Practical Certainty and Cosmological Conjectures

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Most of us, most of the time, assume that there is much of which we can be certain. We know, beyond all doubt, who we are, where we are, what our surroundings are, and so on. Scientific theories, even those that have met with great empirical success, may turn out to be false. But much of our ordinary factual knowledge about things around us is, surely, beyond all doubt. Those well-known sceptical arguments – how do we know we are not hallucinating, or dreaming? – don't, in practice, seem to carry much weight.

But this humdrum, common sense knowledge about our immediate surroundings is all based, it seems, on our experience: what we see, touch, hear. And when one stops to ponder the complexities and mysteries of perception – the intricate and only partly understood processes involved in the simplest act of perception – it can seem rather surprising that we put such trust in perception. All sorts of things could go wrong with the mechanisms of perception; and we have no way of monitoring whether these mechanisms are working properly, inside our brains for example: we take it for granted that our eyes, ears, other sense organs, and brain are all working normally, delivering to us reliable knowledge about the world around us. And for most of us, most of the time, our trust seems well founded. There is, of course, a theoretical reason why our perceptual systems work so well and so reliably: evolution. We have been created by natural selection to have reliable perceptual systems: unreliable perceptual systems are not conducive to survival, and have been eliminated. But this theoretical reason for trusting our senses hardly provides grounds for repudiating scepticism – since sceptical arguments can easily be turned against Darwin's theory of evolution. (The theory applies to three and a half billion years or so of evolution of life on earth; we observe only a very few scattered hints of this evolution in the form of fossils. And that the fossil record supports Darwin's theory is itself a matter of interpretation.)

In practice most of us trust our senses because, for most of us, most of the time, they seem trustworthy – but this reason for trust also falls to well-known sceptical arguments.

There seems to be, in short, an unbridgeable gulf between our ordinary confidence in the absolute certainty of our common sense knowledge about our immediate environment on the one hand, and valid reasons capable of providing support for this confidence, on the other hand.

Philosophers have long struggled with the problem of defeating scepticism, and providing valid arguments for our confident belief in the certainty of our common sense knowledge. In my view, this traditional project of attempting to defeat sceptical doubts is doomed to fail. David Hume and Karl Popper are right: all our factual knowledge is conjectural in character. There is no factual knowledge that is beyond doubt, indubitably certain.

Furthermore, Karl Popper is right to turn the traditional problem of scepticism on its head. Scepticism is not the enemy, to be defeated. Quite the contrary, it is by means of scepticism that we acquire knowledge, we *improve* knowledge. This can be seen most clearly in science. Science makes progress because falsifiable conjectures are subjected to a process of ferocious scepticism; every effort is made to refute them by means of observation and experiment. When a theory is refuted, it becomes clear that something better must be thought up, in turn to be subjected to ferocious attempted empirical refutation, science making progress in knowledge by means of this process of conjecture and refutation. Scientific method, one might almost say, is scepticism directed at the task of acquiring and improving knowledge. This, at least, is Popper's view of the matter (see Popper, 1959, 1963).

Something similar can be said about the way we acquire common sense knowledge of the world around us by means of perception. We open our eyes, and instantly we are aware of the world around us, without any effort or apparent intervention on our part at all. But this, it seems, is an illusion. Decades of work in neuroscience, artificial intelligence and psychology have taught us that our conscious experience of seeing and recognizing things in the world around us is the outcome of extremely complex, if rapid, processing of incoming signals that goes on in our brain, of which we are unaware. It seems likely that we recognize objects as a result of a process of problem-solving, of conjecture and refutation, not unlike that described by Popper in connection with science (see, for example, Pinker, 1998, ch. 4). Seeing, in other words, is the product of scepticism in action.

All our knowledge, theoretical and observational is, it seems, irredeemably conjectural in character. There is no such thing as certainty when it comes to fact.

But there are two things wrong with this Popperian account of the matter.

First, it fails to account for, or to do justice to, the fact that, in real life, we make a sharp distinction between, on the one hand, matters of fact known with such certainty that we are prepared to entrust our life to their truth and, on the other hand, mere speculations, wild guesses, deserving of no trust whatsoever. And second, Popper fails to do what he claims to do, namely solve the problem of induction *even when this problem is interpreted in a minimal, purely methodological way, in such a way that it has nothing to do with degrees of certainty at all*. This second failure would seem to have nothing to do with the first failure at all. But it does – or so I shall argue. For I hope to show that Popper's philosophy of science can be radically changed and *improved* in such a way that it becomes capable of solving the problem of induction (the minimal, *methodological* version of the problem to be considered here, at least, stripped of all concern with degrees of certainty). And this *improved* version of Popper's philosophy of science, despite apparently having nothing to do with the first problem of how we can procure certainty about factual matters, does nevertheless throw a flood of light on this issue. That is what I set out to do in this article.

Let us begin, then, by considering the first of the above two problems - Popper's failure to account for, or do justice to, the distinction we ordinarily draw between certainty and mere conjecture.

