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Bits more basic for physics than fundamental particles?

by [Bengt-Arne Vedin](#)

Abstract

There are several links between information theory — between »information as such« whatever that might mean — and the foundations of nature, i e, basic physics. Well, since physics is a science still evolving (despite propositions that »the end of science« is now in sight), some of the links between information and physics are hypothetical. One linkage is fairly obvious — thermodynamics depends upon entropy or some measure of order or disorder, and that clearly has something to do with information. The other possible relationship might be between the uncertainty that is a key characteristic of quantum mechanics. We can never know everything on the quantum scale; the Heisenberg uncertainty principle tells that the more information we gain in one direction the less we know in another. If we, on that scale, obtain certainty as to one factor, then another will stay entirely undecided — try to affix a position to a quantum particle, and the momentum will be out of bounds entirely. (This is the established dogma currently, though there are some deviating ideas.¹) Then the question arises: who does the actual measuring, with what — what particles, at what level, are involved in this act of, as it is pronounced, forcing the wave function to collapse? This wave function "is" the indeterminate particle: the various statistics describing the probabilities that the particle (which simultaneously takes on aspects of a wave) may be in one state or another. We will now attempt to discuss these different — or are they really different? — interdependencies, starting with black holes.

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1. On the border of a black hole

A black hole is an odd creature, so odd that it sometimes seems to defy the laws of nature, of ordinary physics. One prime example is the so called information paradox, posited by Stephen Hawking and a potentially serious conflict between quantum mechanics and the general theory of relativity. In principle, it is easily described. Everything sucked into a black hole will vanish, and it can never, never come out of that hole again, never be retrieved in this universe. Possibly it might exit in some other, parallel universe on the other side of the black hole, but that is a possibility entirely inaccessible to us, and we can only be concerned with our own universe, and the rules and laws governing it.

Suppose that we send something with a high information content into that black hole. A book, or a computer with software and memory perhaps. Suppose this is the only copy, that is, some original, unique information. If this information is truly lost, then quantum mechanics breaks down. Yes, such a breakdown must take place because quantum mechanics like all of physics is based upon reversibility — any and all processes should be able to, in principle, run in the reverse direction. Not so with black holes, however. Once something is lost into such a one, nothing is retrievable any more. The consequences would be far reaching: energy also might be created or destroyed, even a perpetum mobile designed.

This is very much at the forefront of physics — a hotly disputed topic at that. Thus there are suggestions as to how to resolve the conundrum. How do we, from the outside, at a safe distance, perceive of a black hole? There is an outer limit to it in the sense that when something has passed this absolute borderline, this something is inevitably sucked in, which holds even for light, which is why the hole really is »black« — nothing, not a single photon that has reached that limit can escape.

But relativity still holds. This means that if you where to pass that borderline, you would not perceive it at all, not realize that you are going to get lost into that blackness. You would just move on, and move on until the eventual crash or annihilation or passage into another universe. It also means that from the vantage point of an outside observer, the vehicle — you, the computer memory, or book — would slow down all the more the closer you, the memory, or the book came to the limit, the kind of outer boundary² that is created at the point where »sucking in« starts.

The slowing down would be of the most radical type, which means that also the movements of the atoms or smaller particles making up the atoms would grind to a near

halt. They themselves would not discover that, of course — in their frame of reference, nothing of the sort would happen. We would, from a distance, be able to see in minute detail, as if they were glued to a wall, the innermost parts of nature, innermost parts of that book or that computer memory, or of your brain. Eventually those smallest parts which — according to one of the fresh theories of the inner makings of reality — may take the forms of strings (if that is what they really are, see below) will also be visible.

And it then turns out that such strings constitute the exact counterparts to bits. We can, from the outside, see in slow motion — still motion? — the most detailed informational structure of that which in its own frame of reference, another than ours, is falling to its death in the black hole.

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2. A computer with zero energy consumption?

The entropy of a system is a measure of the disorder of system. It is also proportional to the capacity of a system to hold information. We know — or we believe, according to the standard theory of physics, so with good reason — that the universe is grinding to the heat death, to the even distribution of all matter which then will have been translated into heat, distributed all over that universe, then just a fraction of a degree warmer than absolute zero. Heat does not mean hot, on a human scale.

