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Causal evolution of probability measures

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The causal structure of a spacetime $\mathcal{M}$ is usually described in terms of a binary relation $\preceq$ between events called the casual precedence relation (often referred to as J^+). In my talk I will present a natural extension of $\preceq$ onto the space $P(\mathcal{M})$ of (Borel) probability measures on $\mathcal{M}$, designed to rigorously encapsulate the common intuition that probability can only flow along future-directed causal curves.

Using the tools of the optimal transport theory adapted to the Lorentzian setting, one can utilize thus obtained notion of 'causality between measures' to model a causal time-evolution of a spatially distributed physical entity in a globally hyperbolic spacetime. I will define what it means that a time-dependent probability measure $\mu_t \in P(\mathcal{M})$ evolves causally. I will discuss how such an evolution can be understood as a 'probability measure on the space of worldlines'. I will also briefly present some preliminary results concerning the relationship between the causal time-evolution of measures and the continuity equation.

Primary author: MILLER, Tomasz (Warsaw University of Technology)

Presenter: MILLER, Tomasz (Warsaw University of Technology)

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