Information Theory Rescue Cosmologists

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Abstract

Stephen Hawking described it as the most spectacular failure of any physical theory in history. Can a new theory of information rescue cosmologists? [9]

Considering the positive logarithmic values as the measure of entropy and the negative logarithmic values as the measure of information we get the Information – Entropy Theory of Physics, used first as the model of the computer chess program built in the Hungarian Academy of Sciences.

Applying this model to physics we have an understanding of the perturbation theory of the QED and QCD as the Information measure of Physics. We have an insight to the current research of Quantum Information Science. The generalization of the Weak Interaction shows the arrow of time in the associate research fields of the biophysics and others. We discuss also the event horizon of the Black Holes, closing the information inside.

How the Nature of Information Could Resolve One of the Great Paradoxes of Cosmology

Stephen Hawking described it as the most spectacular failure of any physical theory in history. Can a new theory of information rescue cosmologists?

One of the biggest puzzles in science is the cosmological constant paradox. This arises when physicists attempt to calculate the energy density of the universe from first principles. Using quantum mechanics, the number they come up with is 10^94 g/cm^3.

And yet the observed energy density, calculated from the density of mass in the cosmos and the way the universe is expanding, is about 10^-27 g/cm^3. In other words, our best theory of the universe misses the mark by 120 orders of magnitude.

That's left cosmologists somewhat red-faced. Indeed, Stephen Hawking has famously described this as the most spectacular failure of any physical theory in history. This huge discrepancy is all the more puzzling because quantum mechanics makes such accurate predictions in other circumstances. Just why it goes so badly wrong here is unknown.

Today, Chris Fields, an independent researcher formerly with New Mexico State University in Las Cruces, puts forward a simple explanation. His idea is that the discrepancy arises because large objects, such as planets and stars, behave classically rather than demonstrating quantum properties. And he's provided some simple calculations to make his case.

One of the key properties of quantum objects is that they can exist in a superposition of states until they are observed. When that happens, these many possibilities "collapse" and become one specific outcome, a process known as quantum decoherence.

For example, a photon can be in a superposition of states that allow it to be in several places at the same time. However, as soon as the photon is observed the superposition decoheres and the photon appears in one place.

This process of decoherence must apply to everything that has a specific position, says Fields. Even to large objects such as stars, whose position is known with respect to the cosmic microwave background, the echo of the big bang which fills the universe.

In fact, Fields argues that it is the interaction between the cosmic microwave background and all large objects in the universe that causes them to decohere giving them specific positions which astronomers observe.

But there is an important consequence from having a specific position?—there must be some information associated with this location in 3D space. If a location is unknown, then the amount of information must be small. But if it is known with precision, the information content is much higher.

And given that there are some 10^25 stars in the universe, that's a lot of information. Fields calculates that encoding the location of each star to within 10 cubic kilometers requires some 10^93 bits.

That immediately leads to an entirely new way of determining the energy density of the cosmos. Back in the 1960s, the physicist Rolf Landauer suggested that every bit of information had an energy associated with it, an idea that has gained considerable traction since then.

So Fields uses Landauer's principle to calculate the energy associated with the locations of all the stars in the universe. This turns out to be about 10^-30 g /cm^3, very similar to the observed energy density of the universe.

But here's the thing. That calculation requires the position of each star to be encoded only to within 10 km^3. Fields also asks how much information is required to encode the position of stars to the much higher resolution associated with the Planck length. “Encoding 10^25 stellar positions at [the Planck length] would incur a free-energy cost ~ 10^117 larger than that found here,” he says.

That difference is remarkably similar to the 120 orders of magnitude discrepancy between the observed energy density and that calculated using quantum mechanics. Indeed, Fields says that the discrepancy arises because the positions of the stars can be accounted for using quantum mechanics. “It seems reasonable to suggest that the discrepancy between these numbers may be due to the assumption that encoding classical information at [the Planck scale] can be considered physically meaningful.”

