The Mole Hill Effect: Mathematical and Other Failures in Physics

Peter Marquardt
D-50933 Koeln, GERMANY
e-mail: marquardtp@gamil.com

"We do not stumble over mountains – we stumble over mole hills" – Confucius

This philosophical motto continues to be a welcome inspiration to a distant view of science in general and physics in particular. Here the mole hill serves as metaphor for all those obstacles we tend to overlook in our intellectual efforts. If we watched out for those little mole hills at our feet, we would have a safer excursion to the mountains of science. As exemplified in the following, mole hills come in various kinds of disguises, some of them proving to be quite unsuspected and surprising, with a lot of psychology involved. Thorough observation and analysis (if needed, over and over again) definitely makes you a slow poke; but at times, it's quite rewarding to go slow in science. There is no need to dwell in formulas in order to formulate the warning about dead-end roads, inconsistencies, unjustified conclusions and generalizations, and other kinds of pitfalls which will be presented here in a grab bag fashion. This is just an appetizer for your own mole hill hunting. Once you are on the lookout for those mole hills, you are sure to find more and more, outside science, too. And it's fun to do so.

1. Success…

*is maybe the psychologically speaking trickiest mole hill***.** When is a theory "successful"? Agreed that experimentalists know what they are doing, their results should be accepted, albeit with caution. Interpreting the results is another story. Here is where theories come in, with a barnful of mathematical tools. Reproducing (in lucky cases even predicting) an experimental result is necessary, but not sufficient at all to prove a theory right. Any theory has to pass the "test of time" anew and anew again; there is no final criterion. The usual price for keeping a faulty theory alive is inconsistency which should not be tolerated.

2. Psychological Aspects…

are ubiquitous in the human brain's performance. Usually we are not aware of them - for good reasons. Yet they make us stumble very often in our scientific efforts. Authority is a big deal when people stick to cult theories in spite of knowing better.

The anthropocentric viewpoint, a quite natural feature of the human mind, implies some dangerous consequences in science if uncontrolled. The struggle between the geocentric and heliocentric world views illustrates how hard some anthropocentric views die. Some are still blocking scientific progress: All observer-centered views have to be considered with caution and better be kept out of science. Special Relativity and the Uncertainty Principle alike try to place the observer in the center of Nature's doings. Nature does not make light adjust its speed to the observer because Einstein said it; and our missing knowledge is not an intrinsic natural principle because Heisenberg said it. Nature certainly did not change her ways and laws since the advent of observers!

We have a natural tendency to adopt pet ideas which makes them all the harder to abandon, even if they pull in the wrong direction. But it's a good idea to hold the leash firmly and watch who is holding whom!

3. Assumptions…

are quite familiar and have been the subject of many discussions among the members of the NPA family. Yet assumptions may become dangerous if uncontrolled, shifted, or changed at will. No experiment and no theory can do without them. All the more important is an effort to do some good bookkeeping here. It is helpful to distinguish between different kinds of assumptions, by…

4. Habit

Which velocity matters for the Michelson-Morley (MM) experiment? We have a choice of three: Earth's rotational velocity, orbital velocity around Sun, and cosmic velocity together with solar system, all adding up to the unique absolute velocity vector. Light propagates in the topmost system of reference ("absolute space"). Clearly, Earth's rotation provides the lion's share in changing directions and the cosmic velocity part the lion's share in speed. Yet the MM experiment is usually discussed in terms of the orbital velocity, the one that matters least in the analysis.

5. Dogmatized and Faulty

"All inertial systems are equivalent". Are they? Inertia is a consequence of global energy conservation. In consequence, there can be only one global inertial system, the Universe as a whole. The plurality of "equivalent inertial systems" comes from kinematics. It must not be confused with dynamic principles. "Private systems of reference" do not exist. Like transformations, they are a mathematical convenience to unravel the observer's view and help distinguish between apparent and dynamic motions. This is important for a correct treatment of physical problems – such as the Doppler effect which has a dynamic aspect (source moving) and a kinematic aspect (observer moving). The two scenarios are by no means "equivalent". In any case, the registered change of frequency is an apparent one.

