A Distant View of Physics

Peter Marquardt
111 Stolberger Strasse, D-50933 Cologne, GERMANY
e-mail: marquardtp@gmail.com

Some cult theories of physics suffer from anthropocentric views. Dogmatizing the observer's role, his impressions or influence opens the door to questionable conclusions, like giving a transformation the status of a natural law, relying on "predictive powers" of light and tying its velocity to the observer, formulating the "uncertainty principle" or taking for granted that the universe is finite and started with a Big Bang. It's an irony of 20th century physics that Einstein was rejected where he was halfway right (his objection to Copenhagen quantum theory) and was accepted where he was definitely wrong (his relativity theories and his naive one-photon interpretation of the photoelectric effect). Worse still, "they" now signal to abandon relativity in order to save even more mysterious ideas that are all the rage. We have enough difficulties with other problems and should not bang our heads against walls that may be easily recognized as home-made obstacles, like confusing time and duration, energy and energy changes, dynamics and kinematics, or like over-emphasizing non-physical concepts like "probability" and "signal". A good idea is to step back far enough from the scenario in order to gain a fresh and distant view that not only covers different disciplines of physics but also different centuries - and includes one's own arguments. A distant view also implies that we don't invest our efforts in "understanding" or "explaining" (our experience has shown that this cannot be achieved), but content ourselves to strive for consistency. Here, we really may learn from math: *If you can't explain it - define it.* And math is a good teacher when it comes to getting a distant view. Some quantities and concepts like squared velocities or quantization appear under a new "light" when seen from a distance. There are instances where math seems to produce a correct result, but still fails to give an answer to the physical problem. A correct result is necessary but not sufficient to prove a theory right. No formula can do that. *Il faut reculer pour mieux sauter* - it's advisable to recede for a better jump, but let's be cautious and avoid a jump at conclusions.

1. A Distant View...

It is hard (if at all possible) to tell what physics is about. We have mechanics, electromagnetism, thermodynamics, solid state theory, cosmology, gravitation, quantum physics, nuclear physics, radioactivity, high velocity physics, ... we have gases, liquids, solids and plasmas, we have waves, oscillations, ... we have so many fundamental and derived quantities, distance, duration, mass, charge, energy, force, potential, temperature, heat, ... we have all the formulas, more or less fundamental, made of numbers and dimensions, and we meet so many effects,... - what a mess! Usually, the findings of different physical disciplines are treated quite independent from each other. And we tend to place ourselves in the middle of our observations and take this anthropocentric view for granted. In addition, we have a linguistic and a mathematical mess, too, provoking mistakes where mistakes may easily be avoided from the very beginning. All this (man-made) mess is a big challenge and calls for a giant step away from it and a fresh view from far outside. The fresh view should cover all fields ("finished" or not) and centuries of physics and all kinds of mess, too. And that view must be kept as simple as possible so anybody interested in the problem in question may readily decide whether to share it or develop their own *distant view* (DV). A DV does not care about personal cults and cult theories and *who* said it - it cares only for the *what*. It does not care for "explanations" or "understanding" - it cares only for consistency. The history of physics has (or should have) taught us a valuable lesson: Scientific progress owes much to pioneering DVs.

2. Language

Science can't do without language. Language is an excellent means to manipulate our scientific endeavor and (as we all know from everyday life) to manipulate ourselves. A lot of the precision required for science is lost to ambiguities or sloppy use of language in science.

We sometimes confine ourselves to using the same word in different contexts. Take "time" which is used in (at least) three different meanings: As a mark in some coordinate system ("what time is it?"), as the duration of a process ("it takes some time"), and as an abstraction. Time understood as abstraction is consistent with its fundamental meaning in science. Of course, we can't possibly restructure our language and have to take its traditional ambiguities. But whenever our language offers distinction, let's use it! In physics, the distinction between abstract time (t) and duration (τ) is not only helpful, it is mandatory to avoid confusion.

