' Evil Genius are two of the many thought-provoking classic ideas and topics the CCU naturally brings forward, along with Occam's Razor, the singularity, digital physics and others. As the author has evidenced at UC San Diego's freshman seminar series "Computing and the Universe," the computing connection of the CCU makes these topics more approachable and exciting to students.

c Descartes grew less worried when he discovered something that is definitely real: *I think therefore I exist.*

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## CCU and the Atheism-Creationism Debate

Is there a Creator God? This old question recently underlies plenty of polarized debates between biblical creationists and new atheists. The CCU hypothesis bolsters a strongly agnostic position, in the middle between the two camps. Asimov makes it clear that AC is a God creator for its CCU—albeit a material God who is itself the product of evolution.

Notice how the CCU hypothesis deconstructs classic arguments of the atheist camp. Biologist and atheist Richard Dawkins appeals to Occam's Razor when he argues the probability of a creator is extremely small if everything can be explained without assuming a creator.[6] Occam's Razor is the heuristic according to which we should always make the fewest possible assumptions when explaining phenomena.[d] Science lives by it. However, the CCU hypothesis tells us that creators may *emerge*—they are not independent assumptions. Hence, Occam's Razor does not prove very low probability of a creator. Similarly, the infinite regress argument (aka "turtles all the way down"[9]) fails: According to the CCU a creator, with the requisite computing ability, may emerge in a non-created universe.

Darwin's biological evolution boosted atheism by showing that the emergence of life and humans can be explained without positing a creator. Now computing calls us to ponder another kind of evolution, that of computation and mind, and the result is a boost to agnosticism, which can become a positive force. Vocal new atheist thought-leaders have unnecessarily coupled science with atheist assertions (for example, Dawkins[6]). Their dismissals of philosophy's metaphysical questions are also frequent.[3] A boost to rational agnosticism can remove the purported

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d Dawkins implicitly adopts a particular interpretation of Occam's Razor: If assuming an entity is not necessary then the probability of its *existence* is very low. Instead of this interpretation, one may adopt a purely methodological one (see survey in the Stanford Encyclopedia of Philosophy[13]). Nonetheless, this Viewpoint adopts Dawkins' interpretation and shows that, even so, Dawkins' use of Occam's Razor does not lead to the very low probability conclusion.

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science/metaphysics rift. Practically, once the theory of evolution (and not only) is no more involved into contested metaphysical implications and debates, we can hopefully fully focus on its methodological value and teach it because it produces results.

But are we bound to agnosticism? That is, are we bound to not knowing whether we are or not in a created universe? How about doing some research on it instead?

### Are We in a CCU? Digital Physics and Reasons for a Universe

When Konrad Zuse was not busy inventing the first computers,[5] he was speculating that the universe is a giant computer that continuously executes formal rules to compute its next state.[16] Fredkin,[7] Wolfram,[15] and others further contributed on *digital physics*, which posits that the universe is digital in nature and computation makes it tick.

However, the digital physics proponents did not posit a creator of the universe's computation. Nevertheless, the popular press tends to connect digital physics and the CCU. For example, Rundle[12] reports on the experiment that aims to discover if space and time come in tiny, discrete interacting pieces and considers it as evidence the universe is simulated on a digital computer. Although being in a digital universe would lend more credence to the CCU hypothesis, it fails to clearly imply it. Zuse may be right even if we do not live in a CCU. Vice versa, a CCU need not have the telltale signs of the primitive computer simulations of the 21st century.

If digital physics experiments are not much help in settling the CCU hypothesis, how else would we obtain hints? A favorite tactic is to second-guess whether someone who *could* be a universe creator *would* actually do it. Bostrom's argument talks of simulations where the creators make universes in order to simulate the times of their ancestors.[2,e] Vice versa, cosmologist Max Tegmark argues that any

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e  The students in UCSD's "Computing and the Universe" freshman seminar have their own reasons for a CCU: Imagine a CCU created by an advanced AI civilization, which uploads to the CCU its young and growing-up AI minds to be trained and obtain experience. Or, imagine "reality TV" CCUs—think of the whole universe as a massive *Truman Show*.

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## Are we bound to not knowing whether we are or not in a created universe?

