ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 6, June 2014

Fuzzy Pairwise Strongly Pre-Continuous Mappings

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ABSTARCT: We define and characterize a fuzzy pairwise strongly pre-continuous mappings on a fuzzy bitopological space. We investigate some of their properties. We establish some equivalent conditions of fuzzy pairwise strongly pre-continuous mappings on a fuzzy bitopological space.

KEYWORDS: (τ_i, τ_j)-fuzzy preopen, (τ_i, τ_j)-fuzzy preclosed, (τ_i, τ_j)-fuzzy semi-open, (τ_i, τ_j)-fuzzy semi-closed, (τ_i, τ_j)-fuzzy pairwise precontinuous, (τ_i, τ_j)-fuzzy pairwise semicontinuous, (τ_i, τ_j)-fuzzy pairwise stongly pre-continuous, (τ_i, τ_j)-fuzzy pairwise strongly preclosed.

I. INTRODUCTION

In 1981, K.K. Azad [4] introduced the concept of semi-open sets in fuzzy topology. A.S. Bin Shahana [1] has defined the concept of fuzzy pre-open sets in fuzzy topological spaces.

In 1989, A. Kandil [5] introduced the notation of fuzzy bitopological space. Further in 1996, S.S. Thakur and R. Malviya [9] defined fuzzy semi-open and fuzzy semi-continuous in fuzzy bitopological space. Sampath kumar [10] defined a (τ_i, τ_j)-fuzzy pre-open set and characterized a fuzzy pairwise precontinuous mappings on a fuzzy bitopological space. Further M. Shrivastava, J.K.m maitra And M. Shukla [7] in 2006 defined fuzzy strongly pre-continuous mapping in fuzzy topological space.

In this article we have established equivalent conditions for a mapping to be fuzzy pairwise strongly pre-continuous mapping in fuzzy bitopological space. Further we have studied some properties of fuzzy pairwise pre-continuous mapping.

II. PRELIMINARIES

Let X be a set and let τ_1 and τ_2 be fuzzy topologies on X. Then we call (X, τ_1, τ_2) a fuzzy bitopological space [fbts].

A mapping $f: (X, \tau_1, \tau_2) \rightarrow (Y, \tau_1^*, \tau_2^*)$ is fuzzy pairwise continuous $[fpc]$ if the induced mapping $f: (X, \tau_k) \rightarrow (Y, \tau_k^*)$ is fuzzy continuous for $k = 1,2$.

A mapping $: (X, \tau_1, \tau_2) \rightarrow (Y, \tau_1^*, \tau_2^*)$ is fuzzy pairwise open [fp open] (fuzzy pairwise closed [fp closed]) if the induced mapping $f: (X, \tau_k) \rightarrow (Y, \tau_k^*)$ is fuzzy open (fuzzy closed) for $k = 1,2$.

Notations. (1) Throughout this paper, we take an ordered pair (τ_i, τ_j) with $i, j \in \{1,2\}$ and $i \neq j$.

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 3, Issue 6, June 2014

(2) For simplicity, we abbreviate a τ_i-fuzzy open set μ and a τ_j-fuzzy closed set μ with a τ_i-fo set μ and a τ_j-fc set μ respectively. Also, we denote the interior and the closure of μ for a fuzzy topology $\tau_i - int\mu$ and $\tau_i - cl\mu$ respectively.

Definition 2.1. Let μ be a fuzzy set on a $fbts\ X$. Then we call μ;

(i) a (τ_i, τ_j)-fuzzy semi-open $[(\tau_i, \tau_j) - fso]$ set on X if $\mu \le \tau_i - cl(\tau_j - int(\mu))$[9].
(ii) a (τ_i, τ_j)-fuzzy semi-closed $[(\tau_i, \tau_j) - fsc]$ set on X if $\tau_i - int(\tau_j - cl(\mu)) \le \mu$ [9].
(iii) a (τ_i, τ_j)-fuzzy pre-open $[(\tau_i, \tau_j) - fpo]$ set on X if $\mu \le \tau_i - int(\tau_j - cl(\mu))$[10].
(iv) a (τ_i, τ_j)-fuzzy pre-closed $[(\tau_i, \tau_j) - fpc]$ set on X if $\tau_i - cl(\tau_j - int(\mu)) \le \mu$[10].

Definition 2.2. Let μ be a fuzzy set on a $fbts\ X$.

