BOOK REVIEW

Order in Chaos in Dynamical Astronomy by George Contopoulos, Springer, Berlin, Heidelberg, New York, 2002

In this compendium of the aspects of chaos in dynamical system, especially in Dynamical Astronomy, George Contopoulos is mainly using his own vast experience, which he has after more than 50 years of research in this field. From the very beginning, in the early sixties – the first computation of the third integral in form of an asymptotic expansion by the author of the book – up to modern work on the destruction of tori in connection to orbits captured in stickiness regions close to regular orbits, the reader can learn the basic ideas of chaos and their importance for studying dynamical systems. The fast development of the computers, which allowed, on one hand, to derive many new results using numerical experiments, and, on the other hand, the new understanding of the prophetic view of dynamical systems and their complexity developed already a 100 years ago by Poincaré, lead to a deep insight into the nature of orbits in dynamical systems of two and more degrees of freedom. Especially, the exploration of n-body systems with a large number of point masses led to the surprising result that "the ergodic cases of statistical mechanics and the ordered cases of celestial mechanics are both exceptions and the most general case is in between" (*this book*, p. 3).

The author discusses extensively the numerical results in connection with the theory up to the most recent topics in Galactic Dynamics. The different length of the three main chapters already shows the main purpose of Contopoulos: two thirds of the book are devoted to present the basics of ordered motion in dynamical systems and how chaotic motion can be detected and analyzed. After the description of integrable systems, the reader may learn how to construct formal integrals using series expansions and how the difficulty of resonances can be handled. An important point for the exploration of dynamical systems is the study of periodic orbits: *via* the technique of Poincaré surfaces of sections – extensively used in this book to investigate the complicated structure of the respective phase space – and the discussion of stability of these orbits, a better understanding of the nature of chaos is attained. A major advantage is the use of many examples explained in detail and the large amount of figures to clarify the rather difficult subject. The transition to chaotic motion is well explained and it is discussed together with the appearance of islands of stability in chaotic systems, the detection of the last KAM curve, and the presence of orbits in the stickiness regions due to the presence of cantori. The different methods of detection of chaos are discussed in detail and how one can use them properly. Escaping orbits in two and more degrees of freedom and a short discussion of fractals end this chapter.

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The next part of the book deals with results on the dynamics of galaxies and shows how the orbits in galactic potentials lead to known structures found in real galaxies. *Via* simplified descriptions of the potential of galaxies – using methods developed in the former chapter – it is possible to model the dynamical structure of different galaxies. The last part is devoted to other applications like solar system dynamics, the complicated motion of asteroids, the chaotic motion of planets and some aspects of chaos in relativity and cosmology.

For the researcher in dynamical systems the book is a very good summary of the present knowledge of the role of ordered and chaotic motions in dynamical systems, without going into too sophisticated mathematical details. With the aid of more than 300 figures, the complex interplay of ordered and chaotic motion is illustrated, allowing for a better understanding. For advanced students, it is an excellent textbook concerning different aspects of dynamical systems and, simultaneously, it opens up new problems for continuing research especially in Dynamical Astronomy. This new outstanding book by George Contopoulos closes a gap between Celestial Mechanics and Stellar Dynamics. It should be present in every scientific library because it is of great interest for any physicists dealing with dynamical systems in general.

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