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superintelligence will withdraw in its own self-contemplation and stay out of universe creation.[14,f]

A key problem with creator second-guessing is that it suffers from anthropomorphism, which ironically contradicts the assumption that a creator is a "superintelligent" mind. As *IEEE Spectrum*'s "Singularity" issue[10] summarized, "[after the singularity] the intelligence of ours is no longer the apex of intelligence ... Explaining [the world of a superintelligence] to one of us would be like trying to explain our world to a monkey." Similarly, the reasons for which a superintelligence will or will not create CCUs are most likely incomprehensible by our thinking. For now, agnosticism is the only sure bet: we may be or may not be in a CCU and, if we are, the reasons are unknown.[g]

### Awe and Wonder for Our Place in the Universe

Vinton Cerf inspires us by asking "what if it's us?" who will populate and light the galaxy.[4] Ray Kurzweil goes a step further: A superintelligent mind that will emerge in our merger with advanced computing will end up occupying the galaxy's matter and energy with its computation.[11] These are awesome and inspiring visions of humanity practically reaching deification—via computing!

The CCU hypothesis makes a simple reversal in the superintelligence timeline: The universe-creating superintel-

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f  In the same vein, UCSD students (curiously, the vast majority female) believe that a superintelligence will not create a CCU, since evil and pain would probably be part of any non-trivial CCU.

g  However, the reasons for a CCU are not necessarily completely unknowable. A future brilliant argument may predict past the singularity horizon. Furthermore, certain assumptions can change the probabilities. For example, an anonymous reviewer points out that if a creator's reasons for a CCU carry over to the created creators, then certain probabilities (for example, universes with no CCUs) decrease.

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ligence *may* have already emerged. In an era where pop cosmology books regularly announce the latest explanation to everything under the sun, the CCU's intractable mystery is a call to humility. This may at first seem like a disappointment. Yet, the CCU holds its own awe, wonder, and inspiring messages.

The unknown in the CCU is where its magic lies. It can restore the mystical awe and wonder that you felt looking into a dark sky full of stars when you were a child. What is really out there? Unknown and mysterious possibilities. Most inspiringly, a cosmos where computing and mind are at the center.

Imagine what is our place in this cosmos. We may be on the path to deification by advancing our recently discovered computing technology. Or we may already exist in the thoughts and computations of an AC, as Asimov suggested. Or both. No matter what is your choice, remember the words of the great visionary Clarke:[5] *The truth will be far stranger*. 🄲

**References**
1. Asimov, I. The last question. *Science Fiction Quarterly*, 1956; http://www.thrivenotes.com/the-last-question/.
2. Bostrom, N. Are you living in a computer simulation? *Philosophical Quarterly 53*, 11 (2003), 243–255; http://www.simulation-argument.com/simulation.html.
3. Caroll, S. Physicists should stop saying silly things about philosophy; http://www.preposterousuniverse.com/blog/2014/06/23/physicists-should-stop-saying-silly-things-about-philosophy/.
4. Cerf, V. What if it's us? *Commun. ACM 57*, 3 (Mar. 2014), 7.
5. Clarke, A. *2001: A Space Odyssey.* New American Library, 1968.
6. Dawkins, R. *The God Delusion.* Bantam Books, 2006.
7. Fredkin, E. An introduction to digital philosophy. *International Journal of Theoretical Physics 42*, 2 (Feb. 2003).
8. Galouye, D. *Simulacron-3.* Phoenix Pick, 1964.
9. Hawking, S. *A Brief History of Time.* Bantam Books, 1998.
10. *IEEE Spectrum.* Special Report: The Singularity, 2008; http://spectrum.ieee.org/static/singularity.
11. Kurzweil, R. *The Singularity Is Near: When Humans Transcend Biology.* Penguin Books, 2005.
12. Rundle, M. Physicists may have evidence universe is a computer simulation, 2012; http://www.huffingtonpost.co.uk/2012/10/11/physicists-may-have-evide_n_1957777.html.
13. Stanford Encyclopedia of Philosophy "Simplicity"; http://plato.stanford.edu/entries/simplicity/.
14. Tegmark, M. *Our Mathematical Universe: My Quest for the Ultimate Nature of Reality.* Knopf, 2014.
15. Wolfram, S. A new kind of science. *Wolfram Media*, 2002.
16. Zuse, K. Calculating space. MIT Technical Translation AZT-70-164-GEMIT, http://www.mathrix.org/zenil/ZuseCalculatingSpace-GermanZenil.pdf.

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