3. Abstractions

Abstractions are strong helpers in our scientific efforts. This is best seen considering math. Math is a master science and a noble example when it comes to abstractions. Take numbers. Nobody would believe that, say, the number 5 changes when I take away one coin from a set of five. The specific set changes, but the number 5 stays the same under all circumstances. Numbers are not changed by performing calculations with them. Their great value is that of a quantity to stay, an abstraction gained from uncounted (not "uncountable", please!) observations, operations and examples. Also in physics, we need to define abstractions that serve their purpose because they are not subject to any physical process. Such abstractions are "time" and "space". We need not go into philosophical matters here to estimate their importance/value for physics. We must never confuse "time" (the t type) and "duration" (the τ type), although they are expressed by the same units. What does a clock do? A clock's performance is based on a periodic phenomenon; a clock counts the periods and displays them. Ideally, the periods are events of equal *duration*. A clock does not "measure" time. Unlike language has it, time does not pass, contract, dilate, it does not do anything and is not affected by any physical process. Otherwise it would not serve the purpose it was introduced for. On the other hand, the duration of any process (including the periods underlying a clock's mechanism) may be very well changing when dynamic conditions change. When the period ("frequency") of a wave is observed to change as is the case with the *Doppler* effect (see below), time is needed as the unalterable stage that provides the frame for all physical events. Taking time as such implies its uniqueness and universality - no more discussions needed. For comparison purposes (i. e. the use of clocks), "time" is gifted with a universal scale. Similar considerations hold for "space", "length", and "distance". Size and shape of an object or the distance between objects and their path may very well change under changing dynamic conditions; but that does not affect "space" the least. Although defined in a specific physical context (which casts some "light" on the definition of our length standard, see below) our units eventually rely on abstractions.

4. Anthropocentric Ingredients in Science

Language is an anthropocentric tool by its nature. That's not the whole story of the anthropocentric view. We have a natural tendency to start science on observations as we perceive them. It is quite understandable that the Earth was considered as flat and the Sun was considered to move. Indeed, it has been quite a long way to struggle out of the observer-centered view and those shouters in the desert who started to struggle out cannot be praised enough. They were the pioneers who paved the path to an all-important distinction: *Kinematics* vs. *dynamics*. Kinematics places the observer in the center. In kinematics, it does not matter whether the train is moving or the station. Dynamics, having to do with energy, must be *unique*. No more ambiguity about what is moving and what not. Dynamics leaves no choice. No physical object can have more than one velocity at a "time" (sorry) which then rightfully may be called its absolute velocity. Energy conservation has never been proved wrong. Energy conservation is a unique global principle. What we call inertia is its direct consequence. Hence there is only *one* dynamic inertial system (I.S.) that deserves this name - the Universe as a whole. The ambiguous multitude of invented "inertial frames" moving at uniform speed (they shouldn't be called systems for distinction) are a matter of pure kinematics. Kinematics is fine to help unravel a moving observer's perception, but the faulty conclusion that all observers are "equivalent" is dangerous. It should be borne in mind that Nature's unique playground is *dynamics*.

Example: The *Doppler Effect* both for light and sound requires *uniqueness*. There is a fundamental difference between the source and the observer moving.

Kinematics is where transformations may come in handy as a (sometimes useful) mathematical tool to unravel the different contributions to the observer's absolute motion. Transformations should never be given the status of a physical principle or law.