6. Conflicting

"Wave particle duality" is a prominent example. Waves are always patterns in coherent particle ensembles. There can be no "self-interference" of particles and it does not make sense to attribute wave parameters (wavelength, phase, phase velocity, etc) to single particles. This strict distinction yields a consistent view of physical topics like Planck's radiation law (which is not the emission of individual photons but of coherent bunches) or the photo effect (not a simple "one-photon-in-one electron out" effect). Ensemble effects are the trademark of light – nothing is more common in the Universe!. We should not be surprised if quantization turned out to be a consequence of cooperative ensemble effects.

7. Tacit

They are really hard to control because they sneak in unnoticed and come in great numbers. Ambiguities are the consequence of tacit assumptions.

Suffice it here to illustrate this point with some questions:

"What is the highest mountain on Earth?" usually assumes sea level as reference.

"When is the first anniversary of the discovery of Neptune?" usually assumes 'our' year. Calculate that anniversary in Neptune years and find out the "Neptune anniversary" of its discovery!

8. Absurdity

Assuming an absurdity when in fact there is none may have far-reaching consequences. Take Einstein's "Aarau vision" which he had as a sixteen-year old when in Switzerland: "Riding on a light beam node I would have the impression of permanent darkness. This is absurd, so light must propagate at c with respect to any observer." No, his conclusion is absurd, not what he imagines.

9. Gedanken Experiments

are a special method to establish certain ideas by assuming a made-up scenario. This is well justified if that scenario cannot possibly be realized by a true blue experiment. Gedanken experiments, however, become quite dangerous if their oversimplification is used to establish a conclusion (usually the result of wishful thinking) which in turn is generalized into a natural law. The conclusion "relativity" is usually modeled with just two objects/observers involved, thereby depriving us of the possibility to attain additional knowledge by considering a more complex system. Already a three-body system reveals the logic error of "special relativity" because dynamic velocities have to be unique (energy conservation!) and no object can have more than one velocity in dynamics. The scenarios "observer at rest, source moving" and "source at rest, observer moving" are by no means equivalent! If they were, well-known (really?) phenomena like the Doppler effect where radiation is involved wouldn't be asymmetric. The Doppler effect with necessity requires a superordinate unique reference system, both for sound and light. In contrast to widespread belief, this reference does not just consist of any atoms in question; in fact, a dynamic reference need not be "material" at all.

10. Mathematics…

is not the master of physics but its servant. If used in an uncontrolled way, math is an equally tricky and dangerous mole hill. Mathematics is neutral with respect to physical thinking and without the latter may be more obnoxious than useful. Mathematics doesn't care for the distinct meanings of physical concepts nor does it care for physical dimensions. If a formula fails by dimension, we may safely say that it is bound to fail in physics. If a formula is meaningful for physics, all its components must be meaningful. A theory may owe its success to mathematically produced "correct results". Such is the case with Maxwell's equations (waves must not be produced ignoring their sources) or with Copenhagen "uncertainty". In contrast with widespread belief, Maxwell's equations owe their success to benevolent math and, employing Faraday's induction in terms of the magnetic field which is faulty in itself [1,2], cannot produce electromagnetic waves on a physical basis. The Copenhagen model makes use of the Planck quantum of action without physical authorization; the non-commutativity of "operators" has no physical meaning and does not render the physics behind such a fundamental concept as action. The gamma factor produced by special relativity has nothing to do with dynamics; it must not be converted into dynamics on the basis of a kinematic concept, a faulty one, too, based on two false postulates. It may be considered a calamity that math produces the same gamma factor in two completely different ways, kinematic and dynamic. Only the dynamic gamma factor has physical relevance as confirmed e.g. by the important high-speed 1964 Bertozzi experiment [3] on electrons which has clearly shown non-Newtonian asymptotic approach of c as limiting speed. To avoid confusion, high-speed dynamics should be called neo mechanics [4].

