Scientific Metaphysics

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1 - Introduction

In this paper I argue that physics makes metaphysical presuppositions concerning the physical comprehensibility, the dynamic unity, of the universe. I argue that rigour requires that these metaphysical presuppositions be made explicit as an integral part of theoretical knowledge in physics. An account of what it means to assert of a theory that it is unified is developed, which provides the means for partially ordering dynamical physical theories with respect to their degrees of unity. This in turn makes it possible to assess the empirical fruitfulness of (some) metaphysical theses, in terms of the extent to which they play a role in empirically progressive scientific research programmes. A new conception of physics is developed which makes metaphysical theses an integral part of physics and which, at the same time, makes it possible to assess such theses in terms of their empirical fruitfulness. Circularity objections are rebutted.

Two comments. First, the conception of physics to be expounded and defended here is not entirely new, in that versions have been expounded elsewhere (see especially Maxwell, 1998; see also Maxwell, 1974; 1976, ch. 6; 1984, chs. 5 and 9; 1993; 1997; 1999; 2000; 2001, ch. 3 and appendix 3; 2002). Here I give radically improved arguments for a radically improved version of the view. Second, my title "Scientific Metaphysics" sounds like a contradiction in terms in view of Popper's well-known demarcation criterion which rules that metaphysical theses, being unfalsifiable, are not scientific. But Popper's falsificationist conception of science, along with others, will be found to be defective precisely because of a failure to acknowledge the role that metaphysical assumptions play in science. Furthermore, as I have indicated, a framework will be developed which makes it possible to appraise (untestable) metaphysical theses empirically, in terms of their "empirical fruitfulness", or fruitfulness for empirically successful theory. For physics to be rigorous, it will be argued, it is essential that metaphysical theses are acknowledged as key components of theoretical knowledge in physics, and are appraised empirically in terms of their "empirical fruitfulness". Once the conception of physics defended here is accepted, the title entirely loses its air of being self-contradictory.[1]

2 – Intellectual Rigour Requires that Metaphysical Presuppositions be made Explicit

Many views about science deny that science makes a substantial, persistent, metaphysical (i.e. untestable) assumption about the universe. This is true, for example, of logical positivism, inductivism, logical empiricism, hypothetico-deductivism, conventionalism, constructive empiricism, pragmatism, realism, induction-to-the-best-explanationism, and the views of Popper, Kuhn and Lakatos. All these views, diverse as they are in other respects, accept a thesis that may be called standard empiricism (SE): in science, theories are accepted on the basis of empirical success and failure, and on the basis of simplicity, unity or explanatoriness, but *no substantial thesis about the world is accepted permanently by science, as a part of scientific knowledge, independently of empirical considerations*.[2]

The following argument shows however that SE is untenable.

Whenever a fundamental physical theory is accepted as a part of theoretical scientific knowledge there are always endlessly many rival theories which fit the available evidence just as well as the accepted theory. Consider, for example, Newtonian theory

(NT). One rival theory asserts: everything occurs as NT asserts up till midnight tonight when, abruptly, an inverse cube law of gravitation comes into operation. A second rival asserts: everything occurs as NT asserts, except for the case of any two solid gold spheres, each having a mass of a thousand tons, moving in otherwise empty space up to a mile apart, in which case the spheres attract each other by means of an inverse cube law of gravitation. There is no limit to the number of rivals to NT that can be concocted in this way, each of which has all the predictive success of NT as far as observed phenomena are concerned but which makes different predictions for some as yet unobserved phenomena.[3] Such theories can even be concocted which are *more* empirically successful than NT, by arbitrarily modifying NT, in just this entirely *ad hoc* fashion, so that the theories yield correct predictions where NT does not, as in the case of the orbit of Mercury for example (which very slightly conflicts with NT).[4] And quite generally, given any accepted physical theory, T, there will always be endlessly many *ad hoc* rivals which meet with all the empirical success of T, make untested predictions that differ from T, are empirically successful where T is ostensibly refuted, and successfully predict phenomena about which T is silent (as a result of independently testable and corroborated hypotheses being added on).

As most physicists and philosophers of physics would accept, *two* criteria are employed in physics in deciding what theories to accept and reject: (1) empirical criteria, and (2) criteria that have to do with the simplicity, unity or explanatory character of the theories in question. (2) is absolutely indispensable, to such an extent that there are endlessly many theories empirically more successful than accepted theories, all of which are ignored because of their lack of unity.

Now comes the crucial point. In persistently accepting unifying theories (even though ostensibly refuted), and excluding infinitely many empirically more successful, unrefuted, disunified or aberrant rival theories, science in effect makes a big assumption about the nature of the universe, to the effect that it is such that no disunified theory is true, however empirically successful it may appear to be for a time. Furthermore, without some such big assumption as this, the empirical method of science collapses. Science would be drowned in an infinite ocean of empirically successful disunified theories.[5]

If scientists only accepted theories that postulate atoms, and persistently rejected theories that postulate different basic physical entities, such as fields - even though many field theories can easily be, and have been, formulated which are even more empirically successful than the atomic theories - the implications would surely be quite clear. Scientists would in effect be assuming that the world is made up of atoms, all other possibilities being ruled out. The atomic assumption would be built into the way the scientific community accepts and rejects theories – built into the implicit *methods* of the community, methods which include: reject all theories that postulate entities other than atoms, whatever their empirical success might be. The scientific community would accept the assumption: the universe is such that no non-atomic theory is true.

Just the same holds for a scientific community which rejects all disunified or aberrant rivals to accepted theories, even though these rivals would be even more empirically successful if they were considered. Such a community in effect makes the assumption: the universe is such that no disunified theory is true. Or rather, more accurately, such a community makes the assumption: "no disunified theory is true *which is not entailed by a true unified theory (plus, possibly, true relevant initial and boundary conditions)*". (A true unified theory entails infinitely many approximate, true, disunified theories.) Let us call this assumption "physicalism".

That physicalism is metaphysical can be shown as follows. Physicalism asserts "not T_1 and not T_2 and . . . and not T_∞", where T_1, T_2, . . . T_∞ are infinitely many disunified rivals to accepted physical theories. Physicalism cannot be empirically verified, because this would require that all of T_1, T_2, . . . T_∞ are falsified, but as there are infinitely many of these theories, each requiring a different falsifying experiment, this cannot be done. Equally, physicalism cannot be falsified, as this requires the verification of at least one of T_1, or T_2, . . .or T_∞, which cannot be done as physical theories cannot be verified empirically. Hence physicalism, being neither verifiable nor falsifiable, is metaphysical.

Thus in persistently rejecting empirically more successful but disunified rivals to accepted physical theories, science makes a persistent metaphysical assumption about the world, namely physicalism. Standard empiricism (SE), and all the above doctrines that include SE as a component, are untenable.

Let us call the view that science presupposes physicalism "presuppositionism". Presuppositionism is more rigorous than all the above versions of SE *entirely independent of any justification for accepting physicalism as a part of scientific knowledge* (that is in addition to the one given above). In saying this I am appealing to the following wholly uncontroversial requirement for rigour.

Principle of Intellectual Rigour (PIR) In order to be rigorous, it is necessary that assumptions that are substantial, influential and problematic be made explicit - so that they can be criticized, so that alternatives may be developed and assessed, with the aim of improving the assumptions.[6]

All versions of SE fail to satisfy PIR in just the way in which presuppositionism does satisfy PIR. Presuppositionism makes the assumption of physicalism explicit (and so criticizable and, we may hope, improvable), while all versions of SE deny that science does make any such assumption as physicalism. Thus, quite independent of any claim to solve the problem of induction, presuppositionism is more rigorous, and thus more acceptable, than any of the above versions of SE. And this is the case *even though presuppositionism can provide no justification for accepting physicalism*. It is indeed above all when we have no reason whatsoever for supposing physicalism is true that it becomes all the more important to implement PIR, and make the probably false assumption of physicalism explicit, so that it can be critically assessed, so that alternatives can be considered, in the hope that a thesis nearer the truth can be discovered.

