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FUZZY HX FIELD

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ABSTRACT : **In this paper, we define the notion of fuzzy HX field of a HX field and some of their related properties are investigated. We introduce the concept of an image, pre-image, anti image and anti pre-image of an fuzzy subset and discuss in detail a series of homomorphic and anti homomorphic properties of an fuzzy set are discussed.**
Keywords: fuzzy set, fuzzy HX field, homomorphism and anti homomorphism of an fuzzy HX field, image and pre-image of a fuzzy set.

INTRODUCTION

In 1965, Zadeh [7] introduced the concept of fuzzy subset μ of a set X as a function from X into the closed unit interval [0, 1] and studied their properties. In 1988, Professor Li Hong Xing [7] proposed the concept of HX ring and derived some of its properties, then Professor Zhong [2,3] gave the structures of HX ring on a class of ring. R.Muthuraj et.al[6]., introduced the concept of fuzzy HX ring. In this paper we define a new algebraic structure of a fuzzy HX field of a HX field and investigate some related properties. Also we introduce the image , pre-image ,anti image and anti pre-image of an fuzzy set in an fuzzy HX field and discuss some of its properties under homomorphism and anti homomorphism.

PRELIMINARIES

In this section, we site the fundamental definitions that will be used in the sequel. Throughout this paper, F = (F ,+, ·) is a HX Field.

2.1 Definition [6]

Let R be a ring. In $2^R - \{\phi\}$, a non-empty set $\vartheta \subset 2^R - \{\phi\}$ with two binary operation ' + ' and '.' is said to be a HX ring on R if ϑ is a ring with respect to the algebraic operation defined by

i. $A + B = \{a + b / a \in A \text{ and } b \in B\}$, which its null element is denoted by Q , and the negative element of A is denoted by – A.
ii. $AB = \{ab / a \in A \text{ and } b \in B\}$,
iii. $A (B + C) = AB + AC$ and $(B + C) A = BA + CA$.

2.2 Definition[6]

Let R be a ring. Let μ be a fuzzy ring defined on R. Let $\vartheta \subset 2^R - \{\phi\}$ be a HX ring. A fuzzy subset λ^μ of ϑ is called a fuzzy HX ring on ϑ or a fuzzy ring induced by μ if the following conditions are satisfied. For all $A,B \in \vartheta$,

i. $\lambda^\mu(A - B) \geq \min\{\lambda^\mu(A), \lambda^\mu(B)\}$,

ii. $\lambda^\mu(AB) \geq \min\{\lambda^\mu(A), \lambda^\mu(B)\}$

where $\lambda^\mu(A) = \max\{\mu(x) / \text{ for all } x \in A \subseteq R\}$.

3. Properties of a fuzzy HX Field

In this section we introduce the new concept fuzzy HX field and anti fuzzy HX field. We discuss the concept of image, pre-image, anti image and anti pre-image of a fuzzy HX field under homomorphism and anti homomorphism.

3.1 Definition

Let $(F, +, \cdot)$ be a HX field. A fuzzy subset λ^μ of a HX field F is said to be a fuzzy HX (FHXF) field of F if the following conditions are satisfied. For all $A, B \in F$,

(i) $\lambda^\mu(A-B) \geq \min\{\lambda^\mu(A), \lambda^\mu(B)\}$,

(ii) $\lambda^\mu(AB^{-1}) \geq \min\{\lambda^\mu(A), \lambda^\mu(B)\}$,

Where $\lambda^\mu(A) = \max\{\mu(x) / x \in A \subseteq F\}$.

3.2 Definition

Let $(F, +, \cdot)$ be a HX field. A fuzzy subset λ^μ of a HX field F is said to be an anti fuzzy HX (FHXF) field of F if the following conditions are satisfied. For all $A, B \in F$,

(i) $\lambda^\mu(A-B) \leq \max\{\lambda^\mu(A), \lambda^\mu(B)\}$,

(ii) $\lambda^\mu(AB^{-1}) \leq \max\{\lambda^\mu(A), \lambda^\mu(B)\}$,

Where $\lambda^\mu(A) = \min\{\mu(x) / x \in A \subseteq F\}$.

