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On divisibility and quantum Markovianity for non-invertible dynamical maps

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We analyze the relation between CP-divisibility and the lack of information back flow for an arbitrary not necessarily invertible dynamical map [1,2,3]. It is well known that CP-divisibility always implies lack of information back flow. Moreover, these two notions are equivalent for invertible maps. We show that for a map which is not invertible the lack of information back flow always implies the existence of completely positive (CP) propagator which, however, needs not be trace-preserving. Interestingly, for a class of image non-increasing dynamical maps [majority of examples studied in the literature do belong to this class] this propagator becomes trace-preserving as well and hence the lack of information back flow implies CP-divisibility. This result sheds new light into the structure of the time-local generators giving rise to CP-divisible evolutions. It is shown that if the map is not invertible then positivity of dissipation/decoherence rates is no longer necessary for CP-divisibility.
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Autore principale: Prof. CHRU´SCI´NSKI, Dariusz (Nicolaus Copernicus University Torun)

Relatore: Prof. CHRU´SCI´NSKI, Dariusz (Nicolaus Copernicus University Torun)