Leisure Games with Weiss Theory of Ferromagnetism

Elemír Ušák [a)]

Slovak University of Technology, FEEIT, Ilkovičova 3, 84104, Bratislava, Slovak Republic.

[a)] *elemir.usak@stuba.sk*

Abstract. The ideas presented in this paper emerged as a by-product of our studies, focused on the investigation of the relationships among the chemical composition, synthesis methods, and the resulting structural and electromagnetic properties of ferrites, particularly those in which certain ions, constituting the initial chemical formula, are partially replaced by, for example, rare-earth ions, as well as other magnetic materials (e.g., electrical steels, amorphous alloys and nanocrystalline alloys, etc.). The behavior of these materials, which are essentially either ferromagnetic or ferrimagnetic, can be readily described by the theory, introduced already in 1907 by Pierre-Ernest Weiss [1], and further developed by Werner Heisenberg [2], who explained the nature of the internal "molecular field", postulated by Weiss through a purely quantum mechanical effect–exchange interaction. This theory, a.k.a. the "mean field theory," was later extended to antiferromagnetic and ferrimagnetic substances as well, by Louis Néel, [3, 4].

While mean field theory is foundational and historically significant, it is considered a simplified model of magnetic behavior. It provides valuable qualitative insights and is often used as a starting point for understanding magnetic phenomena. However, it has limitations when it comes to accurately describing complex magnetic interactions, especially at the microscopic level or in systems with strong fluctuations, disorder, or low-dimensional structures. Nevertheless, it remains applicable in certain contexts: for bulk, well-ordered systems where interactions are relatively uniform, mean field theory can still give reasonable approximations. It is particularly useful for qualitative analysis and initial modeling. Therefore, it is convenient for describing some observations reported in this study, which concern bulk three-dimensional materials.

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REFERENCES

1. P.-E. Weiss, “L’hypothèse du champ moléculaire et la propriété ferromagnétique,” Journal de Physique Théorique et Appliquée **6**, 661–690 (1907).
2. W. Heisenberg, “Zur theorie des ferromagnetismus,” Zeitschrift für Physik **49**, 619–636 (1928).
3. L. Néel, “Influence des fluctuations du champ moléculaire sur les propriétés magnétiques des corps,” Annales de Physique **10**, 5–105 (1932).
4. L. Néel, “Propriétés magnétiques des ferrites; ferrimagnétisme et antiferromagnétisme,” Annales de Physique **12**, 137–198 (1948).