It should be clear from the work of the brave DV pioneers that the observer plays an insignificant part on Nature's huge stage. All the more disappointed should we be that the observer-centered view has been smuggled back into 20th century physics. Take the *Michelson-Morley* null result which has been misused to formulate a false one-way postulate from a two-way experiment: "The velocity of light is the same for all observers." What a misleading statement! The *observed* (= apparent) velocity of light depends on the observer's velocity; the *dynamic* (therefore unique) velocity of light does not. Light does not adjust to the observer's state of motion. It propagates independent of both, source and observer. Taking observers or sources as a reference ends up in ambiguity and inconsistency. We don't need to answer the question "*what* does c refer to?" because we simply don't know. We don't know it for sound, either: A hand waving argument like "still air" fakes the problem's solution. We never define what "still air" actually means because none of the atoms that are part of the system serve as reference. Density and compressibility are deceptively simple-looking properties that apply to the system as a whole. They can very well be used in a formula for the velocity of sound without us having to know what this reference "still air" may be. It is more important to rely on a unique reference, material or not (the center of mass of, say, a ring, is non-material).

20th century quantum theory fares no better than special relativity. In fact, it has caused worse damage to physical thinking: The defenders of uncertainty etc. even signal to sacrifice SRT because it is not compatible with their pet ideas - as if inconsistencies between conflicting ideas imply that abandoning one of them proves the winner on the battlefield right.

It is generally believed that a huge revolution took place with the advent of *Planck*'s constant (physics has taken a much greater leap in its history, see below). When it became clear that atoms are pretty small and evade the observers' skill more efficiently than macroscopic objects, the bottle of speculations was opened to free the genie of "uncertainty": "If we don't know it, nature doesn't either" became something like a credo of modern physics. Not caring about the physical background of *action*, a mathematical formalism was allowed to take over, usurping a whole promising branch of physics. Nature certainly did not change her ways when She introduced the human observer. Strangely, in spite of self-imposed uncertainty, the human observer took the liberty to interpret experiments as if they could always be performed on a single isolated atom, electron or even photon, forgetting that the interactions with an omnipresent macroscopic system cannot safely be neglected, let alone switched off. *Einstein*'s interpretation of the photoelectric effect ("one photon in - one electron out") was a big jump at conclusions: In order to save this assumption, the photon was gifted with a mysterious internal frequency, ranging over many decades. The idea of quantization thus became a victim of single-isolated-particle philosophy which in turn gave rise to particle-wave-duality. We should keep in mind that quantization entered the scenario of physics via the probably most common phenomenon in the Universe: Light - which exists in abundance propagating everywhere. Important experiments have demonstrated a low-intensity threshold of interference which suggests regarding incoherent light as a stream of ordered photon *bunches* in lieu of single photons. The ensemble interpretation is more consistent with physical principles - no mysterious "self-interference", no "wave-particle dualism". We may safely say that physical waves are *coherent particle ensemble patterns*. Math cannot distinguish whether the frequency, say, in *Planck*'s radiation law, is an intrinsic frequency of a single particle or the arrival rate of particles in a coherent bunch. Physical waves definitely have to do with energy. It does not make sense to model waves from pure numbers. Nature does not care about "signals" or "probabilities" - they are our (again anthropocentric) business.

Sadly, also the largest possible physical system, the Universe, was squeezed into the anthropocentric view. A premature interpretation of the redshift led to the erroneous Big Bang (originally coined by *Fred Hoyle* as an ironic naming!) which was welcome to a religiously oriented view, climaxing in the so-called "cosmic humiliation" - if the universe were infinite in time and space. Why on Earth should *we* be in the center of a system that is best assumed to be infinite in extension and duration? How self-confident can we humans get?