All the time, in our lives, we carelessly take for granted that a whole lot of matters of fact are known to us with such absolute certainty that we are prepared to entrust our life to their truth without a moment's thought. We drive across bridges, never for a moment entertaining the possibility that these bridges will suddenly collapse. Most of us, most of the time (in wealthy parts of the world at least) eat, drink, walk, climb stairs, sit, lie down, get on with our lives without for a moment thinking there is the remotest possibility that what we eat or drink will poison us, what we walk, climb on or sit or lie down on will abruptly collapse so that we tumble to our death. We do, on occasions, get it wrong. Bridges do collapse; people die in all sorts of unforeseen accidents. Certainty about our immediate environment is not absolute. But on the whole we are confident that we have got it right, and our confidence, most of the time, seems justified. All this is to be sharply contrasted with mere speculation, conjecture, hypothesis and guesswork.

In declaring that *all* our factual knowledge is conjectural in character, Popper seems incapable of doing justice to the distinction between *certainty* and *conjecture* that arises in such a decisive way in real life. There is, of course, within Popper's philosophy, a clear distinction between *knowledge* and *non-knowledge. Knowledge*, and especially *scientific knowledge*, emerges when falsifiable conjectures (theoretical or observational) are subjected to a process of severe attempted falsification and survive this sceptical scrutiny unscathed, unfalsified. *Non-knowledge* consists of factual conjectures that have not been subjected to this process of attempted falsification, or have been subjected to the process, and have fallen by the wayside. It would seem, intuitively, that we have much better reasons for trusting a proposition that has been subjected to sustained attempted falsification, and has survived, than we have for trusting a proposition that has not been so subjected (other things being equal). But Popper is emphatic that no such reasons exist. Highly corroborated scientific theories (i.e. theories that have survived severe testing unscathed) are just as conjectural as unfalsified, uncorroborated theories. Corroboration does not increase certainty.

One way in which a Popperian might seek to draw a distinction between parts of our knowledge that are more, and less, secure, is in terms of the distinction between *observational* and *theoretical* knowledge. Scientific theories, for Popper, are strictly universal: they apply, potentially, to phenomena at all times and places. Observation statements can be interpreted as applying to some quite specific state of affairs at some specific time and place: what this piece of apparatus does in this laboratory at 2 o'clock this afternoon. Observation statements, being restricted to some specific time and place, have far less empirical content than testable universal statements, and thus are capable of being far more secure epistemologically. And just this is assumed by the whole process of testing theories empirically. It is always possible, when a theory clashes with an observation, that the theory is correct and the observation is wrong, but in general, and in the long-term, it is theory that has to give way to observation.

It has sometimes been argued that this distinction between theoretical and observational statements cannot be maintained, as observation statements are "theory-laden", in that they attribute *dispositional* properties to things, and thus invoke universal laws. There can be no doubt that observation statements do attribute dispositional properties to things, implicit in such descriptions as "This piece of copper wire" and "this glass tube". But such statements can be interpreted as implying that the object in question would behave in such and such ways in such and such circumstances, and not that all such objects – all pieces of copper wire at all times and places – will behave in the required ways.

We do have here, then, some sort of basis for distinguishing between more certain and less certain parts of knowledge, within Popper's philosophy. But Popper himself gives scant support for such a view. He makes it quite clear that he is as much a conjecturalist about observational or basic statements as he is about theories. Thus he says "The basic statements at which we stop, which we decide to accept as satisfactory, and as sufficiently tested, have admittedly the character of *dogmas*. . . But this kind of dogmatism is innocuous since, should the need arise, these statements can easily be tested further." And he goes on to say "Experiences can *motivate a decision*, and hence an acceptance or rejection of a basic statement, but a basic statement cannot be *justified* by them – no more than by thumping the table" (Popper, 1959, p. 105).

The distinction we all draw, in real life, between, on the one hand, factual issues about which we can be so confident we routinely entrust our lives to their truth and, on the one hand, factual issues that we deem to be so speculative, so uncertain, we would not bet a penny on their truth, seems to have, for Popper, no *rational* basis. It is a *psychological* distinction, not a valid *epistemological* one. The more a factual claim becomes *corroborated* so, ordinarily, the more we come to have confidence in its truth (or in the truth of its standard empirical consequences[1]), but this, for Popper, is entirely unwarranted. Corroboration, for Popper, does nothing to increase certainty.

Is this a serious failure of Popper's philosophy? Or is Popper correct, here, and our habitual assumption that well-corroborated theories are more reliable and trustworthy than unrefuted uncorroborated ones is an illusion? Some light is thrown on this question, I claim, by consideration of another, and much more serious, problem confronting Popper's philosophy of science, to which I now turn.