Why has this simple argument been ignored by the vast literature on the problem of induction (or underdetermination), referred to in note 3? Two factors are perhaps at work. First, accepting the argument involves acknowledging that science, as it is ordinarily understood (in terms of standard empiricism), lacks rigour. Our understanding of science, and even science itself, need to change if science is to become rigorous and make explicit, and critically assess, implicit, problematic metaphysical presuppositions. Philosophers, tackling the problem of induction, have perhaps been reluctant to take seriously that science, as ordinarily understood, is irrational and needs to be changed. Second, invoking a metaphysical presupposition of unity looks superficially like a well-known and hopelessly invalid approach to the problem of induction: justify scientific theory by an appeal to a metaphysical principle uniformity, and then justify this metaphysical principle by an appeal to the success of science. Aware of the vicious circularity of any such argument, philosophers have instinctively resisted considering the superficially similar, but actually very different, point that rigour requires that substantial, influential, problematic and implicit metaphysical presuppositions need to be made explicit – so that they can be critically assessed and, we may hope, improved.

Presuppositionism does not, perhaps, entirely solve the problem of underdetermination, but it does, when further developed, transform that philosophical and scientifically sterile problem into the scientifically fruitful problem of developing and choosing the most fruitful metaphysics for physics, as we shall see below.

3 – Unity of Physical Theory

We have seen that physics only accepts theories that are unified, and this commits physics to presupposing physicalism. But what ought physicalism to be interpreted to assert, especially if physics is to comply with PIR? In order to answer this question we first need to solve the problem of what it means to assert of a physical theory that it is *unified*. This is a problem that has long resisted solution.[7] Even Einstein (1949, 23) confessed that he did not know how to solve the problem. In section 2 above I indicated ways in which theories can be disunified. The solution to the problem of what it is for a theory to be unified that I now outline extends and develops the above remarks about disunity.

A dynamical physical theory is unified if and only if its content, what it asserts, is the same throughout the range of possible phenomena to which it applies. This requirement is, however, open to being interpreted in the following eight increasingly stringent ways (the first two of which correspond to the two kinds of disunity indicated in section 2). A dynamical physical theory, T, is disunified to degree N if and only if:

(1) T divides spacetime up into N distinct regions, $R_1...R_N$, and asserts that the laws governing the evolution of phenomena are the same for all spacetime regions within each R-region, but are different in different R-regions.

(2) T postulates that, for distinct ranges of physical variables (other than position and time), such as mass or relative velocity, in distinct regions, $R_1,...R_N$ of the space of all possible phenomena, distinct dynamical laws obtain.[8]

(3) In addition to postulating non-unique physical entities (such as particles), or entities unique but not spatially restricted (such as fields), T postulates, in an arbitrary fashion, N - 1 distinct, unique, spatially localized objects, each with its own distinct, unique dynamic properties.

(4) T postulates physical entities interacting by means of N distinct forces, different forces affecting different entities, and being specified by different force laws. (In this case one would require one force to be universal so that the universe does not fall into distinct parts that do not interact with one another.)

(5) T postulates N different kinds of physical entity, differing with respect to some dynamic property, such as value of mass or charge, but otherwise interacting by means of the same force.

(6) Consider a theory, T, that postulates N distinct kinds of entity (e.g. particles or fields), but these N entities can be regarded as arising because T exhibits some symmetry (in the way that the electric and magnetic fields of classical electromagnetism can be regarded as arising because of the symmetry of Lorentz invariance, or the eight gluons of chromodynamics can be regarded as arising as a result of the local gauge symmetry of SU(3)).[9] If the symmetry group, G, is not a direct product of subgroups, we can declare that T is fully unified; if G is a direct product of subgroups, T lacks full unity; and if the N entities are such that they cannot be regarded as arising as a result of some symmetry of T, with some group structure G, then T is disunified.

(7) If (apparent) disunity of there being N distinct kinds of particle or distinct fields has emerged as a result of a series of cosmic spontaneous symmetry-breaking events, there being manifest unity before these occurred, then the relevant theory, T, is unified. If current (apparent) disunity has not emerged from unity in this way, as a result of spontaneous symmetry-breaking, then the relevant theory, T, is disunified.[10]

(8) According to GR, Newton's force of gravitation is merely an aspect of the curvature of spacetime. As a result of a change in our ideas about the nature of spacetime, so that its geometric properties become dynamic, a physical force disappears, or becomes unified with spacetime. This suggests the following requirement for unity: spacetime on the one hand, and physical particles-and-forces on the other, must be unified into a single self-interacting entity, U. If T postulates spacetime and physical "particles-and-forces" as two fundamentally distinct kinds of entity, then T is not unified in this respect.

For unity, in each case, we require N = 1. As we go from (1) to (5), the requirements for unity are intended to be accumulative: each presupposes that N = 1 for previous requirements. As far as (6) and (7) are concerned, if there are N distinct kinds of entity which are not unified by a symmetry, whether broken or not, then the degree of disunity is the same as that for (4) and (5), depending on whether there are N distinct forces, or one force but N distinct kinds of entity between which the force acts.

(8) introduces, not a new kind of unity, but rather a new, more severe way of counting different kinds of entity. (1) to (7) taken together require, for unity, that there is one kind of self-interacting physical entity evolving in a distinct spacetime, the way this entity evolves being specified, of course, by a consistent physical theory. According to (1) to (7), even though there are, in a sense, two kinds of entity, matter (or particles-and-forces) on the one hand, and spacetime on the other, nevertheless N = 1. According to (8), this would yield N = 2. For N = 1, (8) requires matter and spacetime to be unified into one basic entity (unified by means of a spontaneously broken symmetry, perhaps).

As we go from (1) to (8), then, requirements for unity become increasingly demanding, with (6) and (7) being at least as demanding as (4) and (5), as explained above.[11] It is important to appreciate, however, that (1) to (8) are all versions of the same basic idea that T is unified if and only if the content of T is the same throughout the range of possible phenomena to which it applies. When T is disunified, (1) to (8) specify *different* kinds of difference in the content of T in diverse regions of the space, S, of all possible phenomena to which T applies. Or, equivalently, (1) to (8) divide S into sub-regions in <u>different</u> ways, T having a different content in each sub-region. For (1), sub-regions contain physical systems in different locations in spacetime, the content of T being different in different spacetime locations. For (2), sub-regions contain physical systems with different values of physical variables such as mass or relative velocity. For (3), sub-regions contain systems with different dynamically unique objects. For (4), sub-regions contain systems composed of physical entities interacting by means of different forces. For (5), sub-regions contain systems composed of entities with different dynamical properties such as values of mass or charge. For (6), sub-regions contain systems composed of different entities which cannot be transformed into each other by means of symmetry operations. For (7), sub-regions contain systems composed of different entities which cannot be construed to differ only because of the product of spontaneous symmetry breaking. For (8), S contains one sub-system consisting of empty spacetime, and another consisting spacetime plus some physical entity, and the one cannot be transformed into the other by means of a symmetry operation. We have here eight facets of a single conception of unity.[12]

However, corresponding to these eight facets, (1) to (8), there are eight different metaphysical theses, eight different versions of physicalism, any one of which might be held to be the best choice of presupposition for physics. If T is the true theory of everything,[13] then we have eight different theses, each of the form "T is unified up to sense (n)" where n = 1, 2,... 8. Let us call these eight theses "physicalism(n)", where n = 1, 2, ... 8. (N = 1 unless I state otherwise.) Strictly speaking, there are not eight, but infinitely many different versions of physicalism, depending on the degree of disunity, N, that is asserted for any value of n = 1, . . . 7. (n = 8 is exceptional in this respect.) The different versions of physicalism can be specified to be: physicalism(n, N), with n = 1, …7 and N = 1, 2, … ∞, or with n = 8 and N = 1, 2. A two-dimensional grid is placed over an infinite set of metaphysical theses, distinct versions of physicalism corresponding to distinct appropriate values of the coordinates (n,N), these theses being ordered with respect to degrees of unity.

