**Robert DiSalle, *Understanding Space-Time*. CUP, 2006.**

**I.** This book takes the reader on a journey through the history of space-time physics, from Newton, through Kant, Leibniz, Poincaré to Einstein's Special and General Theory of relativity. The book is not concerned with the mathematical aspects of these respective space-time theories, beyond the essential elements. Rather, DiSalle concentrates on the philosophical analysis of the concepts of space, time and motion, in which he sees Newton, Einstein and other contributors to space-time views engaged. But in this book the reader will find little concern for metaphysical debates about substantivalist or relationist interpretations of the ontology of space-time. The concern is more with the kinematic and dynamic aspects of space-time views and the underlying philosophical assumptions. The emphasis is on conceptual analysis and the purpose of the book is to clarify, with respect to space-time theories,

> the nature and function of a-priori presuppositions in science, and the rational motivations for conceptual change in science. (p. 2)

Thus DiSalle stresses early on that his intention is to discuss how the

> transformation of fundamental concepts, like those of space, time and motion, can be understood as a rational development.(p. xii)

DiSalle hopes to achieve this end by focussing on the 'dialectical reasoning' of the physicists involved in developing the notions of space-time. This dialectic is not meant in a Hegelian sense of a synthesis of contrary views but as an engagement of our conceptions of space and time with our increasing knowledge of 'matter and forces in space and time'. This is a very refreshing approach although it is not altogether new. In earlier papers Strong (1957) and

Toulmin (1959) already suggested that the best approach to Newton's notion of absolute space and time is to consider which conceptual job they are supposed to perform in the overall system of mechanics. But in DiSalle's book we find an altogether more systematic application of this approach, extending from Newton to Einstein.

With these commitments DiSalle positions himself within the camp of those philosophers of science who maintain, against Kuhn, the rationality of scientific revolutions. With his approach DiSalle is committed to much more rational continuity between the successive space-time conceptions than Kuhn's paradigm view of scientific revolutions would allow. It comes as a minor disappointment in this very interesting and rich book that DiSalle offers no systematic thoughts on scientific revolutions, no systematic criticism of Kuhn. This is regrettable as Einstein's Special Theory is often regarded as a 'scientific revolution', although Einstein himself saw it as a crowning moment of classical electro-dynamics, whilst the General Theory of Relativity has the hallmark of a true scientific revolution.

**II.** As we now proceed to take a look at some of the strengths of the book we shall notice, along the way, some weaknesses (for instance the Index is rather incomplete). One strength of the book is the clarity of exposition and thought. DiSalle masterfully explains the conceptual details of the various space-time notions without resorting to unnecessary technicalities. In this sense DiSalle delivers what he promises: the emphasis is on conceptual analysis; and DiSalle is surely right that conceptual awareness is often more important than the mathematical details because the latter can be worked out

by the expert once the former is at hand. Einstein agreed with this procedure. DiSalle's procedure than follows the logic of his argument: as the (explicit or implicit) presuppositions need to be clarified before progress can be made, it is appropriate to start with classical mechanics and Newton's attempt to establish the science of mechanics on sound notions, which go beyond 'what the common people conceive (...) as "time", "place" and "space".'

Thus Newton's attempt to solve the problem of motion is discussed within his contemporary problem-situation. Newton shows that the Cartesian relational view cannot solve the problem of motion. In his endeavour to represent Newton as a 'dialectic thinker' who engages with unwarranted presuppositions, to replace them by better founded notions, DiSalle is rather charitable to Newton. He points out that when Newton appeals to absolute space, he does not advance any theses about the ontology of space-time. Rather the postulation of absolute space and time is inspired by empirical reasoning about motion. This theme unites Newton with later physicists:

> At the very least, we can identify a common metaphysical principle uniting general relativity with special relativity and Newton's theory: space-time is an objective geometrical structure that expresses itself in the phenomena of motion. (pp. 15-6)

