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Reversible time travel with freedom of choice

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General relativity allows for the existence of closed time-like curves, along which a material object could travel back in time and interact with its past self. Previous studies by Thorne and others showed that for any choice of initial conditions, consistent dynamics —even in the presence of closed time-like curves — exist. Moreover and counterintuitively, they showed that the examples with self-interaction lead to an infinite number of consistent dynamics. While in these previous studies initial conditions only where subject to the experimenter's choice, we allow for arbitrary operations to be performed in local space-time regions. We find that any such dynamics can be realised through reversible interactions. We further find that consistency with local operations is compatible with non-trivial time travel: Three parties can interact in such a way to be all both in the future and in the past of each other, while being free to perform arbitrary local operations. Finally, the states described in our framework are uniquely determined.

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