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Abstract

New Parameters and Extensive Methodology to Describe the Three Phase Transitions in the *q*-States Clock Model †

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In the q-state clock model the spin has q possible orientations in the plane so it can be understood as a generalization of the Ising model for which $q = 2$. The Hamiltonian is then the scalar product of the neighboring spins mediated by the ferromagnetic exchange interaction J homogeneous through the square lattice with $L'L = N$ spins. It is known that for $q \leq 4$ there is only one phase transition at a temperature T_1, over which the ferromagnetic phase is lost. Using global order parameters it has been previously established that for $q \geq 5$ this transitions moves steadily to lower temperatures as q increases [1]. For large L the appearing of the so called Berezinskii–Kosterlitz–Thouless (BKT) phase characterized by vortex like structures is established, while a second transition to a disordered phase appears at a higher T_2 temperature. In the present paper we deeply characterize the nature of this second transition by means of new local order parameters. Surprisingly, an unexpected subtle transition appears at a temperature slightly over the second one (at T_3) requiring interpretation. This is resolved by considering pure and mixed ferromagnetic, vortex and paramagnetic phases as T increases requiring local order parameters and new methodology to better handle them. Thus, we include now information theory analysis by means of mutability and Shannon entropy characterization. Tendencies towards large N and q values are established.

Reference

1 Negrete, O.A.; Vargas, P.; Peña, F.J.; Saravia, G.; Vogel, E.E. Entropy and Mutability for the q-State Clock Model in Small Systems. *Entropy* **2018**, *20*, 933.