THE UNIVERSAL EXPANSION HYPOTHESIS

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I

In this paper I defend the physical significance of the hypothesis that literally everything in the universe has doubled in size overnight. The contention defended, alternatively, is that everything is in the process of expanding at exactly the same rate. *Prima facie*, of course, these seem utterly vacuous hypotheses. In what respects would the universe differ if *everything* doubled in size? However, doubts arise when closer inspection reveals conventionalist and/or verificationist principles underpinning the arguments most commonly urged against the physical significance of this hypothesis.

The notion of physical significance covers a multitude of sins. I will argue that a universal metrical expansion is *operationally detectable* and hence that the universal expansion hypothesis is falsifiable – not *conclusively* falsifiable (a lesson gained from Popper) but on a par with other scientific hypotheses.

No one is liable to deny the physical significance of the universal expansion hypothesis *tout court*. However, the physical significance of the universal expansion hypothesis *given certain assumptions* certainly has come under question. According to Adolf Grünbaum, for instance, the universal expansion hypothesis is vacuous given certain assumptions about the small-scale structure, or topology, of spacetime. On the other hand, George Schlesinger has argued that the universal expansion hypothesis is vacuous given certain assumptions about accompanying changes to the speed of light, the force of gravity, and so on. It would be difficult to find more able adversaries. Consequently, I argue here for the physical significance of the universal expansion hypothesis on the basis of those assumptions which, according to Grünbaum and Schlesinger, ensure its vacuity.

II

The universal expansion hypothesis is multi-faceted and comes in more and less controversial forms. I will approach it by a series of approximations, or variations, beginning with the least controversial and moving to the more controversial. Consider first, what I will call, the Restricted Expansion Hypothesis (Subversion I):

> *The Restricted Expansion Hypothesis-I*:
> Some, but not all, spatially extended objects have mysteriously and suddenly doubled in size overnight (or are in the process of expanding at exactly the same rate).

Such an event would clearly be operationally detectable. The doubling of the objects concerned could be ascertained by comparison with the objects which had remained unaffected. Even if approximately half of all objects apparently doubled in size while half apparently remained unaffected (leaving aside the problem of a criterion of identity for "objects"), this would only raise problems about *which* group of objects had changed, not the legitimacy of the hypothesis itself.

But this is a bit quick. It can be seen that even the restricted expansion hypothesis is not quite as uncontroversial as it might at first appear by considering the following two subversions:

> *The Restricted Expansion Hypothesis-II*:
> Some, but not all, spatially extended objects have mysteriously and suddenly doubled in size overnight (or are in the process of expanding at exactly the same rate). Included among the objects affected is the standard metre rod in Paris. (1)
> *The Restricted Expansion Hypothesis-III*:
> Some, but not all, spatially extended objects have mysteriously and suddenly doubled in size overnight (or are in the process of expanding at exactly the same rate). The standard metre rod in Paris has not been affected.

(1) In fact, scientists now equate one metre with 1,650,763.73 wavelengths in vacuum of the radiation corresponding to the transition between the levels 2_{p5} and 5_{d5} of the Krypton-86 atom. To avoid complicating the issue I will assume the old standard here.

Now, it may be argued that although the conjecture that all spatially extended objects have doubled in size relative to the customary standard of length has empirical import, the conjecture that the customary standard of length itself has doubled in size relative to other objects is devoid of empirical import. Why? Since the platinum-iridium bar in Paris is the standard in terms of which we *define* geometrical terms such as "length," "distance," "congruent," and so on, to say that, for example, an object remains "self-congruent" if it can be brought into coincidence with the *whole* of the standard metre rod prior to time *t* and *half* the rod thereafter (since the standard rod has itself doubled in size) would simply be to change the *meaning* of "self-congruent". Thus, although the Restricted Expansion Hypothesis-III has empirical import, the Restricted Expansion Hypothesis-II merely amounts to a change in our use of *language*; to the adoption of a new *definition* of "congruent" and related terms. It is not a hypothesis with physical significance, but merely indicates a trivial change in our use of language.

This is not a trivial argument. It was quite common, in many different forms, and in many different areas, not too long ago. It took Quine to point out its fatal weakness: it relies on a faulty semantic theory. The terms "congruent," "length," "distance," and so on, are not *defined* (except implicitly and defeasibly) in terms of metre rods (via "coördinative definitions," "correspondence rules," or whatever). There is nothing *analytic*, in the orthodox empiricist sense, about the statement that a particular rod (or group of rods) remains the same length under spatial transport and from moment to moment. If physical theory comes under pressure any part of it can be changed, even that which we designate the "logical" component ([5], p. 43).

