The Philosophy of Space and Time

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A brilliantly clear and penetrating exposition of developments in physical science and mathematics brought about by the advent of non-Euclidean geometries, including in-depth coverage of the foundations of geometry, the theory of time, Einstein's theory of relativity and its consequences, other key topics.

The Philosophy of Space and Time Details

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From Reader Review The Philosophy of Space and Time for online ebook

Steven Dunn says

I will definitely reread this in the future, perhaps when discussions regarding indefinite metrics and geometrical schemes in gravitation become a little less cloudy. Nonetheless, Reichenbach touches very nicely on the issues that I was able to follow through very well.

Erickson says

This is my second attempt of rereading it, and finally a lot of it makes sense now. Apart from slight unfamiliarity with coordinative definition, the concept of indefinite metric, and general gravitation, most of the rest can be understood much better now. I like the part that geometry can be interpreted as a result of gravitation rather than gravitation interpreted as geometry - that measuring instruments which probes geometry can be thought as probing gravitational field.

I still did not quite comprehend the argument using stereographic projections. But this book is, in my opinion, so good that I will keep it for very long.

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At my level it is very difficult to understand if I did grasp anything at all. But some interesting views such as the equivalence of geometric descriptions based on coordinative definitions was an eye-opener. That geometry of space time is explicable in terms of equivalence of metric and gravitational tensors was something I could not even grasp a bit.

Given the shallow understanding even after reading it, it warrants me to read again some time in future once I have greater grasp on geometry and physics.

Jhc says

A classic by one of our best and most underrated philosophers of science.

Xander says

Hans Reichenbach, one of the twentieth century philosophers affiliated with the European movement of logical positivism, has an amazing gift to explain difficult physical and mathematical concepts in a language that the average reader understands. (Not to mention the highly informative and accessible illustrations he presents.) There's only one caveat: the reader is supposed to be familiar with the theories and experiments concerned. I am no physicist, so I will not write a review like I fully grasp all the intricacies of The Philosophy of Space and Time (1927). I am an interested lay person, familiar with the theories of relativity and classical mechanics (more from a philosophical than a mathematical perspective), so take this review with a grain of salt - or two.

Ever since Euclid, philosophers and scientists have worked with a geometrical system that was based on a handful of definitions and axioms (i.e. self-evident truths) and theorems that were discovered by logical deduction. In the nineteenth century, one of Euclid's axioms - the axiom of parallelism (two parallel lines will never intersect) was under attack. According to mathematicians Bolyai and Lobachevsky this axiom could be refuted and yield undiscovered, non-Euclidean geometrical systems which were totally consistent and independent of Euclid's geometry.

Gauss, a geometrician, when faced with the existence of multiple mutually exclusive geometries started to wonder which one of those systems described our physical world. He tried to measure the curvature on Earth, but (of course) failed. Later, in the twentieth century, Albert Einstein applied a non-Euclidean geometry to our universe in his general theory of relativity. This was groundbreaking: for thousands of years people believed we lived in a Euclidean universe which was describable by plane geometry (the one every kid learns in school).

Einstein came to his discovery by asking physical questions about the universe; and this shows the clear distinction between 'pure' geometry and 'empirical' geometry. Mathematicians can concoct new mathematical relations in their arm chairs, but at the end of the day these theorems stand or fall with empirical observation and experiment. This, at least, seems to be Reichenbach's view in The Philosophy of Space of Time.

Throughout the book, Reichenbach convinces us that empirical evidence should decide about geometry. He starts with explaining the implications of the theory of special relativity for our notions of 'space' and 'time'. Then, in part 3 of the book, he gradually takes us to the general theory of relativity - of which the special theory is only one particular instance - Einstein's theory of gravity. In short: matter and energy (E=mc2) curve spacetime and (reversibly) the curvature of spacetime determines the behaviour of matter and energy.

Basically, the general theory of relativity teaches us that gravity is covariant. In other words: gravity differs per system of coordinates. If one knows the state of one system, one can calculate the state of any other system imaginable - and all those states are equivalent. Questions of truth disappear. According to Einstein's theory, a moving measuring rod is shorter than the exact same rod at rest (as seen from the frame of reference of the rod at rest!!!). No longer: which is the 'true' length of the rod? All lengths are equally true; each coordinate system (the rods) can be said to be at rest with respect to the other.

I find it confusing (and interesting) why Einstein called his theories 'relative' - it seems that it would be much better to have called the theories 'invariant'. Relativity seems to trick people into thinking that 'everything is relative to everything else'. Which really is misleading, since both of his theories only deal with invariant elements in the physical descriptions of the universe and hence, it doesn't really matter if we describe us orbiting the sun or the sun orbiting us. We can pick whatever coordinate system is the most useful, simple, beautiful, etc. and skip over questions of truth. If need be, we can use mathematics to transform this system into another system.

Reichenbach often delves deeply into philosophical implications of our notions of space and time, and there were times in the book that I felt utterly lost - especially when he combined his philosophical investigations with metric tensors in general relativity...

