Advances in the theory of Characteristic Modes

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Abstract

The Characteristic Mode Theory was developed by Professor Roger F. Harrington and his collaborators, relating currents in the radiating structure to the associated modal fields. It has been extensively developed following the paper published by the authors of this communication, revisiting the theory and applying it to the analysis of planar antennas. The latest advances in cubesat, planar lens structures, antennas for MIMO applications for 5G applications and metamaterials are presented.

Characteristic Mode Theory

The theory of characteristic modes can be applied to 3D structures to achieve different types of antennas. As an example, the currents and radiation patterns of the first modes of a cube are shown in Fig. 1 and 2.

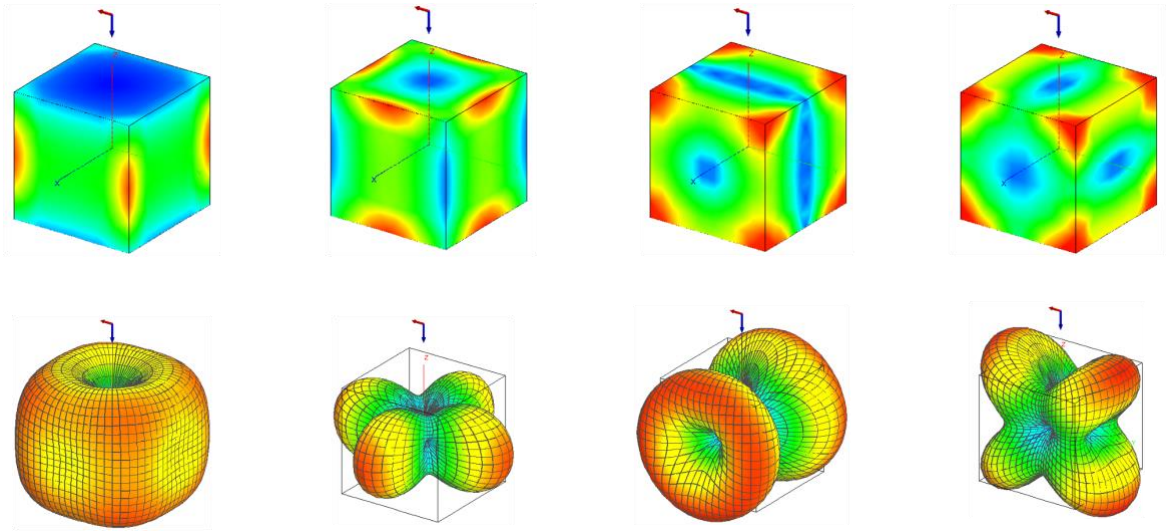

Fig. 1. Current density and radiation pattern of the Electric Characteristic Modes of the cube at first resonance

The presentation will show some applications of lenses, metamaterials and MIMO applications.

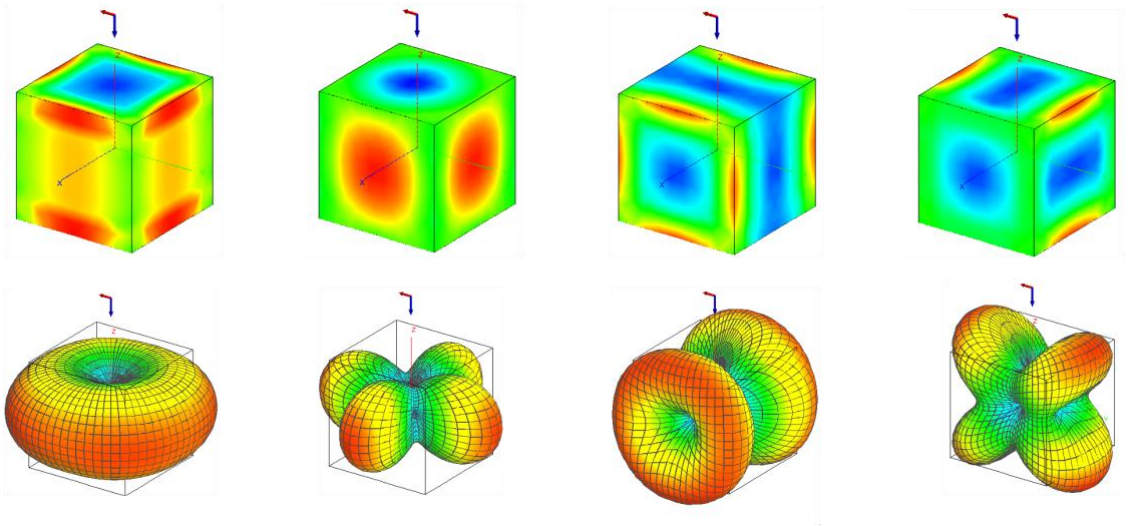

Fig. 2. Current density and radiation pattern of the Magnetic Characteristic Modes of the cube at first resonance

