SUPRA ğ HOMEOMORPHISM IN TOPOLOGICAL SPACES

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Abstract: In this paper, introduced the concept of contra supra $\breve{g}$-continuous functions and contra supra $\breve{g}$-irresolute, slightly supra $\breve{g}$ continuous and obtained the basic properties of supra $\breve{g}$--Homeomorphism and supra $\breve{g}$^*- Homeomorphism. Also related the function with some other functions in supra topological spaces.

Keywords: contra supra $\breve{g}$-continuous functions, contra supra $\breve{g}$-irresolute, supra $\breve{g}$-Homeomorphism and supra $\breve{g}$^*-Homeomorphism, slightly supra $\breve{g}$ continuous functions.

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1. Introduction: In 1983, A.S Mashhour et all,[4] introduced the supra topological spaces and studied S - continuous functions and S^* -continuous functions. In 1996, Dontchev [3] introduced the notion of contra continuous functions. In 2007, Caldas, Jafari, [2] introduced a new class of functions called contra-β continuous functions. In 2013, L.Vidyarani and M.Vigneshwaran[8] introduced and discussed about contra supra N-continuous functions.

I introduced the concept of contra supra $\breve{g}$-continuous functions and contra supra $\breve{g}$-irresolute and obtain the basic properties of supra $\breve{g}$- Homeomorphism and supra $\breve{g}^*$- Homeomorphism. Also related the function with supra slightly $\breve{g}$-continuous functions in supra topological spaces.

2. Preliminaries: Throughout this paper, $(X,\tau),(Y,\sigma),(Z,\eta)$ or X,Y,Z represent non - empty topological spaces on which no separations axioms are assumed unless otherwise mentioned. For a subset A of a spaces (X,τ), $cl(A)$, and $int(A)$ denoted closure and interior of A respectively.

Definition: 2.1 A subfamily μ of X is said to be supra topology on X, if
(i) X,$\phi \in \mu$
(ii) if $A_i \in \mu$ for all $i \in J$, then $\cup \quad A_i \in \mu$. The pair (X,μ) is called supra topological spaces.

The element of μ are called supra open sets in (X,μ) and the complement of supra open sets is called supra closed sets and it is denoted by μ^c.
Definition: 2.2 The supra closure of a set A is denoted by supra $cl(A)$ and defined as supra $cl(A) \subset \cap \quad \{B: B$ is a supra closed and $A \subseteq B\}$. The supra interior of a set is denoted by supra int(A), and defined as supra int(A),and defined as supra int (A) = $\cup$ {B: B is supra open and $A \supseteq$ B

Definition: 2.3 Let (X,τ) be a topological space and μ be a supra topology on X. We call μ a supra topology associated with τ, if $\tau \subseteq \mu$

Definition: 2.4 A subset A of a space X is called
(i) supra semi open set [4], if $A \subseteq cl^{\mu}[int^{\mu}(A)]$
(ii) supra α -open set [3], if A $\subseteq cl^{\mu}[cl^{\mu}(int^{\mu}(A))$
(iii) supra regular closed [], if $A = cl^{\mu}(int^{\mu}(A))$
(iv) supra g -closed [5], if $cl^{\mu}(A) \subseteq U$ whenever $A \subseteq U$ and U is supra open in X
(v) supra b -open [7], if $A \subseteq cl^{\mu}[int^{\mu}(A)]U(int^{\mu}(A))cl^{mu}(A)$

2. Contra Supra $\breve{g}$ Continuous Functions:

Definition: 2.1 Let (X,τ) and (X,σ) be two topological spaces and μ be an associated supra topology with τ. A function $f:(X,\tau)\to(Y,\sigma)$ is called contra supra $\breve{g}$ continuous function if $f^{-1}(O)$ is $\breve{g}$ closed in (X,τ) for every supra open set O in (Y,σ)

Examples: 2.2 Let X = Y = $\{a,b,c\},\tau=\{\phi,\{b\},X\}$ and $\sigma=\{\phi,\{a,c\},X\}$ we have, $\breve{g}(C(X))=\{\phi,\{a,c\},X\}$. Let $f:(X,\tau)\to(Y,\sigma)$ be the identity map. Then f is called contra supra $\breve{g}$ continuous.

