

## Book review

### ***The Birth of String Theory*, Cappelli, Castellani, Colomo, and Di Vecchia (Eds.)**

Sebastian de Haro<sup>1,2</sup>, Jans Henke<sup>1</sup>, and Darrell Tang<sup>1</sup>

[s.deharo@uva.nl](mailto:s.deharo@uva.nl), [janshenke@yahoo.com](mailto:janshenke@yahoo.com), [darrelltws@gmail.com](mailto:darrelltws@gmail.com)

<sup>1</sup>Amsterdam University College  
University of Amsterdam, Amsterdam, the Netherlands

<sup>2</sup>Department of History and Philosophy of Science  
University of Cambridge, Cambridge, United Kingdom

E-mail: [sd696@cam.ac.uk](mailto:sd696@cam.ac.uk)

A. Cappelli, E. Castellani, F. Colomo, P. Di Vecchia (Eds.), “The Birth of String Theory”  
Cambridge University Press (2012)  
664 pages, hardback

ISBN: 9780521197908

*The Birth of String Theory* by Cappelli *et al.* tells the story of the beginnings of string theory and of the evolutionary process it has undergone from its origins in S-matrix theory to its current status as a candidate unification theory. The book is intended for an audience of students and researchers in physics, as well as historians and philosophers of science with some background in quantum field theory.

In the 50s and early 60s, theoretical particle physics focused on formulating a theory to explain the strong interactions. Due to issues with the application of perturbative quantum field theory (QFT) to the strong interactions, theoretical particle physicists shifted their attention to Heisenberg’s ‘S-matrix’ theory, which focused solely on observable quantities. This endeavour led in 1968 to the breakthrough of the famous ‘Veneziano amplitude’, which along with the Dolen-Horn-Schmid (DHS) duality between the  $s$ - and the  $t$ -channels led to the Dual Resonance Model (DRM). Following Veneziano’s scattering amplitude formula, the period between 1969 and 1974 thrived with activity. The Veneziano model was generalised from four to  $N$  particles, and Virasoro produced a different scattering amplitude that led to the Shapiro-Virasoro Model (SVM). DRM and SVM eventually became the starting points of the open and closed string theories, respectively. It was also at this time when it was shown that DRM required 26 space-time dimensions, and that the theory was marred by the presence of unphysical tachyons and unexplained massless particles in its spectrum. It was also realised that the spectrum of DRM corresponded to that of a quantum-relativistic string, and apart from the bosonic string, the Ramond-Neveu-Schwarz fermionic string was also formulated. By 1974, dual models still had several inconsistencies with hadronic phenomenology, and QFT’s success in this field led to a decline of the work on string theory. Scherk and Schwarz were some of the few physicists to continue working on dual models and string theory, and in 1974 they proposed that string theory could be reinterpreted as a quantum theory of gravity and a candidate for the unified theory of all fundamental forces. By 1976, open superstring theory was fully developed in its modern formulation, but was set aside in favour of gauge theories. Few people continued to work on string theory until it was realised that type I superstring theory was the most significant advance in supergravity theory thus far, resulting in another boom in string theory’s popularity that has persisted ever since.

Part I of *The Birth of String Theory* lays out an overview of the history of the development of string theory, giving a general idea of what the rest of the book explores in more intricate

detail. The other parts of the book each begin with an introduction which starts off with a nontechnical overview of the topics covered in that part, and then goes into the technical components behind it. The subsequent chapters cover more of the contemporary theory as well as purely personal accounts and experiences, generally with the more technical chapters near the start of the parts and the personal recollections at the end of the parts. Finally, there is an appendix at the end of the book that delves into technical content relevant for understanding the physical and mathematical arguments made in the main body of the book.

In general, each chapter details the developments in string theory in a chronological order of logical progression, based on the different works of each contributing author towards its construction and formulation, and culminating in a general overview of its history. Early string theory history can be divided into four main eras: 1) pre-DRM; 2) the very exciting and productive period from the Veneziano scattering amplitude in 1968 until dual models were overtaken by QFT around 1974; 3) what can be called the ‘dead period’ from the mid-Seventies until 4) the string theory ‘renaissance’ starting in 1984. The book is conveniently partitioned into main parts that correspond chronologically to these eras, but refining the scheme, dividing the early history into six overlapping segments: 1) the time of the analytic S-matrix, up to 1968; 2) the era of the DRM, 1968-1973; 3) the first string interpretation of DRM, in the period 1970-1973; 4) the movement from the first constructed bosonic string to the fermionic string and the beginnings of supersymmetry, 1970-1974; 5) the development of superstring theory from 1974 to 1977; and 6) the last few years leading up to the string renaissance in 1984. These segments correspond to parts II-VII of the book respectively, with part I being an overview of it all. In this light, the book has one part covering the first era, three discussing the second era, one covering the dead period, and one covering the renaissance period. Leaving nothing out, a chapter at the end of the book is devoted to the developments from 1985 to the present.

