Preface

Understanding the long-term evolution of self-gravitating astrophysical systems, such as for example stellar discs, is now a subject of renewed interest, motivated by the combination of two factors. On the one hand, we now have at our disposal the well established ΛCDM model for the formation of structures. When considered on galactic scales, depending on the nature of the accretion processes, interactions with the circumgalactic environment, may either be constructive (e.g., adiabatic gas accretion) or destructive (e.g., satellite infall). The statistical impacts of these cosmic perturbations on self-gravitating systems are now being quantified in detail. On the other hand, recent theoretical works now provide a precise description of the amplification of external disturbances and discreteness noise as well as their effects on a system's orbital structure over cosmic time, while properly accounting for the effect of self-gravity. These theories offer new physical insights on the dynamical processes at play in these self-gravitating systems on secular timescales.

These two complementary developments now allow us to address the pressing question of the respective roles of nature versus nurture in the establishment of the observed properties of self-gravitating systems. Numerous dynamical challenges are therefore ready to be re-examined in much greater detail than before. Examples include: the secular evolution of the metallicity dispersion relationship in galactic discs, the mechanisms of disc thickening via giant molecular clouds or spiral waves, the stellar dynamical evolution of galactic centres, etc. Characterising the secular evolution of such self-gravitating systems is a stimulating task, as it requires intricate theoretical models, complex numerical experiments and an accurate understanding of the involved physical processes.

The purpose of the present thesis is to describe such secular dynamics in contexts where self-gravity is deemed important. Two frameworks of diffusion, either external or internal, will be presented in detail. These approaches will be applied to various astrophysical systems to illustrate the particular relevance and ability of these approaches to describe the long-term evolution of self-gravitating systems. This thesis will first investigate the secular evolution of discrete razor-thin stellar discs and recover the formation of narrow ridges of resonant orbits in agreement with observations and numerical simulations, thanks to the first implementation of the Balescu–Lenard equation. The spontaneous thickening of stellar discs as a result of Poisson shot noise will also be investigated. These various approaches allow in particular for a self-consistent description of stellar migration and disc thickening. Finally, we will illustrate how the same formalisms allow us to describe the dynamics of stars orbiting a central supermassive black hole in galactic centres. Other processes of secular orbital restructuration will be discussed in less details.

Keywords Evolution of galaxies • Secular dynamics • Gravitation • Diffusion • Kinetic theory

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