



**The Abdus Salam
International Centre for Theoretical Physics**



2234-23

**Meeting of Modern Science and School Physics: College for School
Teachers of Physics in ICTP**

27 April - 3 May, 2011

Physics in a kitchen

Andrey Varlamov
*SPIN-CNR
Rome
ITALY*

Physics of a Good Coffee

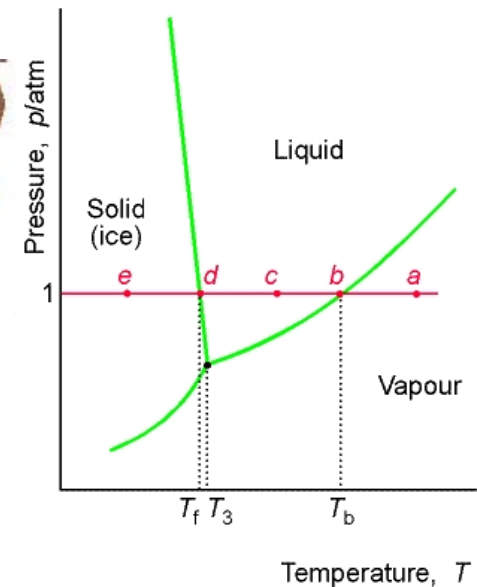
- Andrey Varlamov
SPIN-CNR, Roma
- Giuseppe Balestrino
Universita' "Tor Vergata", Roma



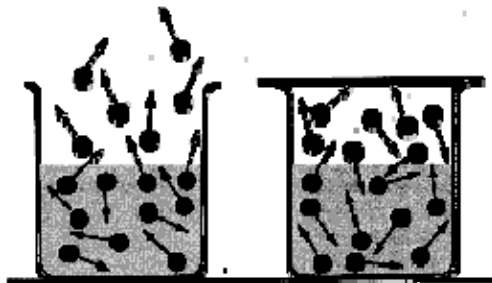
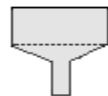
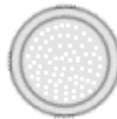
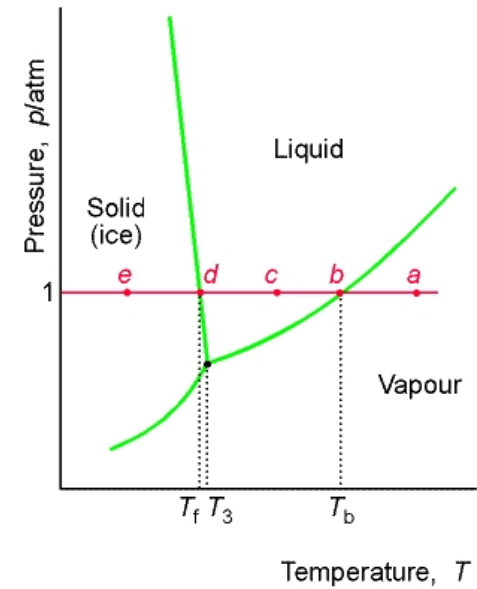
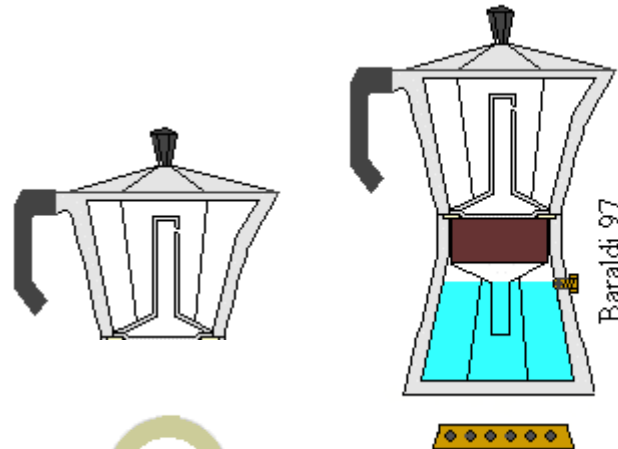
Photo: © gipo.montesanto