Theorem: 2.3 Every contra supra continuous is contra supra $\breve{g}$ continuous function.

Proof: Let $f:(X,\tau)\to(Y,\sigma)$ be a contra supra continuous function.Let O be an supra open set (Y,σ).Since,f is contra supra continuous. Then, $f^{-1}(O)$ is supra closed in (X,τ).Therefore,f is contra supra $\breve{g}$ continuous.

Converse of the above theorem is need not be true. It is shown by example.

Examples: 2.4: Let X = Y = $\{a,b,c\},\tau=\{\phi,\{a,b\},X\}$ and $\sigma=\{\phi,\{a,\},Y\}$ we have, $\breve{G}(C(X))=\{\phi,\{c\},\{a,c\},\{b,c\},X\}$. Let $f:(X,\tau)\to(Y,\sigma)$ be the identity map. Since $f^{-1}\{b,c,\}=\{b,c\}$ is contra supra $\breve{g}$ continuous but not contra supra continuous. In this section, I introduce a new type of continuous functions called supra $\breve{g}$ - continuous function and obtain some of their properties and characterizations.

Theorem: 2.5 Every contra continuous map is contra supra $\breve{g}$ - continuous

Proof: Let (X,τ) and (Y,σ) be two supra topological spaces. Let $f:(X,\tau)\to(Y,\sigma)$ be contra continuous map and A is open in Y. then $f^{-1}(A)$ is an closed set in X. since μ is associated with τ, then $\tau\subset\mu$. Therefore, $f^{-1}(A)$ is supra closed set in X. Since every supra closed set is $\breve{g}^{\mu}$ - closed set Hence f is supra $\breve{g}$ continuous.

The converse of the above theorem is not true.

Theorem: 2.6 Let (X,τ) and (Y,σ) be two topological spaces and μ be an associated supra topology with τ. Let f be a map from X into Y, then the following are equivalent:

(i) f is a contra supra $\breve{g}$ - continuous map.

(ii) The inverse image of a supra closed set in Y is a supra $\breve{g}$- open set in X.

(iii) The inverse image of a supra open set in Y is a supra $\breve{g}$- closed set in X.

Proof: (i) ⇒(ii). Let A be a supra closed set in Y.Then Y - A is supra open set in Y then $f^{-1}(Y-A)=X-f^{-1}(A)$ is a supra $\breve{g}$ - closed set in X. It follows that $f^{-1}(A)$ is a supra $\breve{g}$-open subset of X

$(ii)\Rightarrow(iii)$

Let A be a supra open set in Y.Then Y - A is supra closed set in Y then $f^{-1}(Y-A)=X-f^{-1}(A)$ is a supra $\breve{g}$ - open set in X. It follows that $f^{-1}(A)$ is a supra $\breve{g}$-closed subset of X

$(iii)\Rightarrow(i)$ It obviously true.

Theorem:2.7 Let $(X,\tau),(Y,\sigma)$ and (Z,v) be three topological spaces, If a map $f:(X,\tau)\to(Y,\sigma)$ is contra supra $\breve{g}$ - continuous and $g:(Y,\sigma)\to(Z,v)$ is a contra continuous map,then $g\circ f:(X,\tau)\to(z,v)$ is conta supra $\breve{g}$ - continuous.

Proof: Let F be any supra closed set in (Z,v).Since $g:(Y,\sigma)\to(Z,v)$ is contra continuous.$g^{-1}(F)$ is supra open in (Y,σ).Since $f:(X,\tau)\to(Y,\sigma)$ is contra supra $\breve{g}$ - continuous. $f^{-1}[g^{-1}(F)]=(g\circ f)^{-1}(F)$ is $\breve{g}$ - supra closed in (X,τ) and so $g\circ f$ is contra supra $\breve{g}$ - continuous.

3. Supra $\breve{g}$ - Homeomorphism And Supra $\breve{g}*$ - Homeomorphism:

Definition: 3.1 A bijection $f:(X,\tau)\to(Y,\sigma)$ is called supra $\breve{g}$ - Homeomorphism if f is both supra $\breve{g}$-continuous function and supra - open map

Definition: 3.2 A bijection $f:(X,\tau)\to(Y,\sigma)$ is called supra $\breve{g}*$- Homeomorphism if f and f^{-1} are supra $\breve{g}$-irresolute.

we denoted the family of all supra $\breve{g}$- Homeomorphism (resp.supra $\breve{g}*$- homeomorphism) of a supra topological space (X,τ) onto itself by $S\breve{g}-h(X,\tau)$ (resp.$S\breve{g}^{*}-h(X,\tau)$).

