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# On the existence of a global diffeomorphism between Fréchet spaces

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We provide sufficient conditions for the existence of a global diffeomorphism between tame Fréchet spaces. We prove a version of Mountain Pass theorem which plays a key ingredient in the proof of the main theorem. We apply differentiability in the sense of Micheal and Bastiani.

**Theorem 1** (The Mountain Pass Theorem). *Let  $F$  be a Fréchet space and  $\phi : F \rightarrow \mathbb{R}$  a  $C^1$ -functional satisfying the Palais-Smale condition. Assume  $f \in F$  satisfies  $\inf_{n \in \mathbb{N}} \|f\|^n > r > 0$  for a real number  $r$  and the geometric condition  $\inf_{p \in S(0,r)} I(p) > \max\{\gamma(0), \gamma(f)\} = a$ , where  $S(0,r)$  is a sphere of the radius  $r$ . Then  $\phi$  has a critical value  $c \geq a$  which can be characterized as*

$$c = \inf_{\gamma \in \Gamma} \max_{t \in [0,1]} \phi(\gamma(t)).$$

Where  $\Gamma = \{\gamma \in C([0,1]; F) : \gamma(0) = 0, \gamma(1) = f \in F\}$ .

Let  $E$  and  $F$  be tame Fréchet spaces and  $\tau : E \rightarrow F$  a smooth tame map. Assume that a  $C^1$ -functional  $\iota(x)$  is such that it and its derivative  $\iota'(y)$  are zero if and only if  $x$  and  $y$  are zero. In addition, we suppose that the derivative  $\tau'(e)f = k$  has a unique solution  $f = \nu(e)k$  for all  $e \in E$  and all  $k$ , and the family of inverses  $\nu : E \times F \rightarrow E$  is a smooth tame map.

**Theorem 2.** *Assume that a smooth tame map  $\tau : E \rightarrow F$  and a  $C^1$ -functional  $\iota$  on  $F$  are as above. If the following conditions hold*

**C1:** *for any  $f \in F$  the functional  $j : E \rightarrow \mathbb{R}$  given by*

$$j(e) = \iota(\tau(e) - f)$$

*satisfies the Palais-Smale condition;*

**C2:** *there exist positive real numbers  $a, b$  and  $c$  such that for  $f$  in the disk  $D(0, a)$*

$$\iota(f) \geq c\alpha^b \text{ where } \alpha = \sup_{n \in \mathbb{N}} \|f\|^n. \tag{1}$$

*Then  $\tau$  is a diffeomorphism.*

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