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Phase transitions and charge ordering in a square spin ice model with conserved monopole density YUNLONG XIE, XIAOHUI ZHOU, JUN-MING LIU, Nanjing University, Department of Physics, China — Artificial spin ices represent a class of highly interested frustrated magnetic systems under intensive investigations for fascinating ground states and thermodynamics/dynamics of spin excitations in recent years. As one of these issues, magnetic charge ordering and the corresponding phase transitions in the two-dimensional system are emerging topics in condensed matter physics. In this work, we investigate all the monopole-ordered phases of the square spin ice model using the conserved monopole density algorithm. In low monopole density ($\rho \sim 0$), the Coulomb potential determines the monopoles' dynamics. We test the Coulomb's law in a two-dimension lattice and justify the monopole dimerization which is quite different from the three-dimensional pyrochlore spin ice. These monopole dimers are charge neutral, and the interactions between them have also been investigated using our algorithm. In the cases of high monopole density ($\rho \sim 1$), the system is similar to the dipolar kagome spin ice model, and our simulation results show that there exists an intermediate phase between the paramagnetic phase and the ordered magnetic phase. Such intermediate phase can be distinguished by the order of magnetic charges. In a cooling process, the system undergoes a two-stage magnetic phase transition before freezing to the long range magnetic ordered phase via a staggered charge ordering. Furthermore, a liquefaction process of monopole dimers can be justified upon the increasing effective internal pressure in the isothermal condition.

Jun-Ming Liu
Nanjing University, Department of Physics, China

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