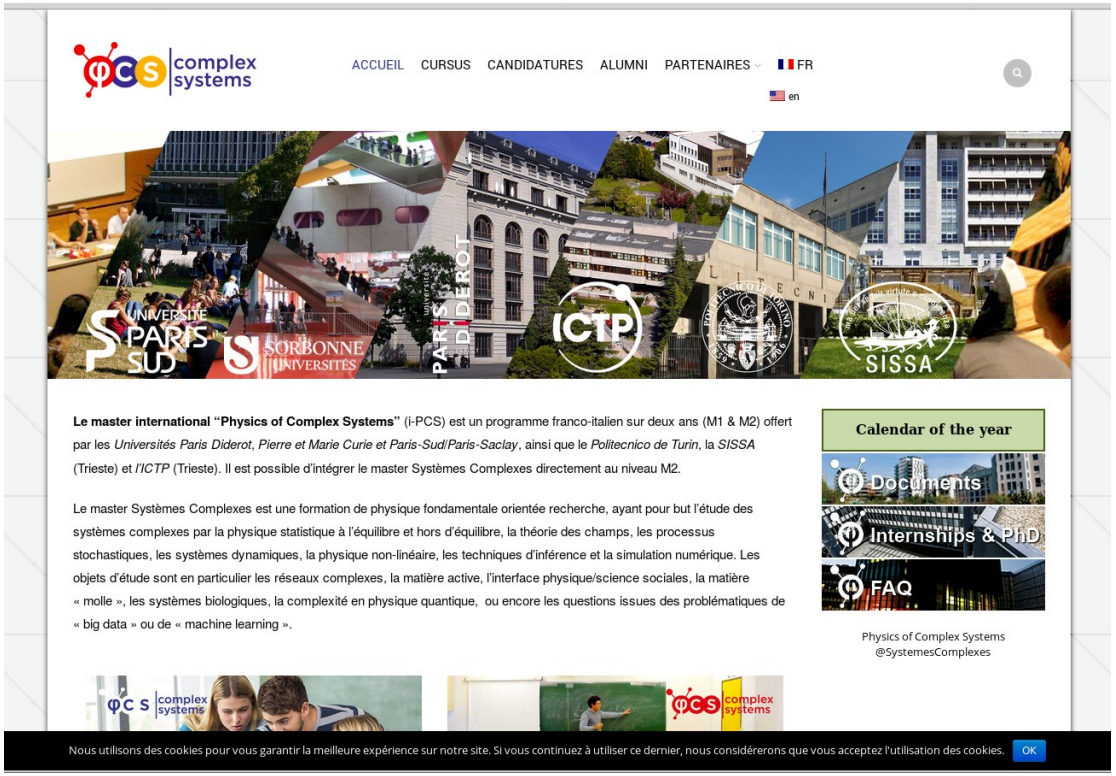
Physics of Complex Systems Master
Kickoff meeting

J.-B. Fournier, D. Mouhanna, C. Texier, E. Trizac

September 7 2020

Welcome… and congratulations !



UP, SU, PSaclay,
Jointly operated with
Polito, SISSA, ICTP

Distinguish
PCS (M2) / iPCS (M1 in Italy + M2)

Organization of the year (PCS+ PCS-like iPCS)

See below for 'true' iPCS

- **First semester** → Dec 18
- Special session on doctoral studies (*a priori* October 19)
- Autumn break Oct 26 - 30 

(no exams before Xmas)
- Tour of labs, Nov 16 - 20
- Second semester courses presentation mid November
- Winter break : 3 weeks (Dec 19 – Jan 10) 

- Exams Jan 11 – 22
- Mini break (3 days) + 2 days *Journées Physique Statistique*
- **Second semester courses** : Feb 1 → March 19
- Exams March 29 - April 2
- Internships → defense in July (France)

More details available on the web

iPCS version

- First semester common
- Start of internship earlier : Feb 1
- Internship sandwiches
  Trieste "Spring" College : Feb 22 → March 19

2016

2017

2018

Program changes every year ; see web
Also open to some Master & PhD students + **some PCS as well**

- Internship defense : mid July in Italy
- Graduation ceremony in October in Italy