Theorem : 3.3 Let $f:(X,\tau)\rightarrow(Y,\sigma)$ be a bijective supra $\breve{g}$ - continuous map. then, the following are equivalent.
(i) f is an $\breve{g}$-open map.
(ii) f is an $\breve{g}$-homeomorphism.
(iii) f is an $\breve{g}$-closed map.
Proof: (i) (ii) : if f is a bijective supra $\breve{g}$ -continuous map, suppose (i) holds. Let V be a supra closed in (X,τ), then V^c is a supra open in (X,τ). Since f is a $\breve{g}$ - open map, $f(V^c)$ is a supra $\breve{g}$-open in (Y,σ). Hence, f(V) is supra $\breve{g}$-closed in (Y,σ) implies f^{-1} is supra $\breve{g}$ -continuous. Therefore, f is a supra $\breve{g}$ -homeomorphism.

(ii) (iii): Suppose f is a supra $\breve{g}$ -homeomorphism and f is a bijective supra $\breve{g}$ -continuous function, then from the definition 3.1, f^{-1} is a supra $\breve{g}$ -continuous, implies f is a supra $\breve{g}$ -closed map

(iii) (i) Suppose f is a supra $\breve{g}$ - closed map, Let V be a supra open in (X,τ), then, V^c is a supra closed in (X,τ). since f is a supra $\breve{g}$ -closed map, $f(V^c)$ is a supra $\breve{g}$ - closed in (Y,σ). Hence f(V) is a supra $\breve{g}$ - open in (Y,σ). Therefore f is a supra $\breve{g}$ -open map.

Remark: 3.4 The composition of two supra $\breve{g}$ -homeomorphism need not be a supra $\breve{g}$ -homeomorphism.

Example: 3.5 Let X = Y = Z = $\{a,b,c\}$ with $\tau=\{\phi,\{a\},\{b\},\{a,b\},X\}$, $\sigma=\{\phi,\{a,b\},Y\}$ and $\eta=\{\phi,\{a\},\{a,b\},Z\}$. Let $f:(X,\tau)\rightarrow(Y,\sigma)$ and $g:(Y,\sigma)\rightarrow(Z,\eta)$ be identity maps, Then f and g are supra $\breve{g}$ -homeomorphism but their g o f : $(X,\tau)\rightarrow(Z,\eta)$ is not supra $\breve{g}$ -homeomorphism.

Theorem: 3.6 Every supra $\breve{g}$ -homeomorphism is supra $\breve{g}$ -continuous.
Proof : It is obviously true from the definition 3.1.
The converse of the theorem need not be true.

Theorem: 3.7 Every supra $\breve{g}^*$ -homeomorphism is supra $\breve{g}$-irresolute.
Proof : It is obviously from the definition. 3.2,
The converse of the theorem need not be true.

Theorem: 3.8 If $f:(X,\tau)\rightarrow(Y,\sigma)$ and $g:(Y,\sigma)\rightarrow(Z,\eta)$ are supra $\breve{g}^*$ -homeomorphism, then the composition g o f is also a supra $\breve{g}^*$ -homeomorphism.
Proof : Let V be a supra $\breve{g}$ -closed set in (Z,η). Since g is a supra $\breve{g}^*$ -homeomorphism g and g^{-1} are supra $\breve{g}$- irresolute, then $g^{-1}(V)$ is a supra $\breve{g}$-closed set in (Y,σ). Now, $(gof)^{-1}(V)=f^{-1}(g^{-1}(V))$. Since f is a supra $\breve{g}^*$ -homeomorphism f and f^{-1} are supra $\breve{g}$ -irresolute, then $f^{-1}(g^{-1}(V))$ is a supra $\breve{g}$ -closed set in (X,τ). Thus, g o f is a supra $\breve{g}$ -irresolute.