The dependence of the meaning of geometrical language on physical theory *broadly* is made evident by reflecting upon the circularity that would result from defining "length," for instance, in terms of transported solid rods alone. "Length" could not be satisfactorily defined in terms of the behaviour of transported solid rods *simpliciter*, only in terms of solid rods *corrected for the effects of deforming influences*. But since the laws used for making such corrections themselves employ length as a variable (Ellis calls them "length laws": Hooke's Law, Newton's Law of Gravitation, Kepler's Third Law of Planetary Motion, Galileo's Law of Free Fall, the Law of Inertia, and the Principle of the Constancy of the Velocity of Light ([1], p. 193)), to define "length" in terms of *appropriately corrected* solid rods would be circular ([4], pp. 104-105).

It may be thought that this difficulty could be overcome by appealing to something like a Ramsey sentence ([6], pp. 212-236). Why not simply identify length with that property *P*, whatever it might be, about which certain high-level scientific claims are true? If first we define "*P*", and then identify *P* with length, no circularity is involved. However, the high-level claims constituting the *definiens* here will only *partially* specify the meaning of *P* – most importantly, will not characterize the property *P* sufficiently to enable its identification with length – unless a good deal of physical theory is involved. In brief, we may be able to avoid the *circularity* by appealing to something like a Ramsey sentence (in a formal sense) but not the *holism* infusing geometrical language.

So, to sum up, the restricted expansion hypothesis – the hypothesis that some, but not all, spatially extended objects have mysteriously and suddenly doubled in size overnight (or are in the process of expanding at exactly the same rate) – would appear to have empirical import, even if the customary standard of length itself is included among the objects affected.

III

Next, consider the attribution of a metrical expansion to *all* spatially extended objects. This is where things get interesting, and the uniqueness of the problem begins to open up. However, we will make one important qualification: not all other operational standards of length measurement have been affected by the expansion. If the length of spatial intervals as furnished by material bodies (metre rods, rulers, pieces of string, ...) suddenly double in size overnight, while the lengths of spatial intervals as furnished by other standards such as measurements of the speed of light, the force of gravity, and so on, remain unchanged, we have two main alternatives:

> *The Universal Expansion Hypothesis-I*:
> All spatially extended objects have mysteriously and suddenly doubled in size overnight (or are in the process of expanding at exactly the same rate), but not all operational standards of length measurement have been affected.

The Universal Expansion Hypothesis-II:
The speed of light, the force of gravity, and so on, have changed in such a way that it *appears* that all spatially extended objects have mysteriously and suddenly doubled in size overnight (or are in the process of expanding at exactly the same rate).

Adolf Grünbaum countenances both of these alternatives. According to Grünbaum, "they incontestably have the same explanatory and predictive import or scientific legitimacy" ([2], p. 161). In particular, Grünbaum countenances the Universal Expansion Hypothesis-I. The idea that all material bodies have doubled in size relative to the metric furnished by measurements of the speed of light, the force of gravity, and so on, is a significant empirical hypothesis. But what Grünbaum does deny is that our choice of either of these particular alternatives is anything more than a mere convention. In particular, the Universal Expansion Hypothesis-I cannot with propriety be construed as meaning that all objects have "really" doubled in size: that they have expanded, as it were, relative to spacetime itself. All it can mean is that all objects have doubled in size relative to other operational standards of length measurement which (we stipulate conventionally to) have remained unchanged. Grünbaum countenances the Universal Expansion Hypothesis-I, but only if it is construed as asserting a *discrepancy* between length measurements by material bodies and length measurements by other standards. That there is a *discrepancy* is a fact and not a convention, but that there has been a *doubling of all material bodies* (if we choose this alternative) is a mere convention devoid of physical import.

Before assessing this challenge to the physical significance of the universal expansion hypothesis we should look a little more closely at *why* Grünbaum holds that the Universal Expansion Hypothesis-I cannot be construed as asserting a real doubling of all material objects. Basically, it rests on the idea that space itself lacks any inherent, intrinsic metric relative to which material bodies could expand. Continuous space cannot possess an intrinsic metric by virtue of the fact that some spatial intervals contain a greater *cardinal number* of points than others for the number of points between *any* two distinct points of a mathematically continuous space is *c*. Nor can continuous space possess an intrinsic metric by virtue of the fact that the individual points in some intervals are *metrically different* from the points in others for the points of continuous space are all alike metrically, *i.e.* dimensionless.

Given this "intrinsic metrical amorphousness" of continuous space, Grünbaum argues, the hypothesis of an instantaneous (or gradual, ratio-preserving) expansion of all spatially extended objects, including all (actual and potential) transport-dependent congruence standards, has no empirical import for a continuous space. A continuous space has no *intrinsic* metric against which such an expansion can be deemed to have occurred ([2], Chap. II).

