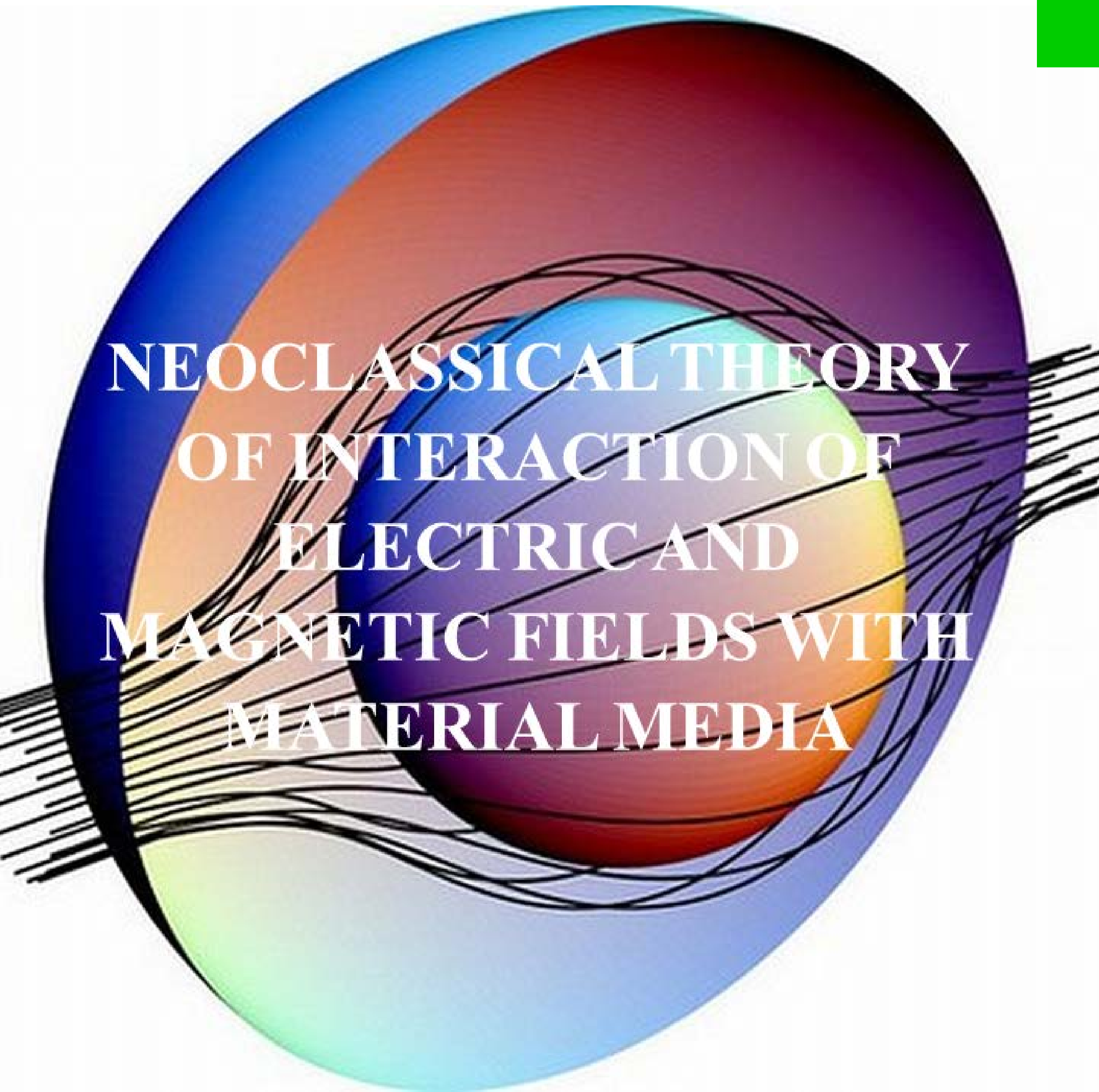
CHAPTER 2



NEOCLASSICAL THEORY OF INTERACTION OF ELECTRIC AND MAGNETIC FIELDS WITH MATERIAL MEDIA

Things are never as they seem.
John Lutz

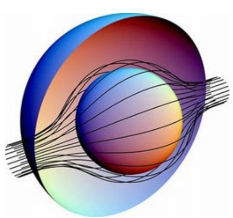
You can learn in Chapter 2

The understanding of EM field - material interactions becomes more and more critical in the practice of engineering. Not rarely enough, the characteristics of materials severely limits the performance of modern radio devices. Therefore, scientists and engineers realized that the materials existing in nature are not sufficient to satisfy to rigorous requirements and on the go to synthesize new materials with combinations of properties never seen before. The topics in this chapter do not cover all ultra-wide spectrum of possible and apparently quantum interactions of EM fields with matters. Reader should consider this chapter as some kind of a digest.

Through the well-known mechanical analogies you will be introduced to a twisting force or torque exerted by external E- and H-fields upon myriad induced or built-in electrical and magnetic dipoles in materials. As a result, most of these dipoles are forced to rotate around their axis, i.e. polarized, aligning in parallel or some certain direction to the external field vector. You learn how to use simple neo-classical atom model, Lorentz's force equation in simplest situations, and Drude-Lorentz's model in more complicated cases to define dielectric and magnetic constants of wide variety of materials starting from dielectric, metal, and ending with many more exotical material like ferro- and ferrimaterial, ferrite, piezo- and other anisotropic crystals, etc. You even might, if you wish, guide the synthesis of new artificial materials with predetermined characteristics using compounds or tiny metal spheres.

Then you can take the next step to investigate the material parameter behavior as a function of frequency. This information is critical while you manage computer simulations or design ultra-broadband devices. Drude-Lorentz's model will help you understand why metals have complex dielectric constant that is negative at optical frequencies, explain phenomena of long distance communications at short waves that reflect from ionospheric plasma with negative dielectric constant, etc.

Clear knowledge of material parameters lets you manage correctly such important issue as boundary conditions that strongly constrain the behavior of EM fields at boundaries between two media having different properties and the integral part of Maxwell's equation in differential form.



Two sections of this chapter will bring you into the world of metamaterials and graphene. Both of them possess absolutely unique electrical and mechanical characteristics. Particularly, the dielectric and magnetic constant of metamaterials might be simultaneously negative such as the refractive index stays real and negative. The most stunning application of this effect is ability of metamaterials to remake Harry Potter's legendary invisibility cloak shown here.

Final sections of this chapter teaches you how to measure remotely the frequency dependable complex parameters of objects using the Kramers-Kronig (K-K) relations and the Eddy current.

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