5. *It Ain't Necessarily So*: How to Avoid Jumping to Conclusions

Once more, the wavelength of a light beam affected by the *Doppler* effect makes a prominent example. Ironically, special relativity sticks to its false postulate and prefers to attribute rigidity to a light beam(!) and rather believes in the contraction of a steel bar(!) thus maintaining a false interpretation of the Michelson-Morley null result with all its strange consequences. (What does that tell about the choice of light wavelengths as length standard to define the meter???). Like time, space must be considered and treated as an abstraction. We have learned no more about gravity from „curved space" than was known in Newton's time. The curvature of the good old time-honored gravitation potential *in space* provides a consistent physical background. The bending of a light beam in a strong gravity gradient does not tell about space bending, like the *Doppler Effect* on the wavelength does not tell about length contraction à la special relativity. Nobody ever talked about "space curvature" near a charge although forces between charges are considerably stronger than those between masses. Potentials are used with great success in other topics, too. *Einstein* had the potential in his hands when using the dimensionless ratio of c^2 over gravity potential in his light bending formula. Yes, now, the c^2 becomes a potential! (This is not as strange as it may look. In mechanics, all v^2 (*dynamic* velocities squared, that is) make swell potentials as can be consistently demonstrated by as old a formula as *Kepler*'s Third Law). What does that c^2 potential tell us about the "most famous formula of all science"? The concept of potentials elegantly bridges the seeming difference between interacting masses and charges. Potentials do not require any "explanation" in order to be used successfully. They are best defined in a consistent way (which is hard enough to do) instead of being explained (which is even harder to do). Since *Faraday* we got used to the general concept of "fields" in lack of anything better. Fields are the abstract name for various kinds of interactions. They are our best ticket yet to consistent mathematical treatment if the leading role of physics in the problem is properly respected. Math must not be the leader in physics. Math has two faces: A most helpful servant to physics - and a terrible master.

6. Math: Useful Servant or Terrible Master?

Math is the noble example for precision. When it comes to precision, no other science beats math and physics greatly benefits from its "other language", formulas. But formulas have to be backed up by physical thinking in order to develop their full benefit.

Both "infinite" and zero are concepts that put a limit to common sense, understanding, and intuition. These concepts should not be carelessly imported into physics. We may safely say that Nature does not allow local singularities. The range of applicability of any formula such as a (1/distance) potential, must be carefully analyzed. Infinity, at the mercy of a formula, may give rise to fruitless discussions about "paradoxes" like those named after *Olbers* and *von Seeliger* which have been mistaken as proofs that the Universe is finite; or to (unscientific) questions that let us get carried away by our "mathematical expectation". Unscientific questions are those not suited to lead to scientific answers ("Did the Universe have a beginning?"; "Where does it expand to?"; "How fast does gravity travel?"). Extrapolations to zero or to infinity are easily performed in math, but their conclusions may be fatal in physics.

The imaginary unit, *i*, may be a helpful ingredient of elegant formalism (as in circuit theory where the use of real and imaginary parts does make sense). The formal use of *i* by Copenhagen quantum theory should be regarded with suspicion.

Math is blind against physical concepts. It can't replace physical thinking.

A prominent fatal error that led to the Lorentz transformation was the confusion of space and time with wave parameters. Of course, the *Doppler Effect* (again!) does not affect space and time but it does affect the wave parameters. It should be noticed, however, that there is a kinematic and a dynamic scenario that must not be confused: The observer moving at $\mathbf{v}_o$ registers the *apparent* phase velocity $\mathbf{c}-\mathbf{v}_o$; the source moving at $\mathbf{v}_s$ causes the wavelength to change (contraction (does that sound familiar?) in front, dilation behind the source), because the wave's motion is limited to **c** and cannot outrun the source for dynamic reasons. (Remember, the *Mach* cone exists for sound and light.) Both cases yield the impression of a changed frequency induced by external motion. (The frequency is due to the source's intrinsic dynamics.)

Disregarding the importance of physical dimensions has caused a lot of unnecessary troubles. "Pure number concepts" like probability, sometimes helpful, must not be taken as basic physical concepts. Probability is a number between 0 and 1, a mathematical rendering of the degree of our missing knowledge. Nature need not care about probabilities. Pure numbers usually don't represent physics. Let's keep this in mind when reading about "probability waves".

7. Dimensions, Please!

A deplorable "theorists' disease" is putting $c = e = h = ... = 1$, working its way towards a pure number and throwing physics overboard. Any equation violating the balance (correctness) of physical dimensions is definitely wrong, no matter how "correct" the result following from it (*Maxwell*'s equations give one good and prominent example).