3.3 Definition

Let μ , λ be any two fuzzy subsets of a set X. A fuzzy subset $\mu \cap \lambda$ is defined as $(\mu \cap \lambda)(x) = \min\{\mu(x), \lambda(x)\}$ for all $x \in X$.

3.4 Theorem

If λ^μ and Θ^μ be two fuzzy HX field of a HX field F, then $\lambda^\mu \cap \Theta^\mu$ is also fuzzy HX field of a HX field F.

Proof

Let λ^μ and Θ^μ be two fuzzy HX fields of a HX field F.

To prove that $\lambda^\mu \cap \Theta^\mu$ is also a fuzzy HX field of a HX field F.

For any $A, B \in F$, we have

(i)
$$\begin{aligned}(\lambda^\mu \cap \Theta^\mu)(A-B) &= \min\{\lambda^\mu(A-B), \Theta^\mu(A-B)\}\\ &\geq \min\{\min\{\lambda^\mu(A), \lambda^\mu(B)\}, \min\{\Theta^\mu(A), \Theta^\mu(B)\}\}\\ &= \min\{\min\{\lambda^\mu(A), \Theta^\mu(A)\}, \min\{\lambda^\mu(B), \Theta^\mu(B)\}\}\\ &= \min\{(\lambda^\mu \cap \Theta^\mu)(A), (\lambda^\mu \cap \Theta^\mu)(B)\}\end{aligned}$$

Hence, $(\lambda^\mu \cap \Theta^\mu)(A-B) \geq \min\{(\lambda^\mu \cap \Theta^\mu)(A), (\lambda^\mu \cap \Theta^\mu)(B)\}$.

(ii)
$$\begin{aligned}(\lambda^\mu \cap \Theta^\mu)(AB^{-1}) &= \min\{\lambda^\mu(AB^{-1}), \Theta^\mu(AB^{-1})\}\\ &\geq \min\{\min\{\lambda^\mu(A), \lambda^\mu(B)\}, \min\{\Theta^\mu(A), \Theta^\mu(B)\}\}\\ &= \min\{\min\{\lambda^\mu(A), \Theta^\mu(A)\}, \min\{\lambda^\mu(B), \Theta^\mu(B)\}\}\\ &= \min\{(\lambda^\mu \cap \Theta^\mu)(A), (\lambda^\mu \cap \Theta^\mu)(B)\}\end{aligned}$$

Hence, $(\lambda^{\mu} \cap \Theta^{\mu})(AB^{-1}) \geq \min\{(\lambda^{\mu} \cap \Theta^{\mu})(A), (\lambda^{\mu} \cap \Theta^{\mu})(B)\}$.

Therefore the intersection of any two FHX fields is also a FHX field of F.

3.5 Theorem

Let λ^{μ} be a fuzzy HX field of a HX field F if and only if $(\lambda^{\mu})^c$ is an anti fuzzy HX field of a HX field F.

Proof

Let λ^{μ} be a fuzzy HX field of F.
To prove that $(\lambda^{\mu})^c$ is an anti fuzzy HX field of F.
For any A,B $\in$ F ,we have

(i) $\lambda^{\mu}(A-B) \geq \min\{\lambda^{\mu}(A), \lambda^{\mu}(B)\}$

$\Leftrightarrow 1-(\lambda^{\mu})^c(A-B) \geq \min\{1-(\lambda^{\mu})^c(A), 1-(\lambda^{\mu})^c(B)\}$

$\Leftrightarrow (\lambda^{\mu})^c(A-B) \leq 1-\min\{1-(\lambda^{\mu})^c(A), 1-(\lambda^{\mu})^c(B)\}$

$\Leftrightarrow (\lambda^{\mu})^c(A-B) \leq \max\{(\lambda^{\mu})^c(A), (\lambda^{\mu})^c(B)\}$

(ii) $\lambda^{\mu}(AB^{-1}) \geq \min\{\lambda^{\mu}(A), \lambda^{\mu}(B)\}$

$\Leftrightarrow 1-(\lambda^{\mu})^c(AB^{-1}) \geq \min\{1-(\lambda^{\mu})^c(A), 1-(\lambda^{\mu})^c(B)\}$

$\Leftrightarrow (\lambda^{\mu})^c(AB^{-1}) \leq 1-\min\{1-(\lambda^{\mu})^c(A), 1-(\lambda^{\mu})^c(B)\}$

$\Leftrightarrow (\lambda^{\mu})^c(AB^{-1}) \leq \max\{(\lambda^{\mu})^c(A), (\lambda^{\mu})^c(B)\}$

Hence $(\lambda^{\mu})^c$ is an anti fuzzy HX field of F.

