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Multistationarity in mass action networks by linear inequality systems

Ordinary Differential Equations (ODEs) are an important tool in many areas of Quantitative Biology. For many ODE systems multistationarity (i.e. the existence of at least two positive steady states) is a desired feature. In general establishing multistationarity is a difficult task as realistic biological models are large in terms of states and (unknown) parameters and in most cases poorly parameterized (because of noisy measurement data of few components, a very small number of data points and only a limited number of repetitions). For mass action networks establishing multistationarity hence is equivalent to establishing the existence of at least two positive solutions of a large polynomial system with unknown coefficients. For mass action networks with certain structural properties, expressed in terms of the stoichiometric matrix and the reaction rate-exponent matrix, we present necessary and sufficient conditions for multistationarity that take the form linear inequality systems. Solutions of these inequality systems define pairs of steady states and parameter values. We also present a sufficient condition to identify networks where the aforementioned conditions hold.