URSI GASS 2023, Sapporo, Japan, 19 – 26 August 2023

Selected Properties of Microwave Networks with Orthogonal and Symplectic Symmetries

Omer Farooq, Afshin Akhshani, Małgorzata Białous, Szymon Bauch, Michał Ławniczak, and Leszek Sirko*
Institute of Physics, Polish Academy of Sciences, Aleja Lotników 32/46, 02-668 Warsaw, Poland;
e-mail: omer.farooq@ifpan.edu.pl; afshin.akhshani@ifpan.edu.pl; bialous@ifpan.edu.pl; bauch@ifpan.edu.pl; lawni@ifpan.edu.pl; sirko@ifpan.edu.pl

The generalized Euler characteristic

$$\chi_G = |V| - |E| - |V_D|, \tag{1}$$

is one of the most important topological and geometrical characteristics of a metric graph. Here, $|V|$, $|E|$ and $|V_D|$ denote, respectively, the total number of vertices, edges and Dirichlet vertices of a graph. In Ref. [1] we showed that the generalized Euler characteristic can be determined (heard) from a finite sequence of the lowest eigenenergies $\lambda_1 \ldots \lambda_N$ of a simple quantum graph, without any need to inspect the system visually.
Here, we discuss the situation when the original graph with orthogonal symmetry is split at edges and vertices into two disconnected subgraphs [2-3]. We show that there is a relationship between the generalized Euler characteristic of the original graph and the generalized Euler characteristics of two disconnected subgraphs. The theoretical predictions are verified experimentally by measuring the spectra of microwave networks simulating quantum graphs.
We also report on experimental studies of the distribution of the reflection coefficient and the imaginary and real parts of Wigner's reaction (K) matrix using open microwave networks with symplectic symmetry and varying absorption.

Acknowledgements

This work was supported by the National Science Centre, Poland, Grant No. UMO-2018/30/Q/ST2/00324.

References

[1] M. Ławniczak, P. Kurasov, S. Bauch, M. Białous, A. Akhshani, and L. Sirko, "A new spectral invariant for quantum graphs", *Sci. Rep*. **11**, 2021, 15342, doi: 10.1038/s41598-021-94331-0.
[2] O. Hul, S. Bauch, P. Pakoński, N. Savytskyy, K. Życzkowski, and L. Sirko, "Experimental simulation of quantum graphs by microwave networks*", Phys. Rev. E* **69**, 2004, 056209, doi: 10.1103/PhysRevE.69.056205.
[3]. O. Farooq, A. Akhshani, M. Białous, S. Bauch, M. Ławniczak, and L. Sirko, "Investigation of the generalized Euler characteristic of graphs and microwave networks split at edges and vertices", *Physica Scripta,* 2023, doi: 10.1088/1402-4896/acb302.