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Symmetries, Cluster Synchronization, and Isolated Desynchronization in Complex Networks

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Many networks are observed to produce patterns of synchronized clusters, but it has been difficult to predict these clusters in general or understand the conditions for their formation. We show the intimate connection between network symmetry and cluster synchronization. We apply computational group theory to reveal the clusters and determine their stability. In complex networks the symmetries can number in the millions, billions, and more. The connection between symmetry and cluster synchronization is experimentally explored using an electro-optic network. We observe and explain a surprising and common phenomenon (isolated desynchronization) in which some clusters lose synchrony while leaving others connected to them synchronized. We show the isolated desynchronization is intimately related to the decomposition of the group of symmetries into subgroups. The results could guide the design of new power grid systems or lead to new understanding of the dynamical behavior of networks ranging from neural to social.