

The Mean Energy in the Canonical and Grand Canonical Ensemble

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For many particles quantum systems, calculating thermodynamical quantities in the canonical ensemble is a very hard task, while it is tractable in the grand canonical ensemble. The second ensemble is then used. The results are supposed to be the same in the thermodynamic limit [1]. Is this actually the case? In this work, we compare the mean energy obtained in the canonical ensemble to that of the grand canonical one. We consider a system of N bosons distributed among two, three and four energy levels. We can calculate the canonical partition function in this case and deduce the canonical mean energy. We compare it to the result of the grand canonical ensemble. The two values differ noticeably. We plot the relative discrepancy as a function of the temperature, for different N values ranging from 10^3 to 10^8 . The curves have a gaussian shape, with a maximum of 0.20.

[1] D.S. Kosov et al. Phys. Rev. **E77**, 021120 (2008).