(i) The (τ_i, τ_j)-semi interior of μ, $[(\tau_i, \tau_j) - sint\mu]$ is
$\cup\{\vartheta: \vartheta \le \mu, \vartheta$ is a $(\tau_i, \tau_j) - fso$ set$\}$ [9].
(ii) The (τ_i, τ_j)-semi closure of μ, $[(\tau_i, \tau_j) - scl\mu]$ is
$\cap\{\vartheta: \vartheta \ge \mu, \vartheta$ is a $(\tau_i, \tau_j) - fsc$ set$\}$ [9].
(iii) The (τ_i, τ_j)-pre interior of μ, $[(\tau_i, \tau_j) - pint(\mu)]$ is
$\cup\{\vartheta: \vartheta \le \mu, \vartheta$ is a $(\tau_i, \tau_j) - fso$ set$\}$ [10].
(iv) The (τ_i, τ_j)-pre clouser of μ, $[(\tau_i, \tau_j) - pcl(\mu)]$ is
$\cap\{\vartheta: \vartheta \ge \mu, \vartheta$ is a $(\tau_i, \tau_j) - fpc$ set$\}$ [10].

Definition 2.3. Let $f: (X, \tau_1, \tau_2) \to (Y, \tau_1^*, \tau_2^*)$ be a mapping. Then f is called;

(i) fuzzy pairwise semi-continuous $[fps$ continuous $]$ mapping if $f^{-1}(\mu)$ is a $(\tau_i, \tau_j) - fso$ set on X for each $\tau_i^* - fo$ set μ on Y [9].
(ii) fuzzy pairwise pre-continuous $[fpp$ continuous$]$ mapping if $f^{-1}(\mu)$ is a $(\tau_i, \tau_j) - fpo$ set on X for each $\tau_i^* - fo$ set μ on Y [10].
(iii) fuzzy pairwise α-continuous $[fpsc$ open$]$ mapping if $f^{-1}(\mu)$ is a $(\tau_i, \tau_j) - f\alpha o$ set on X for each $\tau_i^* - fo$ set μ on Y [9].

It is clear that every $fp\alpha c$ mapping is a $fpsc$ and $fppc$ mappings on $fbts$. But the converse may true in general.

III. FUZZY PAIRWISE STRONGLY PRE-CONTINUOUS MAPPINGS

Definition 3.1. Let $f: (X, \tau_1, \tau_2) \to (Y, \tau_1^*, \tau_2^*)$ be a mapping. Then f is called a fuzzy pairwise strongly pre-continuous $[fpsp$ continuous$]$ mapping if $f^{-1}(\mu)$ is a $(\tau_i, \tau_j) - fpo$ set on X for each $(\tau_i^*, \tau_j^*) - fso$ set μ on Y.

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 6, June 2014

Since any fuzzy open set is a fuzzy semi-open, if follows that every fuzzy pairwise strongly precontinuous map ($fpsp$continuous) is fuzzy pairwise precontinuous (fpp continuous). However, converse may not be true in general. We have the following example.

Example 3.2. Let $X = \{x_1, x_2\}$ and $Y = \{y_1, y_2\}$ and $\mu, \vartheta,\ \mu^*,\ \vartheta^*$ be fuzzy sets defined as follows.

$$\mu(x_1) = 0.5, \mu(x_2) = 0.6,$$

$$\vartheta(x_1) = 0.2, \vartheta(x_2) = 0.4,$$

$$\mu^*(y_1) = 0.3, \mu^*(y_2) = 0.4,$$

and $\vartheta^*(y_1) = 0.4, \vartheta^*(y_2) = 0.5$.

Let $\tau_1 = \{0, \mu, 1\}, \tau_2 = \{0, \vartheta, 1\}$ and $\tau_1^* = \{0, \mu^*, 1\}, \tau_2^* = \{0, \vartheta^*, 1\}$. Then the mapping $f: (X, \tau_1, \tau_2) \to (Y, \tau_1^*, \tau_2^*)$ defined by $f(x_1) = y_1, f(x_2) = y_2$ is fuzzy pairwise precontinuous [fpp-continuous] but not fuzzy pairwise strongly precontinuous [$fpsp$-continuous] mapping.