3.6 Theorem

If λ^{μ} and Θ^{μ} be two fuzzy HX fields of a HX field F, then $\lambda^{\mu} \times \Theta^{\mu}$ is also a fuzzy HX field of a HX field Fx F .

Proof

Let λ^{μ} and Θ^{μ} be two fuzzy HX fields of a HX field F.
To prove that $\lambda^{\mu} \times \Theta^{\mu}$ is also a fuzzy HX field of a HX field F x F .
For any A,B ,C & D$\in\vartheta$,we have

i. $(\lambda^{\mu} \times \Theta^{\mu})((A,B)-(C,D)) = (\lambda^{\mu} \times \Theta^{\mu})((A-C), (B-D))$

$= \min\{\lambda^{\mu}(A-C), \Theta^{\mu}(B-D)\}$

$\geq \min\{\min\{\lambda^{\mu}(A), \lambda^{\mu}(C)\}, \min\{\Theta^{\mu}(B), \Theta^{\mu}(D)\}\}$

$\geq \min\{\min\{\lambda^{\mu}(A), \Theta^{\mu}(B)\}, \min\{\lambda^{\mu}(C), \Theta^{\mu}(D)\}\}$

$= \min\{(\lambda^{\mu} \times \Theta^{\mu})(A,B), (\lambda^{\mu} \times \Theta^{\mu})(C,D)\}$

Hence, $(\lambda^{\mu} \times \Theta^{\mu})((A,B)-(C,D)) \geq \min\{(\lambda^{\mu} \times \Theta^{\mu})(A,B), (\lambda^{\mu} \times \Theta^{\mu})(C,D)\}$

ii. $(\lambda^{\mu} \times \Theta^{\mu})((A,B).(C,D)^{-1}) = (\lambda^{\mu} \times \Theta^{\mu})((A,B).(C^{-1},D^{-1}))$

$= (\lambda^{\mu} \times \Theta^{\mu})((AC^{-1}, BD^{-1}))$

$= \min\{\lambda^{\mu}(AC^{-1}), \Theta^{\mu}(BD^{-1})\}$

$\geq \min\{\min\{\lambda^{\mu}(A), \lambda^{\mu}(C)\}, \min\{\Theta^{\mu}(B), \Theta^{\mu}(D)\}\}$

$\geq \min\{\min\{\lambda^{\mu}(A), \Theta^{\mu}(B)\}, \min\{\lambda^{\mu}(C), \Theta^{\mu}(D)\}\}$

$= \min\{(\lambda^{\mu} \times \Theta^{\mu})(A,B), (\lambda^{\mu} \times \Theta^{\mu})(C,D)\}$

Hence, $(\lambda^{\mu} \times \Theta^{\mu})((A,B).(C,D)^{-1}) \geq \min\{(\lambda^{\mu} \times \Theta^{\mu})(A,B), (\lambda^{\mu} \times \Theta^{\mu})(C,D)\}$

Therefore , $\lambda^{\mu} \times \Theta^{\mu}$ is a fuzzy HX field of a HX field .

3.10 Definition

Let F_1 and F_2 be any two HX fields. Then the function $f : F_1 \rightarrow F_2$ is said to be a homomorphism if it satisfies the following axioms:

i) f(A+B) = f(A) + f(B) and

ii) f(AB) = f(A) f(B), for all A,B $\in F_1$.

3.11 Definition

Let F_1 and F_2 be any two HX fields. Then the function f : $F_1 \rightarrow F_2$ is said to be an anti homomorphism if it satisfies the following axioms:

i) f(A+B) = f(B) + f(A) and

ii) f(AB) = f(B) f(A), for all A,B $\in F_1$.

