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SUPRA B-M$_I$-CONTINUOUS AND SUPRA *B-M$_I$-CONTINUOUS MAPS IN SUPRA TOPOLOGICAL SPACES

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Abstract:
The aim of this paper is to introduce and investigate a new class of continuous and irresolute mapping in supra topological spaces namely supra b-m$_i$-continuous, supra $^*b$-m$_i$-continuous, supra b-m$_i$-irresolute and supra $^*b$-m$_i$-irresolute maps using supra b-m$_i$-closed and supra $^*b$-m$_i$-closed sets and also studied some of its properties.

Keywords: Supra b-m$_i$-closed, supra $^*b$-m$_i$-closed, b-m$_i$-continuous, supra $^*b$-m$_i$-continuous, supra b-m$_i$-irresolute, supra $^*b$-m$_i$-irresolute.

1. Introduction:

In 1970, Levine [8] introduced the concept of generalized closed sets which formed a strong tool in the characterization of topological spaces. Andrijevic[1] derived a new class of generalized open sets in a topological space, the so called b- open sets. In 1983, Mashhour et al. [9] introduced supra topological spaces. In 2010, O.R. Sayed and Takashi Noiri [13] formulated the concept of supra b-open sets and supra b-continuity on topological spaces. In 2011, I. Arockiarani and M. Trinita Pricilla introduced $g^\mu b$-closed[3], $g^\mu br$-closed[4], T^μ-closed[5], $g^\mu b$-continuous[2], $g^\mu br$-continuous[2], T^μ-continuous[5] sets in supra topological spaces. F. Nakaoka and N. Oda[10] derived some applications of minimal open sets. Suwarnlatha Banasode and Mandakini Desurkar[14] introduced generalized minimal continuous maps in topological spaces. In this paper we use the notion of supra b-m$_i$-closed and supra $^*b$-m$_i$-closed sets and introduce supra b-m$_i$-continuous, supra $^*b$-m$_i$-continuous, supra b-m$_i$-irresolute and supra $^*b$-m$_i$-irresolute maps and their properties are derived. Also we investigated the relationship with the other continuous and irresolute maps in supra topological spaces.

2. Preliminaries:

Definition 2.1:[9] A subfamily μ of X is said to be a supra topology on X if

i) $X, \phi \in \mu$

ii) If $A_i \in \mu$ for all $i \in J$, then $\cup A_i \in \mu$. (X, μ) is called supra topological space. The elements of μ are called supra open sets in (X, μ) and complement of supra open set is called supra closed set and it is denoted by μ^c.

Definition 2.2:[9] The supra closure and supra interior of a set *A* are defined as

$$cl^{\mu}(A) = \cap\{B : B \text{ is supra closed and } A \subseteq B\}$$
$$\operatorname{int}^{\mu}(A) = \cup\{B : B \text{ is supra open and } A \supseteq B\}$$

Definition 2.3:[13] Let (X,μ) be a supra topological space. A set *A* is called a supra b-open set if $A \subseteq cl^{\mu}(\operatorname{int}^{\mu}(A)) \cup \operatorname{int}^{\mu}(cl^{\mu}(A))$. The complement of a supra b-open set is called supra b-closed set.

Definition 2.4:[3] Let (X,μ) be supra topological space. A set *A* of (X,μ) is called supra generalized b-closed set (simply $g^{\mu}b$-closed) if $bcl^{\mu}(A) \subseteq U$ whenever $A \subseteq U$ and *U* is supra open. The complement of supra generalized b- closed set is supra generalized b-open set.

Definition 2.5:[4] A subset *A* of a supra topological space (X,μ) is called supra generalized b-regular closed set (simply $g^{\mu}br$-closed) if $bcl^{\mu}(A) \subseteq U$ whenever $A \subseteq U$ and *U* is supra regular open. The complement of supra generalized b-regular closed set is supra generalized b-regular open set.

Definition 2.6:[5] A subset *A* of (X,μ) is called T^{μ}-closed set if $bcl^{\mu}(A) \subseteq U$ whenever $A \subseteq U$ and *U* is supra $g^{\mu}b$-open in (X,μ). The complement of T^{μ}-closed set is called T^{μ}-open set.

Definition 2.7:[2] A mapping $f:(X,\mu_1) \to (Y,\mu_2)$ is said to be $g^{\mu}b$-continuous if $f^{-1}(V)$ is $g^{\mu}b$-closed in *X* for every supra closed set *V* of *Y*.

