Preface

The work described in this monograph has grown, somewhat erratically, over a period of more than thirty years. My interest in the subject was first aroused by the beautiful computations and drawings in Broucke's thesis (1963; see also Broucke 1968), where families of periodic orbits in the restricted three body problem were investigated for the Earth-Moon mass ratio ($\mu = 0.012155$). These drawings suggested that a natural explanation for the existence of the observed families and for the shapes of the orbits could perhaps be found by a recourse to the limit $\mu \to 0$.

As a first step, it appeared necessary to catalog as completely as possible the *generating orbits* obtained in this limit. Generating orbits of the *first species* had been studied by Poincaré (1892) and other authors. Surprisingly, however, the two other species had apparently been neglected. Orbits of the second species, or *orbits with consecutive collisions*, present a comparatively simple problem, using only the equations of the two-body problem; yet no systematic study had ever been done. An inventory of the constituent arcs was presented in Hénon (1968).

Also very little work had been done on families of orbits of the third species, corresponding to *Hill's problem*. A numerical investigation was published in Hénon (1969).

My encounter with Pierre Guillaume in 1966 marked the beginning of a fruitful collaboration. At my suggestion, he started work on the "quantitative" side of the problem, using analytical methods to describe to first order the behaviour of the families of periodic orbits for small μ. For my part, I worked on the "qualitative" side, using invariants given by symmetries and by *Broucke's principle* to determine which branches of families were joined in bifurcations. We could then compare notes and verify that our results were in agreement. Pierre obtained his Ph.D. from Liège University in June 1971. We continued to correspond until his untimely death in December 1973.

In 1975 I received from Donald Hitzl a preprint describing computations of the *critical arcs*, which correspond to an extremum in the Jacobi constant C and play an important role in families of second species orbits. I told him that I had myself done, but not published, similar computations. Don then generously proposed to replace his paper by a joint publication. This led to a very interesting exchange of approaches and results, and resulted in two papers (Hitzl and Hénon 1977a, 1977b).

Since 1972 I have also been in contact with Alexander Bruno, who independently studied the same subject (1972–1981). I was so impressed by his work that, in spite of my meager knowledge of Russian, I translated two of his papers into English, to be able to read them and use them comfortably (Bruno 1972, 1973). His papers have now been collected into a book (Bruno 1990), which has been translated into English (Bruno 1994). A continuation of this work has appeared in a series of more recent papers (Bruno 1993a–1996).

Another high point was the visit of Larry Perko to Nice Observatory from February to May 1977. In his Ph.D. work (1965), Larry had developed powerful mathematical tools for matching different parts of an orbit, and these tools proved to be just what was needed to put the study of second species orbits on a rigorous basis. His visit and our numerous discussions, which continued after his departure, rekindled my interest in the subject and led me to begin the composition of this monograph.

During these thirty years there were long interruptions and also periods of discouragement, when the subject seemed too complex and too academic to be worth pursuing. I found that the difficulty of the problem resides not in the use of any deep concepts or sophisticated techniques, but simply in the number and the variety of details which one must keep in mind simultaneously to make any progress. For this reason, I have spent much effort in trying to find, in each place, the simplest method of presentation, as well as the most appropriate terms and notations.

This is not a mathematical work. Concepts are sometimes advanced on the basis of intuition, or numerical evidence, rather than rigorous proofs. The reasoning is sometimes of a more or less heuristic nature.

Among all the colleagues with whom I have had helpful discussions, I would like to thank in particular those who have been mentioned above: Roger Broucke, Alexander Bruno, Pierre Guillaume, Donald Hitzl, and especially Lawrence Perko, who read an early version of the present work and made many constructive comments and criticisms. I thank also Uriel Frisch for many stimulating conversations (on this and on all other conceivable subjects), and for encouraging me to finish and publish this work.

I seize also this occasion to thank some people whose names should appear more often in acknowledgments: those of our colleagues who have unselfishly devoted a large fraction of their time to the development of wonderful software tools, and then put them in the public domain. In particular I wish to thank Donald Knuth, for TeX; Leslie Lamport, for LaTeX; Tim Pearson, for `PGPLOT`; and Richard Stallman, for `GNU Emacs`. These tools have been of invaluable help to the scientific community at large. In my own modest case, I would never have managed to write this monograph without them.

Nice, September 1997 Michel Hénon

Springer

http://www.springer.com/978-3-540-65904-4

Symmetry and Perturbation Theory in Nonlinear Dynamics
Cicogna, G.; Gaeta, G.
1999, XI, 212 p., Hardcover
ISBN: 978-3-540-65904-4