That’s a fascinating result that raises important questions about the nature of reality. First, there is the hint in Fields’ ideas that information provides the ghostly bedrock on which the laws of physics are based. That’s an idea that has gained traction among other physicists too.

Then there is the role of energy. One important question is where this energy might have come from in the first place. The process of decoherence seems to create it from nothing.

Cosmologists generally overlook violations of the principle of conservation of energy. After all, the big bang itself is the biggest offender. So don’t expect much hand wringing over this. But Fields’ approach also implies that a purely quantum universe would have an energy density of zero, since nothing would have localized position. That’s bizarre. [9]

Considering the chess game as a model of physics

In the chess game there is also the same question, if the information or the material is more important factor of the game? There is also the time factor acting as the Second Law of Thermodynamics, and the arrow of time gives a growing disorder from the starting position.

When I was student of physics at the Lorand Eotvos University of Sciences, I succeeded to earn the master degree in chess, before the master degree in physics. I used my physics knowledge to see the chess game on the basis of Information – Entropy Theory and giving a presentation in the Hungarian Academy of Sciences, proposed a research of chess programming. Accepting my idea there has built the first Hungarian Chess Program "PAPA" which is participated on the 1st World Computer Chess Championship in Stockholm 1974. [1]

The basic theory on which one chess program can be constructed is that there exists a general characteristic of the game of chess, namely the concept of entropy.

This concept has been employed in physics for a long time. In the case of a gas, it is the logarithm of the number of those microscopic states compatible with the macroscopic parameters of the gas.

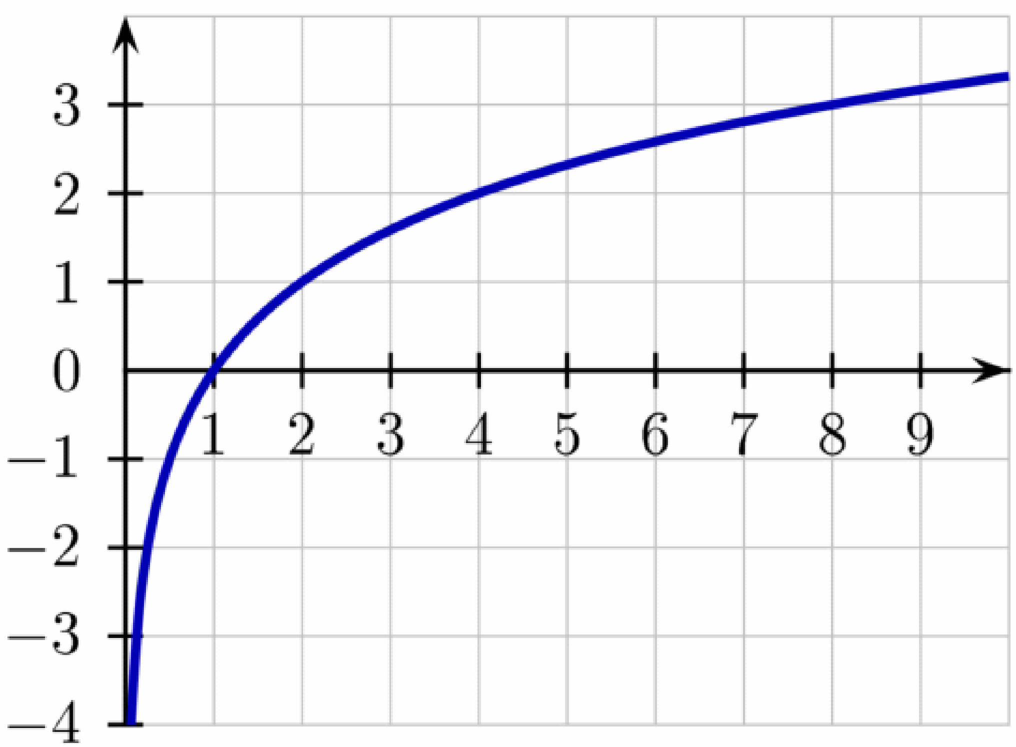
What does this mean in terms of chess? A common characteristic of every piece is that it could move to certain squares, including by capture. In any given position, therefore, the pieces by the rules of the game possess certain states, only one of which will be realized on the next move. The difference of the logarithm of the numbers of such states for Black and White respectively is the "entropy of the position". The task of the computer is then to increase this value for its own benefit.

