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Travels in Four Dimensions: The Enigmas of Space and Time

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The author writes in the preface: "This book arose out of a course of lectures I have given for many years … My purpose in writing it was primarily to introduce the reader to the classic paradoxes and problems of space and time." (x-xi) On the whole, the book succeeds admirably in this goal, and should appeal to a wide audience. Three audiences, in fact. First and foremost, the book can serve as an introductory text for an undergraduate course in the philosophy of space and time. Discussion questions are included after each chapter, and further problems are provided in a separate section at the end of the book. Key arguments are usefully laid out in premise-conclusion format. Because the problems discussed all involve classical, rather than relativistic, concepts of space and time, very little physics is called upon throughout the book. That could be a plus or a minus. Instructors who prefer to include some space-time physics and its philosophical ramifications will want to supplement the book, or turn elsewhere. A second prime audience is the educated layperson with a penchant for puzzles and paradoxes. Of these there should be many. Books on space and time, often by celebrity physicists, fly off bookstore shelves (only, one suspects, to collect dust in home libraries). Most of these readers would do better to start with this book. I can't but agree with the author that "conceptual analysis of the classic paradoxes and problems [is] an important preliminary to thinking about space-time physics." (xii) Finally, the book should appeal to professional philosophers and graduate students of philosophy who seek a lightweight but informative overview of issues in the philosophy of space and time. For, as the author rightly notes: "A great many philosophical problems are affected by views on space and time … these two lie at the heart of metaphysical inquiry." (x) All three audiences will appreciate the author's clarity of expression and engaging style of writing. The frequent use of literary or historical anecdotes to introduce a topic, which might be out of place in a more scholarly philosophical treatise, contributes here to making the book a pleasure to read.

The book covers a lot of ground. Here is a list, chapter by chapter, of just some of the topics discussed. Chapter 1: conventionalism vs. objectivism concerning the temporal metric. Chapter 2: the relation between time and change. Chapter 3: absolutism vs. relationism about space. Chapter 4: non-Euclidean and four-dimensional space. Chapter 5: the topology of time (could time have a beginning? could time be circular?). Chapter 6: the edge of space (could space have a boundary?). Chapter 7: Zeno's paradoxes of plurality and motion. Chapter 8: time's passage (McTaggart's argument and the presentist and the B-theorist responses). Chapter 9: Zeno's Arrow (static vs. dynamic accounts of motion). Chapter 10: backwards causation and time travel. Chapter 11: other times and spaces (the fine tuning argument for multiple universes; the two slit argument for branching space). Chapter 12: the direction of time. With so much ground to cover, the author aims only to provide the opening moves to a given debate; theories are sketched, but never developed in detail. Through it all, the author serves as an informed guide, pointing out avenues of research that are promising, occasionally opinionated, but never doctrinaire.

There are some sections of the book, however, that I do not think are adequate to the task at hand. Most of these, I suspect, result from the author's wish to avoid too much mathematical precision or overly complex argumentation. And no doubt there have to be trade-offs in a book of this sort. But, at least in the four cases mentioned below, I think the author could have been more careful or more thorough.

Consider, for example, the author's response to Zeno's paradox of plurality (called *Parts and Wholes* by the author). The paradox arises on the supposition that a finite-length rod is composed of infinitely many (ultimate) parts. "If we say that each part has a definite, non-zero size, then, since the rod consists of an infinite number of parts of that size, the rod itself must be infinitely long. … if each part has no size, then the rod itself can only be of zero length, since even a infinite number of parts of zero size cannot add up to something of non-zero size." (p.□03) The standard mathematical solution, ensconced in modern measure theory, is to reject additivity for non-denumerably many parts: a rod composed of non-denumerably many points, each of size zero, can have any finite length, or be infinite in length. But the author responds, instead, as follows: "if we say there are an infinite number of parts [in a rod of unit length], what length has each part? That is, what, when multiplied by ∞ (infinity) results in 1? The answer is 1/∞. Each part, in other words, is infinitely small, and the sum of an infinite number of infinitely small magnitudes is a non-zero but finite magnitude." (p. 104). This reasoning is spurious. If we had started instead with a rod of length two units, parallel reasoning would have us conclude that its infinitesimal parts have length 2/∞. But since each half of that rod is a rod of length one, the very same parts must also have length $1/\infty$. Is, then, $1/\infty = 2/\infty$? If multiplying and dividing by ∞ is permissible, why can't we conclude that $1 = 2$? This is not to deny that there are non-standard measure theories that resolve the paradox and allow for infinitesimal lengths. But the author seems to be invoking, instead, what might be called the "naïve" theory of infinitesimals, a theory that is demonstrably inconsistent. (The author also invokes infinitesimals in presenting his solution to Zeno's paradoxes of motion, such as the *Achilles* and *Dichotomy*; but infinitesimals play no role in these paradoxes, since all lengths and durations considered are finite.)

