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LOST IN SPACE

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EINSTEINIAN SPACE, ABSOLUTE SPACE, AND SOCIAL/SOKALLED SPACE

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Introduction

Recently, Alan Sokal has raised the question of the connection between, on the one hand, the representations of space that belong to physics and, on the other, so-called "social spaces" that are marked out by the paths which people take in the course of their day to day lives. In particular, Sokal denies the claim by Bruno Latour, Henri Lefebvre, and others that the representations of physical space are always more or less distorted reflections of social spaces. As he makes the point in typical polemical style:

> intervals in [physical] <u>space-time</u> do not coincide with what we habitually call 'space' and 'time'. Above all, they have nothing to do with [what Virilio calls] the 'geography and history of the world' or the 'chronopolitical regulation of human society' (Sokal 161; see, too, 99, 122, 242).

Sokal reserves special scorn for "social constructivists", such as Bruno Latour, who claim that physics, especially relativity theory, shows us that "space-time stops being objective", and instead is, as Latour puts it, "social through and through" (242, 120).

Rather than directly address the complex issues raised by Sokal, I want to look at Einstein's special theory of relativity, and explore the concepts of space and time that it employs. At the end of these deliberations, I will repose the question of what relevance such concepts have for cultural studies. On the one hand, I will agree with Sokal that there is no substance to the claim that Einstein"s critique of classical Newtonian concepts of absolute space and time counts against the objectivity of space and time as such. On the other hand, against Sokal, I will argue that at least some of the spatio-temporal entities postulated in Einstein"s theory of relativity are "social" in the sense postulated by Latour. I will argue also that Henri Lefebvre's concept of social space, in particular his distinction between absolute and abstract spaces, provides a useful framework in terms of which to think about and illuminate a tension that has been observed within Einstein's work between operationalist and realist approaches to concepts of space and time.

A Day in Dallas

As a means of introducing Einstein's post-classical conceptions of space and time, let me start by asking an apparently simple question: "Where at the current moment in time can you find the place where President Kennedy was shot?". "A particular stretch of road in Dallas" – you may reply. But that stretch of road is now in a different region of space than the one it was in when the President was shot. The earth has moved millions of miles since that fateful day in Dallas. What, then, if we backtrack through space to the site of the President's assassination, now quiet and filled only with cosmic dust, lost somewhere in the wake of the earth's continuing voyage through the Universe? The distance we backtrack depends upon what we take as the velocity with which the earth has been moving since the assasination. But moving relative to what? Relative to the sun, perhaps? But the sun, too, is moving relative to the distant stars, and so, it seems, our backtracking must also allow for the distance that the sun has moved relative to those stars since the assassination. But the distant stars may be moving, too – they appear fixed only because they are so distant. And, there seems to be no natural point at which we can stop this regress of adjustments. In short, it seems that the question of where the assasination "really" took place must always and already be deferred. We can tell a story about the props that furnished the scene of the event – the car, the stretch of road, and so on – but we cannot say where exactly those props were located on the fateful day. Thus, what seems initially to be a perfectly sensible question about space and time turns out to be defective, incapable of any final, definitive answer. It appears that something is wrong with the traditional Newtonian notions of space and time that were used to frame the question from which we started.

This conclusion, for which I will argue in more detail later, is part of Einstein's critique of classical Newtonian concepts of space and time, a critique which, at this point in the argument, depends not upon the abstract propositions of relativity theory, but rather upon uncovering the hidden relational nature of classical concepts of space and time. In what follows, I examine Einstein's critique in more detail, and introduce the replacement concepts of space and time that he propose in SR (Special Relativity).

Reference Frames

A key concept in understanding both SR and NM (Newtonian Mechanics) is that of a reference frame. A reference frame consists of four distinct items or sets of items, which jointly provide a framework in terms of which bodies may be located in space and time. The first such item is a body called the "origin" of the reference frame, the function of which is to provide a point of reference in relation to which all other bodies are located. In particular, the position of a body at a time is identified in terms of its distance from the origin at that time.[1] (In this context, distance is understood a vector quantity, in terms of both magnitude and direction). Since any body is stationary in relation to itself, it follows that a reference frame must treat its own origin as effectively stationary, that is, as not changing location over time. This is the sense in which choosing a reference frame also involves choosing a standard of rest.