11. Replacement Errors

There are prominent cases of replacement errors in physics that have given rise to faulty models with far-reaching consequences. Special relativity chose the transformation of "time" and "space" instead of wave parameters. It is the latter which are relevant for the Doppler effect: Wavelengths are indeed contracting (or dilating). Strangely, the contraction of solid(!) interferometer arms was preferred to the contraction of light(!). General relativity chose the curvature of space instead of considering gravity potentials in space. Copenhagen quantum theory chose probabilities (a purely mathematical concept) to describe wave behavior instead of coherent particle ensembles.

The "success" of any theory may be misleading if its intrinsic inconsistencies are camouflaged by mathematical argumentation.

Math is blind against physical thinking and analysis; it cares neither for meaning nor dimension of quantities – it doesn't have to, because this is physics' task.

12. Confusing Different Concepts…

are closely related with and maybe even originates from math. Math is distinctly different from physics and only in lucky cases (there are still many, to be sure!) do formulas render physical thinking. Moreover, our terminology tends to be ambiguous, but it must not be.

The confusion between abstract concepts (space, time) and physical parameters (wavelength, frequency) has a long history. 'Special' relativity has its roots in a faulty analysis of the Doppler effect. The list of confusions has more "nots" on it:

13. Quantities vs. Their Local Changes

A physical event is due to local changes. A static scenario is rather an idealization and as such may serve as a textbook example. What is usually understood as "energy" is quite different from a local change of energy. The latter is the basis of action which may be defined as the product of the local change of energy and the duration (not "time"!) of the process. Potentials may be the key why that product has a non-zero finite value, Planck's constant.

14. Time vs. Duration

No clock whatever measures "time" – clocks are devices to compare durations of external processes with an inbuilt periodic process. What we call "action" is not an abstract product of "time" and energy – its physical meaning ties a local change of energy to the duration of that process and as such has nothing to do with "uncertainty". Heisenberg arrived at his "principle" by purely mathematical reasoning (non-commutativity of two "operators" supposed to represent energy and time, thus overestimating math and the observers' role, too). By dimension, action is different from energy. Energy conservation implies that we may "save" action, but not energy! And action was a natural principle certainly before observers entered the stage.

15. Determinism vs. Causality

We usually lack the detailed knowledge of all conditions leading to an event; to handle the problem in spite of our lacking knowledge is the task of probability, a mathematical method that has no status in physics. Probability is the expression of our lacking knowledge. Probability does not allow to distinguish whether Nature "plays dice" or not.

16. Dynamics vs. Kinematics

Nature's actions (dynamic events) vs. our observations. Our impression often (or even usually?) does not coincide with what actually happens. Prominent historical example: The geocentric world view which held its position for some 14 centuries.

We should not automatically convert what looks important to us into a physical concept: "Signal" or "information" are what we may interpret as "messages" and as such do not give us physical insight. Arrival rate and degree of coherence of radiation are independent of our interpretation and need not make sense to us, yet they are important physical parameters.

17. Collective (Ensemble) Parameters vs. Single Particle Parameters

The arrival rate of particles traveling in ensembles should be distinguished from intrinsic frequencies attributed to the single particle. This distinction is not always supported by just looking at an experimental result because "frequency" is too unspecific a notion. Experimental results call for caution whenever their interpretation becomes ambiguous. If the presentation of, say, the Planck radiation law, in terms of wave lengths or frequencies are accepted as equivalent, then both, wavelength and frequency, must be wave parameters. Usually, experiments deal with particle ensembles rather than with isolated particles, particularly in the case of light. In general, parameters occurring in thermodynamics (energy, temperature, entropy, etc) are only defined in the context of large enough ensembles. We shouldn't be surprised if quantization turns out to be an ensemble effect [5].

