

# Philosophy and Physics

**Exam here May 8 1:30-4:30pm**

Open book, open note, open internet

Electronic submission encouraged,. You need to bring your own laptop. But blue books also available

4 essay questions.

**419 Term papers due on Thursday, May 3.**

# Overview

- What makes a good theory? How has the answer to this question changed with time?
- What criteria are used to test a theory? The data. The metaphysical organization of the world view (paradigm).
- What determines the historical development of science? Why wasn't the heliocentric theory developed before 1543?
- What can we know?

# Nature of scientific theory

## What does "correctness" mean?

- Agreement with observation is important. However...
- What is observable? (time comparison?)
- Meanings of statements are often changed.
- Theory vs. interpretation.

## What does "preferable" mean?

- Plausible? No
- Conservative? Sometimes
- Simple? An aesthetic judgement. Is general relativity simpler than Euclid?

## What is the relationship between theory and reality?

## When a law appears to be violated, what does it mean?

- It really is wrong, and we need to modify it.
- We have neglected something important.

Predictability of future experiments is sociologically the strongest way of distinguishing between various explanations.

# *The Structure of Scientific Revolutions*

*Thomas Kuhn 1962*

- Science proceeds through “normal” periods where puzzles solved, textbooks written. **Anomalies** — failures of the current paradigm to take into account observed phenomena — accumulate.
- Paradigm shifts—viewpoints preceding and succeeding a paradigm shift are so different that their theories are incommensurable
- To be accepted “the new candidate must seem to resolve some outstanding and generally recognized problem that can be met in no other way and the new paradigm must promise to preserve a relatively large part of the concrete problem solving activity that has accrued to science through its predecessors.”
- Rejection of one paradigm happens when another is available. The decision involves comparing the paradigms AND experiments.

# Paradigm Shifts of concepts in physics

- Time and direction of it
- Space? Aristotle, Galileo, Newton, Einstein, Dirac
- Matter? What is real? Aristotle, Democritus, Descartes, Newton, Maxwell, Bohr, Dirac
- Heat, thermodynamics, Boltzmann
- Local Reality? Bell's theorem
- Determinism vs. randomness, chaos
- Theory of everything, unification
- Cosmology, creation of the universe.
- Current crises: quantum interpretation, gravity & quantum mechanics, dark matter & dark energy

# Kuhn's Postscript

Compared with the notion of progress most prevalent among both philosophers of science and laymen, however, this position lacks an essential element. A scientific theory is usually felt to be better than its predecessors not only in the sense that it is a better instrument for discovering and solving puzzles but also because it is somehow a better representation of what nature is really like. One often hears that successive theories grow ever closer to, or approximate more and more closely to, the truth. Apparently generalizations like that refer not to the puzzle-solutions and the concrete predictions derived from a theory but rather to its ontology, to the match, that is, between the entities with which the theory populates nature and what is “really there.”

Perhaps there is some other way of salvaging the notion of ‘truth’ for application to whole theories, but this one will not do. There is, I think, no theory-independent way to reconstruct phrases like ‘really there’; the notion of a match between the ontology of a theory and its “real” counterpart in nature now seems to me illusive in principle. Besides, as a historian, I am impressed with the implausability of the view. I do not doubt, for example, that Newton’s mechanics improves on Aristotle’s and that Einstein’s improves on Newton’s as instruments for puzzle-solving. But I can see in their succession no coherent direction of ontological development. On the contrary, in some important respects, though by no means in all, Einstein’s general theory of relativity is closer to Aristotle’s than either of them is to Newton’s.

# Kuhn's Postscript

## 5. Exemplars, Incommensurability, and Revolutions

....I have argued that the parties to such debates inevitably see differently certain of the experimental or observational situations to which both have recourse. Since the vocabularies in which they discuss such situations consist, however, predominantly of the same terms, they must be attaching some of those terms to nature differently, and their communication is inevitably only partial. As a result, the superiority of one theory to another is something that cannot be proved in the debate.

