Graph Rewriting Systems and DGGs

What are they and how are they related?

Graph Rewriting Systems:

- A graph rewriting system is a formalism for transforming graphs by applying rules that modify their structure.

- The theory of graph grammars[1] provides a category theoretic framework for how dynamic graphs become rewriting systems.

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1. (Rozen et al, 1997); 2. (Mjolsness, 2019)

Dynamical Graph Grammars:

- Dynamical Graph Grammars[2] (DGGs) are graph rewriting systems with a stochastic rewriting process, plus differential equations.

- DGGs map graphs to a master equation resulting from an operator algebra framework.

- DGGs provide a way to declare a set of **deterministic** and **stochastic** rules to model complex dynamics systems with graphs.

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The Dynamical Graph Grammar Formalism

What are DGGs anyway?

- The DGG formalism is a declarative modeling language L:
  1. A compositional map $\Psi : L \longrightarrow S$ that maps all syntactically valid models $M \in L$ into some space S of dynamical systems.
  2. Conditionally valid or conditionally approximate valid families of Abstract Syntax Tree Transformations.

- Rules map to operators where $\Psi(M) = W(M)$
- The master equation, $\frac{d}{dt}P(t) = W \cdot P(t)$, represents the time evolution of a continuous-time Markov process with formal solution is $P(t) = e^{tW} \cdot P(0)$.
- Hard to solve analytically! So, we need help!

More information can found in (Mjolsness 2022, 2019, 2013, 2010)