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DECOMPOSITIONS OF $M^{(1,2)*}$-CONTINUITY

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ABSTRACT

In this paper, we introduce and investigate the notions of α -sets, semi- open sets, pre-open sets. Then we also introduce the notions of α-continuous mappings, semi-open continuity. Using these concepts we Obtain decompositions of $M^{(1,2)*}$- continuity. Also we investigate some properties and characterizations of these kind of sets with some theorems, examples and counter examples.

INTRODUCTION

Njastad [29] introduced the concepts of an α-sets and Mashhour et al [26] introduced α-continuous mappings in topological spaces. The topological notions of semi-open sets and semi-continuity, and preopen sets and precontinuity were introduced by Levine [25] and Mashhour et al [27], respectively. The concepts of minimal structures (briefly m-structures) were developed by Popa and Noiri [35] in 2000. Kelly [24] introduced the notions of bitopological spaces. Such spaces are equipped with two arbitrary topologies. Lellis Thivagar [46] introduced weakly open sets called $\tau_{1,2}$-open sets in bitopological spaces. In this paper, we introduce $M^{(1,2)*}$-continuity and , and obtain their decompositions in biminimal spaces. At every places the new notions have been substantiated with suitable examples.

PRELIMINARIES

Definition 1.2.1

Let X be a nonempty set and $\wp$(X) the power set of X. A subfamily m_x of $\wp$(X) is called a **minimal structure** (briefly m-structure) on X if $\phi \in m_x$ and X $\in m_x$.

Definition 1.2.2

A set X together with two minimal structures m_x^1 and m_x^2 on X is called a **biminimal space** and is denoted by (X, m_x^1, m_x^2).

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Throughout this paper, (X, m_x^1, m_x^2) (or X) denote **biminimal** space.

Definition 1.2.3

Let S be a subset of X. Then S is said to be $m_x^{(1,2)*}$**-open** if S = A ∪ B where A ∈ m_x^1 and B ∈ m_x^2. We call $m_x^{(1,2)*}$ **-closed** set is the complement of $m_x^{(1,2)*}$-open.

The family of all $m_x^{(1,2)*}$-open subsets of (X, m_x^1, m_x^2) is denoted by $m_x^{(1,2)*}$-O(X).

Example 1.2.4

Let X = {a, b, c}, m_x^1 = {ϕ, X, {a}} and m_x^2 = {ϕ, X, {b}}. Then the sets in {ϕ, X, {a}, {b}, {a, b}} are called $m_x^{(1,2)*}$ **-open** and the sets in {ϕ, X, {b, c}, {a, c}, {c}} are called $m_x^{(1,2)*}$ **-closed.**

Definition 1.2.5

Let S be a subset of X. Then

(i) the $m_x^{(1,2)*}$-interior of S, denoted by $m_x^{(1,2)*}$ **-int(S)**, is defined by ∪ { F / F ⊆ S and F is $m_x^{(1,2)*}$-open};
(ii) the $m_x^{(1,2)*}$-closure of S, denoted by $m_x^{(1,2)*}$ **-cl(S)**, is defined by ∩ {F / S ⊆ F and F is $m_x^{(1,2)*}$-closed}.

Definition 1.2.6

Let S be a subset of X. Then S is said to be

(i) $m_x^{(1,2)*}$-**α-open** if S ⊆ $m_x^{(1,2)*}$-int($m_x^{(1,2)*}$-cl($m_x^{(1,2)*}$-int(S)));
(ii) $m_x^{(1,2)*}$-**semi-open** if S ⊆ $m_x^{(1,2)*}$-cl($m_x^{(1,2)*}$-int(S));
(iii) $m_x^{(1,2)*}$-**preopen** if S ⊆ $m_x^{(1,2)*}$-int($m_x^{(1,2)*}$-cl(S));
(iv) $m_x^{(1,2)*}$-**α-closed** if $m_x^{(1,2)*}$-cl($m_x^{(1,2)*}$-int($m_x^{(1,2)*}$-cl(S))) ⊆ S;
(v) $m_x^{(1,2)*}$-**preclosed** if $m_x^{(1,2)*}$-cl($m_x^{(1,2)*}$-int(S)) ⊆ S;
(vi) $m_x^{(1,2)*}$-**semi-closed** if $m_x^{(1,2)*}$-int($m_x^{(1,2)*}$-cl(S)) ⊆ S.

