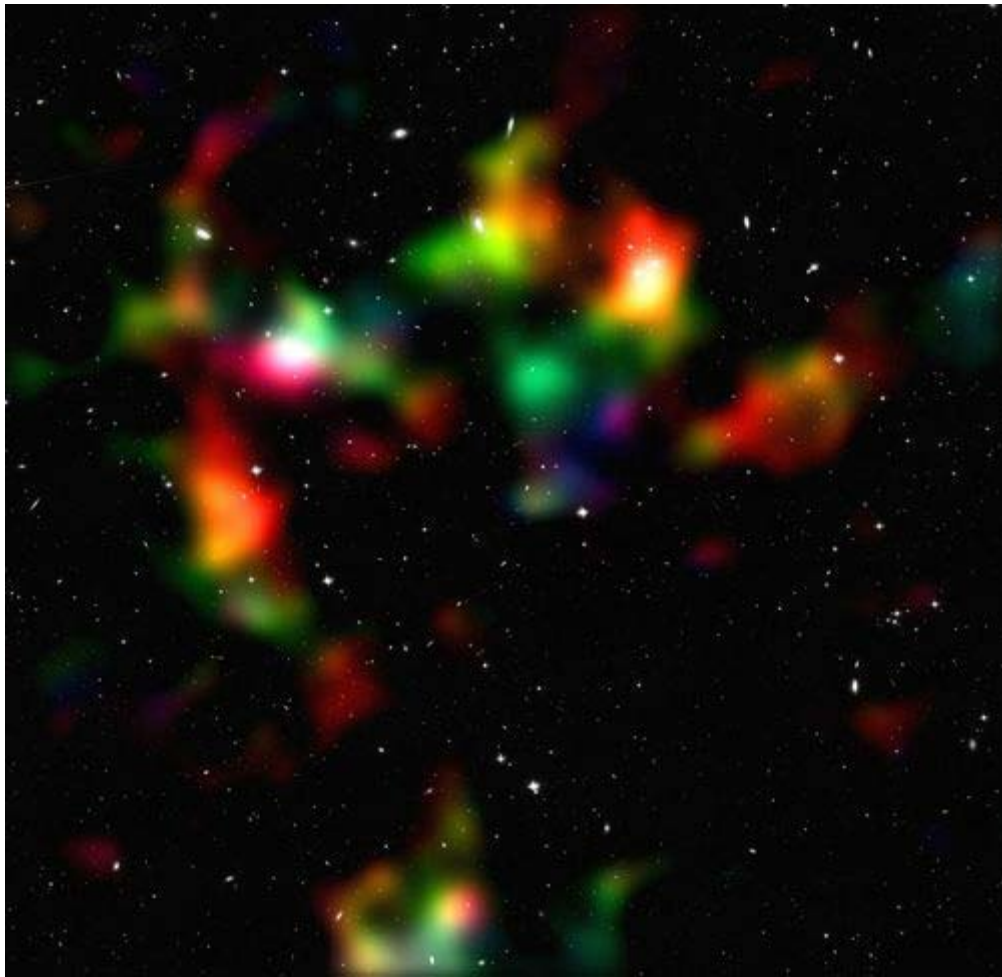


"We May be Living in a Massive Computer-Generated Universe" -- Physicists Say Its Reality Can Now Be Tested

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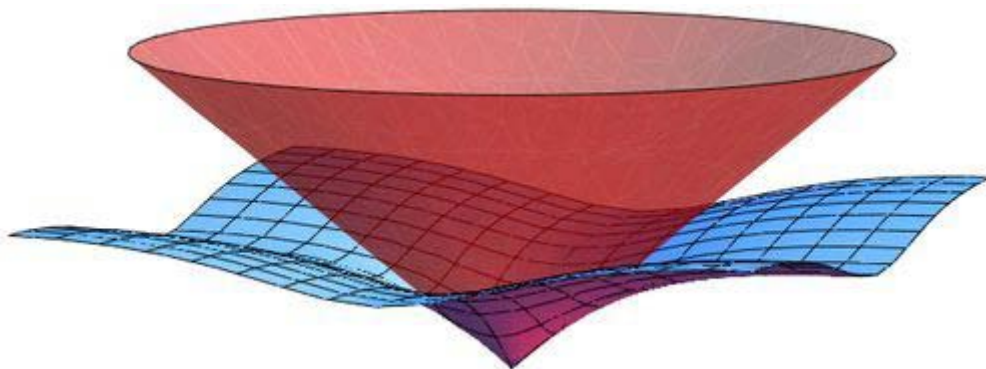


The idea that we may be living in a computer generated universe that has been debated by the greats of philosophy, from Plato to Descartes, who speculated

that the world we see around us could be generated by an 'evil demon'. Plato wrote that reality may be no more than shadows in a cave but the human species, having never left the cave, may not be aware of it.

