Information Conversion to Energy

Author: George Rajna

Abstract

Physicists in Japan have shown experimentally that a particle can be made to do work simply by receiving information, rather than energy. They say that their demonstration, which uses a feedback system to control the electric potential of tiny polystyrene beads, does not violate the second law of thermodynamics and could in future lead to new types of microscopic devices. [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.

Information converted to energy

The experiment, carried out by Shoichi Toyabe of Chuo University in Tokyo and colleagues, is essentially the practical realization of a thought experiment proposed by James Clerk Maxwell in 1871. Maxwell envisaged a gas initially at uniform temperature contained in a box separated into two compartments, with a tiny intelligent being, later called "Maxwell's demon", controlling a shutter between the two compartments. By knowing the velocity of every molecule in the box, the demon can in principle time the opening and closing of the shutter to allow the build-up of faster molecules in one compartment and slower ones in the other. In this way, the demon can decrease the entropy inside the box without transferring energy directly to the particles, in apparent contradiction of the second law of thermodynamics.

Among the many responses to this conundrum was that of Leó Szilárd in 1929, who argued that the demon must consume energy in the act of measuring the particle speeds and that this consumption will lead to a net increase in the system's entropy. In fact, Szilárd formulated an equivalence between energy and information, calculating that $kT\ln 2$ (or about 0.69 kT) is both the minimum amount of work needed to store one bit of binary information and the maximum that is liberated when this bit is erased, where k is Boltzmann's constant and T is the temperature of the storage medium.

Spiral staircase

Toyabe and colleagues have observed this energy-information equivalence by varying an electric field so that it represents a kind of spiral staircase. The difference in electrical potential between successive steps on the staircase is kT, meaning that a thermally fluctuating particle placed in the field will occasionally jump up a step but more often than not it will take a step downwards. What the researchers did was to intervene so that whenever the particle does move upwards they place the equivalent of a barrier behind it, preventing the particle from falling beyond this point. Repeating the process allows it to gradually climb the staircase.

The experiment consisted of a 0.3 µm-diameter particle made up of two polystyrene beads that was pinned to a single point on the underside of the top of a glass box containing an aqueous solution. The shape of an applied electric field forced the particle to rotate in one direction or, in other words, to fall down the potential-energy staircase. Buffered by the molecules in the solution, however, the particle every so often rotated slightly in the opposite direction, allowing it to take a step upwards.

By tracking the particle's motion using a video camera and then using image-analysis software to identify when the particle had rotated against the field, the researchers were able to raise the metaphorical barrier behind it by inverting the field's phase. In this way they could gradually raise the potential of the particle even though they had not imparted any energy to it directly.

Quantifiable breakthrough

In recent years other groups have shown that collections of particles can be rearranged so as to reduce their entropy without providing them with energy directly. The breakthrough in the latest work is to have quantified the conversion of information to energy. By measuring the particle's degree of rotation against the field, Toyabe and colleagues found that they could convert the equivalent of one bit information to $0.28\ kT\ln 2$ of energy or, in other words, that they could exploit more than a quarter of the information's energy content.

Processes taking place on the nanoscale are completely different to those we are familiar with, and information is part of that picture. (Christian Van den Broeck, University of Hasselt)

The research is described in Nature Physics, and in an accompanying article Christian Van den Broeck of the University of Hasselt in Belgium describes the result as "a direct verification of information-to-energy conversion" but points out that the conversion factor is an idealized figure. As he explains, it regards just the physics taking place on the microscopic scale and ignores the far larger amount of energy consumed by the macroscopic devices, among them the computers and human operators involved. He likens the energy gain to that obtained in an experimental fusion facility, which is dwarfed by the energy needed to run the experiment. "They are cheating a little bit," joked Van den Broeck over the telephone. "This is not something you can put on the shelf and sell at this point."

However, Van den Broeck does believe that the work could lead to practical applications within perhaps the next 30 or 40 years. He points out that as devices get ever more miniature the energy content of the information used to control them – kT at room temperature being equivalent to about 4 × 10–21 J – will approach that required to operate them. "Nobody thinks of using bits to boil water," he says, "but that would in principle be possible at nanometre scales." And he speculates that molecular processes occurring in nature might already be converting information to energy in some way. "The message is that processes taking place on the nanoscale are completely different from those we are familiar with, and that information is part of that picture." [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.

