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A deficiency zero theorem for a class of power law kinetic systems with independent decompositions

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In this paper, we study power law kinetics on chemical reaction networks with Independent decompositions, i.e. the network is the union of subnetworks whose reaction sets form a partition of the network's reaction set and the network's stoichiometric subspace is the direct sum of the stoichiometric subspaces of the subnetworks. Our main result is a Deficiency Zero Theorem when the subnetworks are weakly reversible and have linear independent reactant complexes (we denote the latter property as "zero reactant deficiency") and have kinetics with linear Independent kinetic order vectors (we denote this set of kinetics with "PL-RLK"). We elaborate the context of our result by presenting an overview of previous results on network decomposition (which we propose to call "Decomposition Theory") and a discussion of existing Deficiency Zero Theorems. To our knowledge, our result is the first Deficiency Zero Theorem which is valid for a class of kinetics which display non-reactant determined kinetic orders, i.e. there are reactant complexes whose branching reactions have differing kinetic order vectors (we call this set of kinetics "PL-NDK"). In previous work, we showed the occurrence of PL-NDK kinetics in numerous models of complex biochemical systems. We apply our results to characterize the positive equilibria of a power law approximation of R. Schmitz's model of the earth's carbon cycle in its pre-industrial state, which provided the original motivation for our study.

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