Every chess player knows that the more mobility his pieces have and the more constrained are his opponent's, the better his position. For example, checkmate is the best possible state for the attacker, and the chess program playing according to the above principle without the prior notion of checkmate will automatically attempt it if possible.

Entropy is a principle of statistical physics and therefore is only applicable in statistical contexts. The number of microstates of a confined gas is very large and therefore the statistical approach is valid. In chess, however, the number of pieces, a macroscopic parameter, is very small and therefore in this context the "value" of a position cannot be an exact function of entropy. For example, it is possible to checkmate with a total force of a single pawn despite the fact that the opponent has many pieces and various positions available.

Examples of sacrificial combinations further demonstrate this consideration. Therefore we also need specific information about any given position. For example, entropy could be maximized by White giving check, but if the checking piece is then taken, the move was a bad one. The logarithm of the number of variations which have been examined in this way gives the amount of information. In the endgame it is rather inaccurate. Because of the small number of pieces the above noted inadequacy of the statistical principle becomes evident and we need to compute much more information to fill the gap.

We can think about the positive logarithmic values as the measure of entropy and the negative logarithmic values as the measure of information.



Shortly speaking:

- The evaluation of any position is based on the entropy + information.

- The entropy is the logarithm of the possible legal moves of the position.
- The information is simply the depth of the search, since it is the logarithm of the exponential growing number of possible positions, $\log e^x = x$.

E = entropy

I = information

D = depth of search

M = legal moves in any position, M_w for white moves and M_b for black moves

$E = \log M_w - \log M_b = \log M$

And since $\log e^x = x$, $I = D$

We get information + entropy, the value V of any position in the search tree of the current chess position:

$V(D, M) = I + E = D + \log M$

This naturally gives better values for a deeper search with greater mobility. [2]

Using this model in physics

Viewing the confined gas where the statistical entropy not needs the information addition is not the only physical system. There are for example quantum mechanical systems where the information is a very important qualification. The perturbation theory needs higher order calculations in QED or QCD giving more information on the system as in the chess games happens, where the entropy is not enough to describe the state of the matter. The variation calculation of chess is the same as the perturbation calculation of physics to gain information, where the numbers of particles are small for statistical entropy to describe the system. The role of the Feynman graphs are the same as the chess variations of a given position that is the depth of the variations tree, the Information is the same as the order of the Feynman graphs giving the Information of the micro system.

Quantum Information Science

Quantum information science is an area of study based on the idea that information science depends on quantum effects in physics. It includes theoretical issues in computational models as well as more experimental topics in quantum physics including what can and cannot be done with quantum information.

Quantum Computing Research

Quantum computing has been an intense research field since Richard Feynman in 1981 challenged the scientific community to build computers based on quantum mechanics. For decades, the pursuit remained firmly in the theoretical realm.

To understand the quantum world, researchers have developed lab-scale tools to manipulate microscopic objects without disturbing them. The 2012 Nobel Prize in Physics recognizes two of these quantum researchers: David Wineland, of the National Institute of Standards and Technology and the University of Colorado in Boulder, and Serge Haroche, of the Collège de France and the Ecole Normale Supérieure in Paris. Two of their papers, published in 1995 and '96 in Physical Review Letters, exemplify their contributions. The one by Wineland and collaborators showed how to use atomic states to make a quantum logic gate, the first step toward a superfast quantum computer. The other, by Haroche and his colleagues, demonstrated one of the strange predictions of quantum mechanics—that measuring a quantum system can pull the measuring device into a weird quantum state which then dissipates over time.