Debates over theory-choice cannot be cast in a form that fully resembles logical or mathematical proof. In the latter, premises and rules of inference are stipulated from the start. If there is disagreement about conclusions, the parties to the ensuing debate can retrace their steps one by one, checking each against prior stipulation. At the end of that process one or the other must concede that he has made a mistake, violated a previously accepted rule. After that concession he has no recourse, and his opponent's proof is then compelling. Only if the two discover instead that they differ about the meaning or application of stipulated rules, that their prior agreement provides no sufficient basis for proof, does the debate continue in the form it inevitably takes during scientific revolutions. That debate is about premises, and its recourse is to persuasion as a prelude to the possibility of proof. Nothing about that relatively familiar thesis implies either that there are no good reasons for being persuaded or that those reasons are not ultimately decisive for the group. Nor does it even imply that the reasons for choice are different from those usually listed by philosophers of science: accuracy, simplicity, fruitfulness, and the like.

# Kuhn's Postscript

There is no neutral algorithm for theory-choice, no systematic decision procedure which, properly applied, must lead each individual in the group to the same decision.

Two men who perceive the same situation differently but nevertheless employ the same vocabulary in its discussion must be using words differently. They speak, that is, from what I have called incommensurable viewpoints.

One central aspect of any revolution is, then, that some of the similarity relations change. Objects that were grouped in the same set before are grouped in different ones afterward and vice versa. Think of the Sun, Moon, Mars, and Earth before and after Copernicus; of free fall, pendular, and planetary motion before and after Galileo;

# Kuhn's Postscript

## 6. Revolutions and Relativism

One consequence of the position just outlined has particularly bothered a number of my critics. They find my viewpoint relativistic,... it is in any case far from mere relativism.

...it should be easy to design a list of criteria that would enable an uncommitted observer to distinguish the earlier from the more recent theory time after time. Among the most useful would be: accuracy of prediction, particularly of quantitative prediction; the balance between esoteric and everyday subject matter; and the number of different problems solved. Less useful for this purpose, though also important determinants of scientific life, would be such values as simplicity, scope, and compatibility with other specialties. ...Later scientific theories are better than earlier ones for solving puzzles in the often quite different environments to which they are applied. That is not a relativist's position, and it displays the sense in which I am a convinced believer in scientific progress.

# John Lukacs, NYT 6/17/199:

PHOENIXVILLE, Pa. — "Boondoggle" is a relatively new American word. Originally a braided leather lanyard worn by Boy Scouts, in the 1930's it was applied by critics of the New Deal to "useless tasks performed by recipients of its doles."

The proposed supercollider in Texas, at \$8.4 billion, may be one of the greatest boondoggles of all time. But the main problem concerns something more fundamental than cost.

The supercollider is a 53-mile circular tunnel that would accelerate atomic particles at supersonic speeds, smashing atoms into smaller and smaller bits. Many of its proponents tend to argue, among other things, that science may discover the smallest building block of the universe and that the universe can be explained by a Grand Unified Theory. Both assumptions are outdated.

The reduction of the universe to an essential basic particle was first attempted in the 5th century — theoretically, since he had no microscopes or atom-smashers at his disposal — by Democritus, who gave us the name and theory of the atom, establishing it as the basic unit of matter, a notion that has not changed for more than 2,000

years. Democritus was a materialist: He believed that the human soul itself consists of nothing but atoms. Plato did not believe a word of that.

We shouldn't, either. Consider only that Democritus thought the atom was absolutely indivisible. We know that this is not so: during this century (mostly because of equipment capable of "smashing" atoms) physicists have found that atoms include other, smaller particles.