It deserves to be noted in passing that there is a close connection between the "unity" of a physical theory and its "explanatory power". Explanatory power, one might say, is unity plus empirical content. The above explication of "unity" is thus also an explication of "explanatory power".[14]

4 – Conflicting Desiderata for Acceptability of Metaphysical Theses

Physics must exclude empirically successful disunified theories from consideration if theoretical knowledge in physics is to be possible at all. In persistently excluding such disunified theories, physics thereby makes a persistent metaphysical presupposition, as we saw in section 2. But what ought this presupposition to be? Section 3 has revealed that there are at least eight candidates, namely physicalism(n) with n = 1, . . . 8 (and, potentially, many more if N > 1 for some n.) Which of these is the best choice if physics is to comply with PIR?

This question is particularly hard to answer because conflicting desiderata arise when it comes to considering what metaphysical thesis physics should accept.

On the one hand it is reasonable to argue that that thesis should be accepted which can be shown to be the most conducive to progress in theoretical physics so far. In the next section I will demonstrate that this picks out the relatively specific and contentful thesis of physicalism(8) with N = 1.

On the other hand, however, it is reasonable to argue that that thesis should be accepted which has the least content which is just sufficient to exclude the empirically successful disunified theories that current methods of physics do exclude. We have almost no grounds for holding that any version of physicalism is true, or is more likely to be true than some other version. Whatever we choose, we are very likely to choose a thesis that is false. Our best bet, then, is to choose that thesis which has the least possible content which suffices to exclude those disunified theories that are excluded from physics, since the less the content of a thesis – other things being equal – the more likely it is to be true. As we shall see in section 6 below, this leads to a choice quite different from physicalism(8).

Which of these conflicting lines of argument should be accepted?

In answering this question, I proceed as follows. In section 5 I spell out the argument for holding that physicalism(8) is the most fruitful version of physicalism for physics. In section 6 I spell out the argument for accepting the minimal version of physicalism. And in section 7 I argue that a new conception of physics resolves the conflict.

5 – Empirically Fruitful Metaphysics

Before I plunge into my argument for accepting physicalism(8), there is a preliminary question I must answer: Why does the unique fruitfulness of physicalism(8) for physics, supposing it can be established, provide grounds for its acceptance?

The basic idea of PIR, as it applies to physics, is that substantial, problematic, influential and implicit metaphysical assumptions need to be made explicit so that they can be critically assessed, so that alternatives can be developed and considered, in the hope that assumptions more conducive to progress can be developed and accepted. In other words, according to PIR, that assumption ought to be accepted which seems to be the most conducive to progress in theoretical physics.

It is important to appreciate just how profoundly influential over the success or failure of theoretical physics choice of metaphysical thesis, of the kind we are considering, is likely to be. This influence is exercised in two ways. First, the metaphysical presupposition of a community of physicists influences – even determines – the direction in which physicists look in order to develop new physical theories. If physicists are convinced that the universe is made up of point-atoms which interact by means of centrally-directed, rigid forces – as many were for much of the 19th century – then physicists will persistently seek to develop theories which postulate such entities. Physicists who believe that the basic stuff of the universe is energy may be prompted to develop theories of a rather different type. Secondly, and even more important, the metaphysical presupposition of physics, implicit in non-empirical methods of physics, influences – or co-determines (with evidence) – what theories are accepted and rejected. The success or failure of physics will be highly dependent on whether the non-empirical methods adopted – and thus the corresponding metaphysical theses presupposed – are, or are not, conducive to the selection of theories capable of meeting with empirical success. Adopting the methodological principle "accept only theories that postulate atoms" amounts to presupposing that the universe is made up of atoms: if it is, this presupposition and associated methodological principle may well lead to empirical success. But if the universe is not made up of atoms, adopting this methodological principle and presupposing the associated metaphysical thesis is likely to severely stifle scientific progress.

In short, physics must make some metaphysical presupposition for there to be any theoretical knowledge in physics at all. Since the metaphysical theses in question are about the ultimate nature of the universe, the domain of our ignorance, whatever we assume is almost bound to be false. Accepting a false assumption is likely to severely stifle progress in the theoretical physics. It matters enormously, for the progress of physics, that a good choice of metaphysical thesis is made. Just about the only grounds we have for preferring one thesis to another is that one seems to be more conducive to progress in theoretical physics than another. Thus we ought to prefer that thesis which seems to be the most conducive to progress in physics. This is the choice physics needs to make in order to comply with the requirement of rigour of PIR.

Here, now, are the reasons for holding that physicalism(8) should be the preferred metaphysical thesis for physics, largely because this thesis has proved to be more fruitful for progress in physics than any rival thesis.

First, it deserves to be noted that what needs to be made explicit and accepted, if physics is to comply with PIR, is that thesis which is implicit in the current non-empirical *methods* of physics – methods which determine which theories are to be accepted and rejected on grounds of simplicity, unity, explanatoriness. There can be no doubt that, as far as non-empirical considerations are concerned, the more nearly a new fundamental physical theory satisfies all eight of the above requirements for unity, with N = 1, the more acceptable it will be deemed to be. Furthermore, failure of a theory to satisfy elements of these criteria is taken to be grounds for holding the theory to be false even in the absence of empirical difficulties. For example, high energy physics in the 1960s kept discovering more and more different hadrons, and was judged to be in a state of crisis as the number rose to over one hundred. Again, even though the standard model (the current quantum field theory of fundamental particles and forces) does not face serious empirical problems, it is nevertheless regarded by most physicists as unlikely to be correct just because of its serious lack of unity. In adopting such non-empirical criteria for acceptability, physicists thereby implicitly assume that the best conjecture as to where the truth lies is in the direction of physicalism(8). PIR requires that this implicit assumption – or conjecture – be made explicit so that it can be critically assessed and, we may hope, improved. Physics with physicalism(8) explicitly acknowledged as a part of conjectural knowledge is more rigorous than physics without this being acknowledged because physics pursued in the former way is able to subject non-empirical methods to critical appraisal as physicalism(8) is critically appraised, whereas physics pursued in the latter way cannot do this.

The really important point, however, in deciding what metaphysical assumption of unity to accept, is that what needs to be considered is not just current theoretical knowledge, or current methods, but the whole way theoretical physics has developed during the last 400, or possibly 2,000 years. The crucial question is this: What metaphysical thesis does the best justice to the way theoretical physics has developed during this period in the sense that successive theories increasingly successfully exemplify and give precision to this metaphysical thesis in a way which no rival thesis does? The answer is physicalism(8), as the following considerations indicate.