18. Unscientific Questions…

come as speculative ones asking for answers that cannot be possibly given by any scientific method ("Is the Universe finite or infinite?") or faulty ones based on wrong assumptions ("Why does a mirror exchange left and right, but not up and down?"). And there are questions with a metaphysical touch that leads nowhere ("Did time have a beginning?" or "What was before the Universe?").

19. Much Ado About…

is met all too often in modern physics. This mole hill makes us awe where there is no reason to awe. Prominent examples are found in the history of general relativity: The bending of a light beam passing a strong gradient of a gravity potential (not "curved space"!) was already predicted by Newton; the "unexplained" balance of the perihelion precession of Mercury was often presented as the most important part, adding to the fame of general relativity (which cannot do without Newton!). The "most famous formula of science", the alleged free trade between mass and energy, to become the most famous equation of science, does not give a thought as to the dynamic significance of the squared light speed. Einstein's c^2 has no dynamic (= physical) origin. The usual understanding of that equation does not stand a critical test [6]. In the language of generalized potentials, it simply tells us energy equals mass times a velocity squared potential), reminiscent of the well-known Newtonian expression for kinetic energy which is consistent with the low-speed approximation of the absolute gamma factor.

20. Jumping at Conclusions…

takes no effort and therefore occurs quite often in science. The well known cult theories of physics are full of these jumps. The Michelson-Morley null result does not establish the equivalence of all 'inertial systems' (in dynamics, there can be only one true inertial system, the one and only in which energy conservation holds) or the constancy of c with respect to all observers. The asymptotic approach of c in dynamics does not prove the diverging mass increase, and the alleged mass increase in turn may very well be an artifact of changing environmental dynamical conditions as the velocity of a particle approaches c [7]. Hertz' experiments do not justify propagation of electromagnetic waves without charges. The photoelectric effect does not prove the intrinsic frequency of a photon (Einstein's famous jump when he established his naïve interpretation of the effect: "One photon in, one electron out"). The frequency may very well be the arrival rate of photons traveling in rigid coherent ensembles (bunches) – the smaller their spacing in these bunches, the higher their arrival rate. The Planck radiation law does not necessarily tell about randomly emitted single photons. It may turn out that photon bunches replace single photons as suggested by important experiments [8,9] that have disclosed an interference threshold at very low intensities. Electromagnetic waves vs. photons is a beautiful example how competing models have to struggle with their very specific mole hill landscapes. Those who prefer electromagnetic waves have to live with the Maxwell inconsistencies, those who prefer the photon have to cope with the photon's enigmatic properties and behavior. Each side relies on a lot of tacit speculations. And wave-particle dualism does not solve the problem because it combines the speculations.

Speculations in science are fine if declared as such. They may be fruitful; yet often they are blocking independent thought.

21. Ambiguity…

is a general linguistic problem that enters scientific discussions all to easy. Generalized terms ("the velocity of light") are often too unspecific to serve the cause they are expected to serve. Conceptually, it makes a difference whether we speak of phase velocity or energy velocity, even if the two happen to have the same value. Seemingly similar statements, on the other hand, are not necessarily ambiguous and should not be confused. It makes a difference whether I state "The velocity of light is independent of the observers and their motion" or "The velocity of light registered by moving observers depends on their motion." These statements are not in conflict, they simply address to different scenarios, dynamic and kinematic, respectively. Scientific scrutiny should be accompanied by linguistic scrutiny. We may realize that a tacit change of view is often the 'culprit' for misunderstandings. Definitions must be clear (admittedly a hard to do task in physics!) and unique.