The internship is not supposed to start after the Spring College

First semester schedule

S3 - Physics of Complex Systems (PCS) - 2020 / 2021

MONDAY (UP)		TUESDAY (SU, Jussieu)		WEDNESDAY (UP)		THURSDAY (SU, Jussieu)		FRIDAY (SU, Jussieu)	
		08:30 10:30	**Advanced nonlinear physics** *L. Foret & N. Pavloff* T24/25 108 (1/9-15/9) T23/24 103	08:30 10:30	**Statistical field theory** *J.-B. Fournier* ODG 153	08:30 10:30	**Mathematical tools** *G. Roux* T23/24 202 (3/9-17/9) T23/24 103	08:30 10:30	**Computational science** *M. Weigt* T24/34 101 (4/9-18/9) T23/24 105
10:00 12:00	**Nonlinear physics and dynamical systems** *C. Nore* SG 1021	10:45 12:45	**Quantum field theory** *J. Serreau* T24/25 108 (1/9-15/9) T23/24 103	10:45 12:45	**Statistical physics of simple & complex fluids** *M. Durand & G. Foffi* C 222A	10:45 12:45	**Biophysics** *M. Lenz* T23/24 202 (3/9-17/9) T23/24 103	10:45 12:45	**Stochastic processes** *D. Mouhanna & C. Deroulers* T24/34 101 (4/9-18/9) T23/24 105
13:30 15:30	**Statistical field theory** *J.-B. Fournier* SG 1021	13:45 15:45	**Nonequilibrium and active systems** *J. Tailleur* T24/25 102 (1/9-15/9) T23/24 107	13:45 15:45	**Stochastic processes** *D. Mouhanna & C. Deroulers* ODG 255			13:45 15:45	**Numerical simulations** *P. Viot* T24/34 101 (4/9-18/9) T23/24 107
16:00 18:00	**Advanced statistical mechanics** *L. Cugliandolo* C 222A								

C = Condorcet, ODG = Olympe de Gouge, HF = Halle aux farines, SG = Sophie Germain, T13/12 = Tower 13/12, entrance tower 13
UP = University of Paris (Paris Diderot), SU = Sorbonne University

UP SU UP SU SU

The exams

- In January and March (Spring college apart)
- Usually written ; grade over 20
- If grade < 10, possibility of an oral exam.
  Course grade is *saturated to 10*.
- 
  Narrow time window for orals
  (~1 week, before the jury in January)

- Very different from Italian system
- Exams are concentrated (written+oral)
- In practice : 1 session only
  The second session arrives after doct school competition
  → too late / irrelevant
- **First semester usually harder, more packed**

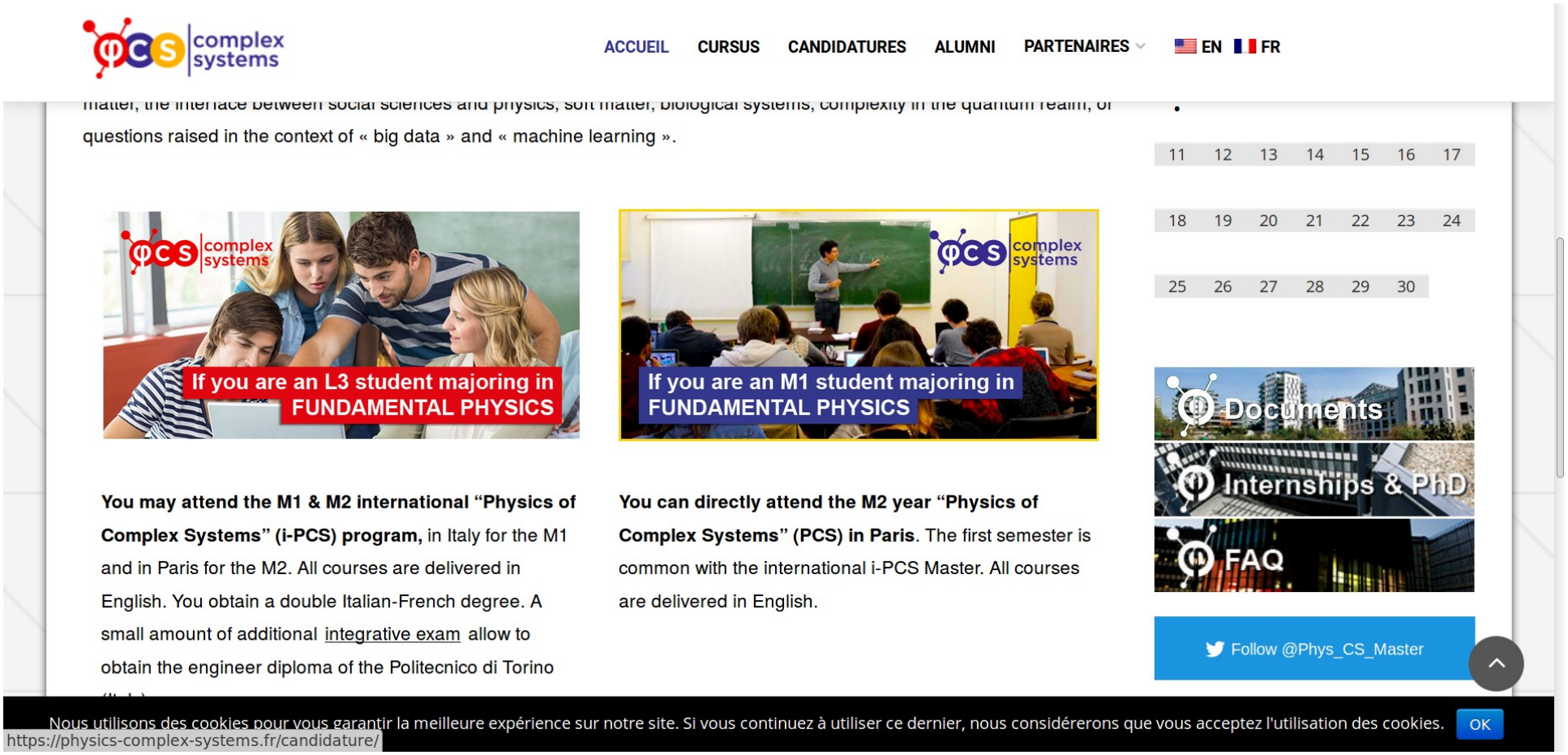
and some PhD applications (abroad)
are in March : second semester irrelevant