All advances in theory in physics since the scientific revolution have been advances in unification, in the sense of (1) to (8) above. Thus Newtonian theory (NT) unifies Galileo's laws of terrestrial motion and Kepler's laws of planetary motion (and much else besides): this is unification in senses (1) to (3). Maxwellian classical electrodynamics, (CEM), unifies electricity, magnetism and light (plus radio, infra red, ultra violet, X and gamma rays): this is unification in sense (4). Special relativity (SR) brings greater unity to CEM, in revealing that the way one divides up the electromagnetic field into the electric and magnetic fields depends on one's reference frame: this is unification in sense (6). SR is also a step towards unifying NT and CEM in that it transforms space and time so as to make CEM satisfy a basic principle fundamental to NT, namely the (restricted) principle of relativity. SR also brings about a unification of matter and energy, via the most famous equation of modern physics, $E = mc^2$, and partially unifies space and time into Minkowskian spacetime. General relativity (GR) unifies spacetime and gravitation, in that, according to GR, gravitation is no more than an effect of the curvature of space-time – a step towards unification in sense (8). Quantum theory (QM) and atomic theory unify a mass of phenomena having to do with the structure and properties of matter, and the way matter interacts with light: this is unification in senses (4) and (5). Quantum electrodynamics unifies QM, CEM and SR. Quantum electroweak theory unifies (partially) electromagnetism and the weak force: this is (partial) unification in sense (7). Quantum chromodynamics brings unity to hadron physics (via quarks) and brings unity to the eight kinds of gluons of the strong force: this is unification in sense (6). The standard model unifies to a considerable extent all known phenomena associated with fundamental particles and the forces between them (apart from gravitation): partial unification in senses (4) to (7). The theory unifies to some extent its two component quantum field theories in that both are locally gauge invariant (the symmetry group being U(1)XSU(2)XSU(3)). All the current programmes to unify the standard model and GR known to me, including string theory or M-theory, seek to unify in senses (4) to (8).[15]

In short, all advances in fundamental theory since Galileo have invariably brought greater unity to theoretical physics in one or other, or all, of senses (1) to (8): all successive theories have increasingly successfully exemplified and given precision to physicalism(8) to an extent which cannot be said of any rival metaphysical thesis, at that level of generality. The whole way theoretical physics has developed points towards physicalism(8), in other words, as the goal towards which physics has developed. Furthermore, what it means to say this is given precision by the account of theoretical unity given in section 3 above.

In assessing the relative fruitfulness of two rival metaphysical theses, M_a and M_b, for some phase in the development of theoretical physics that involves the successive acceptance of theories T_1, T_2, ... T_n, two considerations need to be born in mind. First, how potentially fruitful are M_a and M_b, how specific or precise, and thus how specific in the guidelines offered for the development of new theories? Second, how actually fruitful are M_a and M_b, in the sense of how successful or unsuccessful has the succession of theories, T_1, T_2, ... T_n, been when regarded as a research programme with M_a or M_b as its key idea? When both considerations are taken into account, physicalism(8) comes out as more fruitful for theoretical physics from Newton to today than any rival thesis (at its level of generality). Physicalism(7) is not as specific as physicalism(8), and thus not as potentially fruitful, does not do justice to the way GR absorbs the force of gravitation into the nature of spacetime, and does not do justice to current research programmes which seek to unify matter and spacetime. (All of physicalism(n), n = 1, 2, … 7, are scientifically fruitful to some extent, but decreasingly so as n goes down from 7 to 6… to 1, in view of the decreasing specificity and content of these versions of physicalism.)

The notion of "research programme" appealed to here is similar to, but not the same as, the notion developed by Lakatos (1970). The main differences are as follows. For Lakatos, the "hard core" of a research programme was a testable theory rendered metaphysical by a methodological decision; the main research activity associated with a research programme involved developing successful applications of the theory, guided by the "positive heuristic" stemming from the "hard core". (In all this, Lakatos followed Kuhn's conception of "normal science", giving Lakatosian terms to Kuhnian ideas: see (Kuhn, 1970).) In the text, I have assumed that the metaphysics of a research programme is authentic, inherently untestable metaphysics, the main research task being to develop a succession of theories which progressively capture the metaphysics more and more successfully. The account of "degrees of disunity" given in section 3 above provides a precise way of assessing the extent to which successive "totalities of fundamental physical theory" do, or do not, increasingly successfully capture physicalism. Thus, given such a succession, T_1, T_2, …T_m, with degrees of disunity N_1, N_2, … N_m, of type (5-7), with $N_1 > N_2 > \ldots > N_m$, then T_1, T_2, …T_m do progressively capture physicalism(5-7) more and more successfully. There is nothing like this in the Lakatosian account of research programme, lacking as it does the solution to the problem of unity of theory. Finally, there is a substantial difference in the intended application of the two notions. Whereas I see science as a whole as one gigantic research programme, the hierarchy of versions of physicalism being presupposed as the metaphysical "hard core", it is essential to Lakatos's quasi-Popperian conception of science that science is made up of competing research programmes. This means that, for Lakatos, science cannot be viewed as one gigantic Lakatosian research programme (since, if it were, there could be no competitor). Lakatos does say, it is true "Even science as a whole can be regarded as a huge research programme with Popper's supreme heuristic rule; 'devise conjectures which have more empirical content than their predecessors'" (Lakatos, 1970, 132). But there is here no overall Lakatosian "hard core" or "positive heuristic". This is Popper's conception of science and, for Lakatos, his own conception of research programme is strictly inapplicable to science as a whole. For a more detailed comparison and critical assessment of the two views, see (Maxwell, 2005, section 8).[16]

Some philosophers of science hold that the successive revolutions in theoretical physics that have taken place since Galileo or Newton make it quite impossible to construe science as steadily and progressively honing in on some definite view of the natural world (Kuhn, 1970; Laudan, 1980). If attention is restricted to standard empiricism and physical *theory*, this may be the case. But the moment some form of presuppositionism is accepted, and one considers metaphysical theses implicit in the methods of science, a very different conclusion emerges. *All theoretical revolutions since Galileo exemplify the one idea of unity in nature*. Far from obliterating the idea that there is a persistent thesis about the nature of the universe in physics, as Kuhn and Laudan suppose, all theoretical revolutions, without exception, do exactly the opposite in revealing that theoretical physics draws ever closer to capturing the idea that there is an underlying dynamic unity in nature, as specified by physicalism(8).

There is a further point to be made in favour of physicalism(8). So far, every theoretical advance in physics has revealed that theories accepted earlier are false. Thus Galileo's laws of terrestrial motion and Kepler's laws of planetary motion are contradicted by Newtonian theory, in turn contradicted by special relativity, in turn contradicted by general relativity. The whole of classical physics is contradicted by quantum theory, in turn contradicted by quantum field theory. Science advances from one false theory to another. Viewed from a standard empiricist perspective, this seems discouraging and has prompted the view that all future theories will be false as well, a view which has been called "the pessimistic induction" (Newton-Smith, 1981, 14). Viewed from the perspective of science presupposing physicalism(8), however, this mode of advance is wholly encouraging, since it is required if physicalism(8) is true. Granted physicalism(8), the only way a dynamical theory can be precisely true of any restricted range of phenomena is if it is such as to be straightforwardly generalizable so as to be true of all phenomena. Any physical theory inherently restricted to a limited range of phenomena, even though containing a wealth of true approximate predictions about these phenomena, must nevertheless be strictly false: only a theory of everything can be a candidate for truth!