22. Metaphors…

are ubiquitous in our languages. Take the Universe and what we suppose to make up its background (in all senses of the word). There is a whole zoo of ideas, whatever we call our pets: Field, vacuum, dark matter, c^2 potential, (another exotic animal in that zoo, see [10,11]), etc. 'Something' we don't know has many names. In fact, the multitude of different metaphors tells about the lack of our knowledge concerning the Extra Terrestrial Hopeless Enigmatic Reference (aka E.T.H.E.R., just have a look at the chat between members of the NPA family!). In the sense of our lacking knowledge they all are equivalent which explains the hassle about them. Nature offers us a plethora of these unknown 'somethings'; but that shouldn't disturb us; luckily we don't have to know what they are as long as we can work with them in a consistent way.

23. Giving Math Its Deserved Credit…

belongs to justified and fair criticism, too. Math is a noble example when it comes to avoid unnecessary problems with "understanding" or "explaining" or the summoning of "common sense". Nature's ways do not easily (if at all) give in to these efforts. We could save ourselves a lot of trouble if we learned from math that it may be better to accept consistency as our most worthwhile and rewarding achievement: If you can't explain it, define it (a hard enough to do job, anyway). And there are uncounted cases where math does excellent service in physics with its impeccable consistency, if its service is backed up by physical analysis. Three noble examples are the formulation of *induction* (a true blue physical relativity effect) in terms of the vector potential instead of magnetic fields [7], the derivation of the *dynamic gamma factor* [12] from pure energy considerations (not to be confused with the gamma factor rooting in transformations introduced by special relativity), and the analysis of the *Michelson-Morley experiment* in terms of a classical two-way *Doppler* effect in absolute space [13], the latter being strongly supported by analogous experiments with sound waves showing the same isotropy [14] As long as famous names work as protective shields, faulty cult theories and models have strong defenders. The best weapon against that defense is insisting on cool consistency.

24. Authority…

is one of the worst mole hills. Fame often replaces scientific scrutiny. It should not matter at all who said it (except for historical honesty) – the what is important. Of course, there are great names in science, but it's better to stay with the ship than to worship the captain who has abandoned the ship. The authority mole hill keeps people stumbling over all other mole hills, not just in science. Dogmas based on authority are nothing short of a catastrophe in science. The survival of certain cult theories is a matter of authority-biased acceptance.

The German writer and satirist Kurt Tucholsky (1890 - 1945).put it in fitting words: "Don't let any expert impress you by telling »My friend, I have been doing that for 20 years!«. – One may make also the same mistakes for 20 years." Don't let authority impress you. Never. But we shouldn't go 'bashing' the celebrities of science – they are bashed enough by their own fame. After all, we are all in the same boat, and it's easy to be "all at sea".

25. Aiming Too High…

seems to be the major driving mechanism of scientific endeavor. We wish to "explain" and "understand" and rely on "common sense". Often these (quite understandable) human efforts turn out to be wishful thinking and lead us into dead end roads. What are our hopes to have a grand unified theory of everything if our math doesn't allow us to handle the N body problem without approximations? Of course, aiming sky high encourages funding of expensive experiments. Still, modesty is a good attitude to show facing all those unsolved problems Nature presents us with - past, present, and future. In all modesty, we should be content to arrive at consistency in our modelling which means we watch out for intrinsic contradictions. When it comes to consistency, math certainly teaches us a valuable lesson. It's easier to strive for and achieve consistency in an abstract science like math than in a field where Nature dictates the rules. In physics, consistency is hard to get, but it's a valuable path finder: A lonesome particle can't be a wave; probabilities don't make physical waves; tunneling does not violate energy conservation; no object can move at more than one dynamic velocity; our lacking knowledge is not a natural law; electromagnetic fields do not exist without their sources; etc.

26. Look Out for Mole Hills!

A book could be written on any of the items mentioned and on those not mentioned here. Feel encouraged also not to lose other important ingredients of scientific effort out of sight which usually are not considered or related to science at all (like psychological aspects), but prove to be equally important for our success.

After all, modesty may win us the sympathy of all those who pay for science and who should not feel left out. And being prepared and watching out for all the out-of-science mole hills might prove very rewarding in our everyday lives, too!

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