Popper famously claimed to have solved the problem of induction (Popper, 1972, p. 2), but he did not. It is important to appreciate that the problem of induction comes in three parts. There is the *methodological* part: What are the methodological principles governing selection of theories in science? There is what may be called the *theoretical* part: How can acceptance of theories in science be justified, granted that the aim is to acquire theoretical knowledge? And there is the *practical* part: How can acceptance of theories in science be justified granted that the aim is to accept theories whose standard empirical predictions are sufficiently reliable to be a basis for action? It was, in a sense, this third, *practical* part of the problem that was touched on above.

Once these three parts have been distinguished, it is clear that the *methodological* part needs to be solved before one can sensibly tackle the *theoretical* and *practical* parts. One of the reasons why the problem of induction has remained unsolved for so long is that all the effort has gone into solving the *practical* problem even though the preliminary *methodological* problem has not been solved (which means one seeks to justify the unjustifiable, a project inevitably doomed to failure). Most philosophers probably hold that Popper fails to solve the problem of induction because he fails to solve the *practical* problem. But his failure is much more serious than that. He fails to solve even the preliminary *methodological* problem.

The methodology specified in (Popper, 1959) requires that those theories be accepted which are exactly the wrong theories to be accepted – theories which would never be accepted in scientific practice ever. Given that theory T_1 has been falsified, T_2 is to be accepted if (1) it successfully predicts all that T_1 successfully predicts, (2) successfully predicts the phenomena that falsified T_1, (3) has excess empirical content over T_1, and (4) some of this excess content is corroborated. But (1) to (4) can easily be fulfilled by a theory which amounts to no more than (a) T_1 modified in an *ad hoc* way so as to predict phenomena that falsified T_1, and (b) has additional independently testable and corroborated hypotheses, h_1, h_2, …h_n added on to T_1. The resulting theory, T_2, satisfies all of Popper's requirements, (1) to (4) for being a better theory. Furthermore, given any accepted physical theory (Newtonian theory, classical electrodynamics, general relativity or quantum theory), it will always be possible, in the way indicated, to concoct endlessly many "patchwork quilt" theories that are better, according to (1) to (4).

Such theories are, it may be objected, horribly complex or disunified, in that they consist of diverse theoretical bits and pieces stuck artificially together, and are to be rejected on that account. That is exactly right. But the doctrine of (Popper, 1959) provides no basis for rejecting such "patchwork quilt" theories on such grounds whatsoever. There is, it is true, an account of what it is for a theory to be "simple". The more falsifiable a theory is, so the simpler it is.[2] What this means is that, according to this notion, the "patchwork quilt" theory, T_2, is actually simpler than T_1 (according to Popper's notion of simplicity), and thus more acceptable. The appeal to Popper's notion of simplicity just makes things worse. Not only does it fail to overcome the problem; it reveals that there is an additional defect in (Popper, 1959), namely the account it provides of simplicity. Popper's methodology, in short, persistently requires that theories be accepted that are, in scientific practice, quite properly never considered for a moment. This amounts to a lethal refutation of the methodology.

Subsequently, Popper developed a somewhat more adequate account of simplicity. He says that a "new theory should proceed from some *simple, new, and powerful, unifying idea* about some connection or relation (such as gravitational attraction) between hitherto unconnected things (such as planets and apples) or facts (such as inertial and gravitational mass) or new 'theoretical entities' (such as field and particles)" (Popper, 1963, p. 241). This "*requirement of simplicity*" is, as Popper acknowledges, "a bit vague" (to say the least), but if interpreted as making a substantial demand, it may be regarded as ruling out the "patchwork quilt" theories indicated above which, very strikingly, do not proceed from any "*simple, new"* or "*powerful, unifying idea*".

But in doing this, it commits science, in an implicit, unacknowledged way, to making a substantial *untestable*, i.e. *metaphysical*, assumption about the world, namely that the world is such that all theories which fail to proceed from some "*simple … unifying idea*" are false.[3] For theories of this type, even though being more empirically successful than accepted theories, are never even considered by science. This implicit metaphysical assumption[4] is accepted by science as a part of knowledge so firmly that theories that clash with it are rejected even though being empirically more successful than accepted theories.[5] This, of course, contradicts Popper's demarcation requirement, namely that a factual proposition, in order to be a part of scientific knowledge, must at least be falsifiable[6] (and hence not metaphysical). Furthermore, the attempt to do science in accordance with Popper's demarcation principle violates, in a quite fundamental way, the spirit of his philosophy, in that it leads to the metaphysical assumption being accepted only surreptitiously, and thus being protected from criticism.

