

On necessary and sufficient conditions for strong hyperbolicity

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Abstract: In this work we study constant-coefficient first order systems of partial differential equations and give necessary and sufficient conditions for those systems to have a well posed Cauchy Problem. In many physical applications, due to the presence of constraints, the number of equations in the PDE system is larger than the number of unknowns, thus the standard Kreiss conditions can not be directly applied to check whether the system admits a well posed initial value formulation. In this work we find necessary and sufficient conditions such that there exists a reduced set of equations, of the same dimensionality as the set of unknowns, which satisfy Kreiss conditions and so are well defined and properly behaved evolution equations. We do that by decomposing the systems using the Kronecker decomposition of matrix pencils and, once the conditions are met, finding specific families of reductions. We show the power of the theory in an example, the Klein Gordon equations written as a first order system, and study its Kronecker decomposition and its reductions.