3.12 Definition

Let F_1 and F_2 be any two HX fields. Let C and D are any two fuzzy sets in F_1 and F_2 resp. Let f be a function from F_1 into F_2 then the image of C on F_1 under f is defined as

$$\eta_D^{\alpha}(V) = \begin{cases} \max\left\{\lambda_C^{\mu}(U) : U \in f^{-1}(V)\right\}, & f^{-1}(V) \neq \phi \\ 0 & ,otherwise \end{cases}$$ and

Where $\eta_D^{\alpha} = f(\lambda_C^{\mu})$ also Pre-image of D on F_2 under f is defined as $\left(f^{-1}(\eta_D^{\alpha})\right)(U) = \eta_D^{\alpha}(f(U))$.

3.13 Theorem

Let F_1 and F_2 be any two HX fields. Let C and D are any two fuzzy sets in F_1 and F_2 resp. Let f be an onto homomorphism from F_1 to F_2. If C be the fuzzy HX field of F_1 then f(C) is an fuzzy HX field of F_2.

Proof.

Let C be the fuzzy HX field of F_1 then

(i) $\lambda_c^{\mu}(U-T) \geq \min\left\{\lambda_c^{\mu}(U), \lambda_c^{\mu}(T)\right\}$

(ii) $\lambda_c^{\mu}(UT^{-1}) \geq \min\left\{\lambda_c^{\mu}(U), \lambda_c^{\mu}(T)\right\}$

To Prove that f(C) is an fuzzy HX field of F_2.

Let V = f(U) , W = f(T) $\in F_2$, where $U,T \in F_1$.

Now $\eta_D^{\alpha}\left[f(U) - f(T)\right] = \eta_D^{\alpha}\left[f(U-T)\right]$ (f is homomorphism)

$= \lambda_c^{\mu}(U-T)$ (f is onto)

$\geq \min\left\{\lambda_c^{\mu}(U), \lambda_c^{\mu}(T)\right\}$

$\geq \min\left\{\eta_D^{\alpha}(f(U), \eta_D^{\alpha}(f(T))\right\}$

Hence, $\eta_D^{\alpha}\left[f(U) - f(T)\right] \geq \min\left\{\eta_D^{\alpha}(f(U), \eta_D^{\alpha}(f(T))\right\}$

And $\eta_D^{\alpha}\left[f(U)(f(T))^{-1}\right] = \eta_D^{\alpha}\left[f(U)\, f(T^{-1})\right]$

$= \eta_D^{\alpha}\left[f(UT^{-1})\right]$

$= \eta_D^{\alpha}\left[f(UT^{-1})\right]$

$= \lambda_c^{\mu}(UT^{-1})$ (f is onto)

$\geq \min\left\{\lambda_c^{\mu}(U), \lambda_c^{\mu}(T)\right\}$

$\geq \min\left\{\eta_D^{\alpha}(f(U), \eta_D^{\alpha}(f(T))\right\}$

Hence, $\eta_D^{\alpha}\left[f(U)(f(T))^{-1}\right] \geq \min\left\{\eta_D^{\alpha}(f(U), \eta_D^{\alpha}(f(T))\right\}$

Thus D = f(C) is an fuzzy HX field of F_2.

3.14 Theorem

Let F_1 and F_2 be any two HX fields. Let C and D be any two fuzzy sets in F_1 and F_2 resp. Let f be an onto homomorphism from F_1 to F_2. If D be the fuzzy HX field of F_2 then $f^{-1}(D)$ is a fuzzy HX field of F_1.

Proof.

Let D be the fuzzy HX field of F_2 then

(i) $\eta_D^{\alpha}(V-W) \geq \min\{\eta_D^{\alpha}(V), \eta_D^{\alpha}(W)\}$, (ii) $\eta_D^{\alpha}(VW^{-1}) \geq \min\{\eta_D^{\alpha}(V), \eta_D^{\alpha}(W)\}$

To Prove that $f^{-1}(D)$ is a fuzzy HX field of F_1.