→ Work all courses simultaneously
And start now !

Relevant information on the web

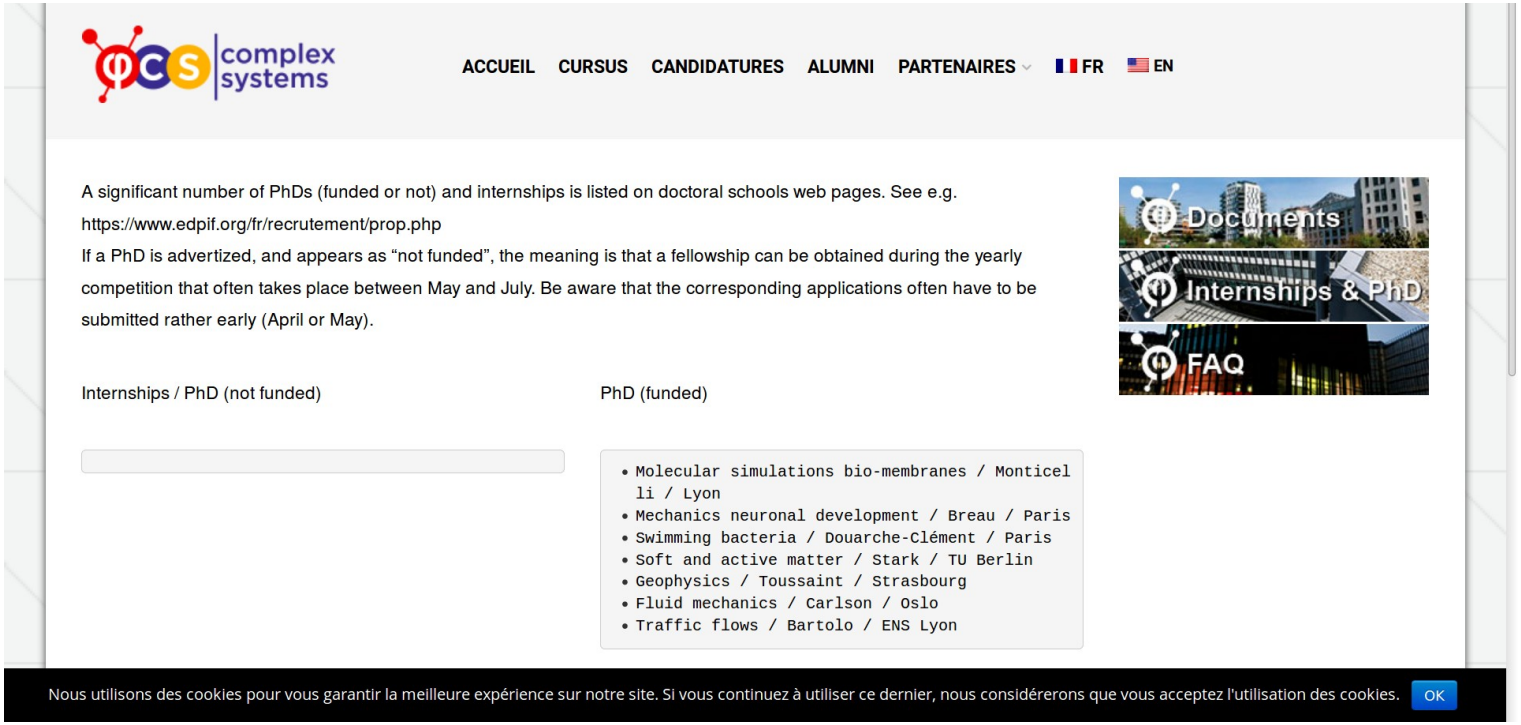
https://physics-complex-systems.fr/

See in particular
Documents + Internships & PhD



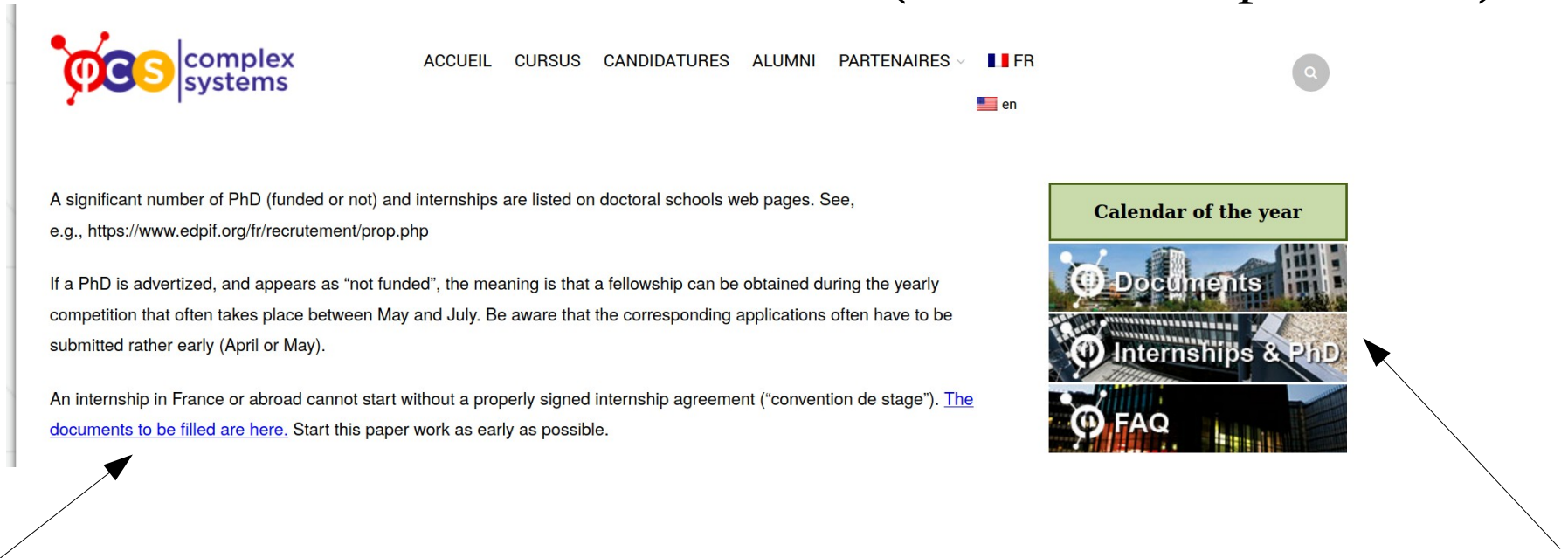
Internships & PhDs

- Doctoral schools websites
- Laboratory web sites
- PCS site



Internships & PhDs

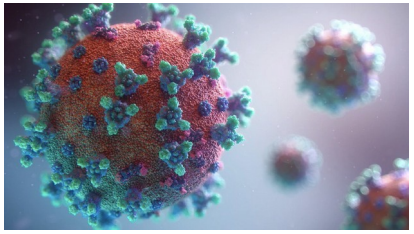
- On you to search for internship/PhD
- Do not hesitate to contact researcher before visit
- Internships (in France) require “convention de stage”, to be completed *before* the beginning
- Relevant docs on the web site (see *Internship & PhD*)



