Forum for Electromagnetic Research Methods and Application Technologies (FERMAT)

Antenna Design Using Characteristic Modes and Related Techniques.

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Response to “Comments and Questions on the EuCAP presentation on, “Scattering Analysis for Arbitrarily Shaped bodies using Characteristic Modes,” by Y. Chen in the EuCAP’16 Special Session on Theory and Application of Characteristic Modes, convened on Monday, April 11, 2016”.

Thanks a lot for your interests in my paper as well as your valuable comments! Some mentioned issues really confused many researchers interested in modal analysis methods. I felt this author raises critical comments for the CM theory, including the CM theory of PEC proposed by Prof Harrington, et. al. in 1965, 1971, which is widely used in various designs. I would also like to sincerely invite any other interesting CM researchers to contribute positive replies. It is helpful for us to reach a common understanding or standardize the definition of the “true modes”. My personal replies are presented in the following.

1. I have given the discussion to explain why the old CM formulation failed in providing correct resonant frequency. It failed because the imaginary parts of the <J, ZJ> in the old formulation does not represent the stored energy in a dielectric system.
2. The pictures showing the modes in a rectangular waveguide are only given to make attendance better understand what is the CM, because our audiences are familiar with modes in a waveguide. CM is definitely a kind of particular mode for radiating and scattering problems. The figures do not show the CM are necessary the counterparts of the modes in waveguides.
3. I disagree with the statement “However, ……, and they (CMs) can never exist without excitations at any frequency, resonance or otherwise”. CMs are determined only from the geometry, material, and the EM environment that the EM body resides in. CMs are not dependent on any external excitations. Although CMs are not exactly the same as the “true modes”, we cannot say CMs resembles the “true modes” because it is “more of an exception than it is a rule”. Large amount of design examples has demonstrated CM theory gives the correct real frequency and the associated modes can be practically excited and measured in our real world. However, the “true modes” mentioned (solved from SEP or other equivalent methods) have complex resonant frequencies, but we can never have complex frequency. We can only get radiation fields at real frequencies.

My understanding is that the modes (including resonant frequency and modal fields) we can obtain in real world should be called as true modes. So, how to define the true modes?

4. Our approach defines and solves resonant frequencies (indicated by eigenvalues) by maximizing the ratio of the radiated power and the stored power. Prof. Harington’s CM formulation for PEC structures also defined the eigenvalues with the exactly same meaning. I really don’t understand your doubt on our resonant frequency definition. Do you mean CM theory cannot accurately solve real resonant frequency? If yes, could you please show the reason. Actually, resonant frequency solved from CM theory have been demonstrated in many antenna designs by many groups worldwide. Do you still believe this is an exception happened?
5. The two antenna designs and the scattering example are presented to show the CM theory (including CM for PEC) at least provides an alternative for antenna designs and scattering analysis. When we discuss the merit of the CM theory, it exhibits very clear physical insights into the radiation and scattering mechanisms of the problems discussed.