Not only does the way physics has advanced from one false theory to the next accord with physicalism(8). The conception of unity sketched in section 3 successfully accounts for another feature of the way theoretical physics has advanced. Let $T_1, T_2, \ldots T_n$ stand for successive stages in the totality of fundamental theory in physics. Each of $T_1, T_2, \ldots T_n$ contradicts physicalism(8), in that each of T_1 etc. asserts that nature is *disunified*, whereas physicalism(8) asserts that it is *unified*. This might seem to make a nonsense of the idea that $T_1, T_2, \ldots T_n$ is moving steadily and progressively towards some future T_{n+r} which is a precise, testable version of physicalism(8). But what section 3 shows is that, even though all of $T_1, T_2, \ldots T_n$ are incompatible with physicalism(8), because disunified, nevertheless a precise meaning can be given to the assertion that T_{r+1} is closer to physicalism, or more unified, than T_r. This is the case if T_{r+1} is (a) of greater empirical content than T_r (since these are candidate theories of everything), or (b) of a higher degree of unity than T_r in ways specified in section 3. Thus the account of unity given above, involving physicalism(1 to 8), gives precision to the idea that a succession of false theories, $T_1 \ldots T_n$, all of which contradict physicalism(8), nevertheless can be construed as moving ever closer to the goal of specifying physicalism(8) as a precise, testable, physical theory of everything.

6 – Metaphysical Minimalism

I turn now to the argument designed to show that that version of physicalism should be accepted which is the weakest available which just suffices to exclude theories more disunified than currently accepted physical theories – at present the standard model (SM) and general relativity (GR). We may take this to be the strongest version of physicalism that is compatible with SM + GR. This, it may be argued, leads to physicalism($n \geq 3$) being accepted. [If only physicalism($n \geq 2$) were accepted, empirically successful rivals to SM plus GR could be concocted that are compatible with physicalism($n \geq 2$) but incompatible with physicalism($n \geq 3$).]

This view, however, faces serious difficulties. First, it may be held that physicalism($n \geq 3$) is not strong enough. SM + GR postulate four different forces, and some 19 different particles: the strongest version of physicalism compatible with current theory is: "physicalism(3) with $N = 1$, plus physicalism(4) with $N \leq 4$, plus physicalism(5) with $N \leq 19$, or physicalism($n \geq 6$)". But it may be argued that this is still not strong enough because physics presupposes that acceptable theories are at least compatible with the clumsy version of physicalism just indicated *when formulated in current concepts of theoretical physics (or some extension of them)*, and the italicised requirement, vague as it is, is nevertheless enormously restrictive. On the other hand, it may be argued that physicalism($n \geq 3$) is too strong, in that it ignores that SM and GR are incompatible with one another, and can only be made compatible by restricting the energies to which SM applies in an *ad hoc* fashion. There are doubts even about the consistency of GR, in that it predicts the existence of black holes and singularities which violate the smoothness of space-time. And SM poses problems too, in part because SM is based on quantum theory, and quantum theory does not apply to measurement, and thus needs to call upon some other theory, in an ad hoc fashion, for a treatment of measurement. It is not clear that SM and GR, taken together or even individually, are compatible with physicalism(2), with $N = 1$.

The attempt to identify that version of physicalism just contentful enough to exclude those disunified theories from physics that need to be excluded has not come up with anything definite or plausible.

7 – The Hierarchical View

Should physics accept physicalism(8) in line with the argument of section 5, and risk committing physics to a highly specific and contentful version of physicalism all too likely to be false, despite its fruitfulness for physics up to the present? Or should physics accept some clumsy version of physicalism indicated in section 6, less contentful and thus more likely to be true, but entirely lacking in fruitful guidelines for the development of new physical theories?

No version of presuppositionism which restricts itself to adopting a single (if composite) metaphysical thesis can resolve the conflicting desiderata satisfactorily, that are highlighted in these two questions. But this conflict is resolved if we adopt a version of presuppositionism which holds that we need to see physics as adopting a *hierarchy* of theses, from physicalism(8) near the bottom of the hierarchy to physicalism(1) at the top: see diagram 1. Physicalism(5-7) are on the same level since they are all but equivalent to one another. As we descend the hierarchy, from level (1) to level (8), theses become increasingly contentful and specific, increasingly potentially fruitful for future progress in theoretical physics but also increasingly likely to be false and in need of revision. As one moves from (1) to (8), the corresponding methodological requirements for unity, not depicted in diagram 1, become increasingly demanding, but also increasingly speculative and uncertain. The totality of physical theory, at any given stage in the development of physics (except when a candidate unified theory of everything has been proposed and accepted) will only satisfy these methodological rules partially; a new theory, in order to be an advance from the standpoint of unity, must lead to a new totality of theory satisfying the methodological rules better than the previous totality.

This hierarchical view has the following advantages over any version of presuppositionism which restricts itself to a single (possibly composite) thesis. First, the hierarchical view does justice to *both* apparently conflicting desiderata, indicated above, which cannot be done if a single metaphysical assumption is made. The hierarchical view includes *both* the uniquely scientifically fruitful thesis of physicalism(8) and the much less specific and problematic theses of physicalism (1) or (2). Second, the hierarchical view, as a result of making explicit metaphysical theses implicitly presupposed in adopting methods associated with levels (4) to (8), facilitates criticism and revision of these methods, which may well need to be done at some stage (if the corresponding metaphysical theses are false). Such criticism and revision is not facilitated if a single thesis is presupposed. Third, the hierarchical view assists revision of the more contentful and specific versions of physicalism low down in the hierarchy by providing a framework of relatively unproblematic assumptions and methods, at levels (1) to (3), which place restrictions on the way the more specific, problematic versions of physicalism may be revised, should the need to do so arise. If a succession of increasingly empirically successful theories are developed, T_1, T_2, . . . , all of which clash with physicalism(8), but which accord increasingly well with physicalism (7), this might be taken as grounds for rejecting or modifying physicalism(8).

The reasons given above for including the relatively specific, scientifically fruitful metaphysical thesis of physicalism(8) in the hierarchy of accepted theses are reasons also for accepting an even more specific, scientifically fruitful metaphysical thesis, should one be available. A glance at the history of physics reveals that a succession of much more specific metaphysical theses have been accepted, or taken very seriously, for a time, each thesis being an attempt to capture aspects of physicalism. Ideas at this level include: the universe is made up of rigid corpuscles that interact by contact; it is made up of point-atoms that interact at a distance by means of rigid, spherically-symmetrical forces; it is made up of a unified field; it is made up of a unified quantum field; it is made up of quantum strings. These ideas tend to reflect the character of either the current best accepted physical theory, or assumptions made by current efforts to develop a new theory. This is not sufficient to be scientifically fruitful in the way that physicalism (8) is. For this, we require that the thesis in question is such that all accepted fundamental physical theories since Newton can be regarded as moving steadily towards capturing the thesis as a testable physical theory, in the manner indicated in section 3. One candidate for such a thesis is the following:

Lagrangianism: the universe is such that all phenomena evolve in accordance with Hamilton's principle of least action, formulated in terms of some unified Lagrangian (or Lagrangian density), L. We require, here, that L is not the sum of two or more distinct Lagrangians, with distinct physical interpretations and symmetries, for example one for the electroweak force, one for the strong force, and one for gravitation, as at present; L must have a single physical interpretation, and its symmetries must have an appropriate group structure (the group not being a product of sub-groups). We require, in addition, that current quantum field theories and general relativity emerge when appropriate limits are taken.[17]

All accepted fundamental physical theories, from Newton on, can be given a Lagrangian formulation. Furthermore, if we consider the totality of fundamental physical theory since Newton (empirical laws being included if no theory has been developed) then, as in the case of physicalism(8), every new accepted theory has brought the totality of physical theory nearer to capturing Lagrangianism. Thus Lagrangianism is at least as scientifically fruitful as physicalism(8). In fact it is *more* scientifically fruitful since it is very much more specific and contentful. The reasons for accepting physicalism(8) are reasons for accepting Lagrangianism too as the lowest thesis in the hierarchy of metaphysical theses, very much more potentially scientifically fruitful than physicalism(8), but also more speculative, more likely to need revision: see diagram 1.

