$$Z = \frac{1}{N!} Z_1^N$$

$$Z_1 = \frac{1}{(2\pi\hbar)^3} \int d^3p\, d^3q\; e^{-\beta\left[\frac{\vec{p}^2}{2m} - \Lambda(xp_y - yp_x)\right]}$$

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נרשום בצורה נוחה לביצוע

$$= \frac{1}{(2\pi\hbar)^3} \int d^3p \cdot d^3q\; e^{-\beta\left[\frac{p_z^2}{2m} + \frac{(p_x + m\Lambda y)^2}{2m} + \frac{(p_y - m\Lambda x)^2}{2m} - \frac{1}{2}m\Lambda^2(x^2+y^2)\right]}$$

$$= \frac{1}{\lambda^3} \int dz\, r\, dr\, d\theta\; e^{\frac{1}{2}\beta m\Lambda^2 r^2}$$

$\begin{cases} \text{מהו שינוי}? \\ \text{ניקח את זה} \\ \mathcal{H} = \frac{\vec{p}^2}{2m} - \frac{1}{2}m\Lambda^2 r^2 \end{cases}$

$$= \frac{2\pi L}{\lambda^3} \int_0^{R^2} d\left(\frac{r^2}{2}\right) e^{\frac{\beta}{2}m\Lambda^2 r^2}$$

$$= \frac{2\pi L}{\beta m\Lambda^2 \lambda^3} \left(e^{\frac{\beta}{2}m\Lambda^2 R^2} - 1\right)$$

$$dF = -f_R dR - f_z dh - S dT + \mu dN$$

②

$$f_R = -\left(\frac{\partial F}{\partial R}\right)_{T,N,h} = kT\frac{\partial}{\partial R}\ln Z$$

נ.ז מכאן,

$$= NkT\frac{\partial}{\partial R}\left[\ln\left(e^{\frac{\beta}{2}m\Lambda^2 R^2} - 1\right)\right]$$

$$= N\,\frac{m\Lambda^2 R}{1 - e^{-\frac{1}{2}\beta m\Lambda^2 R^2}}$$

נבדוק

$$P\, dV = P\, d\left(\pi R^2 L\right)\Big|_{L=const} = P \cdot 2\pi R L\, dR \;\rightarrow\; P = \frac{f_R}{2\pi R L}$$

$$f_R\Big|_{\Lambda\to 0} = N\frac{m\Lambda^2 R}{\frac{1}{2}\beta m\Lambda^2 R^2} \rightarrow P\Big|_{\Lambda\to 0} = \frac{Nk_B T}{\pi R^2 L} = \frac{Nk_B T}{V} \quad \text{(כצפוי)} \quad \Lambda\to 0 \quad \text{עבור}$$