Definition 2.8:[2] A mapping $f:(X,\mu_1) \to (Y,\mu_2)$ is said to be $g^{\mu}br$-continuous if $f^{-1}(V)$ is $g^{\mu}br$-closed in *X* for every supra closed set *V* of *Y*.

Definition 2.9:[5] A mapping $f:(X,\mu_1) \to (Y,\mu_2)$ is said to be T^{μ}-continuous if $f^{-1}(V)$ is T^{μ}-closed in *X* for every supra closed set *V* of *Y*.

Definition 2.10: A proper nonempty subset *A* of a topological space (X,τ) is called

i) A minimal open[10] (minimal closed[12]) set is any open (resp.closed) subset of *X* which is contained in *A*, is either *A* or ϕ.
ii) A maximal open[11] (maximal closed[12]) set is any open (resp.closed) set which contains *A*, is either *A* or *X*.

Definition 2.11:[14] A mapping $f:(X,\tau) \to (Y,\sigma)$ is called minimal continuous map if the inverse image of every minimal open (or minimal closed) set in *Y* is open (or closed) set in *X*.

Definition 2.12:[14] A mapping $f:(X,\tau)\rightarrow(Y,\sigma)$ is called maximal continuous map if the inverse image of every maximal open (or maximal closed) set in *Y* is open (or closed) set in *X*.

Definition 2.13:[14] A mapping $f:(X,\tau)\rightarrow(Y,\sigma)$ is called minimal irresolute map if the inverse image of every minimal open (or minimal closed) set in *Y* is minimal open (or minimal closed) set in *X*.

Definition 2.14:[14] A mapping $f:(X,\tau)\rightarrow(Y,\sigma)$ is called maximal irresolute map if the inverse image of every maximal open (or maximal closed) set in *Y* is maximal open (or maximal closed) set in *X*.

Definition 2.15:[6] For any subset *A* of a topological space (X,τ), is defined to be the intersection of all the g-closed sets containing *A* in a topological space (X,τ).

Definition 2.16:[7] A subset *A* of a supra topological space (X,μ) is called supra b-m$_i$-closed if $bcl^{\mu}(A)\subseteq U$ whenever $A\subseteq U$ and *U* is supra m$_i$-open set in (X,μ).

Definition 2.17:[7] A subset *A* of a supra topological space (X,μ) is called supra $^{*}b$-m$_i$-closed if $bcl^{\mu}(A)\subseteq U$ whenever $A\subseteq U$ and *U* is supra m$_i$-b open set in (X,μ).

3. Supra b-m$_i$-continuous and supra *b-m$_i$-continuous maps:

Definition 3.1: A mapping $f:(X,\mu_1)\rightarrow(Y,\mu_2)$ is called supra minimal continuous map if the inverse image of every supra minimal open (or supra minimal closed) set in *Y* is supra open (or supra closed) set in *X*.

Definition 3.2: A mapping $f:(X,\mu_1)\rightarrow(Y,\mu_2)$ is called supra maximal continuous map if the inverse image of every supra maximal open (or supra maximal closed) set in *Y* is supra open (or supra closed) set in *X*.

Definition 3.3: A mapping $f:(X,\mu_1)\rightarrow(Y,\mu_2)$ is called supra b minimal continuous (briefly supra b-m$_i$-continuous) map if the inverse image of every supra minimal closed set in *Y* is supra b-m$_i$-closed set in *X*.

Definition 3.4: A mapping $f:(X,\mu_1)\rightarrow(Y,\mu_2)$ is called supra $^{*}b$ minimal continuous (briefly supra $^{*}b$-m$_i$-continuous) map if the inverse image of every supra minimal closed set in *Y* is supra $^{*}b$-m$_i$-closed set in *X*.

Definition 3.5: A mapping $f:(X,\mu_1)\rightarrow(Y,\mu_2)$ is called supra minimal T continuous (briefly m$_i$-T^{μ}-continuous) map if the inverse image of every supra minimal open set in *Y* is T^{μ}-open set in *X*.

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Definition 3.6: A mapping $f:(X,\mu_1)\to(Y,\mu_2)$ is called supra maximal T continuous (briefly m_a-T^μ-continuous) map if the inverse image of every supra maximal open set in Y is T^μ-open set in X.

