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TRACING PERIODIC ORBITS IN 3D GALACTIC POTENTIALS USING THE PARTICLE SWARM OPTIMIZATION METHOD

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Abstract: We investigate the efficiency of a numerical algorithm for locating periodic orbits in a Hamiltonian system. The algorithm has been applied successfully on a 3D potential of a barred galaxy. In particular, an appropriate scheme that transforms the problem of finding periodic orbits to the problem of detecting the global minimizers of a function defined on the Poincaré Surface of Section (PSS) of the Hamiltonian system has been developed. In the case of p-periodic orbits, this function is the square of the Euclidean distance on the PSS, between the initial point of the orbit and its p-th intersection with the PSS. The minimizers of the function are computed by applying the Particle Swarm Optimization (PSO) method. PSO is a population based algorithm, i.e., it exploits a population, called a *swarm*, of points to probe promising regions of the search space simultaneously. Each search point, called a *particle*, moves in the search space with a velocity, which is adapted by taking into consideration the 'best' position it has ever encountered as well as the 'best' position that has been attained by all the particles in a neighborhood of it. In our case, the search space is the PSS and the 'best' positions possess lower function values. Using the PSO method, several stable periodic orbits near the corotation of a 3D Ferrers bar potential that were not detected by other methods, have been located. In particular, families of 2D and 3D periodic orbits, associated with inner resonances higher than the 8:1 resonance have been found. Moreover, various p-periodic orbits with $p>1$, have also been detected.

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