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Relative equilibria in symmetric $(2N+1)$-body problems

Consider the Newtonian $(2N+1)$-body problem where $2N$ of the bodies have unit mass and at any time form two regular N-gons with a common centre, and where an additional mass m is centrally situated. It is known that in this context there is a $m_0 > 0$ so that the number of central configurations is three for $m < m_0$ and one if $m > m_0$. Also, it is known that there is a $m_c > 0$, $m_c \neq m_0$, so that the regular $2N$-gon with central mass is linearly stable if $m > m_c$.

Using the discrete and rotational symmetries, we reduce the problem to a three degrees of freedom Hamiltonian system. In this setting, we show that the central configurations mentioned above are in fact relative equilibria and that m_0 marks a pitchfork/steady-state bifurcation. The value m_c marks a Hamiltonian-Hopf bifurcation (i.e., a 1:-1 resonance).