For a supra $\breve{g}$ -closed set V in (X,τ), $(gof)(V)=g(f(V))$. By the hypothesis $f(V)$ is supra $\breve{g}$ -closed set in (Y,σ). Thus, g(f(V)) is supra $\breve{g}$ -closed set in (Z,η). Hence, $(gof)^{-1}$ is supra $\breve{g}$ -irresolute. Therefore, g o f is supra $\breve{g}^*$ - homeomorphism.

Theorem: 3.9 If $f:(X,\tau)\rightarrow(Y,\sigma)$ is a supra $\breve{g}^*$ -homeomorphism, then $\breve{g}-cl(f^{-1}(B))=f^{-1}(\breve{g}-cl(B))$, for every $B\subset Y$ is a supra $\breve{g}$ -closed.
Proof: Since f is a supra $\breve{g}^*$ -homeomorphism, f and f^{-1} are supra $\breve{g}$ irresolute. Let B be a supra $\breve{g}$ -closed set in (Y,σ). Since f is a supra $\breve{g}$- irresolute $f^{-1}(B)$ is supra $\breve{g}$ -closed set in (X,τ). Since, B is a supra $\breve{g}$ -closed set $B=(\breve{g}-cl(B)$. Therefore, $f^{-1}(\breve{g}-cl(B))$ is supra $\breve{g}$ -closed set in (X,τ). Since $f^{-1}(B)$ is a supra $\breve{g}$ -closed set, $\breve{g}-cl(f^{-1}(B))=f^{-1}(B)$ is a supra $\breve{g}$ - closed set in (X,τ). Therefore, $\breve{g}-cl(f^{-1}(B))=f^{-1}(\breve{g}-cl(B))$ is supra $\breve{g}$ - closed set in (X,τ).

Theorem: 3.10 If $f:(X,\tau)\rightarrow(Y,\sigma)$ is a supra $\breve{g}^*$ - homeomorphism, then $\breve{g}-cl(f(B))=f(\breve{g}-cl(B))$, for every $B\subset X$ is a supra $\breve{g}$ - closed.
Proof: Since f is a supra $\breve{g}^*$ - homeomorphism, f and f^{-1} are supra $\breve{g}$ irresolute. Let B be a supra $\breve{g}$ -closed set in (X,τ). Since f^{-1} is a supra $\breve{g}$ irresolute $f(B)$ is supra $\breve{g}$ - closed set in (Y,σ). Since, B is a supra $\breve{g}$ - closed set $B=(\breve{g}-cl(B)$. Therefore, $f(\breve{g}-cl(B))$ is supra $\breve{g}$ - closed set in (Y,σ). Since $f(B)$

is a supra $\breve{g}$ - closed set, $\breve{g}-cl(f(B))=f(B)$ is a supra $\breve{g}$ - closed set in (Y,σ). Therefore, $\breve{g}-cl(f(B))=f(\breve{g}-cl(B))$ is supra $\breve{g}$ - closed set in (Y,σ).

4. Slightly Supra $\breve{g}$ Continuous Functions:

Definition: 4.1 A function $f:(X,\tau)\to(Y,\sigma)$ is called slightly supra $\breve{g}$ continuous at a point $x\in X$, if for each supra clopen subset V of Y containing $f(x)$, there exist supra $\breve{g}$ open set U in x containing X such that $f(U)\subseteq V$. The function f is said to be slightly supra $\breve{g}$ continuous if f is slightly supra $\breve{g}$ continuous at each of its points.

Definition: 4.2 A function $f:(X,\tau)\to(Y,\sigma)$ is said to be slightly supra $\breve{g}$ continuous, if the inverse image of every supra clopen set in Y is supra $\breve{g}$ open in X.

Proposition: 4.3 For a function $f:(X,\tau)\to(y,\sigma)$, the following statements are equivalent:
Def 4.1 and Def 4.2 are equivalent, if the inverse image of every supra clopen set in Y is supra $\breve{g}$ open in X.

