Republic of Iraq
Ministry of Higher Education
& Scientific Research
Al- Muthanna University
College of Science
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Study of Spin Compensation Phenomenon for a Ferrimagnetic Nanowire Using Molecular Mean Field Theory(MMFT)

A Thesis Submitted to the Council of College of Science/Al- Muthanna University as Partial Fulfillment of the Requirements for the Degree of Master of Sciences in Physics

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B.Sc 2003

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2023 A.D **1445 A.H**

ABSTRACT

By using the molecular mean field approach(MMFA), a ferrimagnetic mixed spin-1 and spin-7/2 square nanowire is dealt on the basis of Blume-Capel model(BC), in accordance with, Bogoliubov inequality for free energy. The present nanosystem has spin-1 ions which are located in the middle and in the corners of a rectangular plaquette where there are four other spin-7/2 ions. In this study, one may induce a ferrimagnetic compensation behavior for the exchange interactions which are modified with various crystal fields and different magnetic fields values. It is worth to note that the magnetic properties(for example, the total magnetization versus the crystal field domain) of the proposed nanosystem that the ternary $Gd_{55}Ni_{20}Co_{25}$ and quaternary $Gd_{53}Ni_{24}Co_{20}Dy_3$ have a similar behavior, with magnetization decreasing rapidly to zero when heating, indicating a change from ferromagnetism to paramagnetism. The magnetic anisotropies, i.e., crystal fields have carefully been changed so that one can examine interesting phenomena such as compensation behaviors and characteristic types for the total and sublattices magnetizations as functions of the absolute temperatures. It has been found that the proposed system has many compensation temperatures in the range $(-0.2 \le h/|J_1| < -0.05)$ with fixed values of $D_C/|J_1| = 0.0$, $D_S/|J_1| = -1.0$, when $h/|J_1| = -0.2$, $J_1 = -1, J_2 = -1$, $J_3 = -0.75$. We have found that the proposed nanosystem undergoes six types of different ferrimagnetic features which are N-, P-, Q-, R-, S-, and W-type of magnetic behaviors, respectively. It's worth noting that the occurrence of a compensation point is crucial in terms of technology since at this point, just a little driving field is necessary to change the sign of the resultant magnetization; this property is beneficial in minimizing the hysteresis loop's area. Besides, new features are found that the mixed spin square nanosystem has superparamagnetic behavior when $D_C/|J_1| = 0.5, -0.5$, in the range $-1.0 \le D_S/|J_1| < -0.2$, with $K_BT/|J_1| = 0.75$, $J_2 = -1.0$, $J_3 = -0.75$, and $J_1 = -1.0$, respectively.