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**Equivalence between Strict Viscosity Solution and Viscosity Solution
in the Wasserstein Space and Regular Extension of the Hamiltonian
in $L^2_{\mathbb{P}}$**

This article aims to build bridges between several notions of viscosity solution of first order dynamic Hamilton-Jacobi equations. The first main result states that, under assumptions, the definitions of Gangbo-Nguyen-Tudorascu and Marigonda-Quincampoix are equivalent. Secondly, to make the link with Lions' definition of solution, we build a regular extension of the Hamiltonian in $L^2_{\mathbb{P}} \times L^2_{\mathbb{P}}$. This extension allows to give an existence result of viscosity solution in the sense of Gangbo-Nguyen-Tudorascu, as a corollary of the existence result in $L^2_{\mathbb{P}} \times L^2_{\mathbb{P}}$. We also give a comparison principle for rearrangement invariant solutions of the extended equation. Finally we illustrate the interest of the extended equation by an example in Multi-Agent Control.

Keywords: Optimal transport, viscosity solutions, Hamilton-Jacobi equations, multi-agent optimal control.

MSC: 49L25.