The really important point to appreciate is that this metaphysical assumption of simplicity or unity is profoundly problematic. Even if it is true, it is almost certainly not true in the form in which it is implicitly accepted at any given stage in the development of science. A glance at the history of physics reveals that the specific form the assumption has taken has changed dramatically several times as physics has advanced. In the 17th century it took the form of the corpuscular hypothesis: everything is made up of minute, rigid corpuscles that interact only by contact. In the 18th century this morphed into the assumption that everything is made up of point-particles which interact by means of rigid forces at a distance, which in turn morphed into the assumption that everything is made up of a unified field, which has become, in our time, the assumption that everything is made up of tiny quantum strings in ten or eleven dimensions of space-time. No doubt this latest version of the assumption will fall by the wayside in the future, and will be replaced by something quite different.[7]

Thus, even if there is some kind of unity of physical law in nature, almost certainly it is not the specific kind of unity presupposed at any given stage in the development of science. It is vital, for science itself (for good Popperian reasons) that this assumption is made explicit within science, so that it may be subjected to sustained criticism in the hope of it being *improved*. At once the question arises: How can such criticism be organized so as best to facilitate scientific progress? What kind of methodology – or meta-methodology – gives us our best bet of *improving* the metaphysical assumption of unity, thus facilitating scientific progress?

This fundamental question simply does not arise given Popper's falsificationism, since this denies that any such metaphysical assumption of unity is made by the methods of science. It does arise, perhaps, in a weakened form, if one takes seriously Popper's mature remarks about "scientific research programmes" (Popper, 1976, sections 33 and 37; 1983, section 23; 1982, sections 20-28). Popper acknowledged that metaphysical ideas have played an important role in science in the context of discovery, in suggesting ideas for new theories, but he never recognized that persistent acceptance of unified theories in physics, even against the evidence, means that science makes a persistent metaphysical assumption of unity, this having the status of scientific *knowledge*. Failing to see this, Popper fails to see even the *problem* of how such metaphysical knowledge is to be critically assessed and improved; he certainly fails to solve the problem.[8]

In order to solve this problem of subjecting metaphysical assumptions of science to sustained critical scrutiny, we need to adopt and implement a new conception of science, which I have called *aim-oriented empiricism* (AOE): see (Maxwell, 1974; 1984, ch. 9; 1993; 2002; 2004a; and especially 1998, and 2004b, chs. 1, 2 and the appendix). As I have expounded and defended AOE in some detail elsewhere, here I will be brief. The basic idea is that we need to construe physics (and therefore science) as making a *hierarchy* of metaphysical assumptions concerning the comprehensibility and knowability of the universe, these assumptions becoming less and less substantial, more and more necessary for science and knowledge to be possible at all, as we ascend the hierarchy, and thus becoming increasingly likely to be *permanent* presuppositions of science: see diagram.

The idea is that by means of this hierarchy we separate out what is most likely to be true, and not in need of revision, at and near the top of the hierarchy, from what is most likely to be false, and most in need of criticism and revision, near the bottom of the hierarchy. Evidence, at level 1, and assumptions high up in the hierarchy, are rather firmly accepted, as being most likely to be true (although still open to revision): this is then used to criticize, and to try to improve, theses at levels 2 and 3 (and perhaps 4), where falsity is most likely to be located. Furthermore, this hierarchical structure helps to determine in what ways theories and assumptions, at levels 2 and 3, need to be revised to give the best hope of progress; evidence at level 1, and assumptions at levels 4 and 5, constrain modifications to theses at levels 2 and 3.

