ON THE MONGE–AMPÈRE EQUATION IN INFINITE DIMENSIONS

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Abstract. We prove that the optimal transportation mapping that takes a Gaussian measure γ on an infinite dimensional space to an equivalent probability measure $g\cdot\gamma$ satisfies the Monge–Ampère equation provided that $\log g\in L^1(\gamma)$ and $g\log g\in L^1(\gamma)$.

1. Introduction and Main Result

The Monge–Kantorovich problem and the Monge–Ampère equation have become a very popular object of research in the last decade (see [1], [15], [20], where one can find additional references). In the finite dimensional case, considerable progress has been achieved by Brenier [5] and McCann [13], whose works stimulated a growing flow of publications. Among important earlier contributions one should mention Sudakov's research [16]. In this paper we are interested in the infinite dimensional situation and extend several recent results from [9], [10], [11]. Our principal contribution is a derivation of the Monge–Ampère equation for transformations of Gaussian measures on infinite dimensional spaces. We shall use the following important existence result from [9]. Let X be a locally convex space and let γ be a centered Radon Gaussian measure on X with the Cameron–Martin space H. The natural inner product in H is denoted by $\langle\cdot\,,\cdot\rangle_H$; the corresponding norm is $|\cdot|_H$. One may assume without loss of generality that $X=\mathbb{R}^\infty$, the countable power of the real line, and that γ is the countable power of the standard Gaussian measure; then $H=l^2$. Suppose that we are given a probability measure $g\cdot\gamma$ such that

$$W_H(\gamma,g\cdot\gamma)^2=\inf_{m\in\mathcal{P}(\gamma,g\cdot\gamma)}\int_{X\times X}|x_1-x_2|_H^2\,dm(x_1,x_2)<\infty,$$

where $\mathcal{P}(\gamma,g\cdot\gamma)$ is the set of all Radon probability measures on $X\times X$ whose projections on the first and second factors are γ and $g\cdot\gamma$. Then there exists a unique Borel mapping $T\colon X\to X$ sending γ to $g\cdot\gamma$ such that $W_H(\gamma,g\cdot\gamma)^2=\int_X|T(x)-x|_H^2\,d\gamma$. This mapping is called the optimal transportation plan or the optimal transportation mapping. An effective sufficient condition for $W_H(\gamma,g\cdot\gamma)$ to be finite is the finiteness of entropy

$$\mathrm{Ent}_\gamma g:=\int_X g\log g\,d\gamma<\infty.$$

This is a consequence of the Talagrand inequality ([18], see also [12] for other inequalities of this type). This transportation plan has the form $T=I+\nabla\Phi$, where Φ belongs to the Sobolev class $W^{2,1}(\gamma)$ and is 1-convex (see the definition below). If $g>0$ γ-a.e. and $\log g\in L^1(\gamma)$, then there exists a mapping S such that T and S are reciprocal, i.e., one has

$$T\circ S(x)=S\circ T(x)=x\quad\text{for }\gamma\text{-a.e. }x.$$

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