Review of The Biggest Ideas in the Universe 1

Space, Time and Motion by Sean Carroll

By MGH

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With this book, Sean Carroll wants his readers to actually understand some of the core classical physics that describes our world. Clearly that requires mathematics! But Carroll does not shy away from this, rather he helps illuminate the mathematical principles as well as the physics for the reader. I find this approach very refreshing, it is not a slog of a text book, but the reader is not left feeling cheated by promises of understanding that cannot be met in a book without mathematical details. Sean Carroll entices us into an understanding of the maths as well as giving crystal clear physical insight.

Our host begins with conservation laws and a discussion of Noether’s Theorem (unsurprisingly without any serious maths). This is followed by an introduction to calculus and, although we are not given any exercises, there is a handy appendix to further your calculus and another on the maths of General Relativity.

Chapters 3 and 4 are on dynamics and space. Here Newtonian, Lagrangian, and Hamiltonian formalisms are introduced and here we find the only suggestion of exercise in the book, but it is a good one. Indeed it is an invitation to play with analytical mechanics – brilliant! Space is discussed as setting the backdrop to relativity. Space and the reason we discuss position and momentum in Hamiltonians is explained as well as action at a distance.

Having explained time, parity, and CPT reversibility, Carroll explains entropy and the arrow of time through thermodynamics. This is followed by a philosophical discussion of peoples viewpoints on time. The chapter on spacetime comes next and we are treated to an explanation of the difference between time and space, as well as a clear explanation of the difference between coordinate time and proper time, and the twin paradox. The maths including 4-vectors and index notation at the end of this chapter is straight forward and well explained.

Chapter 7 deals with the necessary geometry for General Relativity, an interesting chapter including information on the metric tensor, parallel transport, curvature, as well as vectors and tensors in general. Then in chapter eight the Einstein Equation is finally given to us so that we can understand it. The Lagrange Density and its relevance to field theory is introduced brilliantly in its simplicity. Then evidence supporting GR in the early days is given.

Finally a chapter on black holes, including the Schwarzchild and Eddington-Finkelstein metrics, and later a discussion of gravitational waves rounds off the book. Throughout the book I was struck by the clarity of Carroll’s thought and explanations. A cracking read, which has made the author (MGH) want to read a GR textbook. Perhaps it will be Sean Carroll's?