Still, (I think) I understood a huge portion of the book, so I will sum up the main points that I took from this (highly recommendable!) book are:

1. Our best physical theories that describe our universe are highly arbitrary, in the sense that ultimately they are based on arbitrarily chosen coordinative definitions (e.g. what we define as a meter is a meter). And these arbitrary decisions don't seem to matter at all for explaining the world we live in! (I believe this view is called 'conventionalism'?)
2. Besides this, these theories seems to converge in showing us how free we are to describe the world we live in. This shouldn't be taken to mean that anything goes, or that this is some sort of postmodern conclusion, ending in 'all science is equally true'. It just means that any system of coordinates can be be used to describe the world - as long as it is emperically confirmed (!) - and can be transformed into any other system of coordinates. And gravity is no longer an invariant factor (i.e. a universal force) but a covariant factor, varying with the system of coordinates chosen. For example, Euclidean geometry can be used to describe the spacetime between the galaxies, where gravity is neglible; we need non-Euclidean geometry when dealing with things like orbits of planets.
3. Ultimately, geometry became physics and Einstein's general theory shows us how geometry in sense IS space(time): the curvature of spacetime is determined by physical phenomena (i.e. matter and energy).
4. The (physical) proof of the objective existence of spacetime, in the sense that experiments and observations in physics have shown us the reality (and nature) of spacetime. This is truly amazing, if you think about it deeply.

To illustrate this last point, consider that Einstein's general theory of relativity not only described all of the earlier (relevant) theories in physics, but also predicted the existence of particular, unobserved phenomena:
- The bending of light rays due to the curvature of spacetime, confirmed by the expedition of Eddington in 1919.
- Gravitational redshifts in locations in spacetime that contain huge masses or amounts of energy, confirmed by experiments in the 1960's.
- The (apparent) slowing of time near strong gravitational fields, confirmed by flying atomic clocks around the world and comparing their measurements with clocks on the ground.

In other words: physical phenomena tell us in what type of universe we live - an Einsteinian universe. How beautiful!

I find another thing very beautiful, which is mentioned early on in The Philosophy of Space and Time. This is the long time it took for people to wake up and realize that Euclid's geometry was only one of many geometries possible. And even after this, it took years for people to realize the importance of the existence of all these systems of geometry for philosophy and science. The beauty of this lies in the fact that even thousands of years of 'certain' knowledge - philosophers tried to model all of science on Euclid! (cf. Descartes, Spinoza, Hume, Kant) - can be plain wrong. Well, not really wrong, in the all or none-sense, but limited. For millennia the most intelligent people thought that Euclid's geometry described the world; nowadays, the most plain (but interested and motivated) people can learn how Euclid's geometry 'only' describes the parts of our universe which are most empty- by approximation. All of the important parts of our universe are governed by a totally different system of geometry. Ironic, and highly telling for the progress of human knowledge.

Still, I wonder if we are zooming in on certain knowledge. Never before have we had so many fundamental theories and so much sophisticated apparatus to do experiments and observations with. Personally, I don't believe in the endless pursuit of knowledge; the history of science allows us a careful positive induction: it seems that we perfect our theories - at least in physics, chemistry and biology - by the year. Somewhere there's a limit of what there is to know: the question is if we, as human beings, will be able to grasp these ultimate truths. Looking at modern physics - with pure mathematical (i.e. mostly untestable) ultimate theories - I think we are rapidly approaching the point where even the most gifted intellects won't be able to make sense of the theories anymore. Food for thought...

A last remark. Great thinkers like Locke, Hume and Kant saw (Euclid's) geometry as analytical knowledge. In other words: one could know everything of geometry by applying Reason (i.e. using logic to deduce new propositions from known ones). All of this was deemed to be certain knowledge, as opposed to empirical knowledge, which we only gather via our senses, which are obviously fallible, and thus this knowledge isn't certain. This is why I find the history of philosophy as well as science interesting: Reichenbach clearly shows how the developments in twentieth century physics (especially general relativity) have shown us that geometry isn't analytical but, on the other hand, is highly arbitrary and should be verified by experiment and observation. In other words: the downfall of what was, for millennia, the textbook example of certainty (i.e. Euclid's geometry) turned out to be the key to the biggest scientific progress since Newton. Now we know that even mathematics is subjected to scientific rigour and hence, should be tested by experiment and observation. Of course there are mathematicians (and physicists) who think otherwise, but I doubt if the mainstream would take this view seriously nowadays. These major breakthroughs and (in Thomas Kuhn's words) paradigm-shifts are what makes science and philosophy interesting.

As I said I'm a lay person, familiary with the key ideas contained in modern physics - and finding them wonderful! - but I wonder: this book was originally written in 1927, at a time when most of the later discoveries related to general relativity weren't yet known. If anyone reads this review and has more knowledge on these topics than I seem to possess: what are the main points in Reichenbach's treatment of space and time that are outdated? And what does modern science and philosophy tell us about these particular points? I would be grateful for any comment.

And if I made any mistakes in my review or misinterpreted some fact, please correct me!