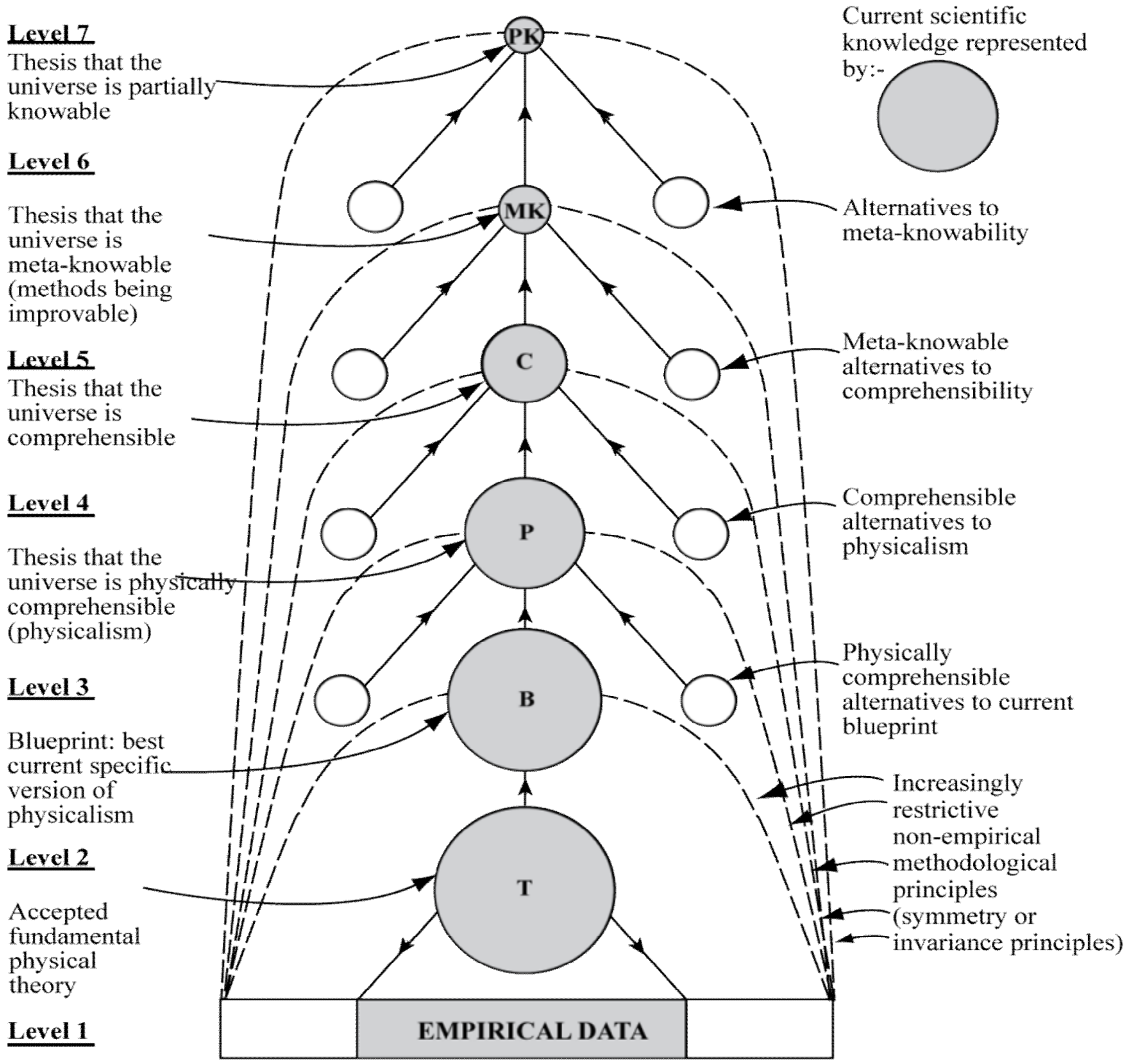

Diagram: Aim-Oriented Empiricism (AOE)

At the top there is the relatively insubstantial assumption that the universe is such that we can acquire some knowledge of our local circumstances. If this assumption is false, we will not be able to acquire knowledge whatever we assume. We are justified in accepting this assumption permanently as a part of our knowledge, even if we have no grounds for holding it to be true. At level 5 there is the rather substantial assumption that the universe is comprehensible in some way or other, the universe being such that there is just one kind of explanation for all phenomena. At level 4 there is the more specific, and thus more substantial assumption that the universe is *physically* comprehensible, it being such that there is some yet-to-be-discovered, true, unified, physical “theory of everything". At level 3 there is the even more specific, and thus even more substantial assumption that the universe is physically comprehensible in a more or less specific way, suggested by current accepted fundamental physical theories. At this level we have the assumptions already indicated: the corpuscular hypothesis, the point-particle hypothesis, the unified field hypothesis, and so on. Given the historical record of dramatically changing ideas at this level, and given the relatively highly specific and substantial character of successive assumptions made at this level, we can be reasonably confident that the best assumption available at any stage in the development of physics at this level will be false, and will need future revision. At level 2 there are the accepted fundamental theories of physics, currently general relativity, and the so-called standard model, quantum field theories of fundamental particles and the forces between them. Here, if anything, we can be even more confident that current theories are false, despite their immense empirical success. This confidence comes partly from the vast empirical content of these theories, and partly from the historical record. The greater the content of a proposition the more likely it is to be false; the fundamental theories of physics, general relativity and the standard model have such vast empirical content that this in itself almost guarantees falsity. And the historical record backs this up; Kepler's laws of planetary motion, and Galileo's laws of terrestrial motion are corrected by Newtonian theory, which is in turn corrected by special and general relativity; classical physics is corrected by quantum theory, in turn corrected by relativistic quantum theory, quantum field theory and the standard model. Each new theory in physics reveals that predecessors are false. Indeed, if the level 4 assumption of AOE is correct, then all current physical theories are false, since this assumption asserts that the true physical theory of everything is unified, and the totality of current fundamental physical theory, general relativity plus the standard model, is notoriously disunified. Finally, at level 1 there are accepted empirical data, low level, corroborated empirical laws.

In order to be acceptable, an assumption at any level from 6 to 3 must (as far as possible) be compatible with, and a special case of, the assumption above in the hierarchy; at the same time it must be (or promise to be) empirically fruitful in the sense that successive accepted physical theories increasingly successfully accord with (or exemplify) the assumption. At level 2, those physical theories are accepted which are sufficiently (a) empirically successful and (b) in accord with the best available assumption at level 3 (or level 4). Corresponding to each assumption, at any level from 7 to 3, there is a methodological principle, represented by sloping dotted lines in the diagram, requiring that theses lower down in the hierarchy are compatible with the given assumption.