- Mid October : a session dedicated to doctoral studies

Misc

- Conditions for internship defense for iPCS
  → Defense in July in France if principal affiliation in France
  → If you are an “italian iPCS” (principal affiliation in Italy)
    - you graduate in July : defense in July in Italy. Only one defense. Grade needed before July 20.
    - you graduate later than July, too late for French grade, you then defend in July in France and later in Italy (autumn usually). Two defenses
- Prolongation of rooms @ cité U
  → you may need your room for the second semester



OK

Not OK

Presentation of courses : compulsory / 18 ECTS

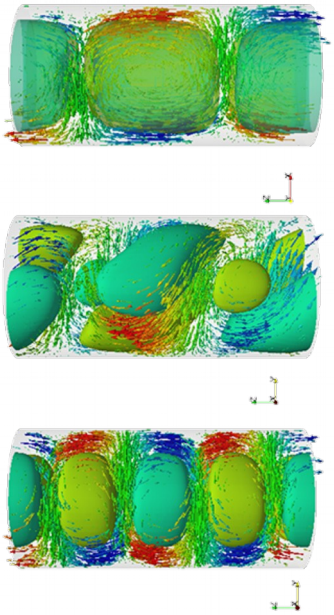
- Non linear physics & dynamical systems
- Stochastic processes
- Computational Science
- Statistical Field Theory

+ 4 elective courses, choose among 8 → 70 possibilities

C. Nore

Non-linear physics and dynamical systems

- Study systems with increasing complexity
- From 1d onwards
- PDE and beyond
- Bifurcation and chaos



See also the elective
"advanced non-linear physics"

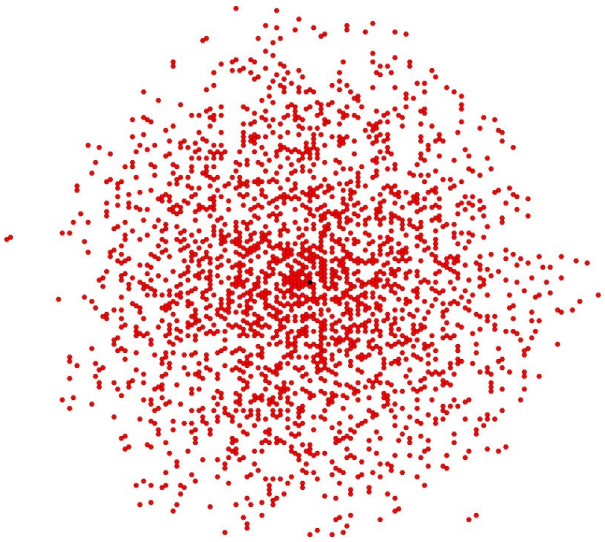
Using a term like nonlinear science is like referring to the bulk of zoology as the study of non-elephant animals (Stanislaw Ulam)

D. Mouhanna

Stochastic processes

C. Deroulers

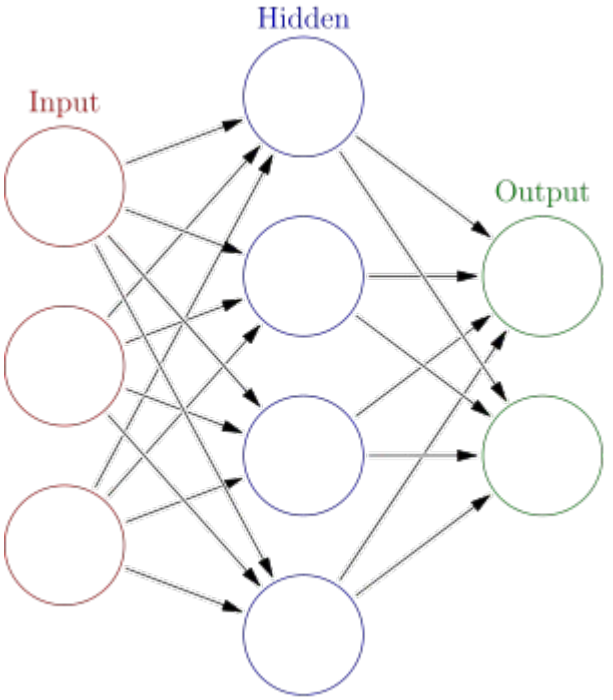
- How to model randomness ?
  Large number of applications
- How to account for random features ?
- Reminder in probability
- Brownian motion
- PDE description
- Example driven → illustrate formal notions and their universal character