Theorem 3.3. Let $f: (X, \tau_1, \tau_2) \to (Y, \tau_1^*, \tau_2^*)$ be a mapping. Then the following statement are equivalent;

(i) f is fuzzy pairwise strongly pre-continuous [$fpsp$ continuous] mapping.

(ii) The inverse image of each (τ_i^*, τ_j^*) $-fsc$ set on Y is a (τ_i, τ_j)-fpc set on X.

(iii) $f((\tau_i, \tau_j) - pcl(\mu)) \le (\tau_i^*, \tau_j^*) - \mathrm{scl}(f(\mu))$ for each fuzzy set μ on X.

(iv) $(\tau_i, \tau_j) - pcl(f^{-1}(\vartheta)) \le f^{-1}\left((\tau_i^*, \tau_j^*) - \mathrm{scl}(\vartheta)\right)$ for each fuzzy set ϑ on Y.

(v) $f^{-1}\left((\tau_i^*, \tau_j^*) - \mathrm{sint}(\vartheta)\right) \le (\tau_i, \tau_j) - pint(f^{-1}(\vartheta))$ for each fuzzy set ϑ on Y.

Proof. (i) ⇒ (ii): Let ϑ be a (τ_i^*, τ_j^*)-fsc set on Y. Then ϑ^c is a (τ_i^*, τ_j^*)-fso set on Y. Since, f is $fpsp$ continuous, $f^{-1}(\vartheta^c) = (f^{-1}(\vartheta))^c$ is a (τ_i, τ_j) $-fpo$ set on X. Hence, $f^{-1}(\vartheta)$ is a (τ_i, τ_j)-fpc set on X.

(ii) ⇒ (iii): Let μ is a fuzzy set on X. Then $f^{-1}\left((\tau_i^*, \tau_j^*) - \mathrm{scl}(f(\mu))\right)$ is a (τ_i, τ_j)-fpc set on X. Thus $(\tau_i, \tau_j) - pcl(\mu) \le (\tau_i, \tau_j) - pcl\left(f^{-1}(f(\mu))\right) \le (\tau_i, \tau_j) - pcl(f^{-1}((\tau_i^*, \tau_j^*) - \mathrm{scl}(f(\mu)))) = f^{-1}\ ((\tau_i^*, \tau_j^*) - \mathrm{scl}(f(\mu)))$. Hence, $f((\tau_i, \tau_j) - pcl(\mu)) \le f(f^{-1}\left((\tau_i^*, \tau_j^*) - \mathrm{pcl}(f(\mu))\right)) \le (\tau_i^*, \tau_j^*) - \mathrm{scl}(f(\mu))$.

(iii) ⇒ (iv): Let ϑ be a fuzzy set on Y. Then $f((\tau_i, \tau_j)\text{-}pcl(f^{-1}(\vartheta))) \le (\tau_i^*, \tau_j^*)\text{-}scl(f(f^{-1}(\vartheta))) \le (\tau_i^*, \tau_j^*) - scl(\vartheta)$. Hence $(\tau_i, \tau_j) - pcl(f^{-1}(\vartheta)) \le f^{-1}(f\left((\tau_i, \tau_j) - pcl(f^{-1}(\vartheta))\right)) \le f^{-1}((\tau_i^*, \tau_j^*)\text{-}scl(\vartheta))$.

(iv) ⇒ (v). Let ϑ be a fuzzy set on Y. Then $(\tau_i, \tau_j)\text{-}pcl(f^{-1}(\vartheta^c)) \le f^{-1}((\tau_i^*, \tau_j^*)\text{-}scl(\vartheta^c))$. Hence, $f^{-1}((\tau_i^*, \tau_j^*)\text{-}sint(\vartheta)) = f^{-1}(((\tau_i^*, \tau_j^*) - pcl(\vartheta^c))^c) \le ((\tau_i, \tau_j) - scl(f^{-1}(\vartheta^c)))^c = (\tau_i, \tau_j)\text{-}sint(f^{-1}(\vartheta))$.

(v) ⇒ (i). Let ϑ be a (τ_i^*, τ_j^*)-fso set on Y. Then $f^{-1}(\vartheta) = f^{-1}\left((\tau_i^*, \tau_j^*) - \mathrm{sint}(\vartheta)\right) \le (\tau_i, \tau_j) - pint(f^{-1}(\vartheta))$.

IJIRSET

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 6, June 2014

Hence $f^{-1}(\vartheta)$ is a (τ_i,τ_j)-fso set on X and therefore, f is $fpsp$ continuous function.