The family of all $m_x^{(1,2)*}$-**α-open** [resp. $m_x^{(1,2)*}$-semi-open, $m_x^{(1,2)*}$-preopen] subsets of X will be denoted by $m_x^{(1,2)*}$ **-αO(X)** [resp. $m_x^{(1,2)*}$-SO(X), $m_x^{(1,2)*}$-PO(X)].

Example 1.2.7

Let Y = {p, q, r}, m_y^1 = {ϕ, Y, {p}, {p, q}} and m_y^2 = {ϕ, Y, {q}}. Then the sets in {ϕ, Y, {p}, {q}, {p, q}} are called $m_y^{(1,2)*}$-open and the sets in {ϕ, Y, {r}, {q, r}, {p, r}} are called $m_y^{(1,2)*}$-closed. We have $m_y^{(1,2)*}$-αO(Y) = {ϕ, Y, {p}, {q}, {p, q}}; $m_y^{(1,2)*}$-SO(Y) = {ϕ, Y, {p}, {q}, {p, q}, {p, r}, {q, r}} and $m_y^{(1,2)*}$-PO(Y) = {ϕ, Y, {p}, {q}, {p, q}}.

Lemma 1.2.8

Let X be a non-empty set and m_x^1, m_x^2 minimal structures on X. For subsets A and B of X, the following properties hold:
(i)A ⊆ $m_x^{(1,2)*}$-cl(A) and $m_x^{(1,2)*}$-int(A) ⊆ A;
(ii)If A is $m_x^{(1,2)*}$-open then A = $m_x^{(1,2)*}$-int(A);
(iii)If A is $m_x^{(1,2)*}$-closed then A = $m_x^{(1,2)*}$-cl(A);
(iv)If A ⊆ B then $m_x^{(1,2)*}$-cl(A) ⊆ $m_x^{(1,2)*}$-cl(B);

(v)If $A \subseteq B$ then $m_x^{(1,2)*}$-int(A) $\subseteq$ $m_x^{(1,2)*}$-int(B);

(vi) $m_x^{(1,2)*}$-cl(X – A) = X – $m_x^{(1,2)*}$-int(A) and $m_x^{(1,2)*}$-int(X – A) = X – $m_x^{(1,2)*}$-cl(A);

(vii) $m_x^{(1,2)*}$-cl(ϕ) = ϕ = $m_x^{(1,2)*}$-int(ϕ) and $m_x^{(1,2)*}$-cl(X) = X = $m_x^{(1,2)*}$-int(X);

(viii) $m_x^{(1,2)*}$-cl($m_x^{(1,2)*}$-cl(A)) = $m_x^{(1,2)*}$-cl(A) and $m_x^{(1,2)*}$-int($m_x^{(1,2)*}$-int(A)) = $m_x^{(1,2)*}$-int(A).

Definition 1.2.9

A biminimal space (X, m_x^1, m_x^2) has the property [u] if the arbitrary union of $m_x^{(1,2)*}$-open sets is $m_x^{(1,2)*}$-open.
A biminimal space (X, m_x^1, m_x^2) has the property [I] if the any finite intersection of $m_x^{(1,2)*}$-open sets is $m_x^{(1,2)*}$-open.

Lemma 1.2.10

The following are equivalent for the biminimal space (X, m_x^1, m_x^2).

(i) (X, m_x^1, m_x^2) have property [u];

(ii) If $m_x^{(1,2)*}$-int(E) = E, then E $\in$ $m_x^{(1,2)*}$-O(X).

(iii) If $m_x^{(1,2)*}$-cl(F) = F, then F^c $\in$ $m_x^{(1,2)*}$-O(X).