Let U, T $\in F_1$ and f(U) = V , f(T) =W$\in F_2$.

$$
\begin{aligned}
\text{Now}\quad \left[f^{-1}(\eta_D^{\alpha})(U-T)\right] &= (\eta_D^{\alpha})\left[f(U-T)\right] \\
&= (\eta_D^{\alpha})\left[f(U)-f(T)\right] \qquad \text{(f is homomorphism)} \\
&= (\eta_D^{\alpha})\left[V-W\right] \\
&\geq \min\{\eta_D^{\alpha}(V), \eta_D^{\alpha}(W)\} \\
&\geq \min\{\eta_D^{\alpha}(f(U)), \eta_D^{\alpha}(f(T))\} \\
&\geq \min\{\{f^{-1}(\eta_D^{\alpha})\}(U), \{f^{-1}(\eta_D^{\alpha})\}(T)\}
\end{aligned}
$$

Hence, $\left[f^{-1}(\eta_D^{\alpha})(U-T)\right] \geq \min\{\{f^{-1}(\eta_D^{\alpha})\}(U), \{f^{-1}(\eta_D^{\alpha})\}(T)\}$

$$
\begin{aligned}
\text{Also}\quad \left[f^{-1}(\eta_D^{\alpha})(UT^{-1})\right] &= (\eta_D^{\alpha})\left[f(UT^{-1})\right] \\
&= (\eta_D^{\alpha})\left[f(U)\,f(T^{-1})\right] \qquad \text{(f is homomorphism)} \\
&= (\eta_D^{\alpha})\left[f(U)\,f(T)^{-1}\right] \\
&= (\eta_D^{\alpha})\left[VW^{-1}\right] \\
&\geq \min\{\eta_D^{\alpha}(V), \eta_D^{\alpha}(W)\} \\
&\geq \min\{\{f^{-1}(\eta_D^{\alpha})\}(U), \{f^{-1}(\eta_D^{\alpha})\}(T)\}
\end{aligned}
$$

Hence, $\left[f^{-1}(\eta_D^{\alpha})(UT^{-1})\right] \geq \min\{\{f^{-1}(\eta_D^{\alpha})\}(U), \{f^{-1}(\eta_D^{\alpha})\}(T)\}$

Therefore, $f^{-1}(D)$ is a fuzzy HX field of F_1.

3.15 Theorem

Let F_1 and F_2 be any two HX fields. Let C and D be any two fuzzy sets in F_1 and F_2 resp. Let f be an onto anti-homomorphism from F_1 to F_2. If C be the fuzzy HX field of F_1 then f(C) is a fuzzy HX field of F_2.

Proof.

Let C be the fuzzy HX field of F_1 then

(i) $\lambda_c^{\mu}(U-T) \geq \min\{\lambda_c^{\mu}(U), \lambda_c^{\mu}(T)\}$, (ii) $\lambda_c^{\mu}(UT^{-1}) \geq \min\{\lambda_c^{\mu}(U), \lambda_c^{\mu}(T)\}$

To Prove that f(C) is an fuzzy HX field of F_2.

Let V = f(U) , W = f(T) $\in F_2$, where U,T$\in F_1$.

$$
\begin{aligned}
\text{Now,}\quad \eta_D^{\alpha}\left[f(U)-f(T)\right] &= \eta_D^{\alpha}\left[f(T-U)\right] \qquad \text{(f is an anti- homomorphism)} \\
&= \lambda_c^{\mu}(T-U) \quad \text{(f is onto)} \\
&\geq \min\{\lambda_c^{\mu}(T), \lambda_c^{\mu}(U)\} \\
&\geq \min\{\lambda_c^{\mu}(U), \lambda_c^{\mu}(T)\} \\
&\geq \min\{\eta_D^{\alpha}(f(U)), \eta_D^{\alpha}(f(T))\}
\end{aligned}
$$

Hence , $\eta_D^{\alpha}\left[f(U)-f(T)\right] \geq \min\{\eta_D^{\alpha}(f(U)), \eta_D^{\alpha}(f(T))\}$

Again $\eta_D^{\alpha}\left[f(U)(f(T))^{-1}\right] = \eta_D^{\alpha}\left[f(U)\,f(T^{-1})\right]$

$$= \eta_D^{\alpha}\left[f(T^{-1}U)\right]$$
$$= \lambda_c^{\mu}\left(T^{-1}U\right) \quad (\text{ f is onto })$$
$$= \lambda_c^{\mu}\left(T^{-1}(U^{-1})^{-1}\right)$$
$$\geq \min\left\{\lambda_c^{\mu}(T^{-1}), \lambda_c^{\mu}(U^{-1})\right\}$$
$$\geq \min\left\{\lambda_c^{\mu}(T), \lambda_c^{\mu}(U)\right\}$$
$$\geq \min\left\{\lambda_c^{\mu}(U), \lambda_c^{\mu}(T)\right\}$$
$$\geq \min\left\{\eta_D^{\alpha}(f(U), \eta_D^{\alpha}(f(T))\right\}$$

Hence , $\eta_D^{\alpha}\left[f(U)(f(T))^{-1}\right] \geq \min\left\{\eta_D^{\alpha}(f(U), \eta_D^{\alpha}(f(T))\right\}$

Thus D = f(C) is a fuzzy HX field of F_2.

