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GLOBAL LINEARIZATION OF DEFICIENCY ZERO CHEMICAL REACTION NETWORK DYNAMICS

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It has been shown by Horn, Jackson, and Feinberg that all deficiency zero chemical reaction networks exhibit a unique and strictly positive steady state solution, which is indicative of linear dynamical systems. We present a novel homeomorphic transformation for deficiency zero chemical reaction systems that linearizes the derived nonlinear dynamics while faithfully maintaining the local and global qualitative properties of the dynamical system. It is further demonstrated that if the number of chemical species is less than or equal to the number of chemical complexes, then the linear and nonlinear topological representation spaces of the derived dynamical phase spaces are homeomorphic. However, if there are more species than complexes, then the homeomorphism holds up to an equivalence relation that defines a topological fiberation of the nonlinear reaction phase space manifold. This fibration generates a set of covering submanifolds that acts to linearize the nonlinear reaction phase space manifold. This transformation philosophically demonstrates why nonlinear chemical reaction networks having deficiency zero behave like linear dynamical systems.

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