But what is the essence of some of these particles? Are they — more exactly their tracks and patterns — not produced by the scientists themselves? This suggests a truth that we often ignore: that, just as nature came before man, man came before the science of nature. Thus the history of science — indeed, science itself — cannot be anything but the history of scientists. Especially when it comes to subatomic particles, we cannot speak of "nature" or of "matter" but only of situations that occur during and because of our observations of matter. It is impossible, as Werner Heisenberg proved with his Uncertainty Principle almost 70 years ago, to exclude the observer from what he observes.

Consider the names physicists have given to many of these particles — names that are often nothing but tortuous linguistic inventions. In his book "The End of Physics — the Myth of a Unified Theory," the physicist David Lindley (senior editor of the journal Science) writes that "the quality of nomenclature in particle physics [has sunk] to new lows." Well after physicists discovered the "neutrino" (to be distinguished from the "neutron") we now have "selectrons" and "sneutrinos" and, "worst

of all, the whole set of quarks turns into a corresponding set of 'squarks.' Where the addition of an initial S doesn't work, diminutive endings have been resorted to, producing a 'photino' to go with the photon, 'gluinos' for gluons."

It does not take much philosophical knowledge to recognize that we are, after more than 500 years, back in the presence of the medieval superstition of nominalism: the tendency to think that once we give a name to a phenomenon we've "got it." That is the very opposite of realism, which in philosophy, art and, indeed, in all intellectual endeavors began to replace nominalism around the time of the Renaissance.

But the assumption that the universe can be reduced to an original particle has already changed — or, rather, degenerated — into a second assumption, the myth of the Unified Theory. Many physicists are now inclined to believe that even if we cannot find the smallest building block of the universe, we can find a mathematical formula that will explain the entire universe: a Theory of Everything...

Given sufficient money (and, I assume, voltage) the supercollider may or may not "produce" the basic unit of the universe, while it will create more subatomic situations that may be formulated mathematically. But more and more mathematical formulas about subatomic matters consist only of untested and untestable assumptions, all of them theoretical and abstract. The belief that the universe is "written in the language of mathematics" is not only wrong, it is entirely outdated. "What is there exact in mathematics except its own exactitude?" Goethe wrote. He was right as mathematicians in the 20th century have confirmed.

**N**ear the end of the Middle Ages, a few theologians (the "scientists" of that time) persuaded a king of France to give them permission for an experiment that had been forbidden by the Roman Catholic Church. They were allowed to weigh the soul of a criminal by measuring him both before and after his hanging. As usually happens with academics, they came up with a definite result: the soul weighed about an ounce and a half.

We laugh at such things, of course. But remember how much suffering such coarse and foolish ideas about the soul produced in the wars of religion during the transition from the Middle Ages to the Modern Age — not to speak of the fact that the soul-weighing experiment was somewhat less costly than the supercollider.

We ought at least to consider the possibility that 100 or 200 years hence people may laugh at the pretensions of some of our scientists, as well as at our gullibility at the end of the 20th century.

We live at the end of a century, and probably at the end of an age, when the time has come to rethink not only some of the technical applications but the very meaning of "progress." To oppose the supercollider is by no means a reactionary position. To believe that the U.S. must not commit itself to such a financial and scientific boondoggle is a step forward, not backward.

My argument is not simply that it is not given to humans to explain everything, including the universe. When human beings recognize that they cannot create everything and cannot see everything and cannot define everything, such limitations do not impoverish but enrich the human mind. They mark the evolution of our consciousness.

Nearly 50 years ago, the French Catholic writer Georges Bernanos said that the atom bomb was "a triumph of technique over reason." Fifty years after us, rats may scurry through the 50 miles of tunnels under Texas hardpan and a few tourists may gape at the remnants of the supercollider, at the ruins of a monument to unreason. □

# A Brief History of the Multiverse - by Paul Davies (New York Times 04/12/2003)

Imagine you can play God and fiddle with the settings of the great cosmic machine. Turn this knob and make electrons a bit heavier; twiddle that one and make gravitation a trifle weaker. What would be the effect? The universe would look very different --so different, in fact, that there wouldn't be anyone around to see the result, because the existence of life depends rather critically on the actual settings that Mother Nature selected.

