Rotating Isotropic Harmonic Oscillator

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Finanțat de Uniunea Europeană NextGenerationEU

Outline

- Quantum isotropic harmonic oscillator under rotation is given by the Hamiltonian:

$$H = \frac{\boldsymbol{P}}{2m} + \frac{1}{2}\omega^2 \boldsymbol{x}^2.$$

- The partition function is given by $Z = Tr[\rho]$, where

$$\rho = \exp\left[-\beta(H - \boldsymbol{\Omega}\cdot\boldsymbol{L} - \boldsymbol{\Omega}_{\boldsymbol{\Sigma}}\cdot\boldsymbol{\Sigma})\right].$$

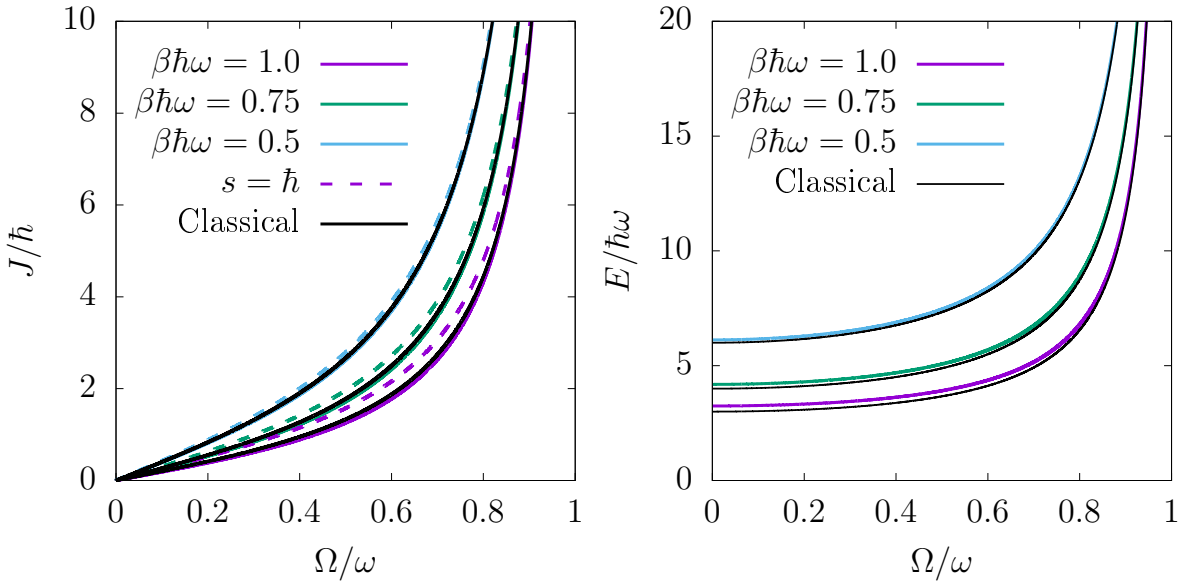
- Thermodynamics quantities: entropy S, orbital and spin angular momenta, $\boldsymbol{L}$ and $\boldsymbol{\Sigma}$ respectively, are computed by differentiating the free energy $F = -k_B T \ln Z$ as follows:

$$S = -\frac{\partial F}{\partial T}, \qquad \mathbf{L} = -\frac{\partial F}{\partial \boldsymbol{\Omega}}, \qquad \boldsymbol{\Sigma} = -\frac{\partial F}{\partial \boldsymbol{\Omega}_{\Sigma}}.$$

- Due to the partition function properties, one can write $Z = Z_L Z_s$, where $Z_L \equiv$ orbital part and $Z_s \equiv$ spin part.

Key points for discussions

- Divergency when the rotational velocity approaches the oscillator strength, i.e. $\Omega \to \omega$;
- Mathematical analyses (asymptotic behavior approach and series expansion analyses);
- Spin does not contribute to the average energy and is independent of position;
- Classical agreement is restored in the limit $\beta \to 0$.



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