It deserves to be noted that something like the hierarchy of metaphysical theses, constraining acceptance of physical theory from above, is to be found at the empirical level, constraining acceptance of theory from below. There are, at the lowest level, the results of experiments performed at specific times and places. Then, above these, there are low-level experimental laws, asserting that each experimental result is a repeatable effect. Next up, there are empirical laws such as Hooke's law, Ohm's law or the gas laws. Above these there are such physical laws as those of electrostatics or of thermodynamics. And above these there are theories which have been refuted, but which can be "derived", when appropriate limits are taken, from accepted fundamental theory – as Newtonian theory can be "derived" from general relativity. This empirical hierarchy, somewhat informal perhaps, exists in part for precisely the same epistemological and methodological reasons I have given for the hierarchical ordering of metaphysical theses: so that relatively contentless and secure theses (at the bottom of the hierarchy) may be distinguished from more contentful and insecure theses (further up the hierarchy) to facilitate pinpointing what needs to be revised, and how, should the need for revision arise. That such a hierarchy exists at the empirical level provides further support for my claim that we need to adopt such a hierarchy at the metaphysical level.

8 – Aim-Oriented Empiricism

The hierarchical view depicted in diagram 1 may need to be rejected in its entirety as physics advances. If we exclude from consideration physicalism($n = 1$, $N = \infty$) which permits anything, the hierarchical view assumes that the universe is at least partially physically comprehensible in the sense that phenomena occur in accordance with physical laws which are more or less disunified, the traditional distinction between laws and initial conditions being presupposed. But even though the universe is physically comprehensible, the traditional distinction between laws and initial conditions might not be observed. The true theory of everything might be cosmological in character, and might specify unique initial conditions for the universe. This possibility, and other possibilities of this kind, could no doubt be accommodated within a modified version of the above hierarchical view. But there are other possibilities, of philosophical interest even if of no interest to physics as at present constituted, which cannot be so accommodated. Perhaps God is ultimately responsible for all natural phenomena, or some kind of cosmic purpose or cosmic programme analogous to a computer programme (as has been suggested). In these cases the universe would be comprehensible but not physically comprehensible – even though it might mimic a physically comprehensible universe.

In order to accommodate these, and other such, possibilities we need to embed the above hierarchical view in a broader view I shall call "aim-oriented empiricism" (AOE), depicted in diagram 2. As versions of AOE have been expounded and defended in some detail elsewhere (see Maxwell, 1998; 1999; 2000; 2001, ch. 3 and appendix 3; 2002; 2005), here I give only a brief exposition. Levels (8) to (6) of AOE, diagram 2, are the same as levels (11) to (9) of the hierarchical view, diagram 1. Level (5) of AOE asserts that the universe is physically comprehensible, one or other of physicalism(5-8) being true – this level combining levels (5) to (8) of diagram 1. (The universe is physically comprehensible to a fairly high degree if physicalism(5) is true, even if physicalism(8) is false.) Level (4) of AOE asserts that the universe is *comprehensible* in some way or other, whether physically or in some other way. This thesis asserts that the universe is such that there is *something* (God, tribe of gods, cosmic goal, physical entity, cosmic programme or whatever), which exists everywhere in an unchanging form and which, in some sense, determines or is responsible for everything that changes (all change and diversity in the world in principle being explicable and understandable in terms of the underlying unchanging *something*). A universe of this type deserves to be called "comprehensible" because it is such that everything that occurs, all change and diversity, can in principle be explained and understood as being the outcome of the operations of the one underlying *something*, present throughout all phenomena. Level (3) asserts that the universe is partially or approximately comprehensible. The possibility that the universe is partially comprehensible *physically* is represented by physicalism(n) with n = 1, 2, 3 or 4. Level (3) also includes the possibility that the universe is partially comprehensible in some *non-physical* way. Level (2) asserts that the universe is such that there is some rationally discoverable thesis about its nature (relative to existing knowledge) which, if accepted, makes it possible progressively to improve methods for the improvement of knowledge. "Rationally discoverable", here, means at least that the thesis is not an arbitrary choice from infinitely many analogous theses. This thesis is to be interpreted as asserting that the universe is not epistemologically malicious, in the sense that apparently improved methods lead to apparent new knowledge which turns out, subsequently, to be illusory, there being no possibility of discovering this before it is revealed. (This is clarified in the next section.) Level (1) asserts that the universe is such that we can continue to acquire knowledge of our local circumstances, sufficient to make life possible.

The hierarchical view, depicted in diagram 1, is embedded in AOE, depicted in diagram 2, as a proper part. As one goes up the hierarchy of levels of AOE, the theses become increasingly insubstantial, and thus increasingly likely to be true (as for the hierarchical view depicted in diagram 1). In fact, level (M+1) implies level (M) for M = 5 to 1.

Reasons for accepting these theses are similar to those given for accepting the hierarchy of theses of the view depicted in diagram 1. The level (4) thesis of comprehensibility of diagram 2 is scientifically fruitful in the same way that physicalism(8) is. Insofar as all accepted fundamental physical theories since Newton have drawn progressively closer to physicalism(8), the same is true of the level (4) thesis of comprehensibility of diagram 2, since physicalism(8) is a special case of this thesis. The totality of fundamental physical theory, in getting steadily closer to exemplifying physicalism(8), gets closer to providing an explanation (in principle) of all phenomena – thus getting closer to exemplifying the comprehensibility thesis of diagram 2. The comprehensibility thesis is more likely to be true than physicalism(8) because it is not as specific and contentful; on the other hand, precisely for this reason, it is not as scientifically fruitful as physicalism(8). (On the other hand, physicalism(8) implies the comprehensibility thesis; if the former is accepted, the latter is as well.) The thesis at the top of the hierarchy, at level (1), asserts 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, since accepting it can only help, and cannot hinder, the acquisition of knowledge whatever the universe is like. Reasons for accepting the level (2) thesis will be discussed in the next section.

Remarks made about the view depicted in diagram 1 apply also, when appropriately modified, to the more general view of AOE depicted in diagram 2. The view depicted in diagram 1 has a more direct relevance to theoretical physics; AOE would become relevant if it emerged that the universe differs radically from the way modern science depicts it to be. AOE is more relevant to the philosophy of physics; it is required to solve the problem of induction (Maxwell, 1998, ch. 5), and to rebut objections of circularity, as we shall now see.

9 - Circularity Problem Solved

One feature of the views depicted in diagrams 1 and 2 may be deemed to be puzzling. Both hold that when metaphysical thesis and physical theory clash, physical theory may be revised, but also metaphysical thesis may be revised. How is such a two-way influence possible? In what follows I consider AOE, since this includes the first hierarchical view as a proper part.

The first point to note is that just such a two-way influence occurs when theory and experiment clash. In general, if a theory clashes with an experiment that has been subjected to expert critical scrutiny and repeated, the theory is rejected. But on occasions it turns out that it is the experimental result that is wrong, not the theory. In a somewhat similar way, if a new theory increases the conflict between the totality of physical theory and the currently accepted metaphysical thesis, at level (6) of diagram 2, the new theory will be rejected (or not even considered or formulated). On occasions, however, a new theory may be developed which increases the conflict between the totality of theory and the current thesis at level (6) but decreases the conflict between the totality of theory and physicalism at level (5) of diagram 2. In this case the new theory may legitimately be accepted and the thesis at level (6) may be revised. In principle, as I have already indicated, theses even higher up in the hierarchy may legitimately be revised in this way. A virtue of the hierarchical views is that they make possible and facilitate such two-way revisions.