Second, a reference frame includes a transportable plumb bob for measuring right angles. The usual way of talking about the workings of such a device presupposes that the space around us has a particular geometrical structure, one that is rich enough to support the notion of angle, or scalar product. But to talk in this way, in terms of an assumption that "space has a particular structure", risks begging one of the metaphysical issues with which SR is concerned. In particular, it presupposes the existence of a reified category of "space". Einstein, by contrast, eschews talk that reifies "space", and instead employs a more modest, operational ontology involving practices of

1 As such, the origin must be identifiable across time, and differentiable in space from other bodies. For convenience, in this essay I take the origin as effectively punctiform, that is, as occupying a single point in space, for example, a molten particle at the center of the Earth, or a mote of dust on the foremost tip of my nose. In Einstein's account of SR, the notion of a punctiform body is realized in terms of a fixed point on a rigid body.

measurement.[2] In Lefebvre's terms, we may say that Einstein shifts attention from a "representation of space", or what Lefebvre calls "absolute space", to a lived "representational space" or "social space" that is marked out by a set of social practices, namely, scientifically prescribed operations of measurement (Lefebvre 231-236).

Third, a reference frame includes a set of transportable clocks that measure time intervals, or elapsed time. It is assumed that these clocks are <u>locally</u> synchronized in the sense that, whenever they are brought into close enough proximity for a direct, unequivocal comparison of their readings, they are found to be in agreement. This assumption of local synchronicity presupposes, in turn, that it is unproblematic to make local comparisons between clock readings of the same event. In more formal terms, it presupposes a relation of "local simultaneity", that is, that there is a fact of the matter whether or not two events in the same spatial neighborhood are simultaneous.

To make such temporal comparisons between events that are <u>not</u> in the same locale is more problematic. Indeed, as I will show, it is a central result of SR that for the most part it is impossible to make such non-local, temporal comparisons. However, and this is one of the key claims that I am concerned to make here, this same result can be derived also from within the theoretical framework of NM, as follows. To see whether clock A agrees with a distant clock B about the timing of a

2 At a formal level, Einstein's assumptions commit him to a certain minimal structuring of what we may call "the manifold of spatial relations", a commitment which, while it does not amount to assuming a full blown Newtonian concept of "absolute space", does allow itself to be reframed in terms that, at a formal level, recapture certain aspects of the Newtonian concept.

particular event E, it seems that, in some way or other, we must transmit signals from E to both clocks, and, after making due allowance for the travel times taken for the signals to be transmitted from E to the respective clocks, we look to see whether the times at which the signals arrive at the clocks are in agreement with each other. But the allowances we make for the travel times depend upon our estimates of the signal speeds. And (as will become apparent from my later discussion of the principle of additivity of velocities) this, in turn, depends upon the reference frame we choose. Thus, even in the context of NM, it seems that, from an operational point of view at least, non-local synchronizing of clocks is not possible in an unequivocal way, without first specifying a choice of reference frame. A fortiori there can no fact of the matter, no single "correct" answer to the question, about whether two non-local events, each timed according to their own local clocks, are simultaneous or not.

Einstein expresses the latter result by indicating that, unless one simply begs the metaphysical issue at question and assumes the existence of some sort of absolute time, local times are capable of operational definition but a single all encompassing global time is not. In formal terms, we may say that, even within NM, the manifold of spatial and temporal relations is structured in terms of the existence of local times but, on closer inspection, does not support the existence of a single global time.

Fourth and finally, a reference frame specifies a set of transportable, infinitely extendible straight rulers that measure distances along a straight line. It is assumed that the rulers are congruent in the sense that whenever they are brought together, they agree on the length of space intervals. (This is the spatial analogue of the assumption of local synchronicity among clocks.)

How, then, are we to understand the Einsteinian strategy that I have applied here of stripping away the abstract, metaphysical structure of Newtonian space, and instead "operationalizing" spatial and temporal concepts in terms of practices of measurement? Sokal dismisses the strategy as merely "a pedagogical fiction" (Sokal 119), nothing more than a rhetorical device reserved for Einstein's semi-popular writings rather than a serious part of his theory's "technical content"(120). Alternatively (and this is the orthodox explanation, that has had considerable currency in the history of science literature) Einstein's operationalism is seen as an aspect of a more general, positivistic tendency in Einstein's work, a readiness to reject "metaphysical" entities that are not measurable or in some way directly verifiable.

