Challenges for TGFT

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Why Tensorial Group Field Theory (TGFT)?

- Motivation: Quantum Gravity

  - "T": tensors generate abstract simplicial pseudo manifolds → random geometry
  - "G": lattice Gauge theory for General relativity (Spin foams, LQG…)
  - "FT": propagating field d.o.f., ''momentum'' scale

- central goal: limit/emergence of continuum spacetime, "geometrogenesis"

  - limit to continuum geometry at criticality (like continuum random geometry)
  - phase transition to 4D semiclassical gravity on critical surface

Characterization of a TGFT

- $\phi_{d,r}^{n}$ theory specified by

  - domain G of dimension d

  - rank-r tensorial invariance (complex $\mathrm{U}(N)$, real $\mathrm{O}(N)$,...)

  - subclass of tensorial interactions up to order n

  - propagation $p^{2\zeta}$

- topological (TQFT) structure: gauge constraint (BF theory) $\rightarrow$ gauge field d.o.f.

- geometric (spin foam) structure: Plebanski constraints: BC, EPRL,... $\rightarrow$ gravitational d.o.f.

What we know

- TGFT "behaves like $d_r = d(r-2)$ dim. local field theory + topological effects"

  - renomalizability for $d_r \leq \frac{2\zeta n}{n-2}$ (multi-scale analysis, parametric, Hopf algebra,...)
  - perturbative RG flows: asymptotic freedom due to melonic dominance
  - non-perturbative: Polchinski eq., Dyson-Schwinger eq., Ward identities,...
  - FRG equations: non-autonomous in $N_k = ak$, symmetry restoration for fixed a
  - at large N_k: Wilson-Fisher type NGFP, asymptotic safety (hints)

- Phenomenology

  - (T)GFT: Tentative interpretation of phases with non-vanishing VEV via condensate states + mean field dynamics $\rightarrow$ condensate cosmology / black holes

Challenges for TGFT

- further classification of models (renormalizability, phase space, NGFPs,...)

  - systematic understanding of non-melonic theories (necklace, $O(N)$-invariance,...)
  - Lorentzian (noncompact) domain, Plebanski constraints (TGFT or coloured simplicial?)
  - ... can field theory push tensors beyond tree/planar universality???

- conceptual questions

  - relation between criticality, continuum limit and phase transitions
  - SSB of global symmetries (associated with IR FPs of RG flow), Goldstone modes
  - observables (trace vs. full correlations), vacua, order parameters, mean field studies