Many-body system perturbed by radiation field [nln25]

Quantum many-body system in thermal equilibrium.

Hamiltonian: $\mathcal{H}_0$.

Density operator: $\rho_0 = Z_0^{-1} e^{-\beta\mathcal{H}_0}$ with $\beta = 1/k_B T$, $Z_0 = \mathrm{Tr}[e^{-\beta \mathrm{H}_0}]$.

Dynamical variable: A (describing some attribute of system).

Heisenberg equation of motion: $\dfrac{dA}{dt} = \dfrac{\imath}{\hbar}[\mathcal{H}_0, A]$.

Time evolution: $A(t) = e^{\imath\mathcal{H}_0 t/\hbar} A e^{-\imath\mathcal{H}_0 t/\hbar}$ (formal solution).

Stationarity, $[\rho_0, \mathcal{H}_0] = 0$, implies time-independent expectation values:

$$\langle A(t)\rangle_0 = \frac{1}{Z_0}\mathrm{Tr}\left[e^{-\beta\mathcal{H}_0} e^{\imath\mathcal{H}_0 t/\hbar} A e^{-\imath\mathcal{H}_0 t/\hbar}\right] = \frac{1}{Z_0}\mathrm{Tr}\left[e^{-\beta\mathcal{H}_0} A\right] = \text{const.}$$

Time-dependent quantities do exist in thermal equilibrium!

Dynamic correlation function: $\langle A(t)A(0)\rangle_0 = \dfrac{1}{Z_0}\mathrm{Tr}\left[e^{-\beta\mathcal{H}_0} e^{\imath\mathcal{H}_0 t/\hbar} A e^{-\imath\mathcal{H}_0 t/\hbar} A\right]$

In an experiment the system is necessarily perturbed:

$$\mathcal{H}(t) = \mathcal{H}_0 - b(t)B,$$

where $b(t)$ is some kind of radiation field (c-number) and B is the dynamical system variable (operator) to which the field couples.

Examples:

$b(t)$	B
magnetic field	magnetization
electric field	electric polarization
sound wave	mass density