3.16 Theorem

Let F_1 and F_2 be any two HX fields. Let C and D be any two fuzzy sets in F_1 and F_2 resp. Let f be an onto anti-homomorphism from F_1 to F_2.. If D be the fuzzy HX field of F_1 then f^{-1}(D) is a fuzzy HX field of F_2.

Proof. Let D be the fuzzy HX field of F_2 then

(i) $\eta_D^{\alpha}(V-W) \geq \min\left\{\eta_D^{\alpha}(V), \eta_D^{\alpha}(W)\right\}$, (ii) $\eta_D^{\alpha}(VW^{-1}) \geq \min\left\{\eta_D^{\alpha}(V), \eta_D^{\alpha}(W)\right\}$

To Prove that f^{-1}(D) is a fuzzy HX field of F_1.

Let U,T$\in F_1$ and f(U) = V , f(T) =W$\in F_2$.

Now, $\left[f^{-1}(\eta_D^{\alpha})(U-T)\right] = (\eta_D^{\alpha})\left[f(U-T)\right]$

$$= (\eta_D^{\alpha})\left[f(T)-f(U)\right] \qquad \text{(f is an anti homomorphism)}$$
$$= (\eta_D^{\alpha})\left[W-V\right]$$
$$\geq \min\left\{\eta_D^{\alpha}(W), \eta_D^{\alpha}(V)\right\}$$
$$\geq \min\left\{\eta_D^{\alpha}(V), \eta_D^{\alpha}(W)\right\}$$
$$\geq \min\left\{\eta_D^{\alpha}(f(U)), \eta_D^{\alpha}(f(T))\right\}$$
$$\geq \min\left\{\{f^{-1}(\eta_D^{\alpha})\}(U), \{f^{-1}(\eta_D^{\alpha})\}(T)\right\}$$

Hence, $\left[f^{-1}(\eta_D^{\alpha})(U-T)\right] \geq \min\left\{\{f^{-1}(\eta_D^{\alpha})\}(U), \{f^{-1}(\eta_D^{\alpha})\}(T)\right\}$

Also $\left[f^{-1}(\eta_D^{\alpha})(UT^{-1})\right] = (\eta_D^{\alpha})\left[f(UT^{-1})\right]$

$$= (\eta_D^{\alpha})\left[f(T^{-1})f(U)\right] \qquad \text{(f is an anti homomorphism)}$$
$$= (\eta_D^{\alpha})\left[f(T)^{-1}f(U)\right]$$
$$= (\eta_D^{\alpha})\left[W^{-1}V\right]$$
$$= (\eta_D^{\alpha})\left[W^{-1}(V^{-1})^{-1}\right]$$
$$\geq \min\left\{\eta_D^{\alpha}(W^{-1}), \eta_D^{\alpha}(V^{-1})\right\}$$
$$\geq \min\left\{\eta_D^{\alpha}(W), \eta_D^{\alpha}(V)\right\}$$
$$\geq \min\left\{\eta_D^{\alpha}(V), \eta_D^{\alpha}(W)\right\}$$
$$\geq \min\left\{\{f^{-1}(\eta_D^{\alpha})\}(U), \{f^{-1}(\eta_D^{\alpha})\}(T)\right\}$$

Hence, $\left[f^{-1}(\eta_D^{\alpha})(UT^{-1})\right] \geq \min\left\{\{f^{-1}(\eta_D^{\alpha})\}(U), \{f^{-1}(\eta_D^{\alpha})\}(T)\right\}$

Therefore, f^{-1}(D) is a fuzzy HX field of F_1.

IV. Conclusion

In this paper we introduce the concept of fuzzy HX field and discuss the basic results on HX subfield. Further investigation may be in fuzzy HX modules on HX module which will give a new horizon in the further study.

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