Exercises

Exercise 1.1 **3-disk symbolic dynamics.** *As periodic trajectories will turn out to be our main tool to breach deep into the realm of chaos, it pays to start familiarizing oneself with them now by sketching and counting the few shortest prime cycles (we return to this in sect. 13.4). Show that the 3-disk pinball has* $3 \cdot 2^{n-1}$ *itineraries of length* n. *List periodic orbits of lengths 2, 3, 4, 5,* $\cdots$. *Verify that the shortest 3-disk prime cycles are 12, 13, 23, 123, 132, 1213, 1232, 1323, 12123,* $\cdots$. *Try to sketch them.*

Exercise 1.2 **Sensitivity to initial conditions.** *Assume that two pinball trajectories start out parallel, but separated by 1 Ångström, and the disks are of radius* $a = 1$ *cm and center-to-center separation* $R = 6$ *cm. Try to estimate in how many bounces the separation will grow to the size of system (assuming that the trajectories have been picked so they remain trapped for at least that long). Estimate the Who's* Pinball Wizard*'s typical score (number of bounces) in a game without cheating, by hook or crook (by the end of chapter 18 you should be in position to make very accurate estimates).*