When theoretical physics has completed its central task, and the true theory of everything, T, has been discovered, then T will (in principle) successfully predict all empirical phenomena at level 1, and will entail the assumption at level 3, which will in turn entail the assumption at level 4, and so on up the hierarchy. As it is, physics has not completed its task, T has not been discovered, and we are ignorant of the precise nature of the universe. This ignorance is reflected in clashes between theses at different levels of AOE. There are clashes between levels 1 and 2, 2 and 3, and 3 and 4. The attempt to resolve these clashes drives physics forward.

In seeking to resolve these clashes between levels, influences can go in both directions. Thus, given a clash between levels 1 and 2, this may lead to the modification, or replacement of the relevant theory at level 2; but, on the other hand, it may lead to the discovery that the relevant experimental result is not correct for any of a number of possible reasons, and needs to be modified. In general, however, such a clash leads to the rejection of the level 2 theory rather than the level 1 experimental result; the latter are held onto more firmly than the former, in part because experimental results have vastly less empirical content than theories, in part because of our confidence in the results of observation and direct experimental manipulation (especially after expert critical examination). Again, given a clash between levels 2 and 3, this may lead to the rejection of the relevant level 2 theory (because it is disunified, *ad hoc*, at odds with the current metaphysics of physics); but, on the other hand, it may lead to the rejection of the level 3 assumption and the adoption, instead, of a new assumption (as has happened a number of times in the history of physics, as we have seen). The rejection of the current level 3 assumption is likely to take place if the level 2 theory, which clashes with it, is highly successful empirically, and furthermore has the effect of increasing unity in the totality of fundamental physical theory overall, so that clashes between levels 2 and 4 are decreased. In general, however, clashes between levels 2 and 3 are resolved by the rejection or modification of theories at level 2 rather than the assumption at level 3, in part because of the vastly greater empirical content of level 2 theories, in part because of the empirical fruitfulness of the level 3 assumption (in the sense indicated above).

It is conceivable that the clash between level 2 theories and the level 4 assumption might lead to the revision of the latter rather than the former. This happened when Galileo rejected the then current level 4 assumption of Aristotelianism, and replaced it with the idea that "the book of nature is written in the language of mathematics" (an early precursor of our current level 4 assumption). The whole idea of AOE is, however, that as we go up the hierarchy of assumptions we are increasingly unlikely to encounter error, and the need for revision. The higher up we go, the more firmly assumptions are upheld, the more resistance there is to modification.[9]

AOE is put forward as a framework which makes explicit metaphysical assumptions implicit in the manner in which physical theories are accepted and rejected, and which, at the same time, facilitates the critical assessment and improvement of these assumptions with the improvement of knowledge, criticism being concentrated where it is most needed, low down in the hierarchy. Within a framework of relatively insubstantial, unproblematic and permanent assumptions and methods (high up in the hierarchy), much more substantial, problematic assumptions and associated methods (low down in the hierarchy) can be revised and improved with improving theoretical knowledge. There is something like positive feedback between improving knowledge and improving (low-level) assumptions and methods – that is, knowledge-about-how-to-improve-knowledge. Science adapts its nature, its assumptions and methods, to what it discovers about the nature of the universe. This, I suggest, is the nub of scientific rationality, and the methodological key to the great success of modern science. AOE specifies a framework of fixed assumptions and associated methods (high up in the hierarchy) within which much more specific, problematic, evolving assumptions and associated methods (low down in the hierarchy) may be critically assessed and improved.

As an integral part of solving the problem of specifying precisely the methods that determine what theories are to be accepted and rejected in science, AOE also solves the problem of what it is to assert of a theory that it is unified (something no other account of scientific method succeeds in doing). Briefly, a theory is unified if its *content*, what it *asserts about phenomena*, is unified. The theory must assert that *the same laws* apply to all phenomena to which the theory applies. It turns out that there are eight distinct ways in which laws of a theory can differ, in different regions of the space of all possible phenomena predicted by the theory. This provides a way of specifying *degrees* of disunity. In giving precision to the idea of a theory being unified in this way, AOE gives precision to that part of scientific method which asserts that acceptable theories must be unified. (For details see Maxwell, 1998, chs. 3 and 4; 2004b, appendix, section 2.)

AOE solves the key *methodological* part of the problem of induction, something which no rival conception of science succeeds in doing. But this solution would seem to make the problem of certainty, with which we began, all the more severe. For in accepting physical theories – or their well-tried empirical consequences – we thereby accept some quite substantial metaphysical conjecture about the entire cosmos, namely that it is physically comprehensible. Grant that we somehow know for certain that the universe is physically comprehensible, then we have rather good grounds for putting our trust in the reliability of standard empirical predictions of well-corroborated theories. But we do not, and cannot, know for certain that the universe is physically comprehensible: this must remain a metaphysical conjecture. Hence all our theoretical knowledge in science – or in physics at least – is irredeemably conjectural in character.

