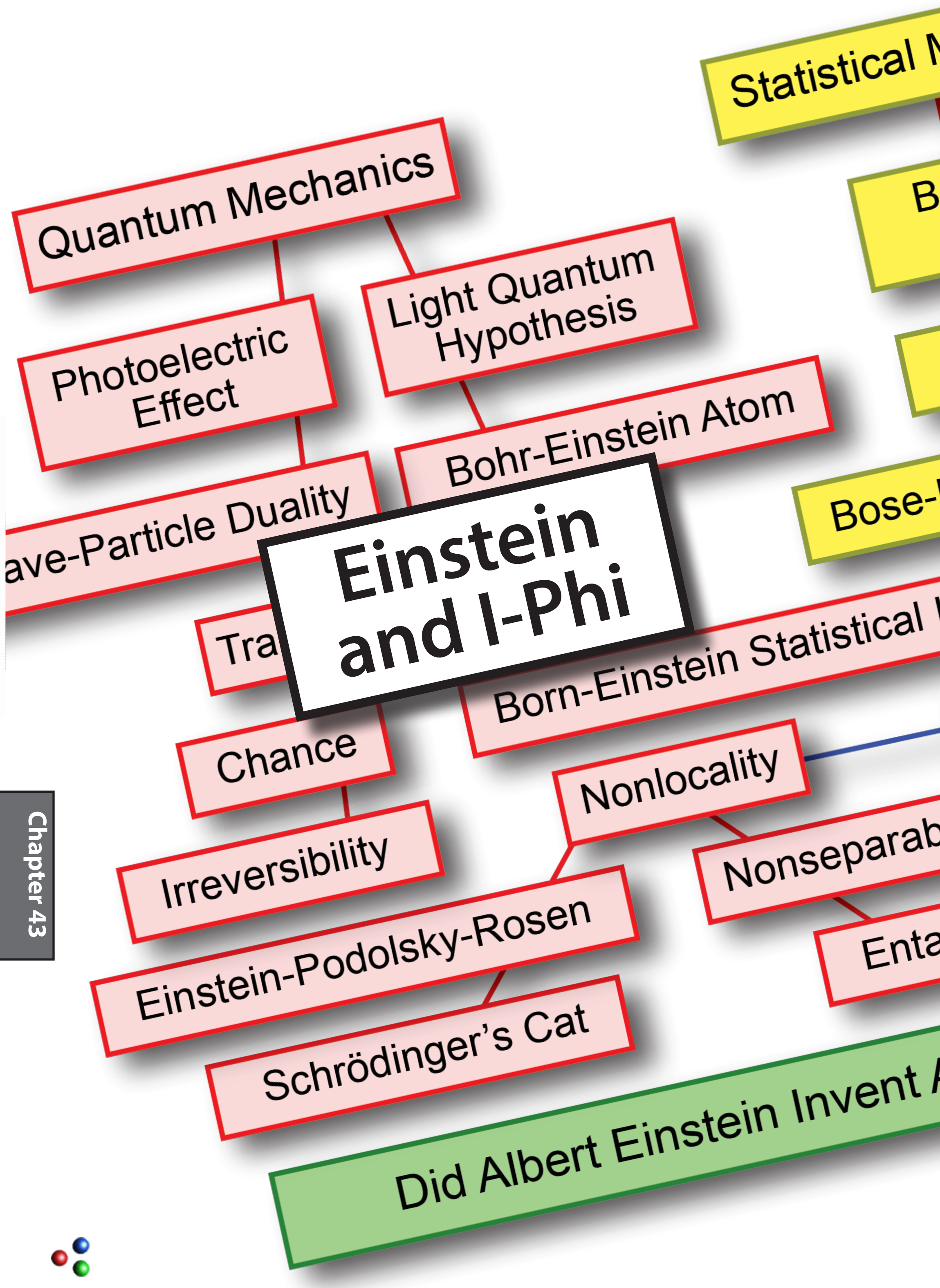
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Chapter 43

Albert Einstein and Information Philosophy

On Information Philosophy

Information is neither matter nor energy, although it needs matter to be embodied and energy to be communicated. Why should information become the new basis for understanding and solving so many problems in philosophy and science?