Definition 3.7: A mapping $f:(X,\mu_1)\to(Y,\mu_2)$ is called minimal $g^\mu b$ continuous (briefly m_i-$g^\mu b$-continuous) map if the inverse image of every supra minimal open set in Y is $g^\mu b$-open set in X.

Definition 3.8: A mapping $f:(X,\mu_1)\to(Y,\mu_2)$ is called maximal $g^\mu b$ continuous (briefly m_a-$g^\mu b$-continuous) map if the inverse image of every supra maximal open set in Y is $g^\mu b$-open set in X.

Definition 3.9: A mapping $f:(X,\mu_1)\to(Y,\mu_2)$ is called minimal $g^\mu br$ continuous (briefly m_i-$g^\mu br$-continuous) map if the inverse image of every supra minimal open set in Y is $g^\mu br$-open set in X.

Definition 3.10: A mapping $f:(X,\mu_1)\to(Y,\mu_2)$ is called maximal $g^\mu br$ continuous (briefly m_a-$g^\mu br$-continuous) map if the inverse image of every supra maximal open set in Y is $g^\mu br$-open set in X.

Theorem 3.11: Every supra $^*b$-m_i-continuous is m_a-T^μ-continuous.

Proof: Let $f:(X,\mu_1)\to(Y,\mu_2)$ be any supra $^*b$-m_i-continuous map and U be any supra maximal open set in Y then U^c is minimal closed set in Y. Therefore $f^{-1}(U^c)$ is supra $^*b$-m_i-closed set in X. As every supra $^*b$-m_i-closed set is T^μ-closed, $f^{-1}(U^c)=\left[f^{-1}(U)\right]^c$ is T^μ-closed set in X. Hence f is m_a-T^μ-continuous.

Theorem 3.12:

- i) Every supra b-m_i-continuous is m_a-T^μ-continuous.
- ii) Every supra b-m_i-continuous is m_a-$g^\mu b$-continuous.
- iii) Every supra $^*b$-m_i-continuous is m_a-$g^\mu b$-continuous.
- iv) Every supra b-m_i-continuous is m_a-$g^\mu br$-continuous.
- v) Every supra $^*b$-m_i-continuous is m_a-$g^\mu br$-continuous.
- vi) Every supra $^*b$-m_i-continuous is supra b-m_i-continuous.

Proof: The proof is similar to theorem 3.11.

From the above theorems we have the following diagrammatic representation.

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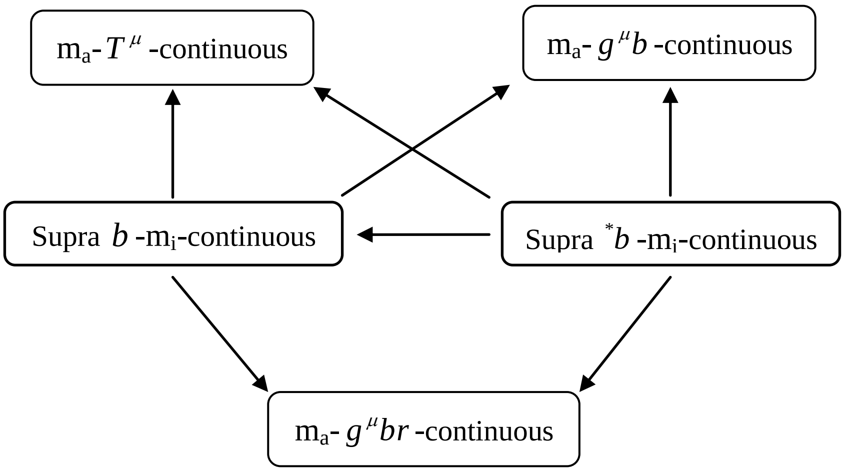

Theorem 3.13:

i) If $f:(X,\mu_1)\to(Y,\mu_2)$ is any supra mapping. Then the following statements are equivalent.
   a) f is supra b-m_i-continuous map.
   b) The inverse image of every supra maximal open set in Y is supra b-m_a-open set in X.
   c) For each $x\in X$ and each supra maximal open set N in Y containing $f(x)$, there exists supra b-m_a-open set M containing x in X such that $f(M)\subseteq N$.

ii) If $f:(X,\mu_1)\to(Y,\mu_2)$ is supra b-m_i-continuous map, then for every subset A of X, $f[cl^{*\mu}(A)]\subseteq cl^{\mu}[f(A)]$.

iii) If $f:(X,\mu_1)\to(Y,\mu_2)$ is supra b-m_i-continuous map, then for every subset B of Y, $cl^{*\mu}[f^{-1}(B)]\subseteq f^{-1}[cl^{\mu}(B)]$.