CHARACTERIZATIONS

Definition 1.3.1

Let S be a subset of X. Then S is said to be

(i)**regular** $m_x^{(1,2)*}$**-open** if S = $m_x^{(1,2)*}$-int($m_x^{(1,2)*}$-cl(S)),

(ii) $m_x^{(1,2)*}$**-semi-regular** if it is **both** $m_x^{(1,2)*}$**-semi-open** and $m_x^{(1,2)*}$**-semi-closed.**

The family of all $m_x^{(1,2)*}$-semi-closed [resp. regular $m_x^{(1,2)*}$-open] sets of X is denoted by $m_x^{(1,2)*}$**-SC(X)** [resp. $m_x^{(1,2)*}$-RO(X)].

The intersection of all $m_x^{(1,2)*}$-semi-closed sets of X containing a subset S of X is called the $m_x^{(1,2)*}$**-semi-closure** of S and is denoted by $m_x^{(1,2)*}$**-scl(S).**

Remark 1.3.2

A subset S of X is $m_x^{(1,2)*}$-semi-closed if and only if $m_x^{(1,2)*}$-scl(S) = S.

Definition 1.3.3

A subset S of X is said to be $m_x^{(1,2)*}$-semi-generalized closed (briefly $m_x^{(1,2)*}$-**sg-closed**) if and only if $m_x^{(1,2)*}$-scl(S) $\subseteq$ F whenever S $\subseteq$ F and F is $m_x^{(1,2)*}$-semi-open set.
The complement of $m_x^{(1,2)*}$-sg-closed set is $m_x^{(1,2)*}$-sg-open.

Example 1.3.4

Let X = {a, b, c}, m_x^1 = {ϕ, X, {a}} and m_x^2 = {ϕ, X}. Then the sets in {ϕ, X, {a}} are called $m_x^{(1,2)*}$-open and the sets in {ϕ, X, {b, c}} are called $m_x^{(1,2)*}$-closed. Also, the sets in {ϕ, X, {b}, {c}, {b, c}} are called $m_x^{(1,2)*}$-sg-closed.

Definition 1.3.5

A subset S of X is said to **be locally** $m_x^{(1,2)*}$**-closed** if S = M $\cap$ N, where M is $m_x^{(1,2)*}$-open and N is $m_x^{(1,2)*}$-closed.

Remark 1.3.6

Every $m_x^{(1,2)*}$-closed set is $m_x^{(1,2)*}$-α-closed but not conversely.

Example 1.3.7

Let X = {a, b, c, d}, m_x^1 = {ϕ, X, {a}, {a, b}} and m_x^2 = {ϕ, X, {a, c}}. Then the sets in {ϕ, X, {a}, {a, b}, {a, c}, {a, b, c}} are called $m_x^{(1,2)*}$-open and the sets in {ϕ, X, {d}, {b, d}, {c, d}, {b, c, d}} are called $m_x^{(1,2)*}$-closed. We have {c} is $m_x^{(1,2)*}$-α-closed set but not $m_x^{(1,2)*}$-closed. Also, the sets in {ϕ, X, {a}, {b}, {c}, {d}, {a, b}, {a, c}, {b, c}, {b, d}, {c, d}, {a, b, c}, {b, c, d}} are called locally $m_x^{(1,2)*}$-closed.

Proposition 1.3.8

Every $m_x^{(1,2)*}$-closed set is locally $m_x^{(1,2)*}$-closed.

Proof

S = X ∩ S where X is $m_x^{(1,2)*}$-open and S is $m_x^{(1,2)*}$-closed. Thus S is locally $m_x^{(1,2)*}$-closed.

Example 1.3.9

The converse of Proposition 1.3.8 is not true in general.
Consider the Example 1.3.7 we have {a} is locally $m_x^{(1,2)*}$-closed but not $m_x^{(1,2)*}$-closed.

Proposition 1.3.10

A subset S of X is $m_x^{(1,2)*}$-α-closed if and only if S is $m_x^{(1,2)*}$-semi-closed and $m_x^{(1,2)*}$-pre closed.