Scientists have long puzzled over this rather contrived state of affairs. Why is nature so ingeniously, one might even say suspiciously, friendly to life? What do the laws of physics care about life and consciousness that they should conspire to make a hospitable universe? It's almost as if a Grand Designer had it all figured out.

The fashionable scientific response to this cosmic conundrum is to invoke the so-called multiverse theory. The idea here is that what we have hitherto been calling "the universe" is nothing of the sort. It is but a small component within a vast assemblage of other universes that together make up a "multiverse."

It is but a small extra step to conjecture that each universe comes with its own knob settings. They could be random, as if the endless succession of universes is the product of the proverbial monkey at a typewriter. Almost all universes are incompatible with life, and so go unseen and unlamented. Only in that handful where, by chance, the settings are just right will life emerge; then beings such as ourselves will marvel at how propitiously fine-tuned their universe is. But we would be wrong to attribute this suitability to design. It is entirely the result of self-selection: we simply could not exist in biologically hostile universes, no matter how many there were.

This idea of multiple universes, or multiple realities, has been around in philosophical circles for centuries. The scientific justification for it, however, is new. One argument stems from the "big bang" theory: according to the standard model, shortly after the universe exploded into existence about 14 billion years ago, it suddenly jumped in size by an enormous factor. This "inflation" can best be understood by imagining that the observable universe is, relatively speaking, a tiny blob of space buried deep within a vast labyrinth of interconnected cosmic regions. Under this theory, if you took a God's-eye view of the multiverse, you would see big bangs aplenty generating a tangled melee of universes enveloped in a superstructure of frenetically inflating space. Though individual universes may live and die, the multiverse is forever.

Some scientists now suspect that many traditional laws of physics might in fact be merely local bylaws, restricted to limited regions of space. Many physicists now think that there are more than three spatial dimensions, for example, since certain theories of subatomic matter are neater in 9 or 10 dimensions. So maybe three is a lucky number that just happened by accident in our cosmic neighborhood -- other universes may have five or seven dimensions. Life would probably be impossible with more (or less) than three dimensions to work with, so our seeing three is then no surprise. Similar arguments apply to other supposedly fixed properties of the cosmos, such as the strengths of the fundamental forces or the masses of the various subatomic particles. Perhaps these parameters were all fluke products of cosmic luck, and our exquisitely friendly "universe" is but a minute oasis of fecundity amid a sterile space-time desert.

How seriously can we take this explanation for the friendliness of nature? Not very, I think. For a start, how is the existence of the other universes to be tested? To be sure, all cosmologists accept that there are some regions of the universe that lie beyond the reach of our telescopes, but somewhere on the slippery slope between that and the idea that there are an infinite number of universes, credibility reaches a limit. As one slips down that slope, more and more must be accepted on faith, and less and less is open to scientific verification.

Extreme multiverse explanations are therefore reminiscent of theological discussions. Indeed, invoking an infinity of unseen universes to explain the unusual features of the one we do see is just as ad hoc as invoking an unseen Creator. The multiverse theory may be dressed up in scientific language, but in essence it requires the same leap of faith.

At the same time, the multiverse theory also explains too much. Appealing to everything in general to explain something in particular is really no explanation at all. To a scientist, it is just as unsatisfying as simply declaring, "God made it that way!"

Problems also crop up in the small print. Among the myriad universes similar to ours will be some in which technological civilizations advance to the point of being able to simulate consciousness. Eventually, entire virtual worlds will be created inside computers, their conscious inhabitants unaware that they are the simulated products of somebody else's technology. For every original world, there will be a stupendous number of available virtual worlds -- some of which would even include machines simulating virtual worlds of their own, and so on ad infinitum.