Anyone familiar with Grünbaum's work will know that it is complex and very detailed. However, we have enough of it here to begin to see what is wrong with the argument. Imagine the situation where a choice has to be made between the hypothesis that all material objects have doubled in size, and the hypothesis that all other operational standards of length measurement have changed in such a way that it appears that all objects have doubled in size, *and* where adopting the former alternative – the Universal Expansion Hypothesis-I – would lead to greater overall simplicity (plausibility, generality, coherence, ...) in our system of physical laws, whereas adopting the latter alternative – the Universal Expansion Hypothesis-II – would make the laws of nature incredibly complex. No matter how successfully the Universal Expansion Hypothesis-I simplifies and unifies our system of physical laws in comparison with the Universal Expansion Hypothesis-II, it appears that Grünbaum would still maintain that our choice of the Universal Expansion Hypothesis-I is merely a matter of convention, on the ground that spacetime is "intrinsically metrically amorphous."

(1) Grünbaum has two responses to this type of problem. First, he sometimes argues that the simplicity of the Universal Expansion Hypothesis-I compared with the Universal Expansion Hypothesis-II is only *descriptive* and not *inductive* simplicity, a distinction drawn from Reichenbach ([7], p. 35). Descriptive simplicity, unlike inductive simplicity, purportedly has no bearing on truth. Two theories which differ only in terms of descriptive simplicity are mere "notational variants"; to be more than this – to be genuine empirical rivals – they must differ in terms of inductive simplicity. However, this response relies on epistemological principles of which Grünbaum cannot avail himself. Given *any* theory we can construct an alternative which is highly complex, *ad hoc*, wildly implausible, ..., but which "saves the data." If Grünbaum does not want

to espouse a general conventionalism on philosophical grounds but only a specific conventionalism on physical grounds – and he is quite explicit about this – then he must rely on his second response.

(2) Second, Grünbaum argues that even if the Universal Expansion Hypothesis-I *were* simpler in the inductive sense, this would not be relevant, for the Universal Expansion Hypothesis-I is conventional not in the sense that there is a viable alternative but in the sense that spacetime is devoid of an inherent metric – *i.e.* is "intrinsically metrically amorphous." However, this shows that Grünbaum is using the term "conventional" in a rather special way, a point noted by Putnam ([4], 105-106). Standardly, a convention requires an alternative. Driving on the left side of the road (in Australia) is a convention because we could just as easily drive on the right. If there is no alternative there is no convention. However, Grünbaum uses "conventional" in a different way. The absence of a viable alternative to the Universal Expansion Hypothesis-I – in particular, the Universal Expansion Hypothesis-II which, *ex hypothesi*, scores very poorly in terms of simplicity, explanatory and unifying power, generality, and so on – is not relevant. Opting for the Universal Expansion Hypothesis-I is conventional in the sense that spacetime is "intrinsically metrically amorphous" – *i.e.* continuous and homogeneous – not in the sense that there is a viable alternative.

But given this special sense of "conventional" no sceptical conclusions follow regarding the physical significance of the Universal Expansion Hypothesis-I. Most importantly, there is no warrant for opposing *factual* to "conventional" given Grünbaum's sense of "conventional", for *this* sense of "conventional" simply means "intrinsically metrically amorphous" – *i.e.* continuous and homogeneous. Grünbaum seems to appropriate the philosophical implications of "conventional" while employing the notion in a non-standard way.

IV

Finally, we consider the hypothesis to which the others have unmistakably been pointing; the most qualification-free and therefore the most controversial.

The Universal Expansion Hypothesis-III:
All spatially extended objects have mysteriously and suddenly doubled

> in size overnight (or are in the process of expanding at exactly the same rate), and various correlative changes have occurred in the speed of light, the force of gravity, and so on, so that all measurements of spacetime intervals *by whatever means* remain unchanged.

If various compensatory changes occurred along with a universal expansion, the combined effect of which was to eliminate all traces of the event, it would seem incontestable that there would be no way of detecting such an expansion operationally. If the force of gravity remained unchanged after a purported universal expansion we would have a way, theoretically, of detecting the change, for a shape which is stable in one gravitational field may break under its own weight in another. But if various compensatory changes occurred along with a universal expansion – if the speed of light changed appropriately, the force of gravity, and so on – so that all measurements of spacetime intervals *by whatever means* remained unchanged before and after the event, it would seem incontestable that there would be no way of detecting such an expansion operationally.