Proof

Let S be $m_x^{(1,2)*}$-α-closed. Then $m_x^{(1,2)*}$-cl($m_x^{(1,2)*}$-int($m_x^{(1,2)*}$-cl(S))) ⊆ S. Hence $m_x^{(1,2)*}$-int($m_x^{(1,2)*}$-cl(S)) ⊆ $m_x^{(1,2)*}$-cl($m_x^{(1,2)*}$-int($m_x^{(1,2)*}$-cl(S))) ⊆ S. Thus S is $m_x^{(1,2)*}$-semi-closed. Also $m_x^{(1,2)*}$-cl($m_x^{(1,2)*}$-int(S)) ⊆ $m_x^{(1,2)*}$-cl($m_x^{(1,2)*}$-int($m_x^{(1,2)*}$-cl(S))) ⊆ S. Thus S is $m_x^{(1,2)*}$-preclosed. Conversely, let S be $m_x^{(1,2)*}$-semi-closed and $m_x^{(1,2)*}$-preclosed. Since S is $m_x^{(1,2)*}$-semi-closed, $m_x^{(1,2)*}$-int($m_x^{(1,2)*}$-cl(S)) ⊆ S implies $m_x^{(1,2)*}$-int($m_x^{(1,2)*}$-int($m_x^{(1,2)*}$-cl(S))) ⊆ $m_x^{(1,2)*}$-int(S). We have $m_x^{(1,2)*}$-int($m_x^{(1,2)*}$-cl(S)) ⊆ $m_x^{(1,2)*}$-int(S) which implies $m_x^{(1,2)*}$-cl($m_x^{(1,2)*}$-int($m_x^{(1,2)*}$-cl(S))) ⊆ $m_x^{(1,2)*}$-cl($m_x^{(1,2)*}$-int(S)) ⊆ S, as S is $m_x^{(1,2)*}$-preclosed. Hence S is $m_x^{(1,2)*}$-α-closed.

Example 1.3.11

A $m_x^{(1,2)*}$-semi-closed or $m_x^{(1,2)*}$-preclosed set need not be $m_x^{(1,2)*}$-α-closed.

(i) Let X = {a, b, c}, m_x^1 = {ϕ, X, {a}} and m_x^2 = {ϕ, X, {b}}. Then the sets in {ϕ, X, {a}, {b}, {a, b}} are called $m_x^{(1,2)*}$-open and the sets in {ϕ, X, {b, c}, {a, c}, {c}} are called $m_x^{(1,2)*}$-closed. We have

(1) $m_x^{(1,2)*}$-αO(X) = {ϕ, X, {a}, {b}, {a, b}};
(2) $m_x^{(1,2)*}$-SO(X) = {ϕ, X, {a}, {b}, {a, b}, {a, c}, {b, c}}.

Therefore {b} is $m_x^{(1,2)*}$-semi-closed but not $m_x^{(1,2)*}$-α-closed.
(ii) Let X = {a, b, c}, m_x^1 = {ϕ, X, {b, c}} and m_x^2 = {ϕ, X, {a, b}}. Then the sets in {ϕ, X, {b, c}, {a, b}} are called $m_x^{(1,2)*}$-open and the sets in {ϕ, X, {a}, {c}} are called $m_x^{(1,2)*}$-closed. We have

(1) $m_x^{(1,2)*}$-αO(X) = $m_x^{(1,2)*}$-SO(X) = {ϕ, X, {a, b}, {b, c}};

(2) $m_x^{(1,2)*}$-PO(X) = {ϕ, X, {b}, {a, b}, {b, c}, {a, c}}.

Therefore {b} is $m_x^{(1,2)*}$-preclosed but not $m_x^{(1,2)*}$-α-closed.

Proposition 1.3.12

A $m_x^{(1,2)*}$-semi-closed set is $m_x^{(1,2)*}$-sg-closed.

Proof

Let S be $m_x^{(1,2)*}$-semi-closed. Then $m_x^{(1,2)*}$-scl(S) = S ⊆ G where S ⊆ G and G is $m_x^{(1,2)*}$-semi-open. Thus S is $m_x^{(1,2)*}$-sg-closed.