However, another, potentially more serious problem faces the two hierarchical views indicated above. Both incorporate what seems to be vicious circularity. Acceptance of theories is influenced by their degree of accord with metaphysical principles, the acceptance of which is in turn, in part, influenced by an appeal the empirical success of physical theories. The claim is that as theoretical knowledge and understanding improves, metaphysical theses and associated methods improve as well. There is something like positive feedback between improving knowledge, and improving knowledge-about-how-to-improve knowledge. This, it is claimed, is the methodological key to the great success of modern science, namely that it adapts its metaphysical assumptions and methods (its aims and methods) to what it finds out about the nature of the universe.[18] But how can such a circular procedure conceivably be valid?

This is not an objection to the arguments and views put forward so far. No attempt has been made to justify claims to theoretical knowledge. The argument has been modest: granted acceptance of current physical theories and adoption of current methods, physics is more rigorous (in that it accords better with PIR) if implicit metaphysical assumptions are made explicit, and those assumptions chosen which seem best to promote what we take to be scientific progress. The circularity objection would arise, however, if we were to go beyond the modest aspirations of sections 2 to 8, and attempt to solve the problem of induction,[19] and justify acceptance of empirically successful unifying theories, within the context of AOE. Or, putting the matter slightly differently, AOE cannot be acceptable because the problem of induction cannot conceivably be solved within its framework: the moment the attempt is made to *justify* acceptance of scientific theories and metaphysical theses as claims to knowledge, vicious circularity set in. How is this circularity objection to be met?

Here, in a nutshell, is the answer. Permitting metaphysical assumptions to influence what theories are accepted, and at the same time permitting theories to influence what metaphysical assumptions are accepted, may (if carried out properly), *in certain sorts of universe*, lead to genuine progress in knowledge. The level (2) thesis of meta-knowability, of AOE, asserts that *this is just such a universe*. And furthermore, crucially, reasons for accepting meta-knowability make no appeal to the success of science. In this way, meta-knowability legitimises the potentially invalid circularity of AOE, and of the component view depicted in diagram 1.

Relative to an existing body of knowledge and methods for the acquisition of new knowledge, possible universes can be divided up, roughly, into three categories: (i) those which are such that the meta-methodology of AOE can meet with no success, not even apparent success, in the sense that new metaphysical ideas and associated methods for the improvement of knowledge cannot be put into practice so that success (or at least apparent success) is achieved; (ii) those which are such that AOE can meet with genuine success; and (iii) those which are such that AOE appears to be successful for a time, but this success is illusory, this being impossible to discover during the period of illusory success. Meta-knowability asserts that this universe is a type (ii) universe; it rules out universes of type (i) and (iii).

Meta-knowability asserts, in short, that the universe is such that AOE can meet with success and will not lead us astray in a way in which we cannot hope to discover by normal methods of scientific inquiry (as would be the case in a type (iii) universe). If we have good grounds for accepting meta-knowability as a part of scientific knowledge – grounds which do not appeal to the success of science – then we have good grounds for adopting and implementing AOE (from levels (8) to (3)).

But what grounds are there for accepting the thesis of meta-knowability at level (2)? There are two.

(a) Granted that there is *some* kind of general feature of the universe which makes it possible to acquire knowledge of our local environment (as guaranteed by the thesis at level (1)), it is reasonable to suppose that we do not know all that there is to be known about what the *nature* of this general feature is. It is reasonable to suppose, in other words, that we can improve our knowledge about the nature of this general feature, thus improving methods for the improvement of knowledge. Not to suppose this is to assume, arrogantly, that we already know all that there is to be known about how to acquire new knowledge. Granted that learning is possible (as guaranteed by the level (1) thesis), it is reasonable to suppose that, as we learn more about the world, we will learn more about how to learn. Granted the level (1) thesis, in other words, meta-knowability is a reasonable conjecture.

(b) Meta-knowability is too good a possibility, from the standpoint of the growth of knowledge, not to be accepted initially, the idea only being reluctantly abandoned if all attempts at improving methods for the improvement of knowledge fail.

(a) and (b) are not, perhaps, very strong grounds for accepting meta-knowability; both are open to criticism. But the crucial point, for the present argument, is that these grounds for accepting meta-knowability, (a) and (b), are independent of the success of science. This suffices to avoid circularity.

If AOE lacks meta-knowability, its circular procedure, interpreted as one designed to procure justified knowledge, becomes dramatically invalid, as the following consideration reveals. Corresponding to the succession of accepted fundamental physical theories developed from Newton down to today, there is a succession of aberrant rivals which postulate that gravitation becomes a repulsive force from the beginning of 2050, let us say. Corresponding to these aberrant theories there is a hierarchy of aberrant versions of physicalism, all of which assert that there is an abrupt change in the laws of nature at 2050. The aberrant theories, just as empirically successful as the theories we accept, render the aberrant versions of physicalism just as scientifically fruitful as non-aberrant versions of physicalism are rendered by the non-aberrant theories we actually accept. If we take it as given that we accept non-aberrant theories, the question of what reasons there are for rejecting empirically successful aberrant theories and associated aberrant versions of physicalism does not arise. But the moment we seek to *justify acceptance* of non-aberrant theories and *rejection* of aberrant theories, within the framework of AOE, the question of what reasons there are for rejecting aberrant theories and associated aberrant versions of physicalism arises. If AOE is bereft of meta-knowability, it is not easy to see what these reasons can be. But AOE with meta-knowability included does provide a reason: the aberrant versions of physicalism assert that this is a type (iii) universe, which violates meta-knowability.

Versions of physicalism(n) for which $n = 1$ or 3 and $N > 1$ would seem to violate meta-knowability. But other versions of physicalism with $N > 1$ need not clash with meta-knowability.

<u>10 – Conclusions</u>

I have argued that if science is to be rigorous it needs to accept explicitly, as a core component of theoretical scientific knowledge, a hierarchy of metaphysical theses (and associated methods) concerning the dynamic unity, the comprehensibility, of the universe. I have shown that the notorious problem concerning the unity, the explanatory character, of physical theory can be solved within this hierarchical view of science. This solution, in turn, provides a precise way of assessing the scientific fruitfulness of rival metaphysical theses, from the standpoint of the empirical progressiveness of the research programmes to which they give rise.

These results have dramatic implications for science, for our understanding of science, and for the relationship between science and philosophy. There is a major increase in the (acknowledged) *scope* of scientific knowledge. Whereas standard empiricism implies that science at present provides us with no knowledge about the ultimate nature of the universe (all current fundamental physical theories being false), the hierarchical view holds the opposite. Current science does include knowledge about the ultimate nature of the universe – knowledge which, though theoretical and conjectural, is nevertheless more secure than any accepted theory such as quantum theory or general relativity: physicalism(5-7) is true, even perhaps physicalism(8). Science becomes much more like natural philosophy, in that it incorporates sustained exploration and assessment of metaphysical theses, and associated metholodogical rules, as an integral, vital part of scientific research. Instead of metaphysics and philosophy being banished from science, they become a vital part of science.

Furthermore, as I have argued in detail elsewhere (Maxwell, 1976, 1984, 1998, 2001, 2004), the arguments of this paper, when extended to take into account, not just the implicit metaphysical assumptions of science, but its implicit value and political assumptions as well, have even more dramatic implications not just for physics or natural science, but for social science, for the humanities, for academic inquiry as a whole.