References

[1] R. Harrington and J. Mautz, "Theory of characteristic modes for conducting bodies," in IEEE Transactions on Antennas and Propagation, vol. 19, no. 5, pp. 622-628, September 1971, doi: 10.1109/TAP.1971.1139999.

[2] R. Harrington and J. Mautz, "Computation of characteristic modes for conducting bodies," in IEEE Transactions on Antennas and Propagation, vol. 19, no. 5, pp. 629-639, September 1971, doi: 10.1109/TAP.1971.1139990.

[3] M. Cabedo-Fabres, E. Antonio-Daviu, M. Ferrando-Bataller and A. Valero-Nogueira, "On the use of characteristic modes to describe patch antenna performance," IEEE Antennas and Propagation Society International Symposium. Digest. Held in conjunction with: USNC/CNC/URSI North American Radio Sci. Meeting (Cat. No.03CH37450), 2003, pp. 712-715 vol.2, doi: 10.1109/APS.2003.1219335.

[4] M. Cabedo-Fabres, E. Antonino-Daviu, A. Valero-Nogueira and M. F. Bataller, "The Theory of Characteristic Modes Revisited: A Contribution to the Design of Antennas for Modern Applications," in IEEE Antennas and Propagation Magazine, vol. 49, no. 5, pp. 52-68, Oct. 2007, doi: 10.1109/MAP.2007.4395295.

[5] Systematic design of antennas using the theory of characteristic modes. Phd Thesis. Cabedo Fabrés, M. (2007). Systematic design of antennas using the theory of characteristic modes. Universitat Politècnica de València. https://doi.org/10.4995/Thesis/10251/1883

[6] Analysis and design of antennas for wireless communications using modal methods. PhD Thesis. Antonino Daviu, E. (2008). Analysis and design of antennas for wireless communications using modal methods. Universitat Politècnica de València. https://doi.org/10.4995/Thesis/10251/2188

[7] E. Antonino-Daviu, M. Fabres, M. Ferrando-Bataller and V. M. R. Penarrocha, "Modal Analysis and Design of Band-Notched UWB Planar Monopole Antennas," in IEEE Transactions on Antennas and Propagation, vol. 58, no. 5, pp. 1457-1467, May 2010, doi: 10.1109/TAP.2010.2044323.

[8] N. Mohamed Mohamed-Hicho, E. Antonino-Daviu, M. Cabedo-Fabrés and M. Ferrando-Bataller, "Designing Slot Antennas in Finite Platforms Using Characteristic Modes," in IEEE Access, vol. 6, pp. 41346-41355, 2018, doi: 10.1109/ACCESS.2018.2847726.

[9] E. Antonino-Daviu, M. Cabedo-Fabrés, M. Sonkki, N. Mohamed Mohamed-Hicho and M. Ferrando-Bataller, "Design Guidelines for the Excitation of Characteristic Modes in Slotted Planar Structures," in IEEE Transactions on Antennas and Propagation, vol. 64, no. 12, pp. 5020-5029, Dec. 2016, doi: 10.1109/TAP.2016.2618478.

[10] D. Sánchez-Escuderos, H. C. Moy-Li, E. Antonino-Daviu, M. Cabedo-Fabrés and M. Ferrando-Bataller, "Microwave Planar Lens Antenna Designed With a Three-Layer Frequency-Selective Surface," in IEEE Antennas and Wireless Propagation Letters, vol. 16, pp. 904-907, 2017, doi: 10.1109/LAWP.2016.2614342.

[11] H. C. Moy-Li, D. Sánchez-Escuderos, E. Antonino-Daviu and M. Ferrando-Bataller, "Low-Profile Radially Corrugated Horn Antenna," in IEEE Antennas and Wireless Propagation Letters, vol. 16, pp. 3180-3183, 2017, doi: 10.1109/LAWP.2017.2767182.