The situation is even worse than this. Take the humble, particular, common sense knowledge with which we began: our ordinary confidence that we can drive across a bridge without it collapsing or that, more prosaically, we can walk across a room: even these items of banal but essential knowledge contain implicit cosmological presuppositions. An assertion like R: "This room will continue to exist for the next minute" requires, for its truth, the truth of the *cosmological* thesis, C: "it is not the case that some unprecedented cosmic convulsion is occurring at the other end of the universe which will spread infinitely fast to engulf and destroy the room in the next second or two". I only *know* R if I *know* C. I cannot possibly *know* C; hence I cannot possibly *know* R.

This simple argument is, in my view, decisive. All common sense, factual knowledge (or what we ordinarily take to be knowledge), however limited in scope, specific and humble, that is in the slightest bit useful and practical in the sense that it inches into the future, in however restricted a fashion, contains a cosmological dimension, and thus must be irredeemably conjectural in character.

The outcome of the discussion so far just seems to intensify the conjectural character of all our knowledge. Not just theoretical scientific knowledge, but even limited observational and experimental knowledge and ordinary, practical, common sense knowledge, inching however slightly into the future, contains a cosmological dimension, and is thus inherently conjectural in character. What light, then, can the above proposed solution to the *methodological* part of the problem of induction throw on the question of the certainty of knowledge when it just seems, if anything, to make things even worse?

I have three points to make to conclude this essay. The first is this. Accept AOE, accept that the level 4 thesis of physicalism is a part of our knowledge, and a sharp distinction can be drawn between *certainty* and *speculation* - a distinction that eludes Popper's account of the matter. Briefly, and roughly, factual propositions which are sufficiently well corroborated and sufficiently in accord with physicalism fall into the category of trustworthy knowledge; all other factual propositions that have not been falsified fall into the category of mere speculation. This, I claim, reflects the way we actually demarcate *trustworthy knowledge* from *mere speculation*. To take an example considered by John Worrall (1989), we do not jump off the top of the Eiffel tower, entrusting our life to the truth of the conjecture that we will float gently down to the ground because this conjecture fails to satisfy the two requirements for trustworthy knowledge. It is no doubt possible to concoct a theory that is more acceptable, according to the methodology of (Popper, 1959), than Newton's or Einstein's theory of gravitation - a patchwork quilt theory concocted to have greater empirical content and success than either - but such a theory would clash severely with physicalism. This demarcates trustworthy knowledge from speculation, but does not provide a *justification* for the distinction. For that, some kind of justification of physicalism is required. Is any forthcoming?

This leads me to my second point. Given AOE, it becomes possible to interpret science as improving our *metaphysical* knowledge about the ultimate nature of the universe in a way which is not possible granted the orthodox, standard empiricist view. The metamethodology of AOE is designed specifically to help us develop and accept those metaphysical conjectures which seem the most fruitful from the standpoint of acquiring empirically testable knowledge about the world. They are, in that sense, the most *empirically fruitful* we have come up with, in that they have sustained a more empirically progressive research programme than any rival theses. The metaphysical, cosmological theses of AOE are, quite simply, the best available, those that are the most likely to be true (at their various levels of generality). This does not justify *the truth* of these theses, but it does justify accepting them as a part of scientific knowledge.

My third and final point is this. Before the scientific revolution, there was much more general awareness, than there is today, that what may be called cosmological circumstances could impact, in perhaps drastic and dreadful ways, on the ordinary circumstances of life. Evil spirits might cast spells and bring catastrophe, even death; comets might bring disaster; the gods might send drought, locusts, storm, the plague, and might even destroy the world. Then came science, and with it the assurance that the natural world is governed by impersonal, utterly reliable physical law. This, it seemed, had been securely established by Newtonian science. Had not Newton himself demonstrated how physical laws can be verified by induction from phenomena|? There remained the niggling philosophical puzzle as to how it is possible to verify laws by means of induction, but this irritating puzzle of induction is best left to philosophers to waste their time on.

This rather common attitude – common at least until recently (scepticism about science having recently become much more widespread) – rests, I suggest, on an illusion. Newton did not establish his law of gravitation by induction from the phenomena, as he claimed to have done. He could not have done this, because it cannot be done.

As it happens, Newton himself anticipated a basic feature of AOE. He recognized explicitly that scientific method makes presuppositions about nature. Three of his four rules of reason, concerned with simplicity, quite explicitly make assumptions about the nature of the universe. Thus rule 1 asserts: "*We are to admit no more causes of natural things than such as are both true and sufficient to explain their appearances*." And Newton adds: "To this purpose the philosophers say that nature does nothing in vain, and more is in vain when less will serve; for Nature is pleased with simplicity, and affects not the pomp of superfluous causes" (Newton, 1962, p. 398). Newton understood that persistently preferring simple theories means that Nature herself is being persistently assumed to be simple.

But this aspect of Newton's thought came to be overlooked. The immense, unprecedented success of natural science after Newton was taken to demonstrate that humanity had somehow discovered the secret of wresting truth and certainty from nature, and only the incompetence of philosophers prevented everyone from knowing exactly what this secret amounted to. Even today there are philosophers who think that the problem of induction will only be solved when this secret of how scientists manage to capture truth and certainty is laid bare for everyone to see and understand.