If a computer can be made to work at slow speed, it will consume very little energy. It would seem as if this could be made to just exactly balance with the slow tailing off of order in the universe. The clock speed of the computer might be adjusted so that it would never discover the slowing off. Just like when we never see the information vanish in the black hole but instead see it in ever greater detail, may we possibly design a thinking machine that in its own time frame features eternal life? Zero energy consumption would hold only for information within the machine, though, but getting it in and out cannot be made for free. Furthermore, zero energy consumption would possibly mean operating at 0 K but the balance for the universe weighs in at 3 K.³ By the way, there is an upper limit to computation speed, set at 1021 bits/Ws so we have some way to go since today's fastest computers are at the order of 1010 bits/Ws. The one concern is that information processing should not reach such a high energy consumption that the whole universe is incinerated.

In the meantime, we know also that there are dissipative processes, far from equilibrium and the overall trailing off, processes creating local chaos and thus lots of new order, local order — at a price: »dissipation«. Thus for a long time we have to look for these local chaotic processes rather than the overall pattern and its in comparison rather uninteresting panorama.

Talking of the long history of information, we cannot discard the links between that which seems so transcendental, information, knowledge, and its physical underpinnings.

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3. A measure of order

May we see information, bits, as physically founded regardless of links to those embattled strings? Embattled they are in the sense that they constitute but one theory — recently evolving into a theory of small thin surfaces, membranes or super membranes, as previously there were superstrings in many dimensions, most often ten, sometimes up to perhaps 26 (we will return to the subject of dimensions presently). What interconnections, if any, may exist between energy, entropy, and information? Because we know that there seem to be a connection between the latter, and the first connection exists by definition, drawing energy into the picture.

The creation, our world, is said to consist of mass, energy, space, time. To regard information as a fifth fundamental, and not just a derivative of the others, may look like a bold conjecture, but there are some strong arguments for it.

A long time ago, Claude Shannon generated the formula as to how much information that existed in a message but he was reluctant to link his equation with entropy even though the formulae turned out to be exactly the same. The linking agent of entropy is that a closed system, left on its own, sees its order decrease, which means that entropy increases — this being a somewhat sloppy rendering of the laws of what is called thermodynamics. Energy is conserved but degraded into heat, more and more evenly distributed. Heat can never be fully recovered into, e.g., mechanical energy. The pattern previously existing is vanishing, thus information. There is more information in order than in disorder.

The mind has a habit of creating patterns, of establishing order, of gathering information. Then there is the problem of subjectivity: who might be able to discern order in a sea of disorder? What are the tools for doing so, tools like mathematics? Then, also, we have the mystery of quantum mechanics, a mystery for the human brain at least, the mystery that Einstein so detested — »God seems to play dice«. Yes, if we look at the innermost parts of the atom, we have already been told that we cannot know simultaneously both position and momentum, i.e., speed. So far so bad — but how does it happen, then, that this basic uncertainty coalesces into our own orderly world? There must be some information transformation in between, giving credence to the idea that information is a basic property of nature.⁴

There is of course an obvious link between information and physics. To actually register anything to memory, we would have to use some medium, be it the brain or some electronic, mechanical, or other contraption. We certainly know that electronics is becoming ever more miniaturized, but somewhere there must be some tiny bit of difference in electrons, atomic states, photons, or whatever, to tell of what the memory contains.

Now suppose that we have one atom, just a single one, that may oscillate between two chambers of a vessel, the chambers linked through a narrow channel. The atom will be equally often in the two chambers if the two are alike. If we only were to measure the position of the atom and then closed the channel at the right moment, we would of course know that it was to be found in that particular chamber, not the other one. That observation, affecting the closure, equates with information. But this information is not gained for free. It may be calculated that the loss of entropy that our ordering of the system implies equates exactly with the energy consumed in measuring, in the

intelligence gathering pinpointing the position of the atom, where thus entropy is increasing instead. Entropy is flowing from our contraption for the atom to the measuring system.

Once and again, there were attempts — we are still referring to the contraption — to close the channels (very often thought experiments, Gedanken experiments) without measurements and the concomitant intelligence. Those attempts were always in vain — information is an absolute necessity.

Eventually, though, it actually turned out to be possible to do the recording of the information for free. But there was a particular twist, an important caveat: it was not possible to erase the information without some cost. Indeed, in principle it is not the collection of information that is costly, but rather the creation of a clean slate, an empty medium to do the recording on. If we start with an empty memory, then the investment has already been made.