But both of these explanations are unsatisfactory: the first (Sokal's) because it dismisses a key element of Einstein's scientific practice, the second because it is in tension with Einstein's evident metaphysical realism in respect of other "metaphysical" spatio-temporal entities, such as 4-dimensional Minkowskian space-time (I discuss this later) not to mention in his debates with Bohr over the "reality" of the particles of Qunatum Mechanics. It also makes it difficult to understand why Einstein includes patently idealized elements, such as infinitely extendible straight rulers, as part of the apparatus belonging to reference frames. To be blunt, from a positivistic point of view, Einstein's strategy of replacing the concept of absolute space with the notion of a reference frame is incomprehensible. It simply replaces one unverifiable, metaphysical construct, namely absolute space, with other, equally far fetched, fictional idealizations.

I shall argue for an alternative explanation of Einstein's operationalism in connection with spatial and temporal concepts. To be specific, I take it as a response to what he saw as insuperable difficulties that cropped up within the Newtonian account of space and time (difficulties that I mentioned briefly in the previous section, and that I turn to in more detail in the next section). To be specific, I take his strategy of operationalizing spatial and temporal concepts as Cartesian in spirit, or, more correctly, an attempt at a phenomenological reduction in something like the Husserlian sense, in other words, an analysis of the concepts of space and time for their phenomenological core content in terms of the results of measurement, which then provide a basis upon which to construct ("synthesize") a new conceptual architectonic which avoids the difficulties afflicting the Newtonian scheme. (Unlike Descartes, of course, Einstein did not take the "basic" facts as epistemically secure.) Having established the concept of a reference frame, I return to the critique of Newtonian concepts of space and time that I introduced in the previous section.

The Vanishing Point

Using a reference frame centered on the origin O, we can set up a Cartesian spatio-temporal coordinate system, that enables us to track a body through space and time. For convenience, in explaining the notion of a coordinate system, I assume a two dimensional space, that is a "flat land" that ignores the height of objects. Setting up a coordinate system involves two simple operations. First, place one of the rulers belonging to the reference frame through O – call that ruler "the X-axis". (The direction of the axis is arbitrary.) Second, place another ruler through O and, using the plumb bob belonging to O, ensure that it is at right angles to X – call that ruler "the Y-axis".

In order to track a body B (also assumed to be punctiform) using the reference frame O, we permanently locate one of the clocks belonging to O in the vicinity of B, that is, we arrange to transport a clock along with B. The spatio-temporal coordinates of B are defined, then, as follows: Drop a straight line from B at time t1 as measured by a clock at B so that, at time t1 as measured by a clock at X1, the line intersects X orthogonally at the point X1. Then the distance of X1 from O as measured along the ruler X is the "x-coordinate" of B – call it "x1". Define a y-coordinate for B at t1 similarly – call it "y1". Then the space time trajectory of B relative to the frame in question is given by the sequence of triples (t1, x1, y1), (t2, x2, y2), (t3, x3, y3) for various times t1, t2, t3, etc. This trajectory tells us where B is in relation to or "relative to" the frame O.

Consider two events E1 and E2, each defined in terms of a particular body or bodies occupying a single space and time point. For example, one might think of E1 as the assassination of President Kennedy in terms of the fatal bullet penetrating his brain, and E2 as the first ray of the morning sun appearing over the horizon in New York, on January 1, 2000. Let us ask what at first sight, from the classical Newtonian point of view that is enshrined in everyday language, seem to be two easy questions (and here I return to the question with which I began this paper): (1) how far apart in time do these two distant events occur, and (2) how far apart in space? According to Einstein, in order to get a grip on these questions, we must operationalize them, that is, ask what measurements we need to make in order to answer them.

Let us think first about the question of temporal separation between E1 and E2. The answer is easy: chose a reference frame including a set of synchronized clocks; place one of the clocks in the vicinity of E1 and another in the vicinity of E2; observe the reading on the E1 clock at the moment that E1 occurs, and similarly for the E2 clock; then the size of the temporal interval between E1 and E2 is equal to the difference between the two readings. (By assuming only the existence of synchronized clocks and local relations of simultaneity, such a procedure does not go beyond the minimal Einsteinian assumptions).

