Formal Theoretical Physics

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IN2P3
Les deux infinis

An attempt at a definition

- The term *Formal Theoretical Physics* refers to research activities on mathematical («formal») aspects of physical theories, whose relevance for experiment (or other applications) is not necessarily immediate.
- Classification according to arXiv includes: *hep-th, gr-qc, hep-ph, quant-ph, cond-mat.stat-mech, cond-mat.str-el, astro-ph.CO, nucl-th, nucl-ex, physics.soc-ph, physics.gen-ph, physics.class-ph, math-ph, physics.bio-ph, q-bio.PE, math.DG, math.AG, math.SP, math.NT, math.GR, math.GT, math.RT, math.CO, ...*

However :

- There may very well be immediate applications
- There is no clear cut distinction between formal and not formal
- Both aspects may be present in the same work
- It is difficult to classify researchers according to this dichotomy

Staff numbers

- 32 «formal» theorists at IN2P3
- 20 Enseignants-chercheurs
  - 11 PR
  - 6 MCF
  - 3 Em
- 12 Chercheurs
  - 5 DR
  - 3 CR
  - 4 Em

Geographical breakdown

APC
6 EC, 2 CNRS, 2 Em

IJCLab
4 EC, 4 CNRS, 3 Em

IPHC
2 EC

LPC
1 CNRS

IP2I
3 EC, 1 Em

LPSC
1 EC, 1 CNRS

LUPM
1 Em

SUBATECH
1 EC

Thematic breakdown

- Three broad categories
  - Gravity
  - Quantum Field Theory
  - Statistical Physics

However :

- This breakdown is largely arbitrary
- There are no clear cut boundaries between categories
- Common methods used to treat different problems
- Different methods used to treat the same problem
- A single researcher may belong to different categories

Thematic breakdown

- Gravity
  - String theory
    Links to: cosmology, black holes, gravitational waves,
    particle models, hadronic and nuclear physics, condensed matter.
  - Loop quantum gravity
  - Tensor group field theory
  - General relativity and modified theories of gravity
    Links to: cosmology, black holes, gravitational waves.

Thematic breakdown

- Quantum Field Theory
  - QFT on curved spacetimes
    Links to: cosmology, black holes.
  - QFT on non commutative spacetimes
    Links to: cosmology, black holes, particle physics.
  - Structural aspects of QFT
    Quantization schemes, renormalization schemes, resummation, vacuum structure.
- Extensions of QFT
  Higher-spin theories, higher-derivative theories, supersymmetry, supergravity.
- Mathematical Physics
  Differential & algebraic geometry, group theory, representation theory, number theory, quantum groups & algebras, spectral theory, geometric topology, combinatorics, ...

Thematic breakdown

- Statistical Physics
  - Equilibrium systems

    Analytical and numerical studies of phase diagrams, confined geometry, van der Waals forces, random geometry.

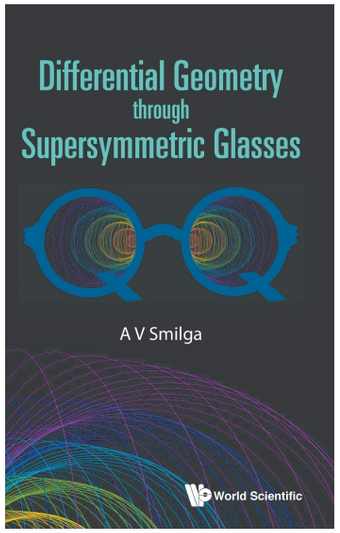
  - Non equilibrium systems

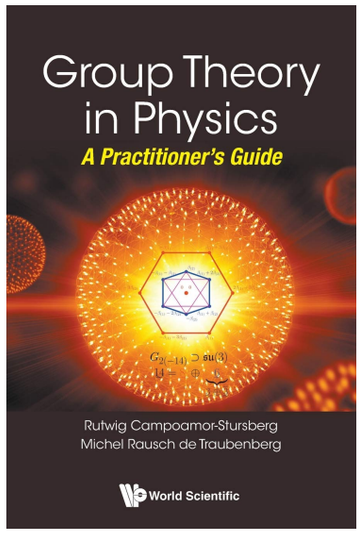
    Stochastic processes, physics of coupled flux (microscopical-level energy conversion), transport phenomena, traffic (road, pedestrian, intercellular).