Heat death (which, it must be told, is now somewhat doubted also) springs out of something called the Carnot cycle. Heat can, as we have noted already, never completely be recovered as, say, electrical or mechanical energy. Might there, for all other parallels, not be an equivalent to the Carnot cycle for information?

Well, if we make an addition, a subtraction, a multiplication, or a division, we impute a couple of numbers, and we arrive at the answer, which is just one single figure. We may do the simple subtraction $4 - 1 = 3$ but if we are just told the answer, 3, we may suggest an infinite number of ways to arrive at it: $5 - 2$, for example, or $6 - 3$, or $1 + 2$. Our original formula $4 - 1$ thus contains more information than the answer, so something must have been lost in the computation. (When we measure on a quantum particle, its wave function collapses, and just one of many previously potential, indeterminate states prevails. And just not as to render »measurement« too magical — this holds for all interaction with the »environment« of the quantum particle.)

Here is the link to the energy cost for erasing information. In a calculator, be it our brains or a computer or an abacus, the original numbers are stored discretely, in some cells. When the answer is arrived at, these stored numbers are erased, and irretrievably so; it would cost energy to restore the original state, energy that is dissipated in the process.

The energy used for clearing memory is negligible in any of today's computers. The more sophisticated memory and calculating devices we design, the lesser will this loss also be. Still there is a natural limit to how cheaply we can erase bits.

There is, however, at least one more trick. Let us never erase anything! We may then run the tape, the computer, backward to get back to the raw, the full information. But then those results are necessarily erased instead? Yes, they are, but before running the thing backwards, we may have made a copy. And copying does not need any minimum energy. The suggestion is that the whole computer might be powered by just Brownian motion, the minuscule thermal vibrations of molecules. The information would manage a trick that is impossible in ordinary thermodynamics — possibly indicating that information is even more fundamental than matter and energy. Well, after all, that tape must have been blank in the first place, and to produce it, energy is required.

There is at least another trick too, and that is to distinguish between different types of information. Remember that information in the sense of discerning patterns must be said to be subjective, and how might subjectivity — relations with the environment, that particular environment — tie in with the world of physics, of quantum states of the electron or the blank tape or the small electronic computer devices?

As a matter of fact, a highly patterned system is something that is highly unlikely, very far from high entropy, and it can be said to contain a lot of information. On the other hand, to describe such a highly ordered pattern takes very little information, while describing a very disordered system requires a description of its every crook and nanny. The ordered state may follow a mathematical formula, or a certain rhythm of figures in a frame of reference. There is even a term for this, algorithmic information. Here the ordered system needs little such information, the disordered huge amounts. Various mathematical entities may be described as more or less ordered in this sense, 1, 2, π , $\sqrt{2}$, e (the base of natural logarithms), and many others.

Here is how Wojciech Zurek suggests reconciling the various aspects of information: the ignorance of the observer is measured by Shannon's statistical entropy, while the randomness of the object is given by its algorithmic entropy — the smallest number of bits required to record it. At measuring, the observer's ignorance decreases as its memory tape grows so that the sum, the physical entropy, stays constant. We thus have the observer and the observed being parts of the same system, the flow of entropy internalized, and another onlooker, regarding the whole system, will see it as constant and indeed consistent. There is thus a law of conservation of information.

If, however, information might be compressed, using clever coding, discovering hidden pockets of order, a pattern where none seemed to be? Then such intelligence would beat the law we have just seen formulated. Actually, it turns out that information theory and computation laws in combination put a limit on how much a message might be compressed. The most compact description still has to contain at least as much information as was present in the original. As with thermodynamics, the best we can ever expect is to break even.

The upshot of all this is that a tape of memory could be used as a store of energy. As Charles Bennett suggests in George Johnson's book,⁵ why not for powering a car?

The absolute randomness or entropy of a number, like π , e , etc., is, as we have just seen, defined by the shortest algorithm that is sufficient for its calculation. With this rule, π is not that random, since there is a finite formula for the calculation of its infinite string of figures.