But this answer to the question of the magnitude of the temporal separation between E1 and E2 is relative to a choice of reference frame. In particular, it is relative to a choice of a set of synchronized clocks. According to NM, however, because the size of the temporal separation is frame-invariant, that is, is independent of the choice of reference frame, it turns out that this hidden relationalism has no effects. In short, in NM (by contrast with SR) the relativity of temporal intervals turns out to be purely conceptual in nature, with no material effects.

A more substantial relativity is apparent for spatial intervals, however, and here I recall the point that I made in the introductory remarks to this paper. If the earth moves a certain distance relative to the sun between the events E1 and E2 taking place, then it seems that we should add this to the estimate of the spatial interval between the two events. And if so, then why not add in the distance moved by the sun relative to the fixed stars, and so on? As I indicated above, there seems no natural end to these additions. Thus, it seems, the question of where, at the moment that the new millenium dawned in NY, the scene of the earlier shooting of President Kennedy is located is not capable of a well-defined answer. In short, we can say that the assassination took place in such and such a car, on such and such a stretch of road, on such and such a day. But from the perspective of a later time it seems difficult, even impossible, to identify the place where those props were located when the event took place.

Of course, a definite answer to the question of the distance of E2 from E1 can be obtained by fiat, by simply choosing a particular reference frame. To be specific, the distance of E2 from E1 relative to a frame with origin O can be defined as the distance of E2 from O minus the distance of E1 from O (the subtraction here is understood vectorially). But this answer, too, is relative to the reference frame, rather than being determined "absolutely". In short, it seems that we can only give a relative answer to our question – relative to a particular reference frame. Moreover, by contrast with the relativity of the time interval between E1 and E2, the relative nature of the space interval between these events makes a material difference. For example, as I indicated above, the distance of E2 from E1 for a reference frame in which the center of the Earth is the origin (that is, in which the center of the earth is treated as stationary) differs from the distance relative to a reference frame in which the Sun is the origin and the Earth is moving.

In sum, on analysis, the Newtonian account of space and time entails a hidden relationalism within spatial and temporal intervals. In particular, for non-simultaneous pairs of events, we cannot talk about the space interval between them except in a relative sense, that is, as relative to a reference frame. Thus, even in NM, it seems, there is no absolute, that is, non-relational, space, except as an abstract metaphysical fiction that has nothing to do with spatial relations as they are operationalized in practices of spatial measurement. And even time, it seems, is relational (or "relative") in NM, albeit not in any way that has material effects.

This result leaves us with a puzzle: having internally deconstructed the Newtonian concepts of absolute space and time, how can we account for the extraordinary power and apparent success of these concepts? The answer lies in the frame-invariance of temporal intervals assumed within Newtonian mechanics (an assumption that I have already discussed) as well as the assumption of frame-invariance of spatial intervals between simultaneous events. In formal terms, the first of these assumptions may be written as follows:

> t[O](E1,E2) = t[O′](E1,E2) (where "t[O](E1,E2)" designates the temporal interval between E1 and E2 relative to reference frame O).

From this principle it follows that any two events E1 and E2 that are simultaneous relative to O (that is, the time interval between them is zero relative to O) are also simultaneous relative to any other reference frame O′. In other words, in NM we can talk in an unproblematic way about "absolute", in the sense of frame-independent, relations of simultaneity.

It is also assumed in NM that:

> FOR ANY TWO EVENTS E1 AND E2 WHICH ARE SIMULTANEOUS, d[O](E1,E2) = d[O′](E1,E2) (where "d[O](E1,E2)" designates the spatial interval between E1 and E2 relative to reference frame O).