And perhaps it is difficult to say whether Newton's talk of a spatial container, empty of all matter, was meant to be more than a helpful analogy. DiSalle's approach encourages him to think that Newton's notions of absolute space and time can be treated as 'theoretical constructs' but this leaves open the question of whether or not Newton believed that they had a referent. His thought experiments (rotating buckets and globes but also the sailor on the ship) seem to suggest that he believed that absolute space and time were

universal reference systems, to which he found an empirical approximation in Jupiter's moons and the 'fixed' stars. Newton believed that there were observable forces (forces on bodies as causes of motion and centrifugal forces in the rotating bucket), which distinguished absolute from relative motion and indicated the existence of such absolute reference frames. Absolute space and time are then idealizations or extrapolations from approximately stable systems in the empirical world. DiSalle is right to stress the fruitfulness of this approach in Newton's problem-situation, which was to find a solution to the problem of motion. This approach neglects, however, that scientific theories have philosophical consequences. It is these consequences, which worried Leibniz in his correspondence with Clarke. Newton seemed to suggest that absolute space and time exist independently of material processes in the world, a view to which Leibniz took exception. DiSalle is eager to absolve Newton from the sin of holding metaphysical beliefs; he is very uncharitable to Leibniz whose relational views on space and time are misrepresented as claims about the order of the co-existence and succession of actual material bodies. Recent Leibniz scholarship has done much to dispel this view: Leibniz actually means 'actual and possible' relations between bodies – a thought which is aptly captured in his notion of the 'geometry of situations'. (Weinert 2006) With this approach Leibnizian relationists are as much entitled to 'inertial reference frames' as theoretical constructs as Newton is, according to DiSalle's approach. But such an empirical approach to the problem of motion dissolves the distinction between substantivalist and relationist interpretations of space-time.

In later chapters DiSalle explains the development of space-time notions from Kant, Helmholtz to Poincaré to culminate in the chapters on the theory of relativity. His chapters on these developments are again a paradigm of clarity, although by DiSalle's expository standards, the notion of general covariance is not well explained. DiSalle's approach again puts Einstein's theories in the context of empirical reasoning about motion in a relativistic context, which leads to a questioning of previously held presuppositions. The basic idea is that space-time structures 'represent' empirical phenomena. Space-time theories are frameworks for the interpretation of spatial and temporal phenomena, which means that through their principles they impose general constraints on the representation. This is a very Einsteinian view of the role of scientific theories. According to Einstein, scientific theories are free inventions of the human mind but their job is to represent an independently given material world. It is this very dialectic situation between concepts and facts, which lead to the philosophical consequences, which DiSalle's approach risks to miss. (This reviewer wondered whether DiSalle's little concern for Einstein's thought experiments, e.g. the rotating disc experiment, which is meant to show the need for non-Euclidean geometry in a theory, which aims to account for gravitational effects, is a side-effect of his approach. Cf. Friedman 2007) For instance part of Einstein's attempt to represent the empirical facts is to highlight the role of symmetries and the covariance principle in the construction of scientific theories. They act as constraints on the representation of the empirical material. Einstein also believed that the four-dimensional view of space-time meant that the passage of time was a human illusion. To be fair, DiSalle captures some of these philosophical dimensions in his discussion of Einstein's distinction between constructive

and principle theories. Not only is his discussion admirably clear, it also highlights the importance of Einstein's distinction between the two theory-types. DiSalle presents the view that principle theories act as a quasi-Kantian framework, which underlines a link between Kant's revolution in philosophy and Einstein's thoughts on science

**III.** The points made in the last section are not meant as a criticism of DeSalle's book. In fact, DiSalle's shift from questions of ontology to a consideration of the presuppositions, which physicists like Newton and Einstein questioned, puts the emphasis on the logical reconstruction of the problem-situation. The historian of science will complain that this approach only produces a biased picture of the historical integrity of the situation. The philosopher of science will add that the dialectical reasoning process not only changes fundamental presuppositions but also affects the philosophical consequences of scientific theories. When Einstein holds the view that time must be a human illusion, because of the relativity of simultaneity, it inevitably invites the question whether a four-dimensional representation implies a block universe. And when Einstein imposes on the laws of physics the principle of covariance, he inevitably invites the question of whether covariance is merely a heuristic principle or whether it has empirical consequences. I suspect that DiSalle would probably agree that philosophical consequences regarding the nature of time and space are embedded in the very problem-situation, to which his conceptual analysis is addressed. His concern is with the fundamental presuppositions in the respective theories, and how they are addressed as a result of new discoveries. This approach

makes this book well-worth reading. It is in fact an important addition to the literature on space-time.

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