It turns out that there has also recently been developed an heuristic, a way of calculating the approximate figure of randomness, something that might prove of great value in, e.g. medicine, such as when trying to detect irregularities in the heartbeat of children, preventing sudden child death.⁶ Information to save lives! Information arrived at through what seems like the most circumspect route. This heuristic does not coincide precisely with the algorithmic result. Thus π , e , etc. would be very random if attempts were made to calculate its entropy. It also turns out that here the base for the counting system, 2, 10, 12 etc. is all-important to the actual result, seemingly indicating a

particular type of subjectivity.

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4. Information deeper than reality?

As far out as though it may seem, some physicists believe information to be a certain kind of physical substance, in a sense more real, more fundamental than those fundamental particles that themselves are being reduced to complicated mathematical formulae. Information constitutes the foundation of all that, the claim suggests.

Information would not change no matter how we choose to transmit it. Well, that certainly holds for the ordinary world. But quantum effects impinge upon information too. Information linked to a quantum particle will be everywhere and nowhere, just about to collapse — still indeterminate. The idea here is that it is not information that is affected in this way but rather the other way around — information is the fundamental agent behind. Then quantum theory would be a theory of information.⁷

A particle can exist in several states. An electron in a magnetic field has two options, spinning clockwise or anti-clockwise versus the field, being »up« or »down« in the physicists language. Affixing the numbers 0 and 1 to these two states might seem fitting enough — one bit, that is, would be stored.

Not quite so. A basic tenet of quantum physics is that the electron carries no determinate spin until you measure it, until you measure the spin. Before measurement, it is schizophrenic enough to exist in a superposition of states offering both up and down simultaneously. Instead of talking about one ordinary bit, we have the information unit of one qubit, with the two ordinary options plus the two mixed in any intermediate proportions.

One might think that two electrons together would offer two qubits. Not so, either, as long as they really belong together. The two electrons would be entangled, even at a large distance, and in an entangled state, if one spin is up, then the other must be down. This again is radically different from classical physics, and because of entanglement, these electrons cannot store the full two qubits.

What is trivial in classical physics no longer is in the quantum world. Superposition's collapse irreversibly when measured upon so there is no way of knowing an electrons state — superpositions and all — before you carry out that measurement.

In the early 90's, Charles Bennett of IBM showed that teleportation would be possible — in principle — in the sense that you might define the exact state of all the particles of an object at one end of a transmission line, transmit this information, and then reconstruct an exact replica at the other end. This must be done by using entanglement since quantum information can neither be copied nor read. Replica that is: we would have an original at the one end and a true copy at the other.

Suppose we want to teleport a particle X, e.g. a photon, from one place to another. We would then use an entangled pair of particles Y and Z, the first at the sending end, the other at the receiving. As mentioned, we cannot just measure the

properties of X because then it collapses and loses some of these properties, all those superpositions. But we may measure a combined property of Y and X, yielding some information about X mixed with some about Y also. There is some collapsing taking place, to be sure, but the missing quantum information about X instead slips down to Z because of its entanglement with Y. The incomplete information about X combined with particle Z allows us to reconstruct a particle identical to the original X — something demonstrated for the first time for photons in 1997.

The caveat is that any small disturbance will destroy the effect completely so going from photons that might be held isolated could prove just an impossible task in reality. There are, however, ideas about how to correct the errors introduced by the nearly inevitable noise and other imperfections. Error correcting codes and built in fault tolerance are two options proved to be feasible.

The quantum world is so weird that Einstein said it could not be so; there must be some certainty; God does not play dice (whereupon Niels Bohr replied: don't you tell God what to do!). The new idea is that the quantum world is the way it is because of some deeper phenomena — in a world of information. Among the smallest pieces of quantum information we have mentioned the cubit. The maximum amount of entanglement in a pair of particles would be an ebit, a single unit of entanglement.

To regard cubits and ebits as particles of information is not just using lofty metaphors. We think of space as being empty, and yet, within the realm of quantum physics, we also regard it as boiling with life as virtual pairs of particles are created and vanish again during a short period of time governed by the Heisenberg uncertainty principle. This even creates a certain force, recently measured. Should such a virtual particle happen to interact with a real particle during its brief existence, then, and only then, it would also have to signal its existence.

The theory goes like this. An ebit, which is the entanglement, represents a kind of virtual information — observe how we here have introduced something new to information theory, because ordinarily, information would always be real. The entanglement of two particles corresponds to creating a virtual pair of information particles, a cubit and an anti-cubit out of an information vacuum — again a correspondence; what, then, about a Heisenberg uncertainty principle for information?