Proof: Suppose (i) holds. Let O be a supra clopen set in Y and $x\in f^{-1}(O)$. Then $f(x)\in O$ and thus there exists a supra $\breve{g}$ - open set U_x such that $x\in U_x\subseteq f^{-1}(O)$ and $f^{-1}(O)=U_X\in f^{-1}(O)U_x$. since, arbitrary union of supra $\breve{g}$ - open set is supra $\breve{g}$ - open, $f^{-1}(O)$ is supra $\breve{g}$ - open in X and therefore f is slightly supra $\breve{g}$ continuous. Suppose (ii) holds. Let $f(x)\in O$, where, O is a supra clopen set in Y. Since f is slightly supra $\breve{g}$ continuous, $x\in f^{-1}(O)$ where $f^{-1}(O)$ is supra $\breve{g}$ open in X. Let $U=f^{-1}(O)$. Then U is supra $\breve{g}$ open in X, $x\in X$ and $F(U)\subseteq O$.

Theorem: 4.4 For a function $f:(X,\tau)\to(y,\sigma)$, the following statements are equivalent.
(i) f is slightly supra $\breve{g}$ continuous.
(ii) The inverse image of every supra clopen set O of Y is supra $\breve{g}$ open in X.
(iii) The inverse image of every supra clopen set O of Y is supra $\breve{g}$ closed in X.
(iv) The inverse image of every supra clopen set O of Y is supra $\breve{g}$ clopen in X.
Proof: (i) (ii) Follows from the above proposition [5.3]
(ii)(iii) Let O be a supra clopen set in Y which implies O^c is supra clopen in Y. By (ii) $f^{-1}(O^c)=(f^{-1}(O))^c$ is supra $\breve{g}$ open in X. Therefore $f^{-1}(O)$ is supra $\breve{g}$ closed in X.
(iii) (iv) By (ii) and (iii) $f^{-1}(O)$ is supra $\breve{g}$ clopen in X.
(iv)(i) Let O be a supra clopen set in Y containing $f(X)$ by (iv) $U=f^{-1}(O)$ is supra $\breve{g}$ clopen in X. Take $U=f^{-1}(O)$, Then $f(U)\subset O$. Hence, f is slightly supra $\breve{g}$ continuous.

Theorem: 4.5 Every slightly supra continuous function is slightly supra $\breve{g}$ continuous.
Proof: Let $f:(X,\tau)\to(y,\sigma)$ be a slightly supra continuous functions. Let O be a supra clopen set in Y. Then $f^{-1}(O)$ is open in X. since, every supra open set is supra $\breve{g}$ - open. Hence f is slightly supra $\breve{g}$ continuous.

Remark: 4.6 The converse of the above theorem need not be true.

Theorem: 4.7 Every supra $\breve{g}$ continuous function is slightly supra $\breve{g}$ continuous.
Proof: Let $f:(X,\tau)\to(y,\sigma)$ be a supra $\breve{g}$ continuous function. Let O be a supra clopen set in Y. Then $f^{-1}(O)$ is supra open in X and supra $\breve{g}$ - closed in X. Hence f is slightly supra $\breve{g}$ continuous.

Remark: 4.8 The converse of the above theorem need not be true.

Theorem: 4.9 Every contra supra $\breve{g}$ continuous is slightly supra $\breve{g}$ continuous.
Proof: Let $f:(X,\tau)\to(y,\sigma)$ be a contra supra $\breve{g}$ continuous function. Let O be a supra clopen set in Y. Then $f^{-1}(O)$ is supra $\breve{g}$ open in X. Hence, f is slightly supra $\breve{g}$ continuous.

Remark: 4.10 The converse of the above theorem need not be true as can be seen from the following.

Theorem: 4.11 Let $f:X\to Y$ and $g:Y\to Z$ be functions. Then the following properties hold.

(i) If f is supra$\breve{g}$ - irresolute and g is slightly supra $\breve{g}$ continuous. Then $(g \circ f)$ is slightly supra $\breve{g}$ continuous.
(ii) If f is supra $\breve{g}$ - irresolute and g is supra $\breve{g}$ continuous then $(g \circ f)$ is slightly supra $\breve{g}$ continuous.
(iii) If f is supra $\breve{g}$ - irresolute and g is slightly supra continuous, then $(g \circ f)$ is slightly supra $\breve{g}$ continuous.
(iv) If f is supra $\breve{g}$ continuous and g is slightly supra continuous, then $(g \circ f)$ is slightly supra $\breve{g}$ continuous.