It is because everything in the universe that is distinguishable from chaos and disorder is an *information structure* that was created since the structureless, pure energy origin of the universe.

As most all of us know, matter and energy are *conserved*. This means that there is just the same total amount of matter and energy today as there was at the universe origin. Einstein showed us that matter can be converted into energy with his equation $E=mc^2$, so there is just one unchanging total of "stuff" in the universe.

But then what accounts for all the *change* that we see, the new things under the sun? It is information, which is not conserved and has been increasing since the beginning of time, despite the second law of thermodynamics, with its increasing entropy, which destroys order.

What is changing is the *arrangement* of the existing matter in what we call information structures. What is emerging is new information. What idealists and holists see is that emergence of immaterial information embodied in material structures.

Living things, you and I, are dynamic growing information structures, forms through which matter and energy continuously flow. And it is information processing that controls those flows!

At the lowest levels, living information structures blindly replicate their information. At higher levels, natural selection adapts them to their environments. At the highest levels, they develop behaviors, intentions, goals, and agency, introducing purpose into the universe.

Information is the modern spirit, the ghost in the machine, the mind in the body. It is the soul, and when we die, it is our information that perishes, unless the future preserves it. The matter remains.

Information can explain the fundamental metaphysical connection between materialism and idealism. Information philosophy replaces the determinism and metaphysical necessity of eliminative materialism and reductionist naturalism with metaphysical possibilities. Alternative possibilities can not exist without ontological chance. Determinism says there is but one possible future.

Many mathematical physicists like the idea of a completely deterministic universe. The Bohmians, Everett's many worlders, John Bell, and the Decoherence theorists are all determinists. They believe that the "wave function of the universe" evolves deterministically, and it does. But they deny the many "collapses of the wave function" which are indeterministic and are the creative source of all new information.

Einstein saw chance as a "weakness in the theory." But the important thing is that he was the first person to see ontological "objectively real" chance in physics. Chance in classical physics had been regarded as epistemological, merely human ignorance.

Perhaps the most amazing thing about information philosophy is its discovery that abstract and immaterial information (the quantum wave field) can exert an influence over concrete matter, perhaps explaining how mind can move body, how our thoughts can control our actions, deeply related to the way the quantum wave function controls the probabilities of locating quantum particles, as first seen, but never understood, by Einstein.

Einstein did not like probabilities but clearly saw that quantum physics is a *statistical* theory.

How abstract *probability* amplitudes Ψ control the *statistics* of experiments remains the *one deep mystery of quantum mechanics*.

Knowledge is information in minds that is a partial isomorphism (mapping) of the information structures in the external world. Information philosophy is a correspondence theory.

Sadly, there is no isomorphism, no information in common, between words and objects. This accounts for much of the failing of analytic language philosophy in the past century. The arbitrary and conventional connections between words and objects is the source of confusion in Niels Bohr's Copenhagen Interpretation of quantum mechanics.

Although language is a fine tool for human communication, it is arbitrary, ambiguous, and ill-suited to represent the world directly. Human languages do not picture reality. Information is the true *lingua franca* of the universe.

The extraordinarily sophisticated connections between words and objects are "free creations of human minds," mediated by the brain's experience recorder and reproducer (ERR). Words stimulate wired neurons to start firing and to play back those experiences that include related objects.

Neurons that were wired together in our earliest experiences fire together at later times, contextualizing our new experiences, giving them meaning. And by replaying emotional reactions to similar earlier experiences, it makes then "subjective experiences," giving us the feeling of "what it's like to be me" and solving the "hard problem" of consciousness.

Without words and related experiences previously recorded in our mental experience recorders, we could not comprehend words. They would be mere noise, with no meaning.

Far beyond words, a dynamic information model of an information structure in the world is presented immediately to the mind as a simulation of reality experienced for itself.

This is why we are creating *animations* of mysterious quantum phenomena to show you the two-slit experiment, entanglement, and the interaction of radiation with microscopic matter that leads to the macroscopic irreversibility underlying the second law of thermodynamics.