Taking the multiverse theory at face value, therefore, means accepting that virtual worlds are more numerous than "real" ones. There is no reason to expect our world -- the one in which you are reading this right now -- to be real as opposed to a simulation. And the simulated inhabitants of a virtual world stand in the same relationship to the simulating system as human beings stand in relation to the traditional Creator.

Far from doing away with a transcendent Creator, the multiverse theory actually injects that very concept at almost every level of its logical structure. Gods and worlds, creators and creatures, lie embedded in each other, forming an infinite regress in unbounded space. This *reductio ad absurdum* of the multiverse theory reveals what a very slippery slope it is indeed. Since Copernicus, our view of the universe has enlarged by a factor of a billion billion. The cosmic vista stretches one hundred billion trillion miles in all directions -- that's a 1 with 23 zeros. Now we are being urged to accept that even this vast region is just a minuscule fragment of the whole.

But caution is strongly advised. The history of science rarely repeats itself. Maybe there is some restricted form of multiverse, but if the concept is pushed too far, then the rationally ordered (and apparently real) world we perceive gets gobbled up in an infinitely complex charade, with the truth lying forever beyond our ken.

# Multiverse

If the universe we see around us is the only one there is, the vacuum energy is a unique constant of nature, and we are faced with the problem of explaining it. If, on the other hand, we live in a multiverse, the vacuum energy could be completely different in different regions, and an explanation suggests itself immediately: in regions where the vacuum energy is much larger, conditions are inhospitable to the existence of life. There is therefore a selection effect, and we should predict a small value of the vacuum energy. ...

We can't (as far as we know) observe other parts of the multiverse directly. But their existence has a dramatic effect on how we account for the data in the part of the multiverse we do observe. It's in that sense that the success or failure of the idea is ultimately empirical: its virtue is not that it's a neat idea or fulfills some nebulous principle of reasoning, it's that it helps us account for the data. Even if we will never visit those other universes.

Science is ... about explaining the world we see, developing models that fit the data. But fitting models to data is a complex and multifaceted process, involving a give-and-take between theory and experiment, as well as the gradual development of theoretical understanding... In complicated situations, ... mottos like "theories should be falsifiable" are no substitute for careful thinking about how science works. Fortunately, science marches on, largely heedless of amateur philosophizing. If string theory and multiverse theories help us understand the world, they will grow in acceptance. If they prove ultimately too nebulous, or better theories come along, they will be discarded. The process might be messy, but nature is the ultimate guide.

[Sean Carroll](http://edge.com) edge.com

A pervasive idea in fundamental physics and cosmology that should be retired: the notion that we live in a multiverse in which the laws of physics and the properties of the cosmos vary randomly from one patch of space to another. According to this view, the laws and properties within our observable universe cannot be explained or predicted because they are set by chance. Different regions of space too distant to ever be observed have different laws and properties, according to this picture. Over the entire multiverse, there are infinitely many distinct patches. Among these patches, in the words of Alan Guth, "anything that can happen will happen—and it will happen infinitely many times".

“Theory of Anything” Any observation or combination of observations is consistent with a Theory of Anything. No observation or combination of observations can disprove it. Proponents seem to revel in the fact that the Theory cannot be falsified. The rest of the scientific community should be up in arms since an **unfalsifiable** idea lies beyond the bounds of normal science. Yet, except for a few voices, there has been surprising complacency and, in some cases, grudging acceptance of a Theory of Anything as a logical possibility. The scientific journals are full of papers treating the Theory of Anything seriously. What is going on?