The analogy goes on. Virtual information particles would not let know of their existence if they were not to interact with real information. When a cubit, which is real but somewhat peculiar information, meets an ebit, the result of entanglement, two classical bits are created — remember the collapse of information — but if then an anti-ebit is created out of this, a cubit is recreated and the anti-ebit may combine with the ebit to define the entangled pair of particles.

Heresy or discovery? This is the way that the proposition comes about that information is at the foundation of all existence and that the basic properties of physics, from quantum matter and up, could all be derived from the basic laws of information, yet to be discovered.

The mechanisms described here are also some of the foundations for the quantum computer that will be much discussed and experimented on in years to come.

5. The arrow of time — information is the key

Perhaps it might seem even more surprising to find that the existence and the characteristics of time, as a physical entity, are linked to information. The fact that time exists is linked to a process of information loss.

This seems so awkward since we all have a very personal relationship with, yes, an experience of, time. Of course it exists. Of course it may be measured, even though it may be experienced as flowing at different speeds. And from Einstein we learnt that it constitutes the fourth dimension, adding to the three spatial ones.

It differs from those spatial dimensions, however, in the sense that time has a direction. In space, we may move about up and down, forward and backward, while time does not seem ever to move backward. How may this asymmetry be explained? Because explained it needs to be, even though our experiences feel self-evident to us.

In the equations of relativity theory, time is one of several dimensions, and as them, it is relative, which is something else than subjective. Signals linking different places in space follow the curvature of time-space, and it makes little sense speaking of »simultaneity« over distances in space. Relative velocities and especially accelerations play important roles. Nonetheless, time features a direction, an arrow.

In physics, reversibility is, as we have claimed, the rule but there is one important field where irreversibility reigns supreme: thermodynamics. Again: all energy is slowly converted to heat and it is impossible to change the direction; entropy increases inexorably. Entropy is a concept for less order, more disorder.

The big bang that most physicists believe was the starting point for our universe was characterized by an immense degree of disorder (it is at that starting point that the supplementary dimensions may not yet have curled up to be so minuscule as not to be observable). How, then, might we conceivably explain a development from maximum disorder to — what? — even larger disorder? The explanation is given by the fact that we have an important force called gravitation. The second law of thermodynamics, which is the one we have just implied leading to the heat death of the universe, applies only in isolated, self-contained systems. In the universe, gravitation and heat are not isolated from each other.

A new, unbroken deck of cards is well ordered, with each color separate and in hierarchical order. After a number of shufflings, it is immensely less ordered. The shuffling as such does not imply any direction, and it is not irreversible in any fundamental sense. But shuffling has destroyed a given order or symmetry, and the unique, the abnormality was this pre-existing order.

Let us now introduce our subject, information, into the discussion. A system in total disorder needs only a few bits to be described. A bottle containing a gas randomly distributed and in equilibrium needs little information to be defined. A container with several hot spots, chemical reactions and unevenly distributed molecules features numerous forces and fields, and therefore it requires, by contrast, a very detailed and

information rich description. When the system approaches equilibrium, when the deck of cards is shuffled, information gets lost — irretrievably, irreversibly.

When a body collapses into a black hole, it loses information. The increasing field of gravity prevents light from exiting and since light cannot travel faster than light, it is also trapped by the hole. To the spectator, the information seems irretrievably lost. The black hole would function as an information sink. As we have seen, it all depends on the frame of reference.

Where, then, did this process start? How can we explain that development may have a direction at all? Especially if it turns out to be true that the universe is pulsating, getting us back to the starting point for the big bang?

The answer may be found in, if we like to express it that way, a version of the anthropic principle, that the universe can only have a certain shape for it to allow for the existence of human beings (well, not necessarily us, but information processing systems, evolving with eons of time and auto catalytic systems and selection pressure and coevolution and competition — a story we will return to). So the fact that we — mankind — are here to observe the universe, to experience it having a dimension of time, requires that same universe to feature certain characteristics, including the arrow of time. If this seems somewhat circular, remember that we have now brought the observer into the picture.