We will analyze all the quantum "mysteries" we hope to solve in terms of information structures and the communication of information between information structures. We will look to find the information in each of the quantum mysteries

Where's the Information in Entangled Particles?

The central mystery in entanglement for eighty years has been how Alice's measurement of a property can be "transmitted," presumably faster than the speed of light, to Bob at a remote space-like separation, so that Bob's measurement of a related property can be perfectly correlated with Alice's measurement.

The information needed is the electron spin or photon polarization direction (up or down) for each particle. The Copenhagen Interpretation says we cannot know those spin values, that they do not even exist until the measurements are made.

Einstein's "objective reality" says that they do have values, independent of our measurements. When we prepare the experiment, we know that one particle is up and the other down, but we don't know which is which.

Because we lack that knowledge, quantum mechanics assumes they are best described by a linear superposition of up-down and down-up. Objective reality, however, says they always will be found in one of those states, *either* up-down or down-up.

Now Einstein's principles of conservation say that the initial properties are conserved as long as there is no external interaction with the two particles. The information is therefore carried along in each particle. Whichever particle starts out with spin up will be measured with spin up at any later time, the other will be found spin down.

We have shown that the opposite spins can be regarded as "hidden constants" of the motion traveling locally from their creation, consistent with Einstein's picture of an "objective reality." When Alice exercises her "free choice" of a spin direction in which to measure, she adds new information to the universe, she "creates" properties that could not have been know at the start of the experiment.

To a quantum physicist of the Copenhagen school, who thinks the particles lack properties simply because we don't know them, it will *appear* as if the particles are communicating the needed correlation information instantly over large distances. See chapter 29.

But the information moves *locally*, only as fast as the particles.

Where's the Information in the Two-Slit Experiment?

Is it in the particles themselves as we found for entanglement? No. Here the Copenhagen physicist is closer to the truth. We know nothing about the current path. We only know particles were fired from a distance away from the two slits.

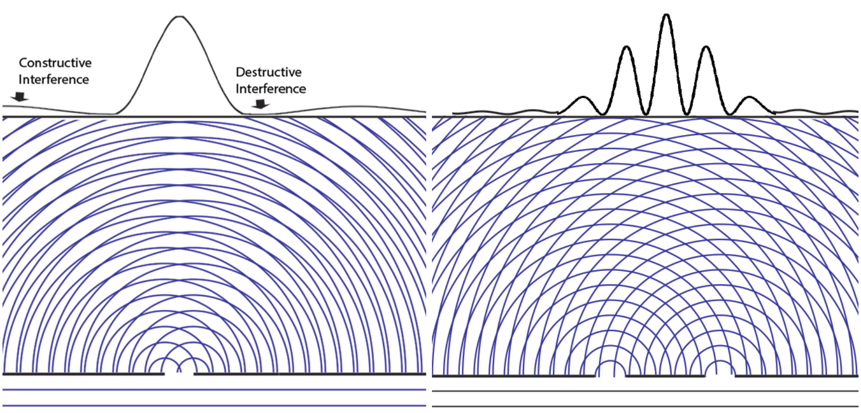
Once a particle hits the screen, we know the beginning and ending of the path, as we do for entanglement, but we do not know which slit the particle went through if both slits are open.

So where is the information that produces one interference pattern when both slits are open, and two distinctly different patterns when either slit 1 or slit 2 is open?

In this case the information is in the wave function, and as Einstein first knew, that information is only statistical information. It gives us only probabilities of finding particles, which we will confirm for very large numbers of particles. We know nothing about an individual path.

Nevertheless, Einstein's "objective reality" says the particle has a path. And his principles of conservation tell us that the particle never splits in two, so it must travel through just one of the slits.

We saw in chapter 33 that the wave patterns are different when one slit is open or both slits are open.



So the ulimate source of the information in the wave field is in the boundary conditions, the distribution of local material, just the way the gravitational field is determined by material nearby.