These two interlinked principles of frame-invariance give the fallacious impression that the spatial and temporal intervals in themselves, and a fortiori the space and time, to which they belong, are somehow absolute. The fallacy in drawing such a conclusion lies in tacitly extending the "absoluteness", qua frame-invariance, of the distance between pairs of simultaneous events, to all pairs of events, whether or nor they are simultaneous.[3]

The difficulties with the Newtonian concepts of space and time that I have discussed so far, in particular their hidden relational nature, can be accommodated easily enough, along lines suggested by Howard Stein, namely by modestly stripping down the rather lush ontology of absolute space and absolute time. To be specific, these difficulties can be avoided by replacing Newtonian absolute space and absolute time with a slimmed down spatio-temporal structure, that supposes only that temporal intervals and spatial intervals between simultaneous events are absolute (that is, frame invariant). But, it turns out, more radical surgery is required, and here we come to the nub of Einstein's critique of Newton.

A corollary of the Newtonian conceptions of space and time is the "law of additivity of velocities", the proof of which I sketch here using an example adapted from Einstein. A car drives along the street at 10 mph relative to the road surface. It passes a man walking at 5 mph, heading in the same direction. How quickly does the car move ahead of the man, as observed from a frame of reference in which the man is stationary? The answer seems childishly obvious: 5 mph. Indeed, it is hard to see how it could be otherwise. By definition, an hour's drive will take the car 10 miles, and in the same time, the man will travel 5 miles in the same direction. Therefore, as an elementary matter of mathematical necessity, it seems, the car is 5 miles

[3] The fallacy lies not in taking frame-invariance as a criterion of "absoluteness". On the contrary, frame-invariance rather than non-relationality is an suitable criterion for the meaning that "absoluteness" has come to take on in the arena of contemporary theoretical physics.

ahead of the man after 1 hour. It follows that the car moves ahead of the man at the rate of 5 mph. QED. More generally, we conclude:

> Additivity of Velocities If B moves with velocity v relative to frame O, and B′ moves with velocity v′ relative to frame O, then relative to a frame with B at the origin, B′ moves with velocity (v′ - v).

But a quick inspection of my "proof" of this law reveals that it smuggles in some non-trivial, dubious assumptions. In particular, the proof assumes that, relative to the reference frame of the road, the distance that the car moves ahead of the man in an hour is identical with the distance that the car moves ahead of the man relative to a quite different reference frame that is centered upon the man as its origin. But, as I have shown, it is exactly such relations of frame-invariance of distances between non-simultaneous events that are dubious, even in classical Newtonian physics.

On second glance, however, this apparent flaw in the proof turns out not to be a source of difficulty. It is true that the estimates of the distances that the man and car respectively travel in an hour depend upon the reference frame. But, according to Newtonian physics, in shifting to a new reference frame, the distance that the man travels will be altered by the same amount as the distance the car travels, an amount that is determined by the relative motion of the new reference frame's origin from the point of view of the old frame. Thus, in taking the difference between these two distances, the contribution due to the relative motion of the reference frame will cancel out. In short, the difference between the two distances will not depend upon the reference frame, even though each of the distances separately exhibits such dependence.

Before considering how this result is affected by the shift to SR, there is an important additional feature of NM that must be introduced. In NM the distance between two events relative to the frame O takes a particularly simple, Pythagorean or Euclidian form:

> $d[0](E1,E2) = \ddot{O}[(x1 - x2)^2 + (y1 - y2)^2 + (z1 - z2)^2]$, where x1, y1, z1 and x2, y2, z2 are the spatial coordinates of the punctiform events E1 and E2 respectively for the Cartesian coordinate system developed from the reference frame O. (I have added in the third spatial coordinate here, in order to make my presentation more realistic.)

Similarly, the temporal interval between two events relative to the frame O takes the form:

$$t[O](E1,E2) = |t1 - t2| = \ddot{O}(t1 - t2)^2$$

In other words, according to NM, relative to any reference frame, space and time intervals are independently Euclidian in structure, that is, they take a Pythagorean form.

Relativity Theory

The big news that Relativity theory offers is that, despite its almost tautologous status, the law of additivity of velocities fails. This is shown empirically by the famous Michelson Morley Experiment, but also on theoretical, or what one might think of as philosophical or even metaphysical, grounds, based upon what Einstein calls "The Principle of Relativity". This plausible metaphysical principle asserts that the laws of physics are frame-invariant, that is, cannot be changed merely by shifting to a new reference frame. In other words, laws cannot be changed merely by adopting new clocks, new rulers, or new plumb-bobs, let alone by making a new choice of origin. It follows, then, that since the laws of physics, specifically Maxwell's laws of electromagnetism, mention the velocity of light, this velocity must be a universal, in the sense of a frame-independent, constant.