Later in the same chapter, the author considers a puzzle about transition. A train is waiting at the station, and then begins to move. If time is dense, so that between any two moments of time there is a third, then there cannot be both a last moment of rest and a first moment of motion. How, then, shall we classify the moment of transition? The author argues that the moment of transition is a last moment of rest. He reaches this conclusion by assuming that it must be either a moment of rest or a moment of motion, and by arguing quite generally that there can never be a first moment of motion. For, he claims, there is no motion until there is a displacement from a prior position; and, if time is dense, there cannot be a first moment of displacement. This conclusion has some untoward consequences. For one thing, it would follow that if time has a first moment, then everything is at rest at that moment. Worse, the author's view would seem to be incompatible with Galilean relativity. For consider a train that is in motion and then comes to a stop. Presumably, by parallel reasoning, the author will say that the moment of transition is a first moment of rest. But an object in motion coming to a stop, as viewed from one reference frame, may be an object at rest beginning to move, as viewed from another reference frame. And, presumably, the moment of transition cannot share its (specific) state of motion with preceding moments according to one reference frame, and with succeeding moments according to another.

If, instead, one invokes the standard mathematical response to questions of (instantaneous) rest and motion, the transition puzzle is easily resolved; whether or not the author's account can stand, the reader should be introduced to the standard resolution. On that account, the state of motion of the train at a given moment is fully determined by the (first and higher-order) time derivatives at that moment. How our *ordinary* concepts of rest and motion relate to the resulting mathematical classifications may be indeterminate. But, plausibly, to be at rest at a moment is just to have the first derivative defined and zero at that moment; to be in motion is just to have it defined and non-zero. (That allows a projectile at the top of its trajectory to be at rest, which seems right.) Whether the transition moment is a moment of rest depends on how the transition takes place: if the transition is abrupt, the first derivative is undefined, and the transition point is neither a moment of rest or of motion. There is nothing arbitrary, or unduly revisionary, in explicating our ordinary concepts of rest and motion in this way.

Another place where oversimplification leads to an unsatisfactory result is the author's presentation of the fine-tuning argument for multiple universes. As the author understands the argument, it is based on a general principle of probabilistic confirmation theory, roughly: "you would be wise to prefer a hypothesis that makes the observed result very likely to one that makes that result very unlikely." (p. 186) That our universe contains life (the "observed result") is very unlikely on the hypothesis that there is only one universe (and no creator), but, according to the author, is made very likely on the hypothesis that our universe is but one of billions and billions of universes, all with different physical constitutions—the *multiverse hypothesis*.

To motivate the argument, the author considers the following supposedly analogous case. Suppose there is a computer designed to print out pages of random numbers; and suppose, on the one page you see, the first thousand digits of the decimal expansion of pi are printed out. The author writes:

> "you do not know whether this is the one and only page that the computer has produced, or whether it is one of millions of pages, the computer having been producing its numbers non-stop for years, and this page has been deliberately selected by someone for your attention. … Given the general principle appealed to a moment ago, that we should choose the hypothesis that makes our observation more, rather than less, likely, we have reason to suppose, just on the basis of what we have before us, that this page is not unique—that it is one of many such pages." (pp. 186-7).