A recurring theme throughout the book is the centrality of collaboration and social interactions between scientists in modern physics, owing to the technological and mathematical complexity of the experiments and calculations required for the subject. As an illustration of this, *The Birth of String Theory* itself has a large number of contributing authors—a total of 38—and four editors. This has led to an (intended) wide range of writing styles, perspectives on the history, and overlapping accounts of the theoretical material. Hence, there is not one single historical narrative but rather the individual perspectives of a number of scientists who contributed to the field, intertwined through the tightly knit atmosphere of mutual influence. Apart from the introductory sections in part I, the book provides little contextualization of the history of string theory independent of the views of those who contributed to it. The personal accounts allow the reader to get an insight into what kind of personalities the physicists involved are or were, adding another interesting dimension to the book. This unique approach is an important point of reference for those who wish to study the history of string theory.

The overarching themes of the book seem to be the recurring questions of how string theory came to be, how it evolved, how it contributed to and was influenced by the understanding of other fields of physics, and why the contributing community of physicists favored string theory over its contemporary competitors. This directly reflects the book’s primary aim: “to document what the theory *was* in the beginning, about forty years ago, and follow the threads connecting its development from 1968 to 1984” (Cappelli, Castellani, Colomo, & Vecchia, 2012, p. 3). Hence, the book does not aim to answer any specific questions, instead exploring how the theory developed and the context in which it did so.

While the book is easiest to appreciate by researchers who are familiar with the technicalities

of the field, the introductory and appended segments help make the book accessible to those who are new to string theory. It does not go into the most specific mathematical arguments behind the development of string theory, and as such serves as an accessible beginner's introduction or intermediate course into the concepts and history of string theory. The book is of interest to scientists and scholars who wish to examine both the social and academic circumstances in which the theory has developed.

The book also contains interesting material for the philosopher of science. Castellani, in her contribution in Part I of the book, envisions three main philosophical roles for the story of the birth of a new scientific theory, and in particular string theory: i) to present a concrete example of how a particular theory has been discovered and developed by a given community and over a certain period of time; ii) to provide 'data' against which ideas about epistemological or methodological issues can be tested; iii) to shed light on the meaning of ideas (such as duality, supersymmetry, and extra dimensions) and mathematical techniques that are nowadays central to theoretical physics. In the professional accounts and personal recollections of the different actors, the philosopher of science will encounter both internal factors (such as form, content, and logic of the theory) and relevant external factors (psychological, sociological aspects influencing scientific work) that have contributed to the birth and development of string theory as it is today. Castellani emphasizes the idea of reading the history of string theory as a case study in the history and philosophy of science. Hence, she stresses the role of models and their relations to theory (Veneziano's amplitude seen as a 'model' of the general S-matrix 'theory'). Another recurring theme is that of theory progress: through generalizations (of Veneziano's amplitude to  $N$  particles, and of more realistic models), analogies (inspired by properties and progress of the mathematical formalism: analogue model, string analogy, gauge analogies), and conjectures.

The editors have thus presented this book such that it can be read with scientific, historical, and philosophical approaches in mind. This is indeed a realistic expectation; the authors' different approaches to often overlapping topics allow the non-expert reader to gain understanding by viewing the same arguments from different perspectives and more than once. The variety in writing styles and approaches to the history also make the book a refreshing read as it is neither too 'textbookey' nor too much of a narrative.

Furthermore, there are also attempts in the book to link developments in string theory to the various developments that occurred in other fields of physics within the same general time frame. By doing so it illustrates the manner in which novel ideas and discoveries in string theory influenced other fields of physics, such as statistical mechanics. On the other hand, it also shows how other fields of physics have contributed to developments in string theory by, for instance, inspiring physicists with analogous arguments that could be applied or providing mathematical devices. The name of string theory itself suggests a history that involves the analogizing of certain phenomena that occur at the microparticle scale to the harmonic oscillators that are familiar from classical mechanics. Of significant interest is the book's excursion into describing and comparing other theories in high energy physics that are often competitor theories to string theory's ambition of describing physics at the smallest scale and unifying the fundamental forces, such as quantum chromodynamics and supergravity. This provides an insight into why certain theories were preferred while their competitors wound up unpopular throughout the various periods in the recent history of high energy physics.

Altogether, the book is successful in giving a range of personal insights into an intriguing and complex part of the history of science. The theory is well-explained; any technical details lacking in this book can be found in other places—with helpful suggestions provided in the book—and is otherwise made up for by the greater attention paid to the reasoning applied in

developing the theory. Thus, the book is a comprehensive introduction into both the technical and historical details of string theory in a step by step manner that follows the personal experiences of each contributing author, in a format that caters in varying degrees to both a specialized and a general audience from differing fields in the sciences and humanities.

### **Reference**

A. Cappelli, E. Castellani, F. Colomo, P. Di Vecchia (Eds.), "The Birth of String Theory", Cambridge University Press (2012).