More recently, the concept that current humanity could possibly be living in a computer simulation comes from a 2003 paper published in *Philosophical Quarterly* by Nick Bostrom, a philosophy professor at the University of Oxford. In the paper, he argued that at least one of three possibilities is true: (1) The human species is likely to go extinct before reaching a “posthuman” stage; (2) Any posthuman civilization is very unlikely to run a significant number of simulations of its evolutionary history. We are almost certainly living in a computer simulation; (3) “the belief that there is a significant chance that we will one day become posthumans who run ancestor simulations is false, unless we are currently living in a simulation.”

The conical (red) surface shows the relationship between energy and momentum in special relativity, a fundamental theory concerning space and time developed by Albert Einstein, and is the expected result if our universe is not a simulation. The flat (blue) surface illustrates the relationship between energy and momentum that would be expected if the universe is a simulation with an underlying cubic lattice.



With current limitations and trends in computing, it will be decades before researchers will be able to run even primitive simulations of the universe. But now a team of physicists at the University of Washington has come up with a

potential test to see if the idea holds water. The team has suggested tests that can be performed now, or in the near future, that are sensitive to constraints imposed on future simulations by limited resources.

Currently, supercomputers using a technique called lattice quantum chromodynamics and starting from the fundamental physical laws that govern the universe can simulate only a very small portion of the universe, on the scale of one 100-trillionth of a meter, a little larger than the nucleus of an atom, said Martin Savage, a UW physics professor.

Eventually, more powerful simulations will be able to model on the scale of a molecule, then a cell and even a human being. But it will take many generations of growth in computing power to be able to simulate a large enough chunk of the universe to understand the constraints on physical processes that would indicate we are living in a computer model.

However, Savage said, there are signatures of resource constraints in present-day simulations that are likely to exist as well in simulations in the distant future, including the imprint of an underlying lattice if one is used to model the space-time continuum.

The supercomputers performing lattice quantum chromodynamics calculations essentially divide space-time into a four-dimensional grid. That allows researchers to examine what is called the strong force, one of the four fundamental forces of nature and the one that binds subatomic particles called quarks and gluons together into neutrons and protons at the core of atoms.

“If you make the simulations big enough, something like our universe should emerge,” Savage said. Then it would be a matter of looking for a “signature” in our universe that has an analog in the current small-scale simulations.

Savage and colleagues Silas Beane of the University of New Hampshire, who collaborated while at the UW’s Institute for Nuclear Theory, and Zohreh Davoudi, a UW physics graduate student, suggest that the signature could show up as a limitation in the energy of cosmic rays.

In a paper they have posted on [arXiv](#), an online archive for preprints of scientific papers in a number of fields, including physics, they say that the highest-energy cosmic rays would not travel along the edges of the lattice in the model but would travel diagonally, and they would not interact equally in all directions as they otherwise would be expected to do.*“This is the first testable signature of such an idea,” Savage said.

If such a concept turned out to be reality, it would raise other possibilities as well. For example, Davoudi suggests that if our universe is a simulation, then those running it could be running other simulations as well, essentially creating other universes parallel to our own.

“Then the question is, ‘Can you communicate with those other universes if they are running on the same platform?’” she said.

Elsewhere this fall, Professor Silas Beane, a theoretical physicist at the [University of Bonn](#) in Germany said that his group of scientists have developed a way to test the 'simulation hypothesis'. If the cosmos is a numerical simulation, there ought to be clues in the spectrum of high energy cosmic rays. Now more than two thousand years since Plato suggested that our senses provide only a weak reflection of objective reality, experts believe they have solved the riddle using mathematical models known as the [lattice QCD](#) approach in an attempt to recreate - on a theoretical level - a simulated reality. Lattice QCD is a complex approach that looks at how particles known as quarks and gluons relate in three dimensions.

"We consider ourselves on some level universe simulators because we calculate the interactions of particles by basically replacing space and time by a grid and putting it in a box," said Beane. "In doing that we face lots of problems for instance the box and the grid size breaks [Einstein's special theory of relativity](#) so we know how to fix this in order to get physical predictions that are meaningful."

"We thought that if we make the assumption that the so-called simulators face some of the same problems that we do in terms of finite resources and so on then, if they are doing a simulation and even though their box size of course is

enormous and the grid size can be very small, as long as the resources are finite then the box size will be finite, the grid size will be finite," Beane added. "And therefore at some level for instance there would be violations of Einstein's special theory of relativity."

According to MIT's Technology Review, "using the world's most powerful supercomputers, physicists have only managed to simulate tiny corners of the cosmos just a few femtometers across (A femtometer is 10^{-15} meters.) That may not sound like much but the significant point is that the simulation is essentially indistinguishable from the real thing (at least as far as we understand it)."

As Carl Sagan said, extraordinary claims require extraordinary evidence. The image at the top of the page shows a smoothed reconstruction of the total (mostly dark) matter distribution in the COSMOS field, created from data taken by the NASA/ESA Hubble Space Telescope and ground-based telescopes. It was inferred from the weak gravitational lensing distortions that are imprinted onto the shapes of background galaxies. The colour coding indicates the distance of the foreground mass concentrations as gathered from the weak lensing effect. Structures shown in white, cyan, and green are typically closer to us than those indicated in orange and red. To improve the resolution of the map, data from galaxies both with and without redshift information were used.