Paul Steinhardt, "*Theories of Anything*" [edge.com](http://edge.com)'

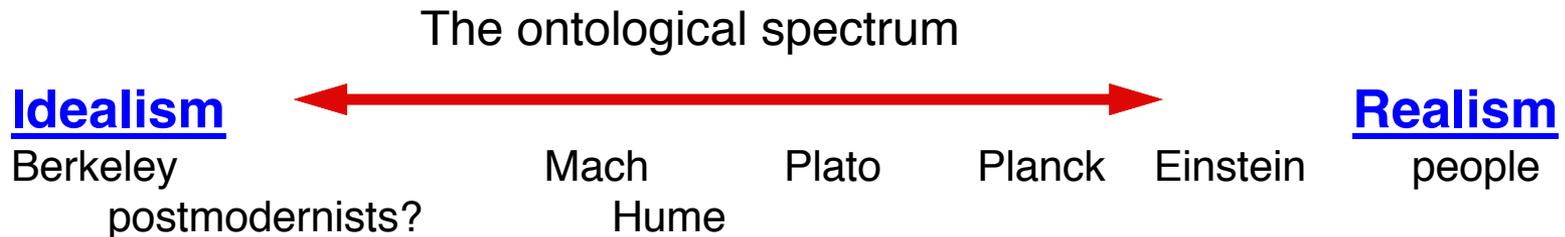
# Explicit Philosophy

Some classical philosophical views.

Hume and Kant: (mid to late 18<sup>th</sup> century)

- Hume (*Treatise on Human Nature*): one can only learn about reality through experience. Causation itself is a mental construct, not inherent in phenomena themselves. However, in pointing out that the idea of induction itself cannot be inductively confirmed (only disconfirmed), Hume implicitly indicated a way in which we seem to approach the world with "hard-wired" prior assumptions.
  - Note two problems with induction:
    - at the deepest level, the argument for it is circular
    - the categories to be used in extrapolating toward the future are not specified by any logical principle
- Kant *Critique of Pure Reason*, agreed with most of this, but argued that there are two valid forms of *a priori* knowledge. One is the reasoning facility (logic) by which we analyze our experiences. The other is mathematics, such as geometry.
  - It was known, however, that as a logical system, Euclidean geometry was not unique, but only one geometry of a larger family. Kant believed it to be the only conceivable actual geometry of the world.

# Views of Reality: a spectrum



- The common person in the street  
There are definite events independent of observation. Our senses record these events. Theories can represent genuine causal patterns inherent in the events. Generally, the features we use to describe things, e.g. size, time..., are inherent in the events themselves. The world consists of collections of 'things'.
- Einstein  
There's a definite real world, of which we are observers, and also parts. But we can't count on even the deepest features to be as they seem. The world follows simple mathematical laws.
- Planck (Realism, not entirely naive):  
The goal of physics is a unified world picture. Laws must be independent of the observer. The picture must be consistent. Simplicity is a means to get to a true, general picture, not an end.

# Views of Reality: a spectrum

- Plato  
The sensed world is an ephemeral approximation to the 'true' world of ideal essences. Reason tells us more about that true world than mere sensation can provide.
- Hume (skepticism):  
Whatever we claim about reality, only senses are available. There is no logical basis for induction. Nevertheless we all must accept it in practice.
- Mach (a particularly subjective version of positivism): Sensory impression is primary. "Substances" are patterns of impressions. No eternal laws. (e.g., atoms aren't real.)
- Notice that Planck and Mach both recognize that we have nothing but sense impressions and the need to organize them simply. Planck implicitly assumes that the sense impressions come from somewhere, and have properties that make them fit into simple patterns. Mach assumes there's something arbitrary about the patterns we find, so that no pattern should be expected to be stable.

# Views of Reality: a spectrum

- Berkeley (almost solipsism):  
You are only aware of your own thoughts. External reality is an unnecessary hypothesis. (This is a popular academic position again.) However, to account for the similarity of perceptions of different people (rather than claim we are all simply thoughts of his) Berkeley invokes the mind of God, in which he claims we all partake.
  - But: Why is it better to postulate "God's mind" than to go with the naïve postulate of reality? If it is meaningless to think of a reality without mind, why does the world in our minds have so much evidence of evolution, death etc., just as if reality went its way independent of our minds?
- Traditional answer to Berkeley:
  - If a stone isn't real, go ahead and kick it.
- Russell's answer to B:
  - If the world is all in my imagination, why does it include the parts of Whitehead's book which I don't understand?