M. Weigt

Computational science

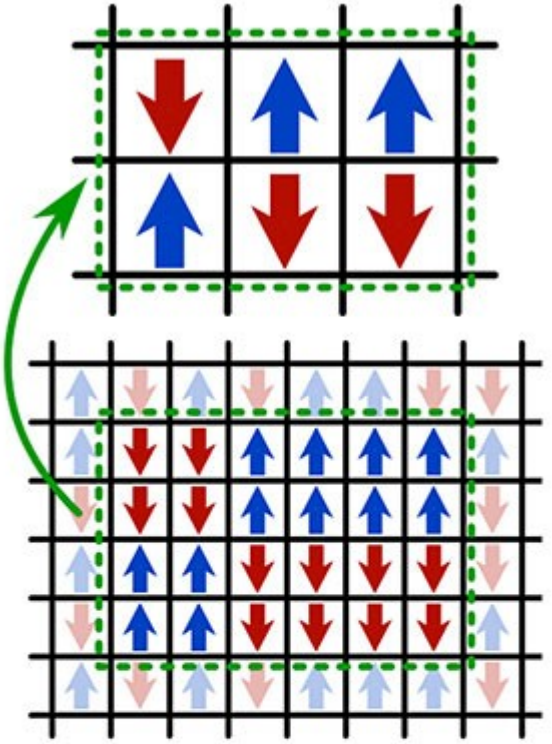
- Keywords
  Information theory, ML, MC, statistics
- Crossroads statistics, computer science, neurosciences, physics
- Introduce core concepts and techniques of ML, both for supervised and unsupervised learning
- Hands on

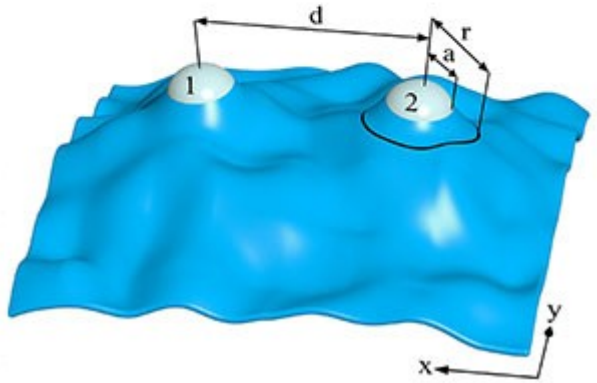


J.B. Fournier

Statistical field theory

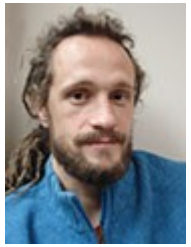
- Describe spatial fluctuations of fields
  coarse graining / importance sym.
- Learn functional integrals, Feynman diagrams, renormalization group
- Emphasis on critical phenomena
  → understand universality
- Scaling ideas





Elective courses
choose 4 → 12 ECTS

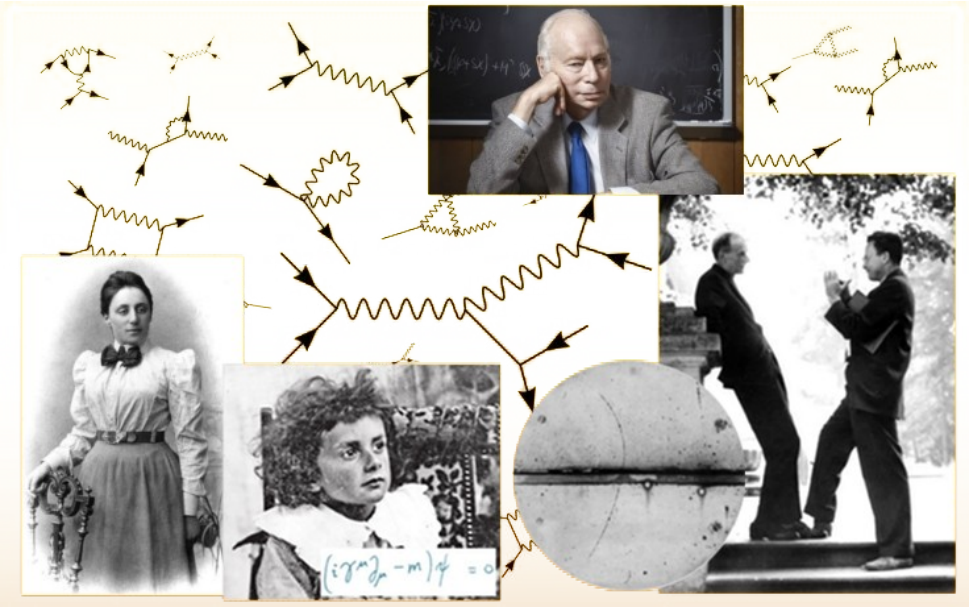
- *Advanced statistical mechanics (Cugliandolo) → wait a bit*
- Advanced non linear physics (Foret-Pavloff)
- Non equilibrium and active systems (Tailleur)
- Numerical simulations (Viot)
- Statistical physics of simple and complex fluids (Durand-Foffi)
- Biophysics (Lenz)
- Quantum field theory (Serreau)
- Mathematical tools (Roux)