Remark 1.3.13

A $m_x^{(1,2)*}$-sg-closed set need not be $m_x^{(1,2)*}$-semi-closed.
Consider the Example 1.3.11 (ii). We have {a, c} is $m_x^{(1,2)*}$-sg-closed but not $m_x^{(1,2)*}$-semi-closed.

Proposition 1.3.14

A $m_x^{(1,2)*}$-closed set is $m_x^{(1,2)*}$-sg-closed.

Proof

Let S be $m_x^{(1,2)*}$-closed. Then S is $m_x^{(1,2)*}$-α-closed and also by Proposition 1.3.10., S is $m_x^{(1,2)*}$-semi-closed. Moreover, by Proposition 1.3.12, S is $m_x^{(1,2)*}$-sg-closed.

Remark 1.3.15

The converse of Proposition 1.3.14 is not true in general.
Consider the Example 1.3.4, {c} is $m_x^{(1,2)*}$-sg-closed but not $m_x^{(1,2)*}$-closed.

Proposition 1.3.16

Let (X, m_x^1, m_x^2) have property [u]. Then any regular $m_x^{(1,2)*}$-open set is $m_x^{(1,2)*}$-open.

Proof

Let S be regular $m_x^{(1,2)*}$-open. Since S = $m_x^{(1,2)*}$-int($m_x^{(1,2)*}$-cl(S)), $m_x^{(1,2)*}$-int(S) = $m_x^{(1,2)*}$-int($m_x^{(1,2)*}$-cl(S)). We have S = $m_x^{(1,2)*}$-int(S). Thus, by Lemma 1.2.10, S is $m_x^{(1,2)*}$-open.

Remark 1.3.17

The converse of Proposition 1.3.16 is not true in general.
Consider the Example 1.3.4, {a} is $m_x^{(1,2)*}$-open but not regular $m_x^{(1,2)*}$-open.

Proposition 1.3.18

Every regular $m_x^{(1,2)*}$-open set is $m_x^{(1,2)*}$-semi-closed.

Proof

Let S be regular $m_x^{(1,2)*}$-open. Then S = $m_x^{(1,2)*}$-int($m_x^{(1,2)*}$-cl(S)). We have $m_x^{(1,2)*}$-int($m_x^{(1,2)*}$-cl(S)) $\subseteq$ S. Thus S is $m_x^{(1,2)*}$-semi-closed.

Proposition 1.3.19

Let (X, m_x^1, m_x^2) have property [𝔲]. Then every regular $m_x^{(1,2)*}$-open set is $m_x^{(1,2)*}$-semi-regular.

Proof

Let S be regular $m_x^{(1,2)*}$-open. Then by Proposition 1.3.18., S is $m_x^{(1,2)*}$-semi-closed and also by Proposition 1.3.16., S is $m_x^{(1,2)*}$-open (and so S is $m_x^{(1,2)*}$-semi-open). Hence S is both $m_x^{(1,2)*}$-semi-open and $m_x^{(1,2)*}$-semi-closed. Thus S is $m_x^{(1,2)*}$-semi-regular.

Remark 1.3.20

Every $m_x^{(1,2)*}$-semi-regular set is $m_x^{(1,2)*}$-semi-closed but not conversely.

Example 1.3.21

Let X = {a, b, c}, m_x^1 = {ϕ, X, {a}} and m_x^2 = {ϕ, X, {b}}. Then the sets in {ϕ, X, {a}, {b}, {a, b}} are called $m_x^{(1,2)*}$-open and the sets in {ϕ, X, {b, c}, {a, c}, {c}} are called $m_x^{(1,2)*}$-closed. We have

$m_x^{(1,2)*}$-αO(X) = $m_x^{(1,2)*}$-PO(X) = {ϕ, X, {a}, {b}, {a, b}};
$m_x^{(1,2)*}$-SO(X) = {ϕ, X, {a}, {b}, {a, b}, {a, c}, {b, c}};
$m_x^{(1,2)*}$-SC(X) = {ϕ, X, {a}, {b}, {c}, {a, c}, {b, c}} and
$m_x^{(1,2)*}$-RO(X) = {ϕ, X, {a}, {b}}.
We have {c} is $m_x^{(1,2)*}$-semi-closed but not $m_x^{(1,2)*}$-semi-regular.