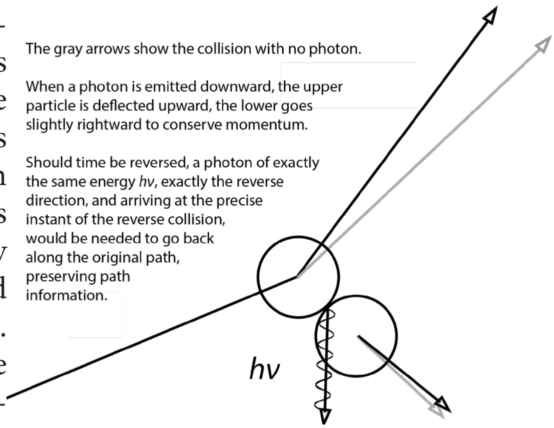
How abstract *probability* amplitude wave function can influence the motions of the particles so that

they produce the *statistics* of many experiments remains the *one mystery of quantum mechanics*.

The mystery is not, as Richard Feynman thought, how the particle can go through both slits. It is somewhat deeper. How the wave function can influence particle motions. The information needed to generate interference patterns is in the wave function.

Where's the Information in Microscopic Irreversibility?

In 1874, Josef Loschmidt criticized his younger colleague Ludwig Boltzmann's attempt to derive from basic classical dynamics the increasing entropy required by the second law of thermodynamics. Loschmidt said that the laws of classical dynamics are time reversible. Consequently, if we just turn the time around, the time evolution of the system should lead to decreasing entropy.



Boltzmann investigated the classical paths of particles in collision to develop his "transport equation." He wondered if after a collision a particle might lose some of the information from a particular collision after colliding with a few more particles. He called this "molecular disorder."

Now Einstein has shown us how information about a path before a collision will be lost during the collision if the collision emits or absorbs a photon. The interaction of radiation with the particles is *irreversible*. Einstein says radiation interactions are not "invertible."

In this case we cannot know the information, but we can say that information needed to reverse collisions has been lost.

Chapter 43

Where's the Information in the Measurement Problem?

Some define the problem of measurement simply as the logical contradiction between two laws describing the motion of quantum systems; the unitary, continuous, and deterministic time evolution of the Schrödinger equation versus the non-unitary, discontinuous, and indeterministic collapse of the wave function. John von Neumann saw a problem with two distinct (indeed, opposing) processes. See chapter 25.

The mathematical formalism of quantum mechanics provides no way to predict exactly when the wave function stops evolving in a unitary fashion and collapses. If it could predict this perfectly, it would no longer be quantum mechanics. Experimentally and practically, however, we can say that this occurs when the microscopic system interacts with a macroscopic measuring apparatus.

It takes energy to record the information about the measurement in the material of the apparatus. for example by moving a pointer, marking a chart recorder, or storing data in computer memory.

New information creation requires a local reduction in the entropy. And in order for that new information to remain stable for a observer to read it, the overall global entropy must increase by a larger amount to satisfy the second law. Waste energy is carried away from the measurement apparatus.

Where's the Information in a Deterministic World?

Pierre-Simon Laplace imagined a super-intelligence that could know the positions, velocities, and forces on all the particles in the universe at one time, together with the deterministic laws of motion, and thus know the universe for all times, past and future. The concept has been criticized for the vast amount of information that would be required, impractical if not impossible to collect instantaneously. And where would the information be kept? If in some part of the universe, there would be an infinite regress of information storage.

Determinists, especially mathematical physicists and compatibilist philosophers, are comfortable with this idea.

A moment's thought tells us that information is being created in the universe at every moment. Which leads us to the question...

How Did All the Information in the Universe Get Created?

Information philosophy has solved this great problem, perhaps the greatest of all problems in physics and philosophy.

And our solution depends on Einstein's expansion of the universe. If the universe were static, it would have come to thermal equilibrium, the "heat death", ages ago.

Many scientists think the universe must have started in a state of very high information. Since information is destroyed by the entropy increase of the second law, they argue there must have been even more information at the beginning than we see today.

