LA FISICA DEI SISTEMI A MOLTI CORPI
Many-Body Physics

II SEMESTRE 9 CFU

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Why

Atomic & Molecular Physics

Condensed Matter: (Quantum) Solids-Liquids-Soft matter

Examples

Electrons in metals
$n \approx 10^{22}\ cm^{-3}$
Carriers in semic.
$n \approx 10^{19}\ cm^{-3}$
Quantum gases
$n \approx 10^{14}\ cm^{-3}$

Biology: Living cells

Nuclear Physics
$\# \approx 10^{2}$

Many-Body-Physics
#part >3

Statistical mechanics & Thermodynamics

High-Energy Physics & Fundamental interactions
Quantum Field Theory
Quark-Gluon Plasma
$n \approx 10^{39}\ cm^{-3}$

Broken Symmetries (Quantum) Phase Transitions

Examples

- Metal-Supercond.
- Para-Ferromagnet
- .....

What: a unifying ide via 2 concepts

CONSERVED QUANTITIES

- Number of particles
- Momentum/current (angular too)
- Energy
- .....

BROKEN SYMMETRIES

- Liquid to Crystal
- Normal to Super Fluidity
- Para to Ferro Magnetism
- .....

Classical λ_{dB} ~ sistem size Quantum

Appear:
- New Hydodynamic modes
- New elastic constants
- Defects

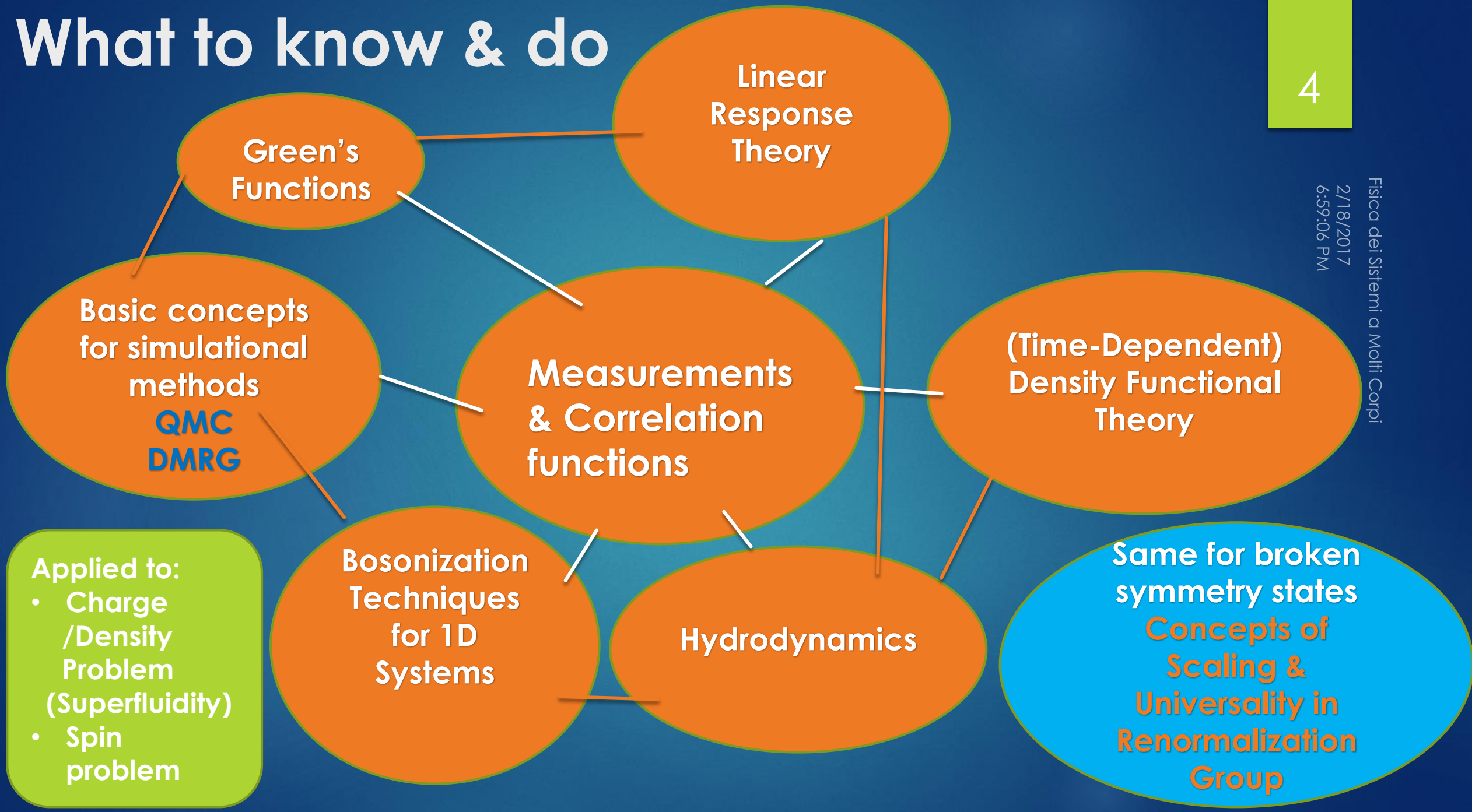
Reduced symmetry

Temperature

Interactions

Dimensionality

What to know & do



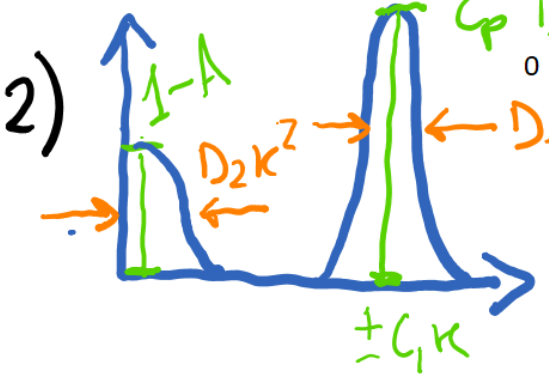
HOW TO CONNECT MACRO&MICRO

↳ RESPONSE FUNCTION

1) $m\frac{d^2}{dt^2}\tilde{\chi}(tt') + m\omega_0^2\tilde{\chi}(tt') + m\gamma\frac{\partial}{\partial t}\tilde{\chi}(tt') = \delta(t-t')$

$\frac{\omega}{c_p}\frac{n}{D_1 k^2}\left(\frac{\partial n}{\partial p}\right)_T \simeq A$

2)



← $D_1, D_2, \omega, c_p, c_1 \left(\frac{\partial n}{\partial p}\right)_T$ micro expressions

3) $I_{ij} = \int d\underline{z}\,(z^2 - z^2)\rho_n(z)$ ← $\lim_{k\to 0}\int_{-\infty}^{+\infty}\frac{d\omega}{2\pi}\frac{\langle[\bar{j}_z^T(1+1), j_z^T(\underline{z}t')]\rangle}{\omega}$

