Gas-Solid Phase Transition in Hardcore-like Systems

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It is known that classical hard spheres undergo a phase transition, the Alder transition, from a gas state to a solid state as the system is compressed. A ground state phase diagram of quantum hardcore bosons was also studied and it was also found that the quantum hardcore bosons localize at much more lower density than the classical counterpart. Their result implies that the quantum hardcore systems are much unstable toward solidification and the quantum effect can help the solidification of bose gases. But the quantum effect, the effect of the zero point motion, on the solidification has not been studied carefully except for the variational study by Nosanow *et al.*, where they found no evidence of the solid state stabilized by the zero point motion. The purpose of our work is to examine the effect of the zero point motion on the solidification of quantum systems by studying the gas-solid phase transition where particles interact with hardcore-like potentials. We calculated the ground state energies of each phase using the Quantum Monte Carlo method, and then, we found that the liquid phase is more stabilized as the effect of the zero point motion increases, that is, the quantum effect never help the solidification at zero temperature. This time, we study the quantum effect on the gas-solid phase transition at "finite temperature". A competition between thermal fluctuation and zero point motion would cause a crossover from the classical phase transition to the quantum one. In this crossover region, the solid phase would be stabilized by the quantum effect.

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