Universality: a bridge between physical scales

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האוניברסיטה העברית בירושלים
THE HEBREW UNIVERSITY OF JERUSALEM

cea

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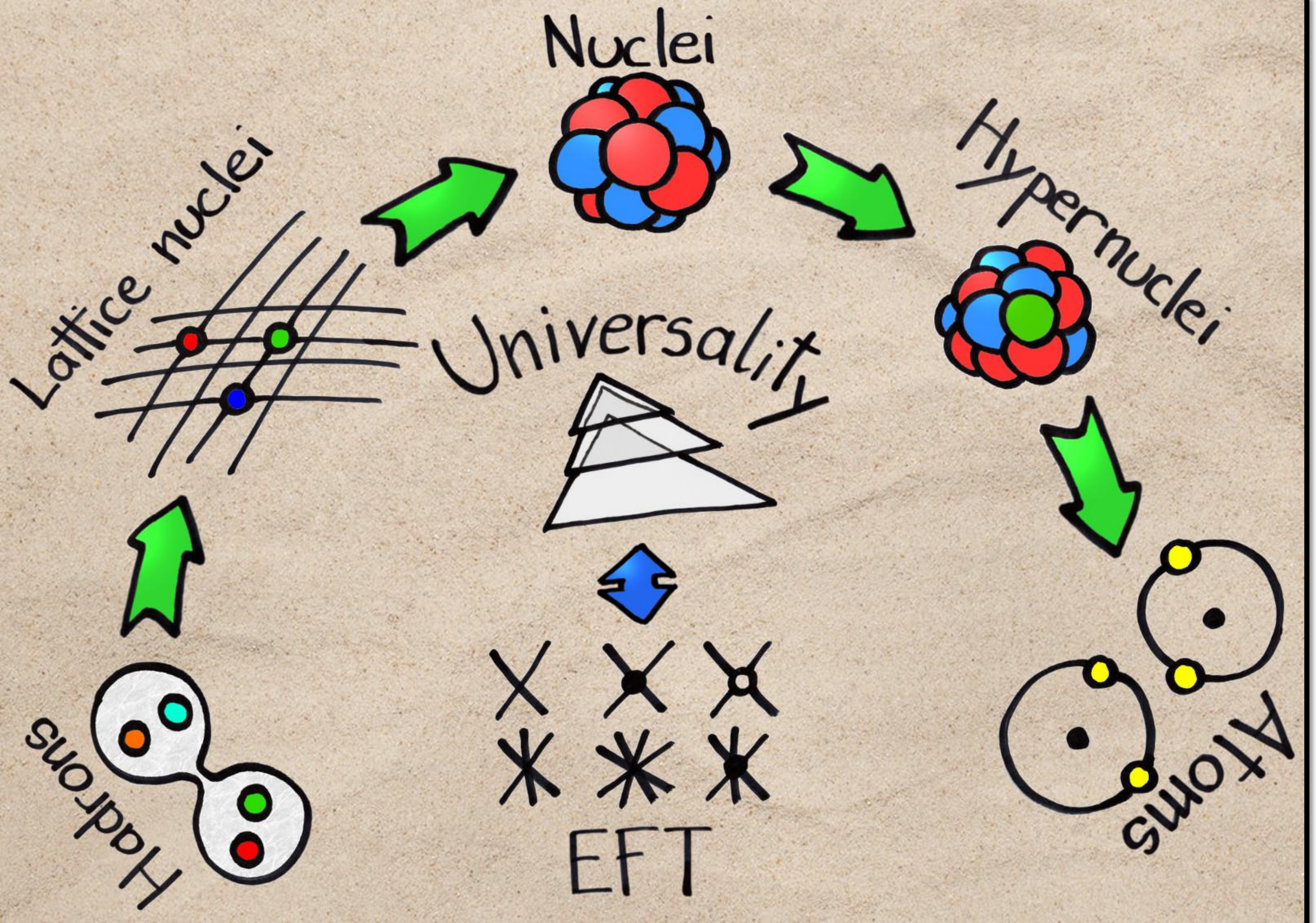
Laboratoire de Physique des 2 Infinis



Hadrons (theory):
E. Braaten et al (2003)

Lattice Nuclei (theory):
N. Barnea et al (2015)
L.C. et al (2017)

Nuclei (theory):
U. van Kolck (1999)
S. König (2017)

Hypernuclei (theory):
H.-W. Hammer (2001)
L.C. (2018)

Atoms (experiments):
C.A. Regal (2003)
M.W. Zwierlein (2003)
M. E. Gehm (2003)
J. T. Stewart (2007)

Building a theory from the microscopic

a_0 two body system size
r_0 interaction range

- Unitarity -

Separation of scales

Systems close to the **Unitary limit** can be found in

- **Atomic physics** (Feshbach resonances, $^6\mathrm{Li} - {}^6\mathrm{Li}$, ...)
- **Nuclear physics** ($n - p$ interaction)
- **Lattice nuclei** (Unphysically large m_π)
- **Hypernuclei** ($\Lambda - n$ interaction)
- **Hadronic physics** ($X(3872)$ Particles)
- **Cold Atom Physics**

similar **macroscopical** proprieties

Es. $a_0 \gg r_0$

Same **theoretical structure**

- Effective field theory -

Leading order

Subleading orders

Qualitative predictions

Quantitative tuning

Systems **hard to be experimentally** accessed

Comparison with experimental data

Numerics: how to solve the Schrödinger equation

Few-body:

I.e., **stochastic variational method**

- Usually variational methods
- Works for 2-8 particles
- Low errors
- Timescale few minutes to few hours
- Good for **fitting** and extraction of **few-body observables**

Many-body:

I.e., **Quantum Monte Carlo**

- Stochastic method
- Works up to 80 particles (with auxiliary field)
- Timescale from few hours to …
- Good for extracting **groundstate observables** in larger systems

Goal: extract observables in few- and many-particle quantum systems;

EFT allows to expand and write the **Hamiltonian**;

Numerical methods allow to compute observables;

Systems in the same **universality class** share similar proprieties:

similar theory,

passage of knowledge from a field to another.

If you want to know more,

see you at the **nuclear Coffee the 15th of December**

or write me at contessi@ijclab.in2p3.fr