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Correction to: Equilibrium of Surfaces in a Vertical Force Field

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In the previous paper [2, Section 3.2], we describe the family of $titled\ [\varphi,\vec{e}_3]$ -catenary cylinders as surfaces obtained from a $[\varphi,\vec{e}_3]$ -catenary cylinder Σ , by rotation of angle $\theta \in]0,\pi/2[$ about the x-axis and dilation by scale factor $1/\cos\theta$. The authors state that the resulting surface, $\widetilde{\Sigma}$, is always a $[\varphi,\vec{e}_3]$ -minimal surface, but this is only true when the starting $[\varphi,\vec{e}_3]$ -catenary cylinder is a grim reaper translating soliton, which follows directly from the relationship between their mean curvatures. In fact, following the same notation as in [2, Section 3.2], $\widetilde{H} = \cos\theta\,H$, and $\widetilde{\Sigma}$ will be a $[\varphi,\vec{e}_3]$ -minimal surface if and only if

$$\dot{\varphi}(u) = \dot{\varphi}(u + y \sin \theta)$$
 for any $y \in \mathbb{R}$,

that is, if and only if Σ is a grim reaper translating soliton. In this case, $\widetilde{\psi}$ will be a *tilted grim reaper cylinder*.

The following result updates the classification of complete flat $[\varphi, \vec{e}_3]$ -minimal surfaces in \mathbb{R}^3 [2, Theorem 3.7]:

Theorem 1. Let $\varphi : \mathbb{R} \to \mathbb{R}$ be a diffeomorphism and Σ be a complete flat $[\varphi, \vec{e}_3]$ -minimal surface in \mathbb{R}^3 . Then, one of the following statements holds

- Σ is a vertical plane.
- Σ is a grim reaper cylinder (maybe tilted).
- Σ is a $[\varphi, \vec{e}_3]$ -catenary cylinder.

Proof. From basic differential geometry, $\Sigma = \gamma \times \Pi^{\perp}$ is a ruled surface and its Gauss map is constant along the rules, where γ is a complete regular curve in a plane $\Pi \subset \mathbb{R}^3$. Thus, Σ can be parametrized by $\psi(s,t) = \gamma(s) + t\vec{v}$, with $\gamma(s)$ a complete regular curve contained in a plane Π and \vec{v} a unit vector

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orthogonal to Π . We may assume that $(s,t) \in \mathbb{R}^2$ and $|\gamma'| = 1$, then, the Gauss map N of ψ and its mean curvature H are given by

$$N(s,t) = \gamma'(s) \wedge \vec{v}, \quad H(s,t) = \kappa_{\gamma}(s),$$

where κ_{γ} is the curvature of γ . Hence, Σ is $[\varphi, \vec{e}_3]$ -minimal if and only if the following relation holds

$$\kappa_{\gamma}(s) = -\dot{\varphi}(\langle \gamma(s) + t\vec{v}, \vec{e}_3 \rangle) \langle \gamma'(s) \wedge \vec{v}, \vec{e}_3 \rangle.$$

Differentiating with respect to t in the above expression, we obtain that

$$0 = \ddot{\varphi}(\langle \gamma(s) + t\vec{v}, \vec{e}_3 \rangle) \langle \vec{v}, \vec{e}_3 \rangle \langle \gamma'(s) \wedge \vec{v}, \vec{e}_3 \rangle.$$

If $\langle \vec{v}, \vec{e}_3 \rangle = 0$, arguing as in [2, Theorem 3.7], for any horizontal rule \mathcal{L} of Σ there exists a $[\varphi, \vec{e}_3]$ -catenary cylinder \mathcal{C} containing \mathcal{L} and tangent to Σ along \mathcal{L} . Thus, from standard theory of uniqueness of solution for an ODE, up to horizontal translation, Σ must coincide with \mathcal{C} . If $\langle \vec{v}, \vec{e}_3 \rangle \neq 0$,

$$0 = \ddot{\varphi}(\langle \gamma(s) + t\vec{v}, \vec{e}_3 \rangle) \langle \gamma'(s) \wedge \vec{v}, \vec{e}_3 \rangle$$

and we can assume that $\ddot{\varphi}$ does not vanish everywhere otherwise, from [1], φ is a linear function and Σ is either a vertical plane or a grim reaper cylinder (maybe tilted). Thus, we have that $\gamma' \wedge \vec{v}$ is orthogonal to \vec{e}_3 and Σ must be a vertical plane.

Now, the Corollary 3.8 in [2] updates to

Corollary 2. Let $\varphi : \mathbb{R} \to \mathbb{R}$ be a increasing diffeomorphism with $\dddot{\varphi} \leq 0$ and Σ be a complete locally convex $[\varphi, \vec{e}_3]$ -minimal surface in \mathbb{R}^3 . If the Gauss curvature vanishes anywhere, then one of the following statements holds

- Σ is a vertical plane.
- Σ is a grim reaper cylinder (maybe tilted).
- Σ is a $[\varphi, \vec{e}_3]$ -catenary cylinder.

Remark 3. Although it does not affect any of the results shown throughout the paper, the Eqs. (6) and (7) in [2, Lemma 2.1] must be change to

$$\nabla^2 H = -\eta \nabla^2 \dot{\varphi} - (\nabla \mathcal{A})(\nabla \varphi, \cdot, \cdot) - H \mathcal{A}^{[2]} - \mathcal{B}$$
 (6)

$$\Delta \mathcal{A} + (\nabla \mathcal{A})(\nabla \varphi, \cdot, \cdot) + \eta \nabla^2 \dot{\varphi} + |\mathcal{A}|^2 \mathcal{A} + \mathcal{B} = 0, \tag{7}$$

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