Measuring spectral properties of nut graphs with coaxial cable networks

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Abstract

Graph theory is of significant interest in theoretical chemistry, as a method to model the electronic structure of chemicals. Of particular interest are nut graphs, which have both nullity one and all vertices are core vertices [1]. This ensures nut graphs have non-trivial electronic properties and behave as omni-conductors [2]. Due to difficulties in synthesising the exact chemical represented by a nut graph, experimental realisations of nut graphs have been limited.

At radio frequencies coaxial cable networks can be modelled by a graph, where edge weights are controlled by the impedance of individual cables, and vertices are given by junctions between cables. Vertex connectivity can be exactly controlled, allowing for a simple way to construct arbitrary graphs. We present experimental measurements of nut graphs constructed from coaxial cable networks. Propagating the coaxial cable network at a single site with a specific radio frequency signal allows us to probe the nullspace of a graph. Eigenstate amplitudes can be measured directly from the network's impedance at a certain vertex, and by measuring two vertex transmission we can find the relative phase of an eigenstate on a site, allowing an experimental snapshot of a graph's nullspace.

[1] - I. Sciriha and P. W. Fowler. *On nut and core singular fullerenes.* Discrete Math., 308(2–3), 267–276, 2008.
[2] - P. W. Fowler, B. T. Pickup, T. Z. Todorova, M. Borg, and I. Sciriha. *Omni-conducting and omni-insulating molecules.* The Journal of Chemical Physics, 140(5), 2014.