This I take to be the view of George Schlesinger. According to Schlesinger, the assertion that a universal metrical expansion is verifiable, even if accompanied by appropriate compensating changes in *all* other operational standards of length measurement, is equivalent to the contradiction "something unverifiable is verifiable" ([8], pp. 69-70). It is no different in kind from any other hypothesis postulating the most bizarre and implausible event, including the appearance of a pink elephant, *if* accompanied by the assertion that appropriate changes have taken place to completely mask the event from detection.

However, some reflection upon the nature of operational detectability suggests that even the Universal Expansion Hypothesis-III is not devoid of physical significance. The crucial point that must not be overlooked is that operational detectability is not theory-independent. To use a familiar example, the same negative parallax measurements of a distant star may constitute operational corroboration of *either* the Euclidean *or* the non-Euclidean structure of spacetime depending on the accepted laws of optics. If it is held, on the basis of the best available physical theory, that light travels in straight lines (geodescis), appropriate measurements of negative parallax may constitute operational corroboration of the non-Euclidean nature of space. Alternatively, if it is held that light does not travel in straight lines those same measurements may constitute operational corroboration of the Euclidean nature of space ([3], p. 81). Operational detectability is thus theory-dependent. Now, it may be that in some future theory, measurements of, for instance, spectral red-shift, will not, as now, constitute operational corroboration of the hypothesis that all objects in the universe are receding from one another with velocities proportional to their distances, but of the hypothesis that all objects in the universe are gradually expanding in size at a uniform, ratio-preserving rate. Just what such a theory would be like in detail it is very difficult to say. Great changes would have to be made to the rest of physical theory. But at best this shows that a universal expansion is *implausible* in the light of present-day physics, not that it is operationally undetectable, and not, therefore, that it is devoid of physical significance.

Of course, this defense of the physical significance of the Universal Expansion Hypothesis-III implies a change: but it is a change in our *theoretical interpretation* of the deliverances of our measuring instruments, not a change to those deliverances themselves as a result of the purported expansion. The possibility that the discovery of a new mathematical theory might prompt such a theoretical reinterpretation cannot be ruled out *a priori*, particularly if the resulting theory is simpler, more plausible, has greater explanatory and unifying power, and so on.

The obvious question arises, however, what have the objects expanded relative to, if not other objects or other standards? One possible answer is: relative to their previous sizes. The *apparent* triviality of this response is lessened by considering the following two points. First, if what was said about the theory-dependence of operational detectability is correct, we may, in a future theory, appeal to spectral red-shift (and/or perhaps other phenomena) as *evidence* for the occurrence of the expansion. Evidence is theory-dependent precisely because operational detectability is; and operational detectability is theory-dependent because it is a form of observation (albeit a highly sophisticated form). Second, we may appeal to the metrical field – if we construe it as a physical field on a par with the electromagnetic field – to explain *why* the expansion is taking place (and why we observe spectral red-shift and other phenomena). There is no reason why this should not be a *causal* explanation. The suggestion that all objects are expanding relative to their previous sizes appears considerably less trivial when we have *evidence* for it and an *explanation* for it. The question then becomes the scientific one: how *good* is the evidence and how *good* is the explanation?

Before closing, let me make one final point. This defense of the Universal Expansion Hypothesis-III is neutral regarding the issue whether spacetime is a kind of substance in which material bodies are located – an absolute theory of spacetime – or merely a system of relations among material bodies – a relational theory of spacetime. In defending the Universal Expansion Hypothesis-III, I have not suggested that all objects have doubled in size relative to an independently existing container space, but relative to their previous sizes. This is compatible with the ontological view that spacetime is like an empty container, distinct from the objects contained within it, *and* with the ontological view that spacetime is nothing over and above material bodies, in the same way that fatherhood is nothing over and above fathers and their offspring. (2)

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REFERENCES

[1] Brian Ellis, "Universal and Differential Forces," *The British Journal for the Philosophy of Science*, XIV (1963).

[2] Adolf Grünbaum, *Geometry and Chronometry in Philosophical Perspective* (Minneapolis: University of Minnesota Press, 1968).

[3] H. Poincaré, *The Foundations of Science* (Lancaster: The Science Press, 1946).

[4] Hilary Putnam, *Mathematics, Matter and Method*, Philosophical Papers, Vol. 1, Second Edition (Cambridge: Cambridge University Press, 1979).

[5] W.V. Quine, "Two Dogmas of Empiricism," in *From a Logical Point of View* (Cambridge: Harvard University Press, 1953).

[6] F.P. Ramsey, *The Foundations of Mathematics and Other Logical Essays* (London: Routledge and Kegan Paul, 1931).

[7] Hans Reichenbach, *The Philosophy of Space and Time* (New York: Dover Publications, 1958).

[8] G. Schlesinger, "It Is False That Overnight Everything Has Doubled In Size," *Philosophical Studies*, XV (1964).

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