**Bond-boson mean-field theory of a two-dimensional hollandite lattice**

**Manas Ranjan Mahapatra and Rakesh Kumar\***

School of physical sciences, Central university of Rajasthan, Ajmer 305817, India

E-mail: rkumar@curaj.ac.in

**Abstract**. Motivated by the pioneer work of Majumdar and Ghosh[1], we constructed and analyzed an exactly solvable model on a two-dimensional hollandite lattice. The three-dimensional hollandite lattice is experimentally realized in the natural minerals of type α-MnO2[3]. The projection of a three-dimensional hollandite lattice on a plane is the lattice of our model. Its unit consists of an octagon that is surrounded by four square plaquettes at alternate edges of the octagon. Here we introduced exchange interactions up to second nearest neighbors. At appropriate values of these interactions, the model shows an exact ground state, which is formed by a product of singlet dimers. Our exact analytical result is reproduced by numerical exact diagonalization method on the lattice of finite sizes. We also employed bond-operator mean-field theory on our model at all parameter regimes[2]. In addition to demonstrating good agreement at the exactly solvable point, this theory unveils exciting and rich many-body phases as we tune the exchange interactions. Again, the spin wave theory results using Holstein-Primakoff transformations confirm the evolution of magnetic phases as the exchange interactions are tuned.

**References:**

1. C.K. Majumdar and D.K. Ghosh, J. Math. Phys. **10**, 1399 (1969).
2. S. Sachdev and R.N. Bhatt, Phys. Rev. B **41**, 9323 (1990).
3. S. Liu, A. R. Akbashev, X. Yang, X. Liu, W. Li, L. Zhao, X. Li, A. Couzis, M.-G. Han, Y. Zhu et al., Sci. Rep. **4**, 6203 (2014).