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On the renormalization of random network models

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Stellingen

Behorende bij het proefschrift

On the Renormalization of Random Network Models

1. The understanding of renormalization for complex networks as a scaling operation akin to a magnifying lens can be complemented with the perspective of the same network being unobservable in some of its constituents. Which information is lost under this operation is often neglected, but can actually help the inference over the unattainable parts.

[Chapter 4]

2. Self-averaging of network models, and hence the assumption that a single network is representative of the whole probabilistic ensemble it was generated from, is not always true and therefore should not be taken for granted during network inference.

[Chapter 3]

3. There exists only one class of interactions between edges in a network that is closed under the flow of renormalization, namely the coupling structure with maximum coordination number equal to 2.

[Chapter 5]

4. Second order random network models can be solved in general and their partition functions computed.

[Chapter 6]

5. Embedding the nodes of a network model with independent edges in a latent, geometrical space is not a necessary condition for the emergence of a non-trivial local clustering coefficient.

[Chapter 3, Aliakbarisani, Boguñá, Serrano, Phys. Rev. Lett. 135, 197402, (2025)]

6. Log-periodicity in the eigenmodes of an adjacency matrix is a distinctive feature of discrete

scale-invariance, and can be found in the structure of eigenmodes of a self-similar network model.

[Chapter 2, Sornette Phys. Rep. 297, 239–270, (1998)]

7. There are graph models reproducing real network properties that defy the low-rank hypothesis of complex systems by having an infinite, although sublinear, rank and a spectral bulk edge growing with the same scaling of the signal.

[Chapter 2; Thibeault, Allard, Desrosiers, Nat. Phys. 20, 294—302, (2024)]

8. Irreducible higher-order correlations naturally emerge from renormalization over unobservable sections of an interacting system. One can mathematically deal with them in the paradigm of effective field theories, but to justify their claimed irreducible nature solid empirical evidence of mechanisms beyond pairwise coupling should be put forward.

[Chapter 4; Battiston et al., Nat. Phys. 17, 1093–1098 (2021); Peixoto et al., arXiv:2602.16937 (2026)]

9. “Anarchism, while perhaps [...] the most attractive political philosophy, is certainly excellent medicine for epistemology, and for the philosophy of science.” However, Feyerabend’s argument should not allow complex-systems scientists to abandon self-questioning regarding their own research’s epistemological foundations.

[Feyerabend, Paul, ‘Against Method: Outline of an Anarchistic Theory of Knowledge’, London 1975]

10. The European Research Council and public research institutes in general should firmly uphold the ban on dual civilian-military use in research programmes.

Alessio Catanzaro

Leiden, 10 september 2026