IBM scientists believe they're on the cusp of building systems that will take computing to a whole new level. On Feb 28, 2012 the IBM team presented major advances in quantum computing device performance at the annual American Physical Society meeting. Using a variety of techniques in the IBM laboratories, scientists have established three new records for retaining the integrity of quantum mechanical properties in quantum bits, or qubits, and reducing errors in elementary computations. These breakthrough results are very close to the minimum requirements for a full-scale quantum computing system as determined by the world-wide research community. [3]

Quantum computing in neural networks is one of the most interesting research fields today. [4] The biological constructions of the brain are capable to memorize, associate and logically thinking by changing their quantum states. The machine learning of Artificial Intelligence will be one of the mainstreams of the Quantum Computing, when it will be available. Probably the main challenge will be to simulate the brain biologic capability to create new quantum states for logical reasoning, since we don't know nowadays how it is work exactly in the brain. [8]

The General Weak Interaction

The Weak Interactions T-asymmetry is in conjunction with the T-asymmetry of the Second Law of Thermodynamics, meaning that locally lowering entropy (on extremely high temperature) causes for example the Hydrogen fusion. The arrow of time by the Second Law of Thermodynamics shows the increasing entropy and decreasing information by the Weak Interaction, changing the temperature dependent diffraction patterns. A good example of this is the neutron decay, creating more particles with less known information about them. [5]

The neutrino oscillation of the Weak Interaction shows that it is a general electric dipole change and it is possible to any other temperature dependent entropy and information changing diffraction pattern of atoms, molecules and even complicated biological living structures.

We can generalize the weak interaction on all of the decaying matter constructions, even on the biological too. This gives the limited lifetime for the biological constructions also by the arrow of time. There should be a new research space of the Quantum Information Science the 'general neutrino oscillation' for the greater then subatomic matter structures as an electric dipole change.

There is also connection between statistical physics and evolutionary biology, since the arrow of time is working in the biological evolution also. [6]

The Fluctuation Theorem says that there is a probability that entropy will flow in a direction opposite to that dictated by the Second Law of Thermodynamics. In this case the Information is growing that is the matter formulas are emerging from the chaos. So the Weak Interaction has two directions, samples for one direction is the Neutron decay, and Hydrogen fusion is the opposite direction.

Black Holes revisited

The Black Holes are the counter example, where the matter is so highly concentrated that the entropy is very low and the information is high but closed inside the event horizon.

The problem is with the Black hole that it is not a logical physical state of the matter by the diffraction theory, because we cannot find a temperature where this kind of diffraction patterns could exist. [5]

Also the accelerating charges of the electric current say that the charge distribution maintains the accelerating force and this viewpoint of the relativity does not make possible an acceleration that can cause a Black Hole. The ever growing acceleration simply resolved in the spin. [7]

The spin is one of the most generic properties of the Universe, not only the elementary particles are spinning, but also the Sun, Earth, etc. We can say that the spin is the resolution of the constantly accelerating matter solving the problem of the relativity and the accelerating Universe. The gravity is the magnetic effect of the accelerating matter, the attracting force between the same charges; working by the electromagnetic oscillations, because of this is their universal force. Since this effect is relatively weak, there is no way for the gravitation force to compress the matter to a Black Hole.

Conclusions

Beyond this is the even deeper question of how the universe came to be classical at all, given that cosmologists would have us believe that the big bang was a quantum process. Fields suggests that it is the interaction between the cosmic microwave background and the rest of the universe that causes the quantum nature of the universe to decohere and become classical. [9]

My opinion is that information and matter are two sides of the same thing in physics, because the matter is the diffraction pattern of the electromagnetic waves, giving the temperature dependent different structures of the matter, the information about them arrives by the electromagnetic waves and also the entropy or uncertainty as the measure of disorder. [7]

The Fluctuation Theory gives a probability for Information grow and Entropy decrease seemingly proportionally with the gravitational effect of the accelerating Universe, against the arrow of time by the Second Law of Thermodynamics. The information and entropy are the negative and positive sides of the logarithmic curve, describing together the state of the matter.

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