Now—although this is suppressed at the end—it is important to note that the general principle does not support the many-page hypothesis by itself; rather, it supports the conjunction of the many-page hypothesis and the hypothesis that only a page with the printout of the expansion of pi would be selected for our attention. For the many-page hypothesis by itself does not make it more likely that we are looking at a printout of the expansion of pi if the page we are looking at was randomly selected from all the pages that have been printed, no matter how many pages have been printed.

When the argument for the multiverse hypothesis is presented, however, the "selection effect" has totally dropped out:

> Postulating a multiverse is like postulating that the page of random numbers that just happens to match the expansion of pi is just one of many such pages, produced by many machines, running over many years. As long as our universe is unique, the fact that it contains life is (the hypothesis of a creator aside) remarkable. But once we see it as one of billions of universes, each with a different physical make-up, the fact becomes less remarkable. Indeed, we may even be tempted to say that, given enough universes, it was inevitable that one should contain the conditions necessary for life. (p. 188-9)

But the multiverse hypothesis does not make the fact that our universe contains life less remarkable if we could equally well have found ourselves in any of them. As the fine-tuning argument is usually presented, the observational selection effect—that we could only find ourselves in a universe that contains life—plays an essential role. But it is not at all obvious how or whether the general principle of confirmation theory is supposed to apply in this case. The "selection effects" in the multiverse case and in the computer case do not seem to be analogous.

Perhaps the author thinks that the argument for the multiverse hypothesis does not rest upon there being an observational selection effect. In the passage quoted above, the author shifts between applying the general principle to the claim that *our* universe contains life and the weaker claim that *some* universe contains life. Indeed, the multiverse hypothesis does make it more probable that *some* universe contains life. But the general principle is fallacious when applied to an existential proposition entailed by our observation rather than to the observation itself. Suppose the "observed result" is that I am hungry. Then I also know by observation that someone is hungry. Consider the hypothesis that you have not eaten all day. That hypothesis makes it very likely that someone is hungry. But it would not be rational for me to believe that you have not eaten all day on the basis of my observation that I am hungry.

One final example. At the end of an otherwise nice discussion of time travel, the author leaves the reader with a puzzle, and a misleading suggestion as to its import. The case considered is this:

> Peter and Jane, both 20 years old, are out for a walk one day in 1999 when suddenly a time machine appears in front of them. Out steps a strangely familiar character who tells Jane that he has an important mission for her. She must step into the machine and travel forward to the year 2019, taking with her a diary that the stranger hands to her. In that diary she must make a record of her trip. Obligingly, she does as she is asked and, on arrival, meets Peter, now aged 40. She tells Peter to travel back to 1999, taking with him the diary she now hands him, and recording his trip in it. On arrival in 1999, he meets two 20-year olds called Peter and Jane, out for a walk, and he tells Jane that he has an important mission for her. (pp. 180-1)

The puzzle comes from asking: how many entries are there in the diary when Peter hands it to Jane? According to the author, "there does not appear to be a consistent answer." Whatever number of entries one says the diary contains – say, n – it seems there must be two more than that; for Jane records an entry when she travels forward in time, making $n+1$, and then Peter records an entry when he travels back in time, making $n+2$, and then hands the very same diary to Jane that we supposed has only n entries.

Now, the puzzle certainly raises some interesting questions. (Where did the diary come from? Does the diary age like ordinary objects? From a four-dimensional perspective, the diary is what might be called a "roundworm.") But it is misleading to suggest that there is any problem of (logical) consistency. It is easy enough to fill out the story in ways that, though odd, preserve consistency. Perhaps the entries are cleanly erased prior to the hand-off to Jane, so that the diary is blank when Jane gets it. Perhaps every entry is perfectly written over a previous entry, leaving no added trace, so that the diary has two entries when Jane gets it. The story could also have been filled out in a way that ruled out these and all other fixes. Then the story would indeed become an inconsistent time travel story. But, of course, there are inconsistent stories that that have nothing to do with time travel, for example, inconsistent space travel stories. In either case, it is not the time travel or the space travel that is to blame for the inconsistency, but the incompetent storyteller.