But it is easy to see that this priciple of the constancy of the velocity of light contradicts the law of additivity of velocities. Re-imagine the above scenario of a car moving past a man, after substituting a ray of light for the car. If the velocity of light relative to the road is c mph, then, according to the law of additivity of velocities, the speed of the ray of light relative to the frame of reference centered upon the man as origin is (c-5) mph. But that contradicts the claim that the velocity of light is frame-independent. *QED*

It follows that the elegant Newtonian structure of an absolute Euclidian space and time must be revised. But how? Here, too, the principle of relativity, in particular, its corollary in the form of the principle of the constancy (qua frame-independence) of the velocity of light, shows the way. Consider any two point events E1 and E2 that are located on what Einstein calls "the light cone", that is, E1 coincides with a light ray passing through a particular region of space and time, while E2 coincides with that same light ray passing through a distant region of space and time. Thus one way of measuring the speed of light c[O], relative to a frame O, is to divide the distance between E1 and E2, relative to O, by the time taken to traverse this distance, relative to the same frame O. That is, c[O] = d[O](E1,E2)/t[O](E1,E2). The principle of constancy of light means that this equation must be the same for all frames of reference O, which, in turn, means that, for all frames O, d[O](E1,E2) = c[O].t[O](E1,E2). Then, because distance and time functions in SR retain the classical Pythagorean form in all reference frames, this means that for all frames O:

> Ö[(x1 - x2)^2 + (y1 - y2)^2 + (z1 - z2)^2] = c[O].Ö(t2 -t1)^2, where x1, y1 ,z1 ,t1 and x2, y2, z2, t2 are the spatial and temporal coordinates of the punctiform events E1 and E2 respectively relative to O.

Thus, with a bit of algebraic manipulation, for all frames O,

$$(x1 - x2)^2 + (y1 - y2)^2 + (z1 - z2)^2] - c[O]^2.(t2 -t1)^2 = 0$$

And this, in turn, entails that the semi-Euclidian, quadratic form (x1 - x2)^2 + (y1 - y2)^2 + (z1 - z2)^2] - c[O]^2.(t2 -t1)^2 is frame-invariant, that is, it takes the same values in all frames of reference. In other words, SR entails that the combined 4-dimensional space-time manifold has an absolutely semi-Euclidian structure.

A consequence of this, that I do not have the space to demonstrate here, is that, although they all share the same Pythagorean form, when spatial and temporal intervals are considered separately, they are not frame invariant. In other words, by insisting upon the frame-invariance of a combined spatio-temporal interval, SR entails that spatial and temporal intervals taken separately are frame dependent, a fact that we noted already in connection with the spatial intervals between (non-simultaneous) events described in NM. Thus, SR formalizes and extends the hidden relationalism implicit in the Newtonian concepts of space and time. As such, it undermines the "objectivity" and more specifically the absoluteness (understood as frame invariance) of the classical metaphysical entities of space and time.

In sum, instead of independently assigning each of the space and time manifolds an absolute (frame invariant) Euclidian structure, SR proposes that it is the combined 4-dimensional space-time manifold – so-called Einstein-Minkowski space-time – that has an absolutely semi-Euclidian structure. In other words, SR proposes an absolute and thus objective 4-dimensional space-time structure in place of the objective 3-dimensional space and 1-dimensional time featured in NM. In particular, it is the combined spatio-temporal interval Ö$(x1 - x2)^2 + (y1 - y2)^2 + (z1 - z2)^2] - c[O]^2.(t2 - t1)^2$, rather than that of the separate spatial and temporal intervals, that is invariant. This result, it turns out, is both necessary and sufficient to establish the constancy of the velocity of light that is required by the principle of relativity. In short, SR does not surrender objectivity in the sense of frame invariance, but instead shifts it to a more abstract level, from 3+1 dimensions to 4. It seems, then, that Sokal is correct in his claim that the objectivity of physical entities is not undermined in SR.

