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Analysis of equilibrium states in a Pople-Karasz model using mean and Gaussian curvatures

In earlier works on Pople-Karasz model [1, 2], equilibrium states are displayed by contour mapping, where one coordinate is associated with the orientational order parameter S and the other with the positional order parameter Q. In this work, we introduce their geometric analysis by determining mean and Gaussian curvatures (H, K). From the temperature variation of H and K in the disordered state ($S = Q = 1/2$), we have reported the local shapes of equilibrium free energies for the stable and unstable solutions. It is important to mention that a minimal surface for the disordered case with $H = 0$, $K < 0$ is explicitly observed. For the ordered case ($S > 1/2$,$Q > 1/2$), it is found that the curvature H displays a cusp singularity and a convergence of K is observed at the criticality. These results are compared with the similar works [3] and a very good agreement is found.

[1] M. Keskin, Ş. Özgan, A Model for Studying How to Obtain the Metastable States, Physica Scripta 42 (1990) 349-354.

[2] Ş. Özgan, Investigation of stable, metastable and unstable solutions on molecular crystals, Mod. Phys. Lett. B 21 (2007) 817-830.

[3] R. Erdem, Mean and Gaussian curvatures of equilibrium states for a spin-1 Ising system: existence of minimal surface in the paramagnetic solutions, Eur. Phys. J. Plus 138 (2023) 306.

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