Theorem 3.4. Let $f:(X,\tau_1,\tau_2)\to(Y,\tau_1^*,\tau_2^*)$ be a bijection. f is $fpsp$ continuous mapping if and only if for each fuzzy set μ on X.

$$(\tau_i^*,\tau_j^*)-\mathrm{sint}(f(\mu))\le f\left((\tau_i,\tau_j)-pint(\mu)\right).$$

Proof: Let μ be a fuzzy set on X. Then, by Theorem 3.3,
$f^{-1}((\tau_i^*,\tau_j^*)-\mathrm{sint}(f(\mu)))\le(\tau_i,\tau_j)-pint\left(f^{-1}(f(\mu))\right)$.

Since f is a bijection,

$(\tau_i^*,\tau_j^*)-\mathrm{sint}(f(\mu))=f\left(f^{-1}\left((\tau_i^*,\tau_j^*)-\mathrm{pint}(f(\mu))\right)\right)\le f((\tau_i,\tau_j)-pint(\mu))$.
Conversely, let ϑ be a fuzzy set on Y. Then
$(\tau_i^*,\tau_j^*)-\mathrm{sint}\left(f(f^{-1}(\mu))\right)\le f\left((\tau_i,\tau_j)-pint(f^{-1}(\vartheta))\right)$.

Recall that f is a bijection. Hence
$(\tau_i^*,\tau_j^*)-\mathrm{sint}(\vartheta)=(\tau_i^*,\tau_j^*)-\mathrm{sint}(f(f^{-1}(\vartheta)))\le f((\tau_i,\tau_j)-pint(f^{-1}(\vartheta)))$.
and $f^{-1}((\tau_i^*,\tau_j^*)-\mathrm{sint}(\vartheta))\le f^{-1}(f\left((\tau_i,\tau_j)-pint(f^{-1}(\vartheta))\right))$
$=(\tau_i,\tau_j)-pint(f^{-1}(\vartheta))$.

Therefore, by theorem 3.3, f is $fpsp$ continuous mapping.

Definition 3.5. Let $f:(X,\tau_1,\tau_2)\to(Y,\tau_1^*,\tau_2^*)$ be a mapping. Then f is called

(i) a fuzzy Pairwise strongly pre-open [$fpsp$ open] mapping if $f(\mu)$ is a $(\tau_i^*,\tau_j^*)-fso$ set on Y for each $(\tau_i,\tau_j)-fpo$ set μ on X.
(ii) a fuzzy Pairwise strongly pre-closed [$fpsp$ closed] mapping if $f(\mu)$ is a $(\tau_i^*,\tau_j^*)-fsc$ set on Y for each (τ_i,τ_j)-fpc set μ on X.

Theorem 3.6. Let $f:(X,\tau_1,\tau_2)\to(Y,\tau_1^*,\tau_2^*)$ be a mapping. Then the following statement are equivalent:

(i) f is $fpsp$ open mapping.
(ii) $f((\tau_i,\tau_j)-pint(\mu))\le(\tau_i^*,\tau_j^*)-\mathrm{sint}(f(\mu))$ for each fuzzy set μ on X.
(iii) $(\tau_i,\tau_j)-pint(f^{-1}(\vartheta))\le f^{-1}((\tau_i^*,\tau_j^*)-\mathrm{sint}\,(\vartheta))$ for each fuzzy set ϑ on Y.

Proof. (i) $\Rightarrow(ii)$. Let μ be a fuzzy set on X. Then $f((\tau_i,\tau_j)-pint(\mu))$ is a $(\tau_i^*,\tau_j^*)-fso$ set on Y and $f\left((\tau_i,\tau_j)-pint(\mu)\right)\le f(\mu)$. Hence

$$f\left((\tau_i,\tau_j)-pint(\mu)\right)=(\tau_i^*,\tau_j^*)-\mathrm{sint}(f\left((\tau_i,\tau_j)-pint(\mu)\right))$$