$$Q = \frac{(K \times S \times \Delta P \times \rho)}{(L \times \eta)}$$



Italian Moca



Filtration: the Darcy Law

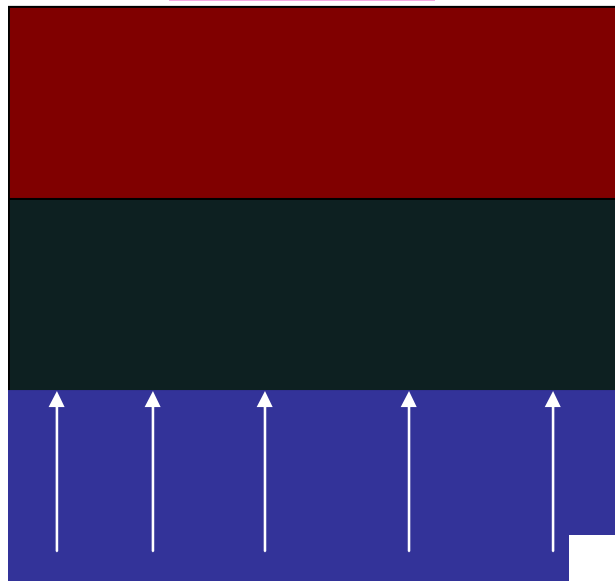
$$Q = \kappa S \Delta P \rho / (\eta L)$$



$$\Delta P = Q \eta L / (S \rho \kappa)$$

$$P = P_{\text{atm}}$$

$$Q = m/t \sim 200 \text{ g/min}$$



$$\eta(\text{ }^\circ\text{C}) = 10^{-3} \text{ Pa s}$$

$$S \sim 10 \text{ cm}^2$$

$$L \sim 1 \text{ cm}$$

$$\kappa \sim 10^{-12}$$

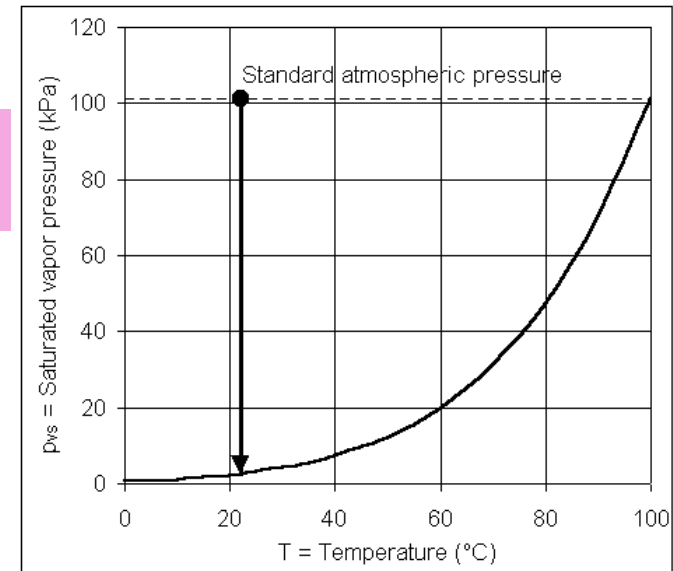


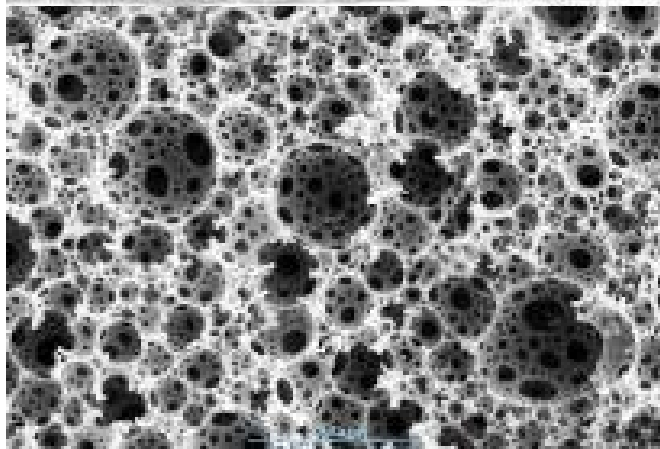
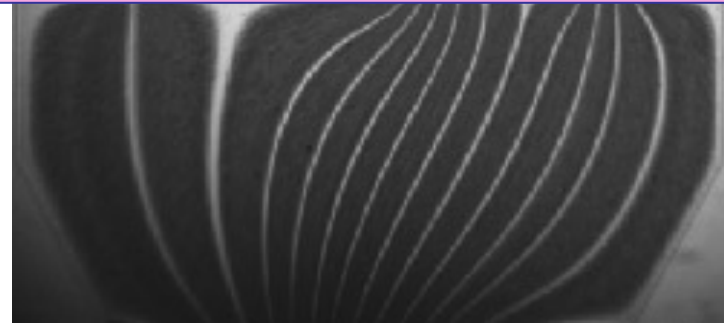
Table 12.1: TEMPERATURE DEPENDENCE OF PRESSURE OF SATURATED WATER VAPOR.