Proof:

i) (a)$\Rightarrow$(b): Let N be any supra maximal open set in Y. Then N^c is minimal closed set in Y. By (a) $f^{-1}(N^c)=[f^{-1}(N)]^c$ is supra b-m_i-closed set in X. It follows that $f^{-1}(N)$ is supra b-m_a-open set in X.

(b)$\Rightarrow$(c): For each $x\in X$, let N be any supra maximal open set in Y containing $f(x)$. So $x\in f^{-1}(N)$ and by (b) $f^{-1}(N)$ is supra b-m_a-open set in X. Let $f^{-1}(N)=M$. Then $f(M)=f[f^{-1}(N)]\subseteq N$ which implies that $f(M)\subseteq N$.

(c)$\Rightarrow$(a): For each $x\in X$, let N be any supra maximal open set in Y containing $f(x)$. Then N^c is supra minimal closed set in Y. By (c) there exists a supra b-m_a-open set M such that

$f(M) \subseteq N$. Then $f(M) = f[f^{-1}(N)] \subseteq N$. Then $M = f^{-1}(N)$ is a supra b-m$_a$-open set in *X*. Therefore $[f^{-1}(N)]^c = f^{-1}(N^c)$ is supra b-m$_i$-closed set in *X*. Hence f is supra b-m$_i$-continuous map.

ii) Let $f:(X,\mu_1)\rightarrow(Y,\mu_2)$ is supra b-m$_i$-continuous map such that for any $A \subseteq X$. Let $y \in f[cl^{*\mu}(A)]$. Let N be supra maximal open set in *Y* containing y. Then there exists a point $x \in X$ and a supra b-m$_a$-open set *M* such that $y = f(x) \in f[cl^{*\mu}(A)]$. So $x \in cl^{*\mu}(A)$ and $f(M) \subseteq N$. Here M is a supra b-neighborhood of x. Since $x \in cl^{*\mu}(A)$, $A \cap M \neq \phi$ holds and hence $f(A \cap M) = f(A) \cap f(M) = f(A) \cap N \neq \phi$. Therefore $y = f(x) \in f(A) \subseteq cl^{\mu}[f(A)]$. Hence $f[cl^{*\mu}(A)] \subseteq cl^{\mu}[f(A)]$ for every subset *A* of *X*.

iii) Let $f:(X,\mu_1)\rightarrow(Y,\mu_2)$ is supra b-m$_i$-continuous map and *B* be any subset of *Y*. Then $f(B) \subseteq X$. Putting $A = f^{-1}(B)$ in (ii) above, we get $f[cl^{*\mu}(f^{-1}(B))] \subseteq cl^{\mu}[f(f^{-1}(B))]$. Therefore $cl^{*\mu}[f^{-1}(B)] \subseteq f^{-1}[cl^{\mu}(B)]$.

Theorem 3.14:

i) If $f:(X,\mu_1)\rightarrow(Y,\mu_2)$ is any supra mapping. Then the following statements are equivalent.
   a) f is supra $^*b$-m$_i$-continuous map.
   b) The inverse image of every supra maximal open set in *Y* is supra $^*b$-m$_a$-open set in *X*.
   c) For each $x \in X$ and each supra maximal open set *N* in *Y* containing $f(x)$, there exists supra $^*b$-m$_a$-open set *M* containing x in *X* such that $f(M) \subseteq N$.

ii) If $f:(X,\mu_1)\rightarrow(Y,\mu_2)$ is supra $^*b$-m$_i$-continuous map, then for every subset *A* of *X*, $f[cl^{*\mu}(A)] \subseteq cl^{\mu}[f(A)]$.

iii) If $f:(X,\mu_1)\rightarrow(Y,\mu_2)$ is supra $^*b$-m$_i$-continuous map, then for every subset *B* of *Y*, $cl^{*\mu}[f^{-1}(B)] \subseteq f^{-1}[cl^{\mu}(B)]$.

Proof: The proof is similar to theorem 3.13.

Remark 3.15: The composition of two supra b-m$_i$-continuous(supra $^*b$-m$_i$-continuous) maps need not be supra b-m$_i$-continuous(supra $^*b$-m$_i$-continuous).