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 6, June 2014

$$\leq (\tau_i^*, \tau_j^*) - sint(f(\mu)).$$

(ii) ⇒(iii). Let ϑ be a fuzzy set on Y. Then

$$f\left((\tau_i, \tau_j) - pint(f^{-1}(\vartheta))\right) \leq (\tau_i^*, \tau_j^*) - \mathrm{sint}(f(f^{-1}(\vartheta)))$$

$$\leq (\tau_i^*, \tau_j^*) - \mathrm{sint}\ (\vartheta).$$

Hence $(\tau_i, \tau_j) - pint(f^{-1}(\vartheta)) \leq f^{-1}\left(f\left((\tau_i, \tau_j) - pint(f^{-1}(\vartheta))\right)\right)$

$$\leq\ f^{-1}\left((\tau_i^*, \tau_j^*) - \mathrm{sint}\ \vartheta\right).$$

(iii) ⇒ (i). Let μ be a $(\tau_i, \tau_j) - fpo$ set on X. Then

$$\mu = (\tau_i, \tau_j) - pint(\mu) \leq (\tau_i, \tau_j) - pint(f^{-1}(f(\mu)))$$
$$\leq f^{-1}\left((\tau_i^*, \tau_j^*) - \mathrm{sint}(f(\mu))\right).$$

We have $f(\mu) \leq f(f^{-1}((\tau_i^*, \tau_j^*) - \mathrm{sint}(f(\mu)))) \leq (\tau_i^*, \tau_j^*) - \mathrm{sint}(f(\mu))$.

Hence $f(\mu) = (\tau_i^*, \tau_j^*) - \mathrm{sint}(f(\mu))$. Consequently, $f(\mu)$ is a $(\tau_i^*, \tau_j^*) - fso$ set on Y and therefore, f is $fpsp$-open mapping.

Theorem 3.7. A mapping $f: (X, \tau_1, \tau_2) \to (Y, \tau_1^*, \tau_2^*)$ is $fpsp$-closed mapping if and only if $(\tau_i^*, \tau_j^*) - \mathrm{scl}(f(\mu)) \leq f((\tau_i, \tau_j) - pcl(\mu)))$ for each fuzzy set μ on X.

Proof. Let μ be a fuzzy set on X. Then $f((\tau_i, \tau_j) - pcl(\mu))$ is a (τ_i^*, τ_j^*)-fso set on Y and $f(\mu) \leq f\left((\tau_i, \tau_j) - pcl(\mu)\right)$. Hence

$$(\tau_i^*, \tau_j^*) - \mathrm{scl}(f(\mu)) \leq (\tau_i^*, \tau_j^*) - \mathrm{scl}\left(f\left((\tau_i, \tau_j) - pcl(\mu)\right)\right)$$
$$= f\left((\tau_i, \tau_j) - pcl(\mu)\right).$$

Conversely, let μ be a (τ_i, τ_j)-fpc set on X. Then

$$(\tau_i^*, \tau_j^*) - \mathrm{scl}(f(\mu)) \leq f((\tau_i, \tau_j) - pcl(\mu))$$
$$= f(\mu).$$

Consequently, $f(\mu)$ is a $(\tau_i^*, \tau_j^*) - fpc$ on Y and therefore f is a $fpsp$-closed mapping.

Theorem 3.8. Let $f: (X, \tau_1, \tau_2) \to (Y, \tau_1^*, \tau_2^*)$ be a bijection. Then the following statements are equivalent:

(i) f is $fpsp$-closed mapping.

(ii) $f^{-1}\left((\tau_i^*, \tau_j^*) - \mathrm{scl}\ (\vartheta)\right) \leq (\tau_i, \tau_j) - pcl(f^{-1}(\vartheta))$ for each fuzzy set ϑ on Y.

(iii) f is $fpsp$-open mapping.

(iv) f^{-1} is $fpsp$ continuous mapping.

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 6, June 2014

Proof. (i)⇒(ii). Let ϑ be a fuzzy set on Y. Then by Theorem 3.7,

$$(\tau_i^*,\tau_j^*)-\mathrm{scl}(f(f^{-1}(\vartheta)))\le f((\tau_i,\tau_j)-pcl(f^{-1}(\vartheta))).$$

Hence $f^{-1}((\tau_i^*,\tau_j^*)-\mathrm{scl}(f(f^{-1}(\vartheta)))\le f^{-1}(f((\tau_i,\tau_j)-pcl(f^{-1}(\vartheta))))$.