It has become a bad habit to completely neglect constant potentials and, worse yet, to replace them by a meaningless zero. This bad habit causes inconsistencies in *Maxwell's* electrodynamics and it casts a bad light on operator physics whenever "free particles" are considered.

In spite of its great successes, *Maxwell* electrodynamics has no physical legitimacy for waves (another case of benevolent math, see below). The pet of Copenhagen quantum theory is the "free particle". Energy, position and momentum of a "free" particle are meaningless in physics. Above all, physics is the *science of energetic interactions in complex dynamic systems*. Important physical concepts like energy, action, force, power should not be discussed in terms of lonesome particles.

The blindness of math makes it easy to come up with (mathematically) correct results. Correct definitely has a different meaning in math and in physics. The "mathematical correct" is only part of the "correct" in physics. Consistent physical analysis (including respect of dimensions) is equally important. The widespread belief that a "correct" result proves a theory right is dangerous. Here we must concede that science can only be proved in the negative (*Popper*'s falsification criterion). And that negative proof is only possible on the battlefield specific to the science in question - it can't be delivered by an auxiliary science. Math is the servant of physics, not its master.

A defective theory may come up with a result that seems to prove it right while owing the result to "benevolent" math.

A small collection of prominent examples:

Special Relativity (SRT): The upper velocity limit as expressed by the gamma factor must not be introduced via some transformations with their arbitrary kinematic velocities. Uniqueness is Nature's principle. Only accepting the Universe as the only I.S. and referring all absolute velocities to it do we arrive at the dynamic gamma factor that makes sense in physics. High velocity physics should be called *neomechanics* to separate it from the mess SRT has caused. It's a calamity that the kinematic factor à la SRT looks the same as the dynamic gamma factor based on the principle of action - another hint at the blindness of math.

Copenhagen Quantum Theory (CQT): "Operators" are nice mathematical toys, but they do not give physical insight. The momentum operator (with a questionable imaginary unit and Planck's constant built in) already provides the momentum by dimension, so it operates on a pure number. Likewise, the position operator. Pure numbers, it can't be emphasized too much, usually make no suitable quantities in physics. Operators as defined by CQT deliver a rather inconsistent picture. The conjugate pairs (momentum, position) and (energy, time) don't make sense. Position $\mathbf{r}$, unless in a specified *dynamic* environment, is meaningless. Of course, position necessarily changes when momentum $\mathbf{p}$ is non-zero. The "time" it takes the observer to determine energy is a misleading anthropocentric ingredient. Moreover, the hassle about the definition of a "time operator" exhibits another defect of the operator formalism. Non-commutativity is no excuse to introduce an anthropocentric concept like uncertainty and, worse yet, turn it into a natural principle. Nature does not care about our knowledge. The only way to get the conjugate pairs work in the spirit of physics is to consider local *changes*(!) of momentum and position in a dynamic context which corresponds to a local *change* of energy E and the process is characterized by a specific *duration* $\Delta\tau$ (not "time", please!). Now *both* products ($\Delta E \Delta\tau$) and ($\Delta\mathbf{p}\Delta\mathbf{r}$) are on equal footing and consistently represent a unique physical principle: *Action*. Action occurs everywhere, not just where and when our observation may influence the local event. The missing link between ($\Delta E \Delta\tau$) and ($\Delta\mathbf{p}\Delta\mathbf{r}$) is best searched in the world of potentials.

