MEMORY EFFECTS ON NUCLEAR DYNAMICS

-Restoring forces in Fermi liquid.
Two incompressibilities:

(i) Statics:

$$K = 9\frac{\partial^2(E/A)}{\partial\rho^2}\rho^2|_{\mathrm{eq}}$$

Classical liquid (water); Dispersion relation for $\omega\ \tau \ll 1$

$$\omega^2 = c_1 q^2 - i\omega\gamma q^2$$

First sound velocity

$$c_1 = \sqrt{\frac{K}{9m}},$$

$$\hbar\omega = \sqrt{\frac{\hbar^2 K}{9m}}q, \qquad \omega\ \tau \ll 1$$

(ii) Dynamics:

Quantum Fermi liquid; Dispersion relation

$$\omega^2 = c_{0,\omega} q^2 - i\omega\gamma q^2$$

$$c_{0,\omega} \approx \sqrt{\frac{K + \Delta K_\omega}{9m}} = \sqrt{\frac{K'_\omega}{9m}}$$

K'_ω - dynamic incompressibility

$$\Delta K_\omega \approx K + \frac{24}{5}\epsilon_F \operatorname{Im} \frac{\omega\tau}{1 - i\omega\tau}$$

Rare collision regime $\omega\tau \to \infty$

$$\Delta K_\omega \approx 2 \cdot K \quad \Longrightarrow \quad K'_\omega \approx 3 \cdot K$$

-Temperature dependence;
Relaxation time

$$\tau = \frac{\hbar\,\beta}{T^2 + (\hbar\,\mathrm{Re}\,\omega/2\pi)^2}, \qquad \beta = 1.5 \div 5 \ \mathrm{MeV}$$

Particle density fluctuations

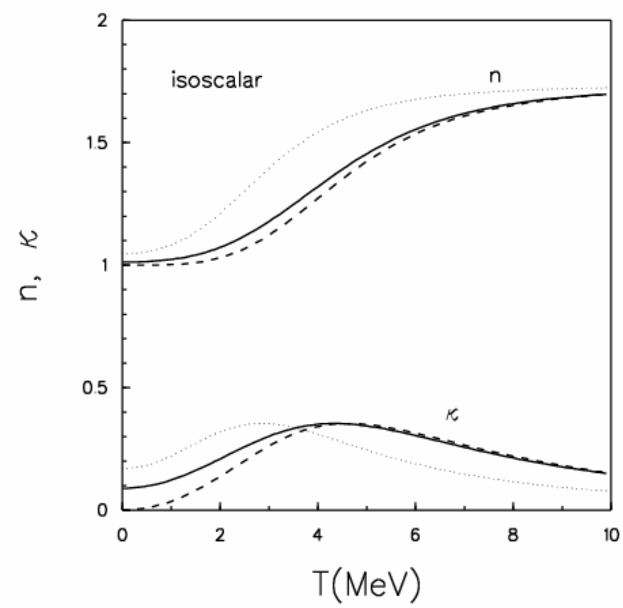
$$\delta\rho \sim \exp(i\mathbf{q}\cdot\mathbf{r} - i\omega t)$$

$$q = \frac{\omega}{c_0}(n + i\varkappa), \quad \omega - \text{real}, \quad c_0 = \sqrt{\frac{3\cdot K}{9m}}$$

n - refraction coefficient, $\varkappa$ - attenuation coefficient

$$n = 1 \quad \text{if} \quad \omega\tau \gg 1, \qquad n = \frac{c_0}{c_1} \approx \sqrt{3} \quad \text{if} \quad \omega\tau \ll 1$$

Fig. 1: $n(T)$ and $\varkappa(T)$



Giant Monopole Resonance

1) Dispersion relation:

(i) Classical liquid drop (water)

$$K = 9\frac{\partial^2(E/A)}{\partial\rho^2}\rho^2|_{\mathrm{eq}}$$

$$\hbar\omega = \sqrt{\frac{\hbar^2 K}{9m}}q, \qquad\qquad \omega\,\tau \ll 1$$

(ii) Quantum liquid (nuclear Fermi liquid)

$$\omega \approx \sqrt{\frac{3 \cdot K}{9m}} q, \qquad \omega\ \tau \gg 1$$

2) <u>Boundary conditions:</u>

(i) Classical liquid drop (water)

$$q \approx \frac{\pi}{R}, \qquad \omega\ \tau \ll 1$$

(ii) Quantum liquid (nuclear Fermi liquid)

$$q \approx \frac{\pi}{\sqrt{3} \cdot R}, \qquad \omega\ \tau \gg 1$$