Evaluation is performed through

- Specific competences

  Conceptual knowledge and how-to: up to 18 points

  Procedural knowledge and how-to: up to 6 points

  Phenomenological knowledge and how-to: up to 4 points
- Like-skills (awareness, communication,...): up to 5 points

THANK YOU FOR YOUR ATTENTION!

(WAITING FOR MANY OF YOU ☺)

Textbooks and papers

- **General:**

– Chaikin and Lubensky, *Principles of Condensed Matter Physics*, Cambridge University Press (1995)

– Kadanoff and Baym, *Quantum Statistical Mechanics,* Benjamin (1962)

– Iadonisi, Cantele, and Chiofalo, *Introduction to Solid State Physics and Crystalline Nanostructures*, Springer (2014)

– Grosso and Pastori Parravicini, *Solid State Physics*, Academic Press (2000)

- **Useful for specific parts:**

– Martin, *Measurements and Correlation Functions*, Gordon and Breach (1968)

– Hohenberg and Martin, *Microscopic Theory of Superfluid Helium*, Annals of Physics 34, 291-359 (1965)

– Baym, *Microscopic Description of* Superfluidity, in Math. Methods in *Solid-State&Superfluid Theory*, Clark&Derrick Eds., Oliver&Boyd (1969)

– Vignale, Ullrich, Conti, *Time-Dependent DFT and beyond the Adiabatic Local Density Approximation*, PRL 79, 4878 (1997)

– Foulkes, Mitas, Needs, and Rajagopal, Quantum Monte Carlo Simulations of Solids, Revue of Modern Physics 73, 33 (2001)

– Schollwok and White, *Methods for Time Dependence in DMRG*, in *Effective Models for Low-Dimensional Strongly Correlated Systems*, Batrouni and Poilblanc Eds., p. 155 AIP, Melville, New York (2006)

- **More**

– Nozières and Pines, *Theory of Quantum Liquids I – II*, Westview Press (1999)

– Forster, *Hydrodynamic Fluctuations, Broken Symmetry, And Correlation Functions,* Adv. Books Classics (1995)

– Bloomfield, *How Things Work*, Wiley (2013)