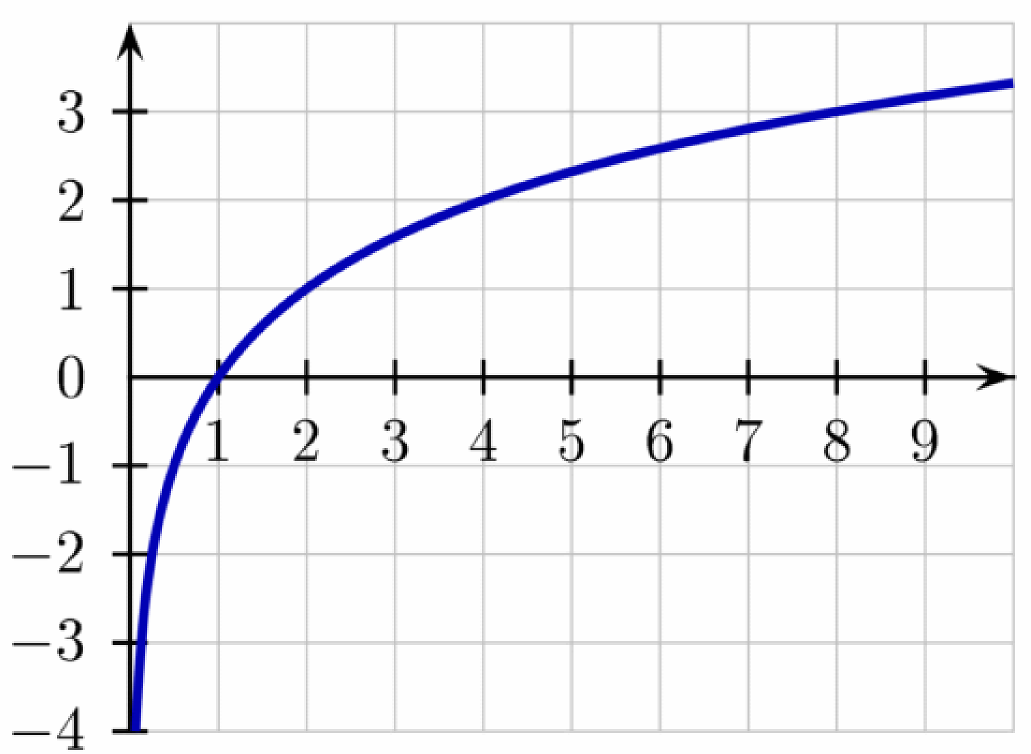
What does this mean in terms of chess? A common characteristic of every piece is that it could move to certain squares, including by capture. In any given position, therefore, the pieces by the rules of the game possess certain states, only one of which will be realized on the next move. The difference 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

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.

References

[1] The world computer chess championship, Stockholm 1974
Author: Jean E. Hayes, David Levy
Publisher: University Press (Edinburgh) ISBN 0852242859
http://chessprogramming.wikispaces.com/Papa

http://chessprogramming.wikispaces.com/George+Rajna

[2] Information – Entropy Theory of Artificial Intelligence
Author: George Rajna
Publisher: Vixra.org http://vixra.org/abs/1201.0063

[3] IBM Quantum Computing Press Release - Tues, Feb 28, 2012
Author: IBM Research Team
Publisher: IBM http://ibmquantumcomputing.tumblr.com/

[4] Quantum computing in neural networks
Author: P. GRALEWICZ
Publisher: arXiv.org http://arxiv.org/abs/quant-ph/0401127

[5] 3 Dimensional String Theory
Author: George Rajna
Publisher: Vixra.org http://vixra.org/abs/1112.0064

[6] The application of statistical physics to evolutionary biology
Author: Guy Sella and Aaron E. Hirsh
Publisher: Hebrew University of Jerusalem Department of Biological Sciences, Stanford University, Stanford, CA 94305 http://www.pnas.org/content/102/27/9541.full.pdf+html

[7] The Magnetic Field of the Electric Current and the Magnetic Induction
Author: George Rajna
Publisher: Vixra.org http://vixra.org/abs/1112.0058

[8] Automated Quantum Reasoning: Non-Logic _Semi-Logic _Hyper-Logic
Author: Bob Coecke
Publisher: Oxford University Computing Laboratory http://www.researchgate.net

[9] Information converted to energy

http://physicsworld.com/cws/article/news/2010/nov/19/information-converted-to-energy