But this is an illusion. Even our most humdrum, particular, practical knowledge of aspects of our immediate environment, as we have seen, let alone the mighty claims to knowledge of science, contains a cosmological element which must remain conjectural. Modern science has, it seems, made a profound discovery about the ultimate nature of the cosmos, namely that it is physically comprehensible. Once AOE is accepted, it becomes clear that this thesis, despite its *metaphysical* and *cosmological* character, is one of the most firmly established theoretical propositions of science (in that physical theories, in order to be accepted, must accord with this proposition as far as possible, and theories which clash with it too stridently are not even considered, even though they would be much more empirically successful than accepted theories if considered). Given this cosmological thesis that the universe is physically comprehensible, the way we in practice distinguish trustworthy knowledge from mere speculation becomes clear. Nevertheless, despite its central place and role in science, the thesis remains inherently conjectural in character. Practical certainty has this usually unacknowledged conjectural and cosmological dimension inherent in it.

As it is, our attitude towards the thesis that the universe is physically comprehensible is highly hypocritical. The fundamental role that it plays in science, in technology, in our whole culture and way of life, is denied. Non-scientists deny it because they do not want to confront the grim implications the thesis has for the meaning and value of human life – the difficulty of seeing how there can be consciousness, freedom, meaning and value if the universe really is physically comprehensible.[10] Scientists deny it, because they do not want to acknowledge that there is an element of *faith* in science. They confidently distinguish science from religion on the grounds that, whereas religion appeals to dogma and faith, in science there is no faith and everything is assessed impartially with respect to evidence. But this, as we have seen, is nonsense. There is an element of faith in science too. The real difference between science and religion – most dogmatic religions that is – is that whereas science subjects its articles of faith to sustained critical scrutiny, modifying them in the direction of that which seems most fruitful from the standpoint of the growth of knowledge, dogmatic religion does nothing of the kind.

A more honest recognition of the presence of cosmological conjectures inherent in science, and inherent even in our most humble items of practical knowledge would involve recognizing that all our knowledge is indeed conjectural in character without, thereby, destroying the distinction we make between practical certainty and speculation.

Does AOE solve all three parts of the problem of induction, insofar as they can be solved, and not just the *methodological* part? Elsewhere I have argued that AOE does indeed do this: see (Maxwell, 1998, ch. 5; 2004b, appendix, section 6; and 2005).

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Notes

[1] This qualification is essential. Many scientific theories, like Newtonian theory, highly corroborated at one stage, turn out subsequently to be false, even though most of their standard empirical consequences continue to be true.

[2] There is another account of simplicity in (Popper, 1959), but Popper quite properly declares that if the two conflict, the one indicated in the text takes precedence.

[3] Unified theories imply countless approximate, disunified theories. If there is a true, unified "theory of everything", T, then there will be countless true, approximate, disunified theories, implied by T. The metaphysical assumption implicit in those methods of science that rule out acceptance of disunified theories must be formulated to assert "no disunified theory is true *that cannot be derived from a true unified theory*".

[4] That the assumption is untestable, and thus metaphysical, can easily be seen as follows. It asserts, roughly, that all disunified theories are false, that is "not T_1 & not T_2 & … not T_∞", where

T_1, T_2, … T_∞ are the infinitely many disunified theories. In order to falsify this proposition, just one of T_1, T_2, … T_∞ needs to be verified, but physical theories cannot be verified. In order to verify the proposition, all of the theories T_1, T_2, … T_∞ need to be falsified, but as there are infinitely many of them, this cannot be done either. The proposition in question, being neither verifiable nor falsifiable, is thus untestable and metaphysical.

[5] For more detailed developments of this argument see (Maxwell, 1974; 1984, ch. 9; 1993; 1998, ch.2; 2002; 2004a; 2004b, ch. 1, and appendix, section 1).

[6] More correctly perhaps, a factual proposition, in order to be a part of scientific knowledge, must be either falsifiable on its own, or an ingredient of a falsifiable theory which would be less falsifiable were the proposition in question to be removed.

[7] For a suggestion of my own see my (2004b, appendix, section 5).

[8] In (Popper, 1959, pp. 31-32), there is a sharp distinction between the contexts of discovery and justification, methodology being concerned only with the latter. Metaphysical ideas associated with science, arising for Popper only in the context of discovery, play no part in scientific method. But once it is acknowledged that metaphysical ideas, implicit in the persistent rejection of empirically successful disunified theories, are a permanent part of *scientific knowledge itself*, it becomes clear that any adequate theory of scientific method must take these metaphysical ideas into account. It was this that Popper never appreciated.

[9] In my (2004b, appendix, section 5), I put forward a rival to the level 4 thesis of physicalism.

[10] Elsewhere I have sought to show how consciousness, free will, the experiential world, meaning and value can exist even though the universe is physically comprehensible: see (Maxwell, 1966; 1968; 1984, ch. 10; and especially 2001).