But the reverse is true. The early universe was far denser than today. Particles were jammed together at an extraordinarily high temperature which prevented even elementary particles like protons and neutrons from forming, let alone atoms (which did not become stable for the first 380,00 years) or the galaxies, stars, and planets (which had to wait over 400 million years for the gas to cool down enough for gravity to overcome the high pressure and temperature, and the radiation to cool to a black sky everywhere).

The expansion opened up space between the gas particles. As Boltzmann's and Einstein's statistical mechanics would have described it, there appeared many more phase-space cells for the fixed number of particles to arrange themselves in.

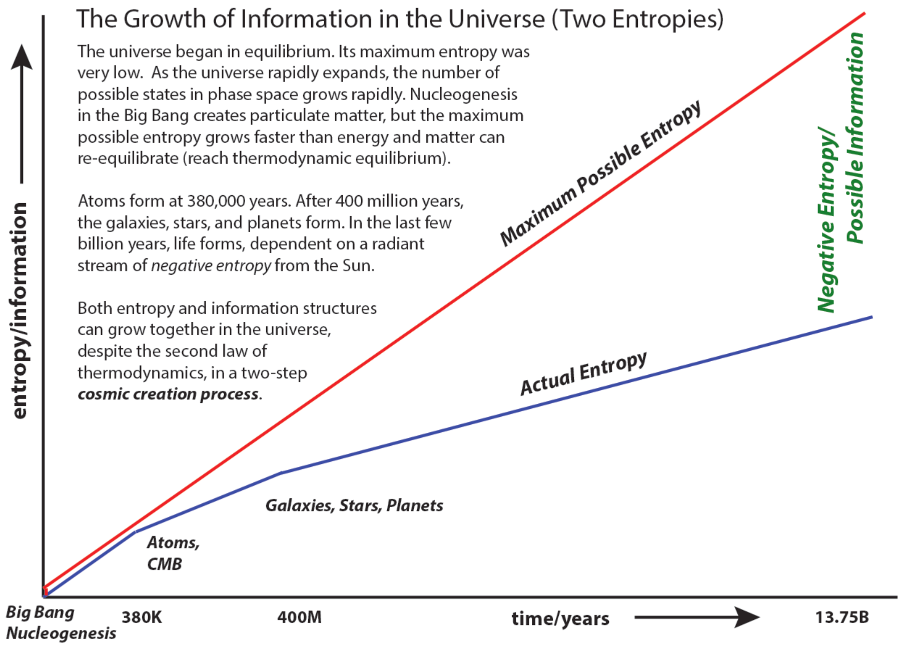
And the *arrangement* of particles is their *information structure*.

The early universe was at nearly maximum entropy and minimal information. The expansion increased the maximum possible entropy, and it did it faster than the gas and radiation could approach a new equilibrium with that new maximum entropy. [1] The difference between the maximum and the actual entropy we call negative entropy, or potential information.

Now each new bit of information created has to go through the same two steps we have identified as necessary to create any information structure, from a quantum measurement to a nucleotide position in a strand of DNA.

Similar steps are the basis of our two-stage model of free will. First quantum chance allows *alternative possibilities* to exist Then a "free choice" , *adequately determined* to make us responsible for our actions, creates the new information in our decision.

1 See Layzer, 1991



1. The Quantum Step. Whenever matter is rearranged to create a new information structure, the quantum processes involve a collapse of the wave function that introduces an element of chance. Without chance and alternative possibilities, no new information is possible. With those possibilities, things could have been otherwise.

2) The Thermodynamic Step. A new information structure reduces the local entropy. It cannot be stable unless it transfers away enough positive entropy to satisfy the second law of thermodynamics, which says that the total entropy (disorder) must always increase.

Information philosophy tells a story of cosmic and biological evolution that is but one creation process all the way from the original cosmic material to life on earth to the immaterial minds that have now discovered the cosmic creation process itself!

These same two steps are involved in our minds whenever we freely create a new idea! Most of our ideas are simply inherited as the traditional knowledge of our culture. This book emphasizes how many of our ideas about quantum physics we owe to Albert Einstein. But many new thoughts are the work of our creative imaginations. And in that sense, we are all co-creators of our universe.