Definition 3.16: A mapping $f:(X,\mu_1)\rightarrow(Y,\mu_2)$ is called supra minimal irresolute map if the inverse image of every supra minimal open (or supra maximal closed) set in *Y* is supra minimal open (or supra maximal closed) set in *X*.

Definition 3.17: A mapping $f:(X,\mu_1)\to(Y,\mu_2)$ is called supra maximal irresolute map if the inverse image of every supra maximal open (or supra minimal closed) set in *Y* is supra maximal open (or supra minimal closed) set in *X*.

Definition 3.18: A mapping $f:(X,\mu_1)\to(Y,\mu_2)$ is called supra b minimal irresolute (briefly supra b-m$_i$-irresolute) map if the inverse image of every supra b-m$_i$-closed set in *Y* is supra b m$_i$-closed set in *X*.

Definition 3.19: A mapping $f:(X,\mu_1)\to(Y,\mu_2)$ is called supra $^*b$ minimal irresolute (briefly supra $^*b$-m$_i$-irresolute) map if the inverse image of every supra $^*b$-m$_i$-closed set in *Y* is supra $^*b$-m$_i$-closed set in *X*.

Theorem 3.20:

i) Every supra b-m$_i$-irresolute mapping is supra b-m$_i$-continuous.

ii) Every supra $^*b$-m$_i$-irresolute mapping is supra $^*b$-m$_i$-continuous.

Proof: It is obvious.

Theorem 3.21: If $f:(X,\mu_1)\to(Y,\mu_2)$ is supra b-m$_i$-continuous map and $h:(Y,\mu_2)\to(Z,\mu_3)$ is supra maximal irresolute map, then $h\circ f:(X,\mu_1)\to(Z,\mu_3)$ is supra b-m$_i$-continuous map.

Proof: Let N be supra minimal closed set in *Z*. Then N^c is supra maximal open set in *Z*. Since $h:(Y,\mu_2)\to(Z,\mu_3)$ is supra maximal irresolute map, $h^{-1}(N^c)=[h^{-1}(N)]^c$ is supra maximal open set in *Y*. Therefore $h^{-1}(N)$ is supra minimal closed set in *Y*. But $f:(X,\mu_1)\to(Y,\mu_2)$ is supra b-m$_i$-continuous map. Therefore $f^{-1}[h^{-1}(N)]=(h\circ f)^{-1}(N)$ is supra b-m$_i$-closed set in *X*. Hence $h\circ f:(X,\mu_1)\to(Z,\mu_3)$ is supra b-m$_i$-continuous map.

Theorem 3.22: If $f:(X,\mu_1)\to(Y,\mu_2)$ is supra $^*b$-m$_i$-continuous map and $h:(Y,\mu_2)\to(Z,\mu_3)$ is supra maximal irresolute map, then $h\circ f:(X,\mu_1)\to(Z,\mu_3)$ is supra $^*b$-m$_i$-continuous map.

Proof: It is similar to theorem 3.21.

Theorem 3.23:

i) If $f:(X,\mu_1)\to(Y,\mu_2)$ is any supra mapping. Then the following statements are equivalent.
   a) f is supra b-m$_i$-irresolute map.

b) The inverse image of every supra b-m$_a$-open set in Y is supra b-m$_a$-open set in X.
c) For each $x \in X$ and each supra b-m$_a$-open set N in Y containing $f(x)$, there exists supra b-m$_a$-open set M containing x in X such that $f(M) \subseteq N$.

ii) If $f:(X,\mu_1)\to(Y,\mu_2)$ is supra b-m$_i$-irresolute map, then for every subset A of X, $f\left[cl^{*\mu}(A)\right]\subseteq cl^{\mu}[f(A)]$.

iii) If $f:(X,\mu_1)\to(Y,\mu_2)$ is supra b-m$_i$-irresolute map, then for every subset B of Y, $cl^{*\mu}\left[f^{-1}(B)\right]\subseteq f^{-1}\left[cl^{\mu}(B)\right]$.

Proof: It follows from the theorem 3.13.