$$P(T) = P_{\text{atm}} + P$$

Temperature, °C	96.18	99.1	99.6	99.9	100	101	110.8
Pressure, kPa	88.26	98.07	100	101	101.3	105	147

$$\Delta P \sim 4 \cdot 10^4 \text{ Pa} \rightarrow T^* \sim 110 \text{ }^\circ\text{C}$$

The limitation of the Darcy Law at small pressures: opening of the capillars



$$P_c \approx \frac{2\sigma}{r}$$

Filtrazione

$$\Delta P_{\min} \approx \frac{2\sigma}{r}$$

$$r \sim 0.1 \text{ mm}$$

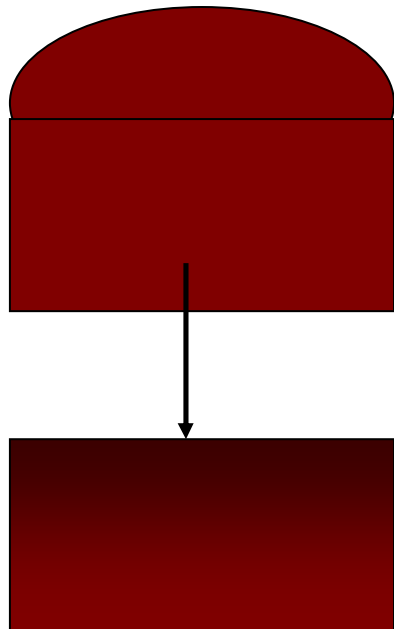
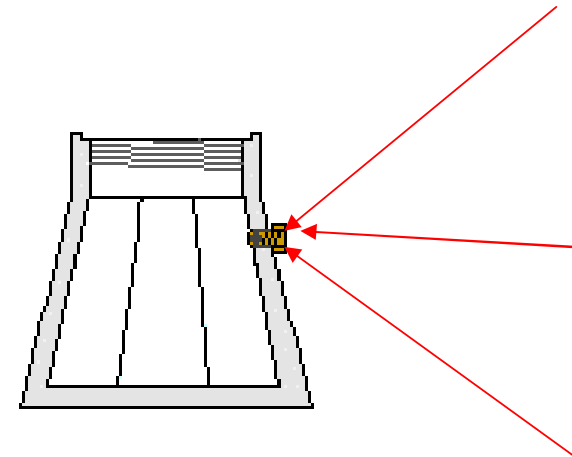
$$\sigma = 0.072 \text{ N/m}$$

$$\Delta P_{\min} = 0.05 \text{ atm}$$

Moka explosion.

$$PV = m/\mu RT$$

$$M = 150 \text{ g}, V = 200 \text{ cm}^3$$
$$T_{max} \sim 300 \text{ }^\circ\text{C} \rightarrow P_{max} \sim 10^3 \text{ atm}$$
$$E \sim PV \sim 40 \text{ KJ} \rightarrow v = 200 \text{ m/s}$$

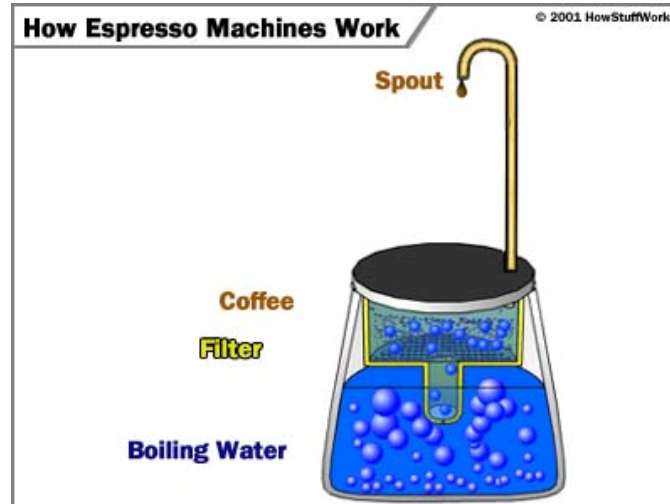


$$\kappa \sim 10^{-12}$$

$$\kappa \sim 10^{-13} \sim 10^{-14}$$



Espresso machine



$$\frac{(K \times S \times \Delta P \times \rho)}{(L \times \eta)}$$