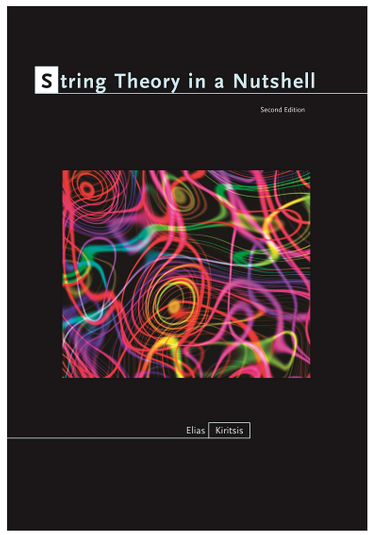
Links to: medical physics (cancerous tumors models).

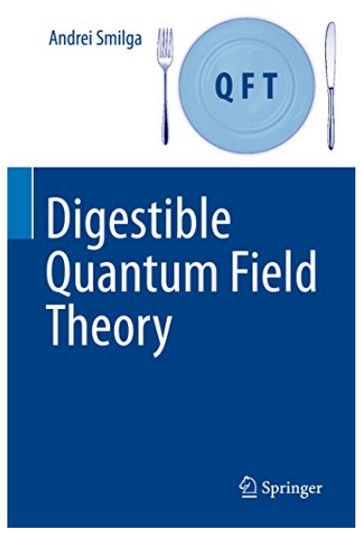
General observations

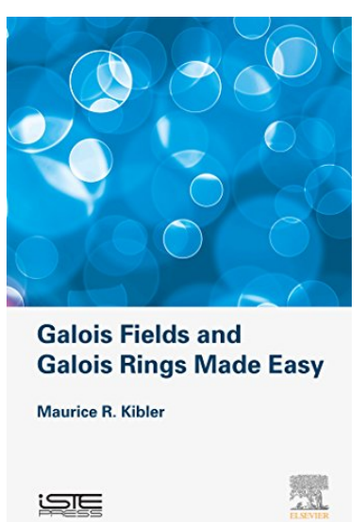
- Regular and high-quality scientific production
  - Close to 400 articles over the past 5 years
  - High-impact peer-reviewed journals

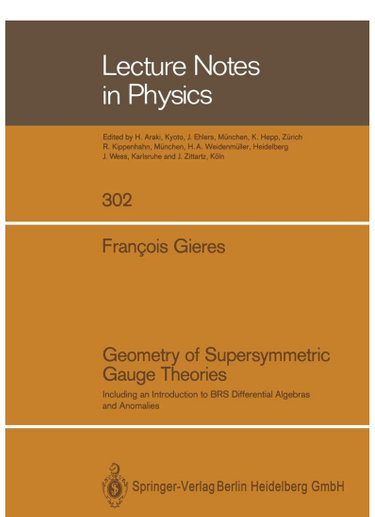


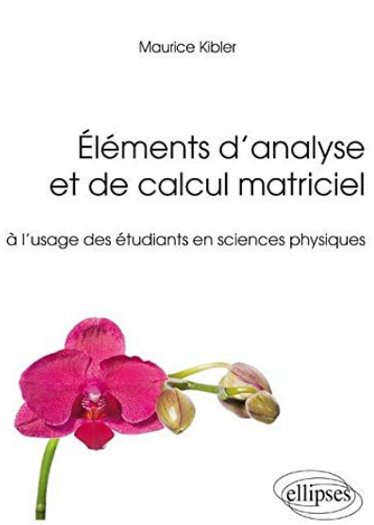












General observations

- Extensive network of (inter)national collaborations
  - Well over 100 institutes in 5 continents
  - Over a dozen French universities and grandes écoles
  - Organization of international schools and conferences
- Great thematic diversity
- Numerous PhD students and interns, some postdocs
- Funds include: Horizon, COST, PICS, various Labex , 1 ERC, 1 Masterprojet IN2P3

General observations

- Numerous interactions with applied fields
  - Astrophysics & cosmology *astro-ph.CO*
  - Particle phenomenology *hep-ph*
  - Hadronic physics *hep-ph*
  - Nuclear physics *nucl-th, nucl-ex*
  - Medical applications & biology *physics.bio-ph, q-bio.PE*
  - Condensed matter *cond-mat.stat-mech, cond-mat.str-el*

Thank you for your attention