Remark 1.3.22

$m_x^{(1,2)*}$-α-closed sets and regular $m_x^{(1,2)*}$-open sets are independent of each other.
Consider the Example 1.3.4. We have {c} is $m_x^{(1,2)*}$-α-closed but not regular $m_x^{(1,2)*}$-open and Consider the Example 1.3.21. We have {a} is regular $m_x^{(1,2)*}$-open but not $m_x^{(1,2)*}$-α-closed.

Remark 1.3.23

$m_x^{(1,2)*}$-preclosed sets and $m_x^{(1,2)*}$-open sets are independent of each other.
Consider the Example 1.3.21. We have {c} is $m_x^{(1,2)*}$-preclosed but not $m_x^{(1,2)*}$-open and {a} is $m_x^{(1,2)*}$-open but not $m_x^{(1,2)*}$-preclosed.

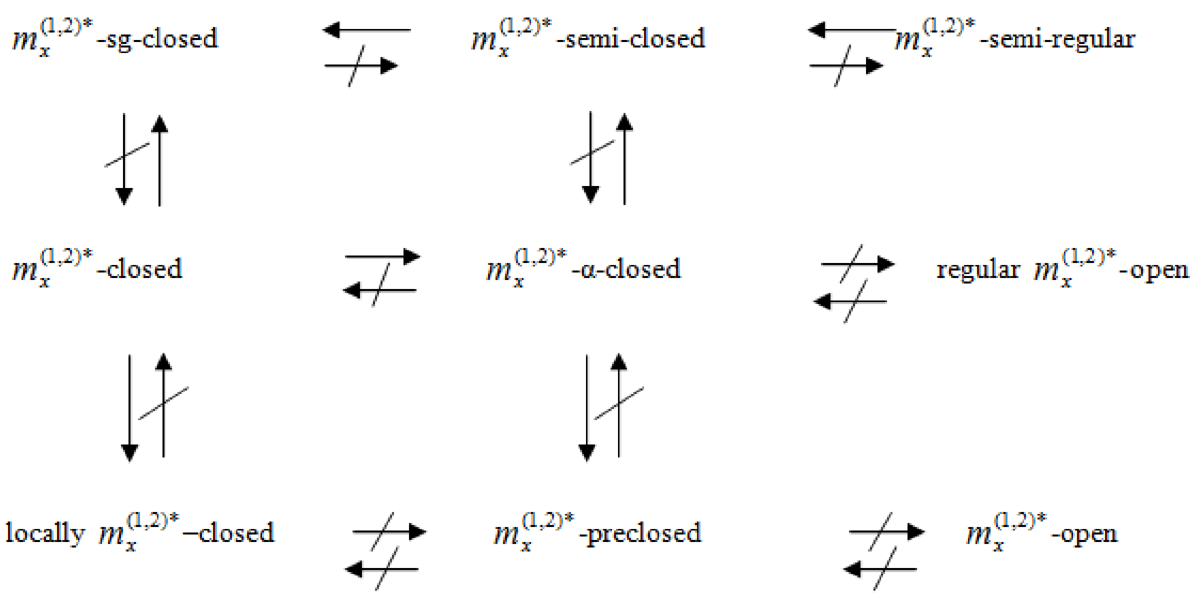
Remark 1.3.24

Locally $m_x^{(1,2)*}$-closed sets and $m_x^{(1,2)*}$-preclosed sets are independent of each other.

Consider the Example 1.3.21. We have {a} is locally $m_x^{(1,2)*}$-closed but not $m_x^{(1,2)*}$-preclosed and Consider the Example 1.3.11 (ii). We have {b} is $m_x^{(1,2)*}$-preclosed but not locally $m_x^{(1,2)*}$-closed.