Theorem 3.24:

i) If $f:(X,\mu_1)\to(Y,\mu_2)$ is any supra mapping. Then the following statements are equivalent.
a) f is supra $^*b$-m$_i$-irresolute map.
b) The inverse image of every supra $^*b$-m$_a$-open set in Y is supra $^*b$-m$_a$-open set in X.
c) For each $x \in X$ and each supra $^*b$-m$_a$-open set N in Y containing $f(x)$, there exists supra $^*b$-m$_a$-open set M containing x in X such that $f(M) \subseteq N$.

ii) If $f:(X,\mu_1)\to(Y,\mu_2)$ is supra $^*b$-m$_i$-irresolute map, then for every subset A of X, $f\left[cl^{*\mu}(A)\right]\subseteq cl^{\mu}[f(A)]$.

iii) If $f:(X,\mu_1)\to(Y,\mu_2)$ is supra $^*b$-m$_i$-irresolute map, then for every subset B of Y, $cl^{*\mu}\left[f^{-1}(B)\right]\subseteq f^{-1}\left[cl^{\mu}(B)\right]$.

Proof: It follows from the theorem 3.23.

Theorem 3.25: If $f:(X,\mu_1)\to(Y,\mu_2)$ is supra b-m$_i$-irresolute map and $h:(Y,\mu_2)\to(Z,\mu_3)$ is supra b-m$_i$-irresolute map, then $h\circ f:(X,\mu_1)\to(Z,\mu_3)$ is supra b-m$_i$-irresolute map.

Proof: Let N be supra b-m$_i$-closed set in Z. Then by hypothesis $h^{-1}(N)$ is supra b-m$_i$-closed set in Y. But $f:(X,\mu_1)\to(Y,\mu_2)$ is supra b-m$_i$-irresolute map. Therefore $f^{-1}\left[h^{-1}(N)\right]=(h\circ f)^{-1}(N)$ is supra b-m$_i$-closed set in X. Hence $h\circ f:(X,\mu_1)\to(Z,\mu_3)$ is supra b-m$_i$-irresolute map.

Theorem 3.26: If $f:(X,\mu_1)\to(Y,\mu_2)$ is supra $^*b$-m$_i$-irresolute map and $h:(Y,\mu_2)\to(Z,\mu_3)$ is supra $^*b$-m$_i$-irresolute map, then $h\circ f:(X,\mu_1)\to(Z,\mu_3)$ is supra $^*b$-m$_i$-irresolute map.

Proof: Let N be supra $^*b$-m$_i$-closed set in Z. Then by hypothesis $h^{-1}(N)$ is supra $^*b$-m$_i$-closed set in Y. But $f:(X,\mu_1)\to(Y,\mu_2)$ is supra $^*b$-m$_i$-irresolute map. Therefore $f^{-1}[h^{-1}(N)]=(h\circ f)^{-1}(N)$ is supra $^*b$-m$_i$-closed set in X. Hence $h\circ f:(X,\mu_1)\to(Z,\mu_3)$ is supra $^*b$-m$_i$-irresolute map.

Theorem 3.27: If $f:(X,\mu_1)\to(Y,\mu_2)$ is supra b-m$_i$-irresolute map and $h:(Y,\mu_2)\to(Z,\mu_3)$ is supra b-m$_i$-continuous map, then $h\circ f:(X,\mu_1)\to(Z,\mu_3)$ is supra b-m$_i$-continuous map.

Proof: Let N be supra minimal closed set in Z. Then by hypothesis $h^{-1}(N)$ is supra b-m$_i$-closed set in Y. But $f:(X,\mu_1)\to(Y,\mu_2)$ is supra b-m$_i$-irresolute map. Therefore $f^{-1}[h^{-1}(N)]=(h\circ f)^{-1}(N)$ is supra b-m$_i$-closed set in X. Hence $h\circ f:(X,\mu_1)\to(Z,\mu_3)$ is supra b-m$_i$-continuous map.

Theorem 3.28: If $f:(X,\mu_1)\to(Y,\mu_2)$ is supra $^*b$-m$_i$-irresolute map and $h:(Y,\mu_2)\to(Z,\mu_3)$ is supra $^*b$-m$_i$-continuous map, then $h\circ f:(X,\mu_1)\to(Z,\mu_3)$ is supra $^*b$-m$_i$-continuous map.

Proof: Let N be supra minimal closed set in Z. Then by hypothesis $h^{-1}(N)$ is supra $^*b$-m$_i$-closed set in Y. But $f:(X,\mu_1)\to(Y,\mu_2)$ is supra $^*b$-m$_i$-irresolute map. Therefore $f^{-1}[h^{-1}(N)]=(h\circ f)^{-1}(N)$ is supra $^*b$-m$_i$-closed set in X. Hence $h\circ f:(X,\mu_1)\to(Z,\mu_3)$ is supra $^*b$-m$_i$-continuous map.

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