# Progress?

*“One passage of Democritus that does survive is a dialogue between the intellect and the senses. The intellect starts out, saying: “By convention there is sweetness, by convention bitterness, by convention color, in reality only atoms and the void.” This one line already puts Democritus shoulder-to-shoulder with Plato, Aristotle, or any other ancient philosopher you care to name.*

But the dialogue doesn't stop there. The senses respond, saying:  
“Foolish intellect! Do you seek to overthrow us, while it is from us that you take your evidence?” *Scott Aaronson*

# Some ideas people argue about

- Dualism:
  - It is often assumed that Mind and Matter are two separate categories. That runs into some obvious problems, in that all the minds of which we are aware are obviously strongly affected by their material underpinnings. Furthermore, minds evolved in a seemingly continuous way from matter that seems mindless. Is there a way to get around the apparent dualism? Can mind affect matter and *vice versa*? If so, in what way are they distinct? Why not just describe mind as a particular organization of matter?
- Berkeley says everything is mind. (no matter)
  - But he then has to add assumptions about the universal mind that, in effect, are equivalent to assuming a material world.
- Russell says everything is matter. (never mind)
  - How does one test this claim?
  - defines matter as "that which obeys the laws of physics" Which laws? We still don't have all the laws of physics! If we say that the laws of physics are the things needed to describe how everything behaves, isn't our argument circular?

# Materialism and Mentalism

- The crude form of materialism: All things are made of solid constituents. Each constituent is described by a set of numbers (*e.g.*, position). These are the primary properties. Events are relations between things. Secondary properties are the large-scale descriptions of collections of and interactions between the primaries.
- The sophisticated form: Russell: That which obeys the laws of physics. But since those laws aren't fully set, matter becomes anything that fits into some coherent laws. So the question of whether everything is "matter" ceases to be a question about what everything is "made of" but rather a question about what types of laws are universally obeyed by phenomena.
  - Implicitly, the materialist view is that the deepest laws will continue to be of a mathematical form, i.e. in the broad class described by Galileo, and will not revert to the more directly value-laden Aristotelian form.
- A real question (non-semantic): Is there a special set of laws needed to describe mind, or are all mental processes outcomes of the same laws that affect other matter?
  - Obviously, there are mental phenomena which are easiest to describe using special constructs, but the question is whether these are complicated *outgrowths* of the ordinary physical laws or *violations* of them.

# What is the relationship between Physics and Philosophy?

- Intuitively obvious notions can be wrong!!
  - Copernicus: the earth is moving
  - Einstein: absolute time doesn't exist; space and time are unified and curved
  - Bohr-Bell: there may be no deep reality
- Rationalist/idealist approach [Plato, Aristotle, Leibnitz, Kant ...] is wrong. Dogmatic statements are often wrong. We cannot figure out the universe by thinking hard (Einstein is a counter example)
- Is philosophy reduced to semantics or history? "*The sole remaining task for philosophy is the analysis of language*" Wittgenstein. It should stay out of physics.
- Philosophy is a critical observer of science to clarify fundamental aspects. Physics is the best science to study the scientific process because there are many well-tested theories.
- What has physics contributed to our understanding?
  - New models and paradigms of thinking about the world (2 sphere model, mechanism, statistical mechanics, quantum mechanics, relativity, big bang model ...)
  - We have several extremely good models: quantum mechanics, electron-magnetism,... Does this mean that they are real?
  - Many famous physicists have raised philosophical questions [ Newton, Mach, Einstein, Bohr, Feynman, Hawking ...]
- How does physics fit into our understanding of the world around us: all fields depend to some extent on our interaction with the world and our hidden assumptions.