Remark 1.3.25

By the previous Propositions, Examples and Remarks, we obtain the following diagram where $A \rightarrow B$ means A implies B but B does not imply A and $A \nleftrightarrow B$ means A and B are independent.



DECOMPOSITION OF $M^{(1,2)*}$-CONTINUITY

Proposition 1.4.1

Let (X, m_x^1, m_x^2) have property [I]. Let S be a subset of X such that $m_x^{(1,2)*}$-cl(S) □ $m_x^{(1,2)*}$-O(X). Then the following are equivalent.

(i)S is $m_x^{(1,2)*}$-open.

(ii)S is an $m_x^{(1,2)*}$-α-open and locally $m_x^{(1,2)*}$-closed.

Proof.

(i) $\Longrightarrow$ (ii):

Let S be an $m_x^{(1,2)*}$-open. Then S is $m_x^{(1,2)*}$-α-open. Also $S = X \cap S$ where S is $m_x^{(1,2)*}$-open and X is $m_x^{(1,2)*}$-closed. Thus S is locally $m_x^{(1,2)*}$-closed.

(ii) $\Longrightarrow$ (i):

Let S be $m_x^{(1,2)*}$-α-open and locally $m_x^{(1,2)*}$-closed. Since S is $m_x^{(1,2)*}$-preopen, $S \subseteq m_x^{(1,2)*}$-int($m_x^{(1,2)*}$-cl(S)). Since S is locally $m_x^{(1,2)*}$-closed, $S = U \cap m_x^{(1,2)*}$-cl(S) where U is $m_x^{(1,2)*}$-open. Also $S = U \cap m_x^{(1,2)*}$-cl(S) $\cap$ U = U $\cap$ S $\subseteq$ U $\cap$ $m_x^{(1,2)*}$-int($m_x^{(1,2)*}$-cl(S)) $\subseteq$ U $\cap$ $m_x^{(1,2)*}$-cl(S) = $m_x^{(1,2)*}$-int(U $\cap$ $m_x^{(1,2)*}$-cl(S)) = $m_x^{(1,2)*}$-int(S). We have S $\subseteq$ $m_x^{(1,2)*}$-int(S). But $m_x^{(1,2)*}$-int(S) $\subseteq$ S. Hence S is $m_x^{(1,2)*}$-open.

Definition 1.4.2 [51]

A function $f : X \longrightarrow Y$ is said to be

(i) $M^{(1,2)*}$-continuous if $f^{-1}(V)$ is $m_x^{(1,2)*}$-open in X for every $m_y^{(1,2)*}$- open subset V of Y.

(ii) $M^{(1,2)*}$-α-continuous if $f^{-1}(V)$ is an $m_x^{(1,2)*}$-α-open in X for every $m_y^{(1,2)*}$-open subset V of Y.

We introduce a new function as follows:

Definition 1.4.3

A function f : X $\longrightarrow$ Y is said to be $M^{(1,2)*}$-LC continuous if f^{-1}(V) is a locally $m_x^{(1,2)*}$-closed in X for every $m_y^{(1,2)*}$-open subset V of Y.

Theorem 1.4.4

Assume that the $m_x^{(1,2)*}$-closure of any subset of X is $m_x^{(1,2)*}$-open. Let f : X $\longrightarrow$ Y be a function where X has property [I]. Then the following are equivalent.

(i)f is $M^{(1,2)*}$-continuous.
(ii)f is $M^{(1,2)*}$-α-continuous and $M^{(1,2)*}$-LC continuous.

Proof

It is a decomposition of $M^{(1,2)*}$-continuity from Proposition 1.4.1.

Conclusion

Though the concept of biminimal spaces has been identified as a difficult territory in Mathematics, we have taken it up as a challenge and cherishingly worked out this study. Moreover it also has applications in some important fields of Science and Technology. Hence, most of the results in this paper can be extended to Fuzzy biminimal topology also. This study would open up the academic flood gates and new vistas in the fields of biminimal spaces and fuzzy biminimal spaces including fuzzy biminimal ideal spaces for further research studies.

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