Since f is a bijection,

$$f^{-1}\left((\tau_i^*,\tau_j^*)-\mathrm{scl}\ (\vartheta)\right)\le(\tau_i,\tau_j)-pcl(f^{-1}(\vartheta)).$$

(ii)⇒(i). Let μ be a fuzzy set on X. Then

$$f^{-1}\left((\tau_i^*,\tau_j^*)-\mathrm{scl}(f(\mu))\right)\le(\tau_i,\tau_j)-pcl\left(f^{-1}(f(\mu))\right).$$

Hence $f\left(f^{-1}\left((\tau_i^*,\tau_j^*)-\mathrm{scl}(f(\mu))\right)\right)\le f\left((\tau_i,\tau_j)-pcl\left(f^{-1}(f(\mu))\right)\right)$.

Since f is a bijection,

$$(\tau_i^*,\tau_j^*)-\mathrm{scl}(f(\mu))\le f\left((\tau_i,\tau_j)-pcl(\mu)\right).$$

Therefore by the theorem 3.7, f is $fpsp$-closed mapping.

(ii) ⇒(iii). Let ϑ be a fuzzy set on Y. Then

$$f^{-1}\left((\tau_i^*,\tau_j^*)-\mathrm{scl}(\vartheta^c)\right)\le(\tau_i,\tau_j)-pcl(f^{-1}(\vartheta^c)).$$

$$\begin{aligned}(\tau_i,\tau_j)-pint(f^{-1}(\vartheta)) &= ((\tau_i,\tau_j)-pcl(f^{-1}(\vartheta^c)))^c\\ &\le f^{-1}(((\tau_i^*,\tau_j^*)-\mathrm{scl}(\vartheta^c))^c)\\ &= f^{-1}\left((\tau_i^*,\tau_j^*)-\mathrm{sint}\ (\vartheta)\right).\end{aligned}$$

Hence f is $fpsp$-open mapping from Theorem 3.6 .

(iii) ⇒(iv). Let ϑ be a fuzzy set on Y. Then

$$(\tau_i,\tau_j)-pint(f^{-1}(\vartheta))\le f^{-1}\left((\tau_i^*,\tau_j^*)-\mathrm{sint}\ (\vartheta)\right).$$

Since f is a bijection. by Theorem 3.4 , f^{-1} is $fpsp$ continuous mapping.

(iv) ⇒(ii). It is clear from Theorem 3.3.

We have the following corollaries from Theorem 3.3, Theorem 3.7 and Theorem 3.6.

IJIRSET

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 6, June 2014

Corollary 3.9. Let $f:(X,\tau_1,\tau_2)\rightarrow(Y,\tau_1^*,\tau_2^*)$ be a mapping. Then f is $fpsp$ closed and $fpsp$ continuous if and only if $f\left(\left(\tau_i,\tau_j\right)-pcl(\mu)\right)=\left(\tau_i^*,\tau_j^*\right)-\mathrm{scl}(f(\mu))$ for each fuzzy set μ on X.

Corollary 3.10. Let $f:(X,\tau_1,\tau_2)\rightarrow(Y,\tau_1^*,\tau_2^*)$ be a mapping. Then f is $fpsp$ open and $fpsp$ continous if and only if $f^{-1}(\left(\tau_i^*,\tau_j^*\right)-\mathrm{scl}(\vartheta))=\left(\tau_i,\tau_j\right)-pcl(f^{-1}(\mu))$ for each fuzzy set ϑ on Y.

Theorem 3.11. Let $(X,\tau_1,\tau_2),(Y,\sigma_1,\sigma_2),(Z,\omega_1,\omega_2)$ be fuzzy topological spaces. If $f:X\rightarrow Y$ is fuzzy pairwise strongly precontinuous [$fpsp$ continuous] mapping and $g:Y\rightarrow Z$ is fuzzy pairwise semicontinuous [fps continuous] mapping then $gof:X\rightarrow Z$ is fuzzy pairwise precontinuous [fpp continuous] mapping.

Concluding remark:

1. We have introduced and studied new kind of map fuzzy pairwise Strongly pr-econtinuos maps on fuzzy bitopological spaces.
2. We defined the relation between fuzzy pairwise pre continuous and fuzzy pairwise strongly continuous map. We investigated some of their properties.
3. We proved that the fuzzy pairwise storgly pre-continuous map is stronger form of fuzzy paqairwise pre-continuous map by use of example.
4. We have established some significant properties of fuzzy pairwise strogly pre-continuous maps.
5. We introduce and study new kind of fuzzy pairwise strongly pre-closed and investigate of their properties.

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