But this is not the final word in the debate. On the contrary, by taking seriously Einstein's strategy of operationalizing the structure of space and time, I have shown, contra Sokal, that Lefebvre's concepts of "social space and time" are instantianted in SR, at least in the version that Einstein himself promulgated. Science may not be "social through and through" as Latour claims but, it seems, at least some of the entities that it invokes belong to the social realm. In the next section, I further turn the tables on Sokal by attacking another of his claims. In particular, I question his assertion that physics has nothing to do with, let alone anything to learn from, cultural studies and sociology. I argue to the contrary that, by showing that social and absolute concepts of space and time are intermingled within Einstein's views, cultural studies illuminates otherwise puzzling aspects of the Einsteinian revolution. In particular, cultural studies help to cast light upon the otherwise puzzling relation between Einstein's metaphysical realism and his strategic operationalism.

Abstract Space/Absolute Space

Our experience of space is organized in terms of what Lefebrvre calls an "abstract space", an uneasy alliance between two structures. On the one hand, there exists what he calls a "representation of space" or "absolute space", that is, a symbolic representation of places, directions, and shapes. On the other, there exists a "representational space" or "lived space" that is addressed to the body rather than to the intellect. The latter is implicit in the way that people structure their environment in terms of normative boundaries that separate the sacred from the profane, the forbidden from the permitted (Lefebvre, 231-233, 235-236).

According to Lefebvre these two aspects of abstract space, the "absolute" and the "lived", do not simply reflect each other as Panofsky claims (258), but instead exist in dialectical tension. To be specific, the representational forms of absolute space take on an ideological role in a traditional marxist sense, namely as misrepresentations that conceal or mystify "real", that is, lived, social relations. Lived spaces, on the other hand, are ideological in an Althusserian sense. That is, they are implicit maps, that show where people go/do not go, or more correctly, where they are allowed/not allowed to go.

According to Lefebvre, these two aspects of abstract space, the lived and the absolute, are in mutually destructive tension. The lived erodes and is eroded by the system of representations that always and already work to misrepresent it. As Lefebvre puts it, "no sooner is it [lived space] conceptualized [in absolute terms] than its significance wanes and vanishes" (236). In this context, abstract space may be seen as an illusion, created by a continual flickering between the "representation of space" and "representational space", that is, between purely symbolic absolute space that is "located nowhere" and the concrete realities of lived space.[4]

These Lefebvrian concepts can be used to cast light upon Einstein's operationalism. In SR, we have seen, Einstein retreats from the absolute space of NM, and instead grounds his concept of space in operations of measurement, that is, in particular normative scientifically prescribed social practices. Thus, he may be seen as shifting within the levels of what Lefebvre calls "abstract space", from the absolute (or purely conceptual) to the "lived", that is, from what Lefebvre also calls the representation of space to representational space. In the course of making this shift, we have seen that "gaps" appear in the classical symbolic structure of space, gaps that, within the Newtonian architectonic, are hidden by assuming the existence of fictional locations, such as the present location of the place where President Kennedy was shot.[5]

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4 Sokal 236. There is a third aspect of the uneasy "unity" that makes up abstract space, what Lefebvre calls its "phallic" aspect (286-287), as embodied in the space traced by "real" spatial practices determined by the architecture, but also by the well trodden (if not always totally legal) paths by which people make a space for themselves (245). This third aspect is related in an interesting and complex way to Lefebvre's "representational space". That is, because it is normative, representational space is always and already an attempt to discipline, even to domesticate, the real of social practices, even as such practices resist, bypass, and move between the prescribed, "phallic" spaces that are laid out in advance for their deployment.

5 In Lacanian terms, the gaps hidden by these fictions are candidates for the Real. Such gaps function according to the logic of *Film Noir*, that

But as has been traditional in science, the symbolic reasserts itself, and the gaps disappear behind a new symbolic structure. To be specific, Einstein engineers a return to an absolute conception of space and time, represented by the metaphysics of Minkowskian 4-dimensional space-time. Lefebvre's scheme enable us to understand this historical shift between Einstein's early, critical operationalism and his subsequent return to metaphysical realism as no more than one among many momentary flickerings within the perenially unstable, dialectical structure of abstract space.

Where do these considerations leave us in relation to Sokal? In the final analysis, Einsteinian physics does not provide a sustained deconstructive critique of the concept of objectivity.

