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**Numerical Methods for Gremban's Expansion of Signed  
Graphs**

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Signed graphs are an interesting subset of the typical graph problem. They not only show how two vertices can be positively related but also how negative relations as well. Data scientists have studied linear solvers for unsigned, undirected graph Laplacians at length, but the supplementary knowledge of signed graphs, gives current solvers difficulty. Gremban's Expansion [?] can be used to transform the signed, undirected graph Laplacian into an unsigned, undirected graph Laplacian. The solution to the linear system of the expanded matrix yields the solution to the linear system of the original matrix. Unsigned, undirected graph Laplacian solvers have been shown to be robust, thus, using Gremban's Expansion, current solvers can also solve the signed, undirected graph Laplacian linear system. This paper delves into the numerical stability and applicability of Gremban's expansion for signed graph Laplacians. A tight error bound for Gremban's expansion for a symmetric linear system is shown. It is also shown that Gremban's expansion can be extended to nonsymmetric graph Laplacians. Both manufactured and real-world signed, undirected graph Laplacians are tested with various solvers to show that the expansion is numerically stable.