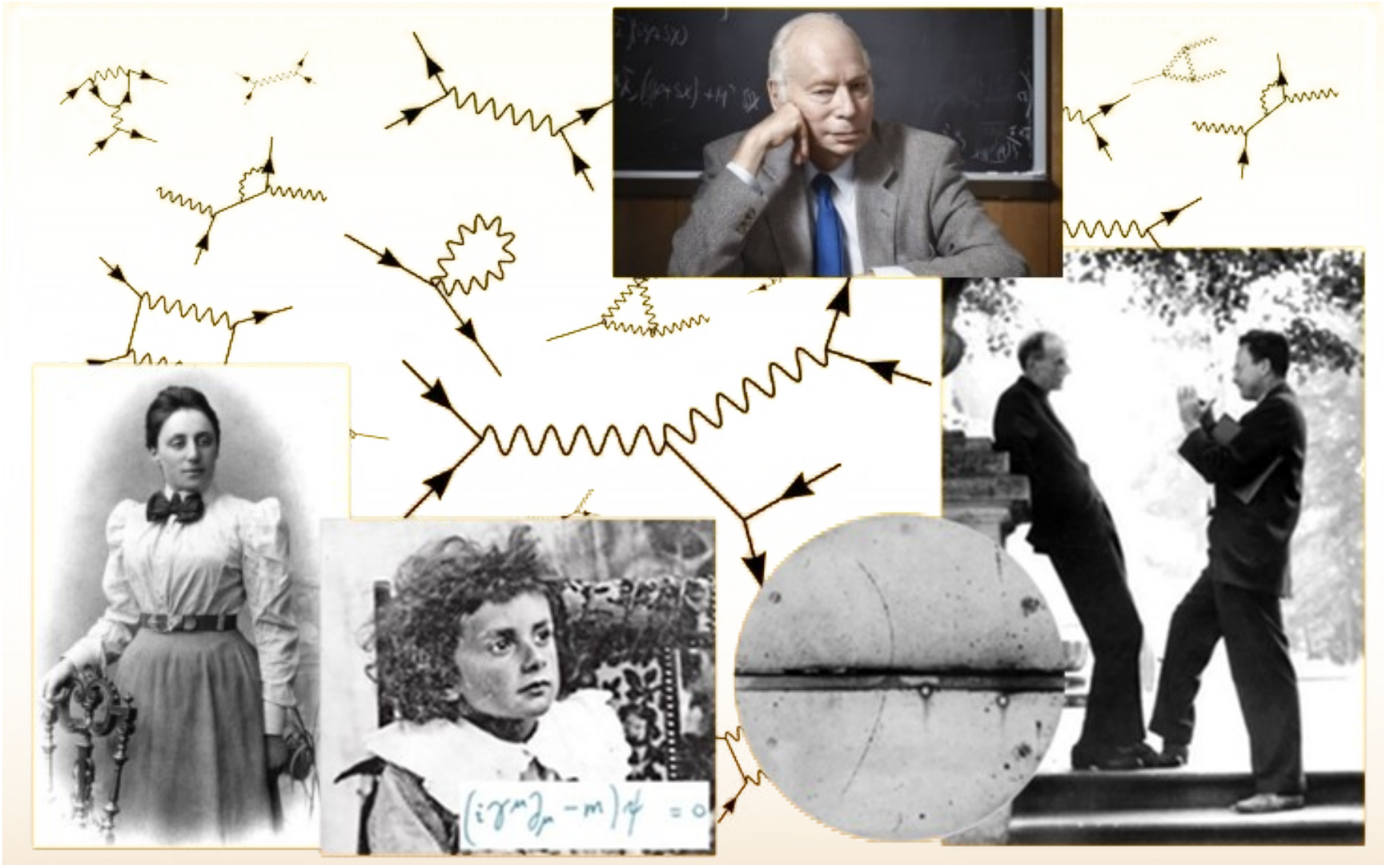


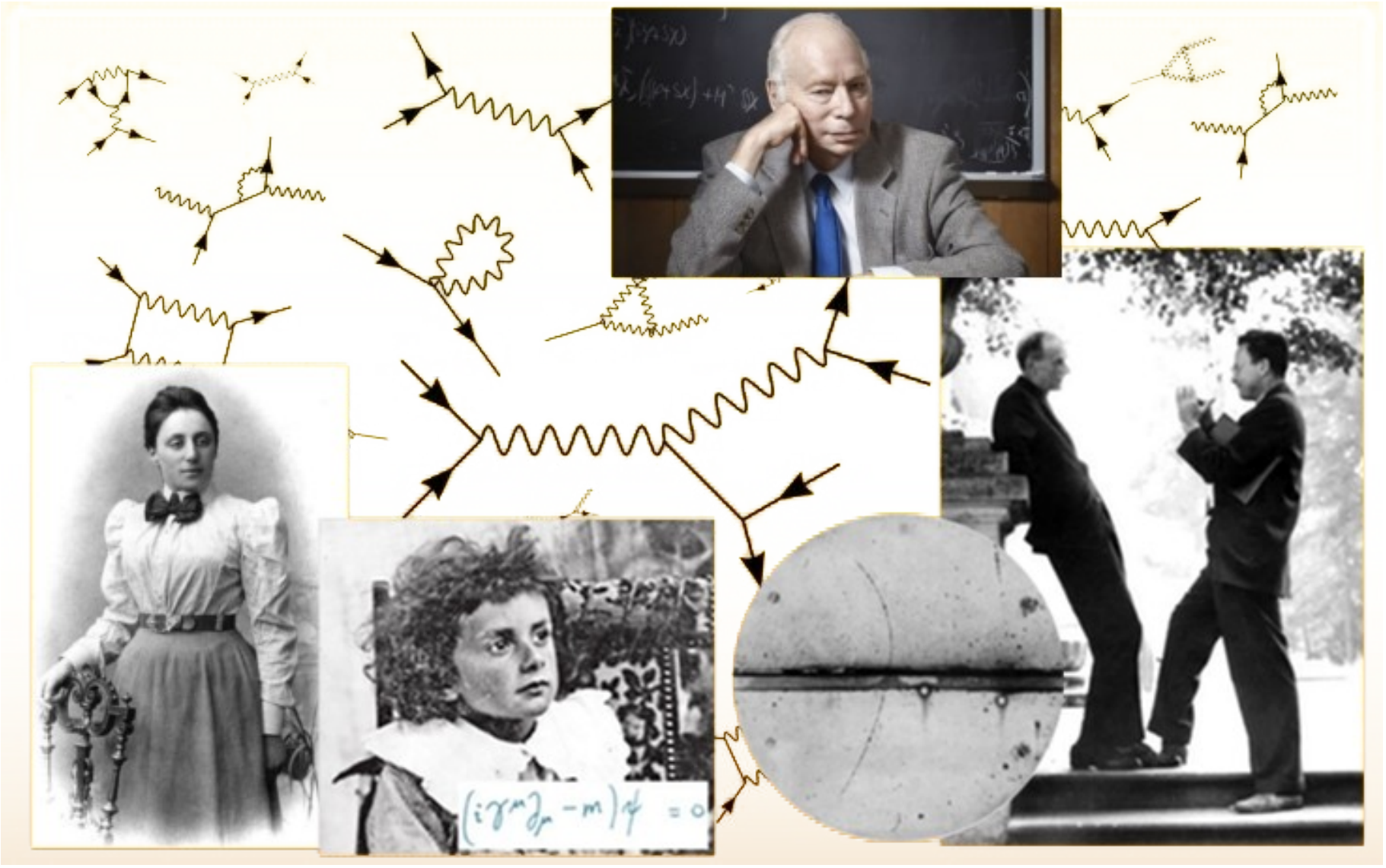
Quantum field theory

J. Serreau

- Basics, unification of Quantum mechanics and Special relativity
- Issues ? Solutions ?
- Successes : prediction of antiparticles, Casimir effect…
- Tools : canonical quantization, path integrals, Klein Gordon, Dirac equations
- Symmetry




$(i\gamma^\mu\partial_\mu - m)\psi = 0$


$(i\gamma^\mu\partial_\mu - m)\psi = 0$

Weinberg