FLORIDA ATLANTIC UNIVERSITY

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PhD Dissertation Defense

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Homoclinic Dynamics in a Spatial Restricted Four Body Problem

Friday, July 9, 2:00pm

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The set of transverse homoclinic intersections for a saddle-focus equilibrium in the planar equilateral restricted four body problem admits certain simple homoclinic orbits which form the skeleton of the complete homoclinic intersection, or homoclinic web. In this thesis, the planar restricted four body problem is viewed as an invariant subsystem of the spatial problem, and the influence of this planar homoclinic skeleton on the spatial dynamics is studied. Starting from the vertical Lyapunov families emanating from saddle focus equilibria, we compute the stable/unstable manifolds of these spatial periodic orbits and look for intersections between these manifolds near the fundamental planar homoclinics. In this way, we are able to continue all of the basic planar homoclinic motions into the spatial problem as homoclinics for appropriate vertical Lyapunov orbits which, by the Smale Tangle theorem, suggest the existence of chaotic motions in the spatial problem. While the saddle-focus equilibrium solutions in the planar problems occur only at a discrete set of energy levels, the cycle-to-cycle homoclinics in the spatial problem are robust with respect to small changes in energy. The method uses high order Fourier-Taylor and Chebyshev series approximations in conjunction with the parameterization method, a general functional analytic framework for invariant manifolds. Tools that admit a natural notion of a-posteriori error analysis. Finally, we develop and implement a validation algorithm which we later use to obtain Theorems confirming the existence of spatial homoclinic dynamics. This approach, known as the Radii polynomial, is a contraction mapping argument which can be applied to both the parameterized manifolds and the Chebyshev arcs. When the approach succeeds, it guarantees the existence of a true solution near the approximation and provides an upper bound on the C0 norm of the truncation error.

Please contact Dr. Hongwei Long (hlong@fau.edu) for an electronic copy of the dissertation.

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