Proof:
(i) Let O be a supra clopen set in Z, since, g is slightly supra $\breve{g}$ continuous, $g^{-1}(O)$ is supra $\breve{g}$ open in Y. since , f is supra $\breve{g}$ irresolute, $f^{-1}(g^{-1})))$ is supra $\breve{g}$ open in X. since $(g \circ f)^{-1}(O) = f^{-1}(g^{-1}(O))$. $g \circ f$ is slightly supra $\breve{g}$ continuous.
(ii) Let O be a supra clopen set in Z, since g is supra $\breve{g}$ continuous , $g^{-1}(O)$ is supra open in Y, since f is supra $\breve{g}$ irresolute, $f^{-1}(g^{-1}(O))$ is supra $\breve{g}$ open in X. Hence $g \circ f$ is slightly supra $\breve{g}$ continuous.
(iii) Let O be a supra clopen set in Z. since g is slightly supra continuous, $g^{-1}(O)$ is supra open in Y. since f is supra $\breve{g}$ - irresolute, $f^{-1}(g^{-1}(O))$ is supra $\breve{g}$ open in X. Hence $g \circ f$ is slightly supra $\breve{g}$ continuous.
(iv) Let O be a supra clopen set in Z. since g is slightly supra continuous, $g^{-1}(O)$ is supra open in Y. since f is supra $\breve{g}$ continuous, $f^{-1}(g^{-1}(O))$ is supra $\breve{g}$ open in X. Hence $g \circ f$ is slightly supra $\breve{g}$ continuous.

Theorem: 4.12 Let $f: X \to Y$ and $g: Y \to Z$ be functions. Then the following properties hold.
(i) If f is slightly supra $\breve{g}$ continuous and g is perfectly supra $\breve{g}$ continuous, Then $(g \circ f)$ is supra $\breve{g}$ - irresolute.
(ii) If f is slightly supra $\breve{g}$ continuous and g is contra supra continuous then $(g \circ f)$ is slightly supra $\breve{g}$ continuous.
(iii) If f is supra $\breve{g}$ - irresolute and g is contra supra $\breve{g}$-continuous. Then $(g \circ f)$ is slightly supra $\breve{g}$ continuous.

Proof:
(i) Let O be a supra $\breve{g}$ - open in Z. since g is perfectly supra $\breve{g}$ continuous, $g^{-1}(O)$ is supra open and supra closed in Y. since f is slightly supra $\breve{g}$ continuous, $f^{-1}(g^{-1}(O))$ is supra $\breve{g}$ - open in X. Hence $g \circ f$ is supra $\breve{g}$ - irresolute.
(ii) Let O be a supra clopen in Z. since g is contra supra continuous, $g^{-1}(O)$ is supra open and supra closed in Y. since f is slightly supra $\breve{g}$ continuous, $f^{-1}(g^{-1}(O))$ is supra $\breve{g}$ - open in X. Hence $g \circ f$ is slightly supra $\breve{g}$ continuous.
(iii) Let O be a supra clopen in Z. since g is supra contra $\breve{g}$ -continuous, $g^{-1}(O)$ is supra $\breve{g}$ - open and supra $\breve{g}$ - closed in Y. since f is supra $\breve{g}$ - irresolute, $f^{-1}(g^{-1}(O))$ is supra $\breve{g}$ - open and supra $\breve{g}$ - closed in X. Hence $g \circ f$ is supra $\breve{g}$ continuous.

Theorem: 4.13 If the function $f: (X, \tau) \to (y, \sigma)$ is slightly supra $\breve{g}$ and (X, τ) is - $T_{1/2}$ space, then f is slightly supra continuous.
Proof: Let O be a supra clopen in Y. since, g is slightly supra $\breve{g}$ continuous, $f^{-1}(O)$ is supra $\breve{g}$ open in X, since X is - $T_{1/2}$ space, $f^{-1}(O)$ is supra open in X. Hence f is slightly supra continuous.

Theorem: 4.14 If the function $f: (X, \tau) \to (y, \sigma)$ is slightly supra $\breve{g}$ continuous and (Y, σ) is locally indiscrete space, then f is supra $\breve{g}$ continuous.
Proof: Let O be an open subset of Y. since (Y, σ) is a locally indiscrete space. O is closed in Y. since f is slightly supra $\breve{g}$ continuous, $f^{-1}(O)$ is supra $\breve{g}$ - open in X. Hence, f is supra $\breve{g}$ continuous.

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