This is where we have to return to the number of dimensions constituting our physical world. As was told previously, to explain the fundamental forces of nature, it has been suggested that there exists something between ten and perhaps up to twenty-six different dimensions, not just four, those dimensions, however, now — but not necessarily early in the history of the universe — folded up in very small, imperceptible measures; and there have been suggestions that there exists several time dimensions also, not just one. For the macroscopic laws of nature existing, however, there must be just three space dimensions, and one for time — else, among many other things, information transmission would be hopelessly distorted, so impossible. This may be a minor inadequacy compared to the fact that intelligent life would be entirely impossible. This is the weak anthropic principle: we wouldn't be here to discuss the world of three plus one dimensions unless there were precisely those dimensions. ⁸

We just mentioned that information cannot leave the black hole because light is trapped and nothing moves faster than light. There is a loophole of sorts in this reasoning, and it is a loophole that was used by Einstein in the 30s to argue against quantum theory — a loophole that has attracted a lot of interest demonstrated, i a, in a number of ingenious experiments (real ones as well as of the Gedanken type) refuting Einstein's argument but also raising confounding questions.

The quantum phenomenon referred to is the fact that an elementary particle may be in several different states, and a definite one is defined only when the particle is measured upon, i a, when it is interacting with the macroscopic world — the collapse of the wave function already referred to. This in turn means that in processes where two particles — including light particles or photons — are created, if one of these entangled particles is measured upon, we know immediately the corollary characteristics of the other one. The usual feature measured would, as we have mentioned, be the electron's spin, which

has two different values, one particle displaying one, the other necessarily carrying the opposite spin.

It has now been proved that if we measure on one of these twin particles, causing the state of indeterminacy to collapse into a specific state, then the state of the second particle collapses also, and it does so instantaneously, even if the particles have traveled far apart. The conundrum is how this might happen while the rule that nothing can travel faster than light still applies.

The conundrum is actually much more profound. All particles of the universe, or at least quite a few, have a history of relationships like this, so all of it would seem to be linked through an invisible web. Explanations from invisible force fields to mystic powers of our senses have been evoked and suggested. One thing is certain and that is that this problem will continue to be in the focus of physics research for quite some time. It may well be that it is that conundrum that holds the key to the mystery. Or it may be that precisely what we perceive as reality, aggregated actions of particles whose wave functions have collapsed, constitutes an impenetrable shield from the entirely different »reality« that physicists are striving to come to grips with, developing ever more sophisticated mathematical models, containing ever stranger concepts like chromodynamics and quarks and charm.

There is an entirely different way of coming to grips with this problem, and that is by adopting a multiverse point of view. Every collapse of the wave function is associated with the particle »opting« for one of several equally likely outcomes — or even a less likely one. The multiverse view suggests that this is what happens in one universe; but there are an infinite number of parallel universes where the other options are realized. As a matter of fact, there are physical phenomena that can be explained by this version of physics but which confound all other currently available theories — while there have been no loopholes discovered in the multiverse view so far.⁹

This is obviously far from our intuition. Even further away is the concept that in such a multiverse, time does not exist. We have to remind ourselves, time and again, that we are here on the level of a true application of quantum physics, thus far away from classic physics. In the world of our senses, which observe phenomena according to classic physics, time and thermodynamics and just one universe do exist — but when we come down to more profound problems, classic physics won't do.

Such problems, such phenomena are fundamental enough to be mentioned here though they would crop up in many other treatises as well, in physics to be sure, in philosophy, and in discussions of the human conditions — not to mention science fiction. It will not be possible to use, for example, the effect of instant disentanglement to transport material bodies of distances with the immediacy beating the speed of light. But what might happen — and we should here only take this as an example, and warn about the fact that such speculation, discussion, and development are already taking place — is that information might be transported over large distances instantaneously, if systems profiting from this effect may eventually be developed.

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Bengt-Arne Vedin, Metamatic AB, är ansvarig för Ruben Rausings Fond för forskning om nyföretagande och innovation, ledamot av regeringens Småföretagsdelegation, Teldoks redaktionskommitté mm. Konsult, föreläsare och skribent. Tidigare adjungerad professor i innovationskunskap vid Tekniska högskolan i Stockholm. Arbetar för närvarande bl a med att för Institutet för Framtidsstudier, dit han också är knuten, kartlägga "fronten" vad gäller forskning och praxis inom kreativitet och innovation. Längsta uppdrag: Teldoks redaktionskommitté, största engagemang: Ruben Rausings Fond.

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