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sustains plot by hinting at mysterious, shadowy forces, the explanation of which is always and already deferred, and which, on closer inspection, always vanish into no-sense. Similarly, the shots in *Film Noir* are structured by frames – the shadows cast by venetian blinds, staircases, and so on – that mark out spaces that have no meaning. *Film Noir,* thus, functions as a kind of perverse negative of ideology in both traditional marxist and Althusserian senses of the term. That is, it is a symbolic site where the Real is exposed, but also a reverse of the all-encompassing world of simulacra that is created through the provision of instant global news coverage by television and the new media. It is, thus, no accident, as one might say, that the period of *Film Noir* coincides with the rise of television. The relation that I am proposing between *Film Noir* and ideology resembles the relation between Kafka's stories and ideology. On this point, see Zizek's discussion in chapter 1 of *Sublime Object of Ideology*. I owe many of these points to Hugh Manon's work on *Film Noir*. Manon focuses upon the strange sequences of numbers, lists of signifers, and mysterious X factors circulating through the text of *Film Noir*, which, although without any apparent meaning or relevance within the story, gesture towards hidden forces conspiring behind the scenes, as well as upon the strange, shadowy, liminal spaces, empty, framed by venetian blinds, stair cases, etc. that thread through *Film Noir's* visual space.

On the contrary, Einstein's moment of critique quickly gives way to a post-deconstructive reinscription of the absolute, albeit at a more abstract level. Thus, it seems, at least on this point Sokal is correct. But Sokal errs in totally separating physics from cultural studies. In particular, he misses the way in which cultural studies illuminates the history as well as the present of science. The putative slave (cultural studies) turns the tables on the master (science). In particular, Lefebvre's concept of social space provides insight into the historical course of theoretical physics, and in particular, into the methodological tensions between operationlism and realism that surface in and structure the Einsteinian revolution.

REZUMAT

Recent, Alan Sokal ridica problema legăturii dintre, pe de o parte, reprezentările spațiului care țin de fizică și, pe de altă parte, așa-numitele „spații sociale" care sunt marcate de traseele pe care oamenii le urmează în viața de zi cu zi. În particular, Sokal contrazice ceea ce Bruno Latour, Henri Lefebvre și altii susțin, și anume că reprezentările spațiului fizic sunt întotdeauna reflexii mai mult sau mai puțin distorsionate ale spațiilor sociale. El își demonstrează punctul de vedere într-un stil polemic tipic: „intervalele în spațiul-timp fizic nu coincid cu ceea ce denumim de obicei 'spațiu' și 'timp'". În plus, ele nu au nici o legătură cu (ceea ce Virilio denumeste) „geografia și istoria lumii" sau „reglarea cronopolitică a societății umane"(Sokal 161; v. 99, 122, 242). Sokal îi disprețuiește cu precădere pe 'constructiviștii sociali', cum este Bruno Latour, care pretind că fizica, în special teoria relativității, ne arată că

„spațiul-timp încetează a fi obiectiv" și este, în schimb, după cum Latour spune, „numai și numai/prin excelență social".

Mai curând decât să mă refer direct la problemele complexe ridicate de Sokal, vreau să abordez teoria specială a relativității a lui Einstein și să explorez conceptele de spațiu și timp pe care ea le implică. La sfârșitul acestei discuții voi repune problema relevanței pe care astfel de concepte o au pentru studiile culturale. Pe de o parte, voi fi de acord cu Sokal în ceea ce privește nefondarea ideii că critica lui Einstein asupra conceptelor clasice, newtoniene, de spațiu și timp absolut se opune obiectivității spațiului și timpului în sine. Pe de altă parte, în contradicție cu Sokal, voi argumenta ideea că măcar unele din entitățile spațio-temporale postulate de Einstein în teoria relativității sunt „sociale" în sensul postulat de Latour. Voi argumenta, de asemenea, că teza spațiului social, a lui Henri Lefebvre, în special distincția lui între spațiile absolute și cele abstracte, propune un cadru util în legătură cu care să se gândească și să se pună în lumină tensiunea între abordările operaționaliste și realiste ale conceptelor de spațiu și timp, care fusese observată în opera lui Einstein.