Maxwell Electrodynamics: The great successes of *Maxwell*'s electrodynamics easily camouflages its flaws. It may sound strange, but the purely mathematical derivation of waves is no physical legitimacy, the main inconsistency being the neglect of the sources and carrying on with local changes of the **E** and **B** fields. No sources (charges) - no **E** and **B** fields. Moreover, *Maxwell*'s equations make use of induction which is a slowly varying and hence radiation-free phenomenon. And $\nabla \bullet \mathbf{B} = 0$, failing by dimension, is a purely mathematical equation and has swept aside the fact that the vector potential **A** is more fundamental than its derivative **B**. It should not surprise that induction without **B** field is not described by Maxwell theory. The presence of charges is needed for electromagnetic phenomena and cannot be thrown overboard just because a mathematical procedure requires it. Electromagnetic waves were discovered in the vicinity of charges, and they are always detected by means of charges. What conclusion about the propagation of light thru deep space do we draw from here?

Math becomes dangerous when it makes thought experiments (a linguistic oxymoron!) look like real experiments. Thought experiments (the German "gedanken experiment" tells you where they blossomed first!) may be helpful to figure out a result when the experiment actually cannot be performed (like dropping an object in a tunnel thru the Earth's center and asking about the oscillation period). Or they may be helpful to state a textbook problem. But they are really nasty when they are based on a set of false assumptions and claim to end up with the findings of a natural principle or law.

Unless backed up by physical analysis, the message of math becomes ambiguous in physics, delivering meaningless results. On the other hand, math, and this is one of the greatest lessons it teaches, its *intrinsic* consistency is impeccable. One single counter example suffices to disprove a seemingly correct statement. Math distinguishes between *necessary* and *sufficient* conditions. Being an abstract science working with abstractions, it can afford to do so. Nature's phenomena are the result of so many (mostly unknown) conditions none of which can be nailed down to be a sufficient cause. Only necessary conditions may be indicated (for example, the presence of oxygen, the gravity to keep it confined for us, its density, temperature, the biological functions of our bodies, etc. are all necessary conditions for our breathing - none of them is sufficient). This might be called the "*principle of the* *missing sufficient condition*" and makes many problems in natural science pretty hard to solve or intractable at all. But it helps to keep track of as many necessary conditions we can name. For any theory, it is necessary that it produces a result that complies with experiment (taking for granted that the experiment fulfils the necessary condition of being properly performed for simplicity here). The reverse is not true. One necessary condition for an equation to be correct is that its physical dimensions be correct. The reverse is not true. For any theory, it is necessary that it be consistent (i.e. no conflicting or changing assumptions). The reverse is not true. Etc.

8. The Taste of a Distant View

Physics took its greatest leap when the concept of *energy* entered the stage. In retrospect, it comes as no wonder that force, producing conspicuous local effects like feeling a weight or a change of velocity, entered the stage long before energy, the "silent giant of physics"; and that it took quite a long time to replace the old "vivid force" by kinetic energy. Today it should be clear, that energy is more fundamental than force. Energy is conserved, force is not, as already the old lever so impressively demonstrates. By the way, energy conservation tells us we can't "save" *energy*. What we may save is *action*. Strangely, the (fruitless) aims at a "world formula" try to figure out Nature's doings in terms of forces: "If we knew all the force laws...". It's a good thing we don't!

Once you get the taste of a DV, it's easy (and fun, too!) to find your own examples. Turn loose your pet ideas and let them roam freely to see what they are doing. Don't get tied up by them! And don't be surprised if your DV slows you down - that's quite natural. A DV of a few selected problems is far more rewarding than rushing thru all possible problems and trying to jump to the stars when there is no contact to solid ground. Don't forget to include the linguistic and mathematical problems. It's a good idea to keep formulating questions in "distant view style" all the "time"!

The principle of the missing necessary condition may be taken as a pathfinder thru science: We should content ourselves with the "How?" questions and try to fit our result into a fairly consistent picture. Exhausting ourselves with the "Why?" doesn't get us any scientific answers. "Explaining" and "understanding", quite understandable efforts, are like looking for the pot of gold at the end of the rainbow. We should have learned that the rainbow moves along with ourselves and does not wait for us to find out about its end.