Perhaps the time has come for philosophers to take note of these arguments which have such revolutionary implications for our intellectual landscape.

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Notes

1. It is widely appreciated that some metaphysical theses have influenced science in the context of discovery, in influencing scientists to try to develop certain sorts of theories, and to ignore others: see, for example, Watkins (1958), Popper (1959, 278). What is being argued here is very different. I argue that there are metaphysical theses, neither falsifiable nor verifiable, which are an integral part of theoretical scientific knowledge, more firmly established, indeed, than such highly corroborated theories as quantum theory and general relativity. Science is more rigorous if this is acknowledged rather than denied. All this differs dramatically even from Popper’s later views concerning the important role that metaphysical research programmes play in science: see Popper (1976, sections 33 and 37; 1983, section 23; 1982, sections 20-28). Popper held on to his demarcation criterion to the end, and never wavered from holding metaphysical theses,

however scientifically fruitful, to be “unscientific”: for discussion of this point see Maxwell (2004; 2005).

2. For discussion of the claim that Kuhn and Lakatos defend versions of SE see Maxwell (1998, 40).

3. All the possible phenomena, predicted by any dynamical physical theory, T, may be represented by an imaginary "space", S, each point in S corresponding to a particular phenomenon, a particular kind of physical system evolving in time in the way predicted by T. In order to specify severely disunified rivals to T that fit all available evidence just as well as T does, all we need do is specify a region in S that consists of phenomena that have not been observed, and then replace the phenomena predicted by T with anything we care to think of. Given any T, there will always be infinitely many such disunified rivals to T. This point is inherent in Nelson Goodman’s “new paradox of induction” (see Goodman, 1954), although the kind of empirically successful disunified rivals considered by Goodman in his discussion of “grue” and “bleen” are but one kind of a number of kinds of disunified theories, as we shall see in section 3. There is a vast philosophical literature on the underdetermination of theory by evidence: for an excellent recent discussion, and reference to further literature, see Howson (2000): see especially ch. 1, pp. 30-4, 75-7, and ch. 5. See also Lipton (2004).

4. For a more detailed discussion of empirically successful *ad hoc* rivals to accepted theories, see Maxwell: (1974; 1993; 1998, 51-4).

5. It may be objected that the universe might have been genuinely disunified, so that physics could consist only of a great number of physical laws. In this case, it may be argued, physics could not be construed as making a metaphysical assumption about underlying unity. But even in this counterfactual situation, endlessly many very much more disunified but empirically more successful rival laws could easily be formulated: these would have to be rejected on non-empirical grounds, or physics would drown in an ocean of rival laws. The persistent rejection of such much more disunified but empirically more successful rivals would involve the methods of physics making an implicit metaphysical assumption, to the effect that nature is unified to some extent at least (all grossly disunified laws being false). It is necessary to make some such assumption, however disunified the totality of accepted laws may be – even if the assumption made is rather weak in character, in that only gross disunity is denied.

6. See Maxwell: (1984, 224; 1998, 21).

7. See Salmon (1989) for a survey of attempts to solve the problem. See also Maxwell (1998, 56-68).

8. A referee has put forward the following objection. “(1) and (2) need to be more tightly specified: as they stand they admit cases of artificial disunity. Divide up space arbitrarily into distinct regions R1, R2 ..., Rn. Take a law L that applies to all of space and form these distinct laws: “In R1, L”, “In R2, L”, ..., “In Rn, L”. Because each of these n laws mentions a distinct region of space they ARE distinct laws. Of course, they are ‘inessentially’ distinct, but it's up to the author to spell out that intuitive judgment in terms that will withstand logical scrutiny.” My reply is as follows. The *content* of “In R1, L”, “In R2, L”, ..., “In Rn, L” is the same as the *content* of “L (applicable to all of space)”; this suffices to make the former unified according to requirement (1). Even though T specifies n distinct regions in the space of possible phenomena to which it applies, T is unified, in senses (1) and (2), if its content is the same as the content of a theory which does not specify any distinct regions in this space. For further discussion of

"artificial disunity" see Maxwell (1998, ch. 4; 2004, appendix, section 2).
9. An informal sketch of these matters is given in Maxwell (1998, ch. 4, sections 11 to 13, and the appendix). For rather more detailed accounts of the locally gauge invariant structure of quantum field theories see: Moriyasu (1983), Aitchison and Hey (1982: part III), and Griffiths (1987, ch. 11). For introductory accounts of group theory as it arises in physics see Isham (1989) or Jones (1990).
10. For accounts of spontaneous symmetry breaking see Moriyasu (1983) or Mandl and Shaw (1984).
11. The account of theoretical unity given here simplifies the account given in (Maxwell 1998, chs. 3 and 4), where unity is explicated as "exemplifying physicalism", where physicalism is a metaphysical thesis asserting that the universe has some kind of unified dynamic structure. Explicating unity in that way invites the charge of circularity, a charge that is not actually valid (see Maxwell 1998, 118-23 and 168-72). The account given in this paper forestalls this charge from the outset.
12. This point is of fundamental importance for the problem of induction. Traditionally, the problem is interpreted as the problem of justifying exclusion of empirically successful theories that are *ad hoc* in sense (1): How can evidence from the past provide grounds for any belief about the future? This makes the problem seem highly "philosophical", remote from any problem realistically encountered in scientific practice. But the moment it is appreciated that the problem of justifying exclusion of empirically successful theories that are *ad hoc* in sense (1) is just an extreme, special case of the more general problem of excluding empirically successful theories that are *ad hoc* in senses (1) to (8), it becomes clear that this latter problem is a scientific problem, a problem of theoretical physics itself. For the implications of this crucial insight, and for a proposal as to how the problem of induction is to be solved exploiting it, see (Maxwell 1998, especially chs. 4 and 5).
13. It may seem that there is rather a jump here, from T referring to any fundamental dynamical physical theory in (1) to (8), to T referring to a "theory of everything". However, the proper way to apply (1) to (8) is to the totality of fundamental physical theory (whether this consists of many or just one theory), and thus, in a sense, to candidate "theories of everything" (If a range of phenomena have no theory, then empirical laws governing these phenomena must be treated as theories.). If we do not do this, disunity could always be evaded, as far as (4) to (7) are concerned at least, by chopping a theory disunified to degree N into N distinct unified theories. When it comes to non-empirical considerations governing choice of theory, what matters is the way individual theories fit into the totality of fundamental physical theory – the degree of unity of the whole of fundamental physical theory.
14. This explication of the "unity" and "explanatory power" of theories improves on proposals put forward by Friedman (1974), Kitcher (1981), Watkins (1984) and others. For a critical assessment of these and other proposals see Salmon (1989). For my criticism of the proposals of Friedman, Kitcher and Watkins and others, see Maxwell (1998, 61-8). This book also contains a detailed account of my positive theory of explanatory power: see especially chs. 3 and 4.
15. For further discussion see (Maxwell 1998, 80-89, 131-40, 257-65 and additional works referred to therein).
16. Note 1 above indicates how my view differs from Popper's "metaphysical research programmes".

17. Lagrangianism is discussed in Maxwell (1998, 88-9).
18. See Maxwell (1974, especially part II) and, more recently, Maxwell (1998, 17-19). Others too have argued that the methods of science improve with improving knowledge, but have done so only within the framework of standard empiricism: see, for example, Boyd (1980).
19. No attempt is being made here, I hope it is clear, to solve the problem of induction. I merely seek to rebut the objection that the problem cannot conceivably be solved, granted AOE. Elsewhere, however, I have argued, more positively, that the problem can be solved granted AOE: see Maxwell (1998, ch. 5; 2004, appendix, section 6).