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Fuzzy rw Super- Continuous Mapping

M. K. Mishra*, M. Shukla, U. Aarthi*****

*Prof EGSPEC Nagapattinam,,**Asst. Prof. AGCW Karaikal,***ECE(IV) EGS PEC Nagapattinam
drmkm1969@rediffmail.com

Abstract- In this paper we extend the concepts of rw super closed sets and rw super continuous mappings in fuzzy topological spaces and obtain several results concerning the preservation of fuzzy g- super closed sets. Furthermore we characterize fuzzy rw super continuous and fuzzy rw- super closed mappings and obtain some of the basic properties and characterization of these mappings.

Index Terms- Fuzzy super closure fuzzy super interior fuzzy super closed set, fuzzy super open set fuzzy g- super closed sets, fuzzy g- super open sets, fuzzy g- super continuous, fuzzy rw super closed, fuzzy rw -super continuous and fuzzy gc-super irresolute mappings.

I. INTRODUCTION

After the introduction of fuzzy sets by Zadeh [17] in 1965 and fuzzy topology by Chang [3] in 1968, several researches were conducted on the generalizations of the notions of fuzzy sets and fuzzy topology. Thakur and Malviya [14] introduced the concepts of fuzzy g- closed sets , fuzzy g-continuity and fuzzy gc-irresolute mappings in fuzzy topological spaces.

In this paper we introduce the concepts of fuzzy rw -super closed and fuzzy rw -super continuous mappings using fuzzy g-super closed sets .This definition enables us to obtain conditions under which maps and inverse maps preserve fuzzy g- super closed sets. We also characterize fuzzy $T_{½}$ -spaces in terms of fuzzy rw super continuous and fuzzy rw -super closed mappings. Finally some of the basic properties of fuzzy rw super continuous and fuzzy a -super closed mappings are investigated.

II. PRELIMINARIES

Let X be a non empty set and I= [0,1]. A fuzzy set on X is a mapping from X in to I. The null fuzzy set 0 is the mapping from X in to I which assumes only the value is 0 and whole fuzzy sets 1 is a mapping from X on to I which takes the values 1 only. The union (resp. intersection) of a family $\{A_\alpha: \alpha\in\Lambda\}$of fuzzy sets of X is defined by to be the mapping sup A_α (resp. inf A_α) . A fuzzy set A of X is contained in a fuzzy set B of X if $A(x) \le B(x)$ for each $x\in X$. A fuzzy point x_β in X is a fuzzy set defined by $x_\beta(y)=\beta$ for y = x and $x_\beta(y) = 0$ for $y \neq x$,$\beta \in [0,1]$ and $y\in X$ .A fuzzy point x_β is said to be quasi-coincident with the fuzzy set A denoted by $x_{\beta q}A$ if and only if $\beta + A(x)>1$. A fuzzy set A is quasi–coincident with a fuzzy set B denoted by A_qB if and only if there exists a point $x\in X$ such that $A(x) + B(x)>1$.For any two fuzzy sets A and B of X, $A \le B$ if and only if $\rceil(A_qB^c)$[5].A family τ of fuzzy sets of X is called a fuzzy topology [1] on X if 0,1 belongs to τ and τ is closed with respect to arbitrary union and finite intersection .The members of τ are called fuzzy open sets and their complement are fuzzy closed sets. For any fuzzy set A of X the closure of A (denoted by cl(A)) is the intersection of all the fuzzy closed sets of A and the interior of A (denoted by int(A))is the union of all fuzzy open subsets of A.

Defination2.1 [6]: Let (X,τ) fuzzy topological space and $A\subseteq X$ then

1. Fuzzy Super closure $scl(A)=\{x\in X:cl(U)\cap A\neq\phi\}$

2. Fuzzy Super interior $sint(A) =\{x\in X:cl(U)\le A\neq\phi\}$

Definition 2.2[5,6]: A fuzzy set A of a fuzzy topological space (X,τ) is called:

(a) Fuzzy super closed if $scl(A) \le A$.

(b) Fuzzy super open if 1-A is fuzzy super closed scl(A)=A

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Remark 2.1[5,6]: Every fuzzy closed set is fuzzy super closed but the converses may not be true.

Remark 2.2[5,6]: The intersection of two fuzzy super closed sets in a fuzzy topological space (X,ℑ) may not be fuzzy super closed. For

Definition 2.2[1,5,6,7]: A fuzzy set A of a fuzzy topological space (X,τ) is called:

(a) fuzzy semi super open if there exists a super open set O such that O≤ A≤ cl(O).
(b) fuzzy semi super closed if its complement 1-A is fuzzy semi super open.

Remark 2.3[1,5,7]: Every fuzzy super open (resp. fuzzy super closed) set is fuzzy semi super open (resp. fuzzy semi super closed) but the converse may not be true .

Definition 2.3[7]: A fuzzy set A of a fuzzy topological space (X,τ) is called fuzzy w-super closed if cl(A) ≤ U whenever A ≤ U and U is fuzzy semi super open.

Remark2.4[5,6]: Every fuzzy super closed set is fuzzy w-super closed but its converse may not be true. For,

Definition 2.4[3,7]: A fuzzy sets A of a fuzzy topological spaces (X,ℑ) is called fuzzy regular super open if A = int(cl(A)).

Definition 2.5[3,7]: A fuzzy sets A of a fuzzy topological spaces (X,ℑ) is called fuzzy regular super closed if A = cl(int(A)) .

Remark 2.5: Every fuzzy open (resp. fuzzy regular super closed) set is fuzzy regular super open (resp. fuzzy regular super closed) but the converse may not be true [ ].The family of all fuzzy regular super open (resp. fuzzy regular super closed) sets of a fuzzy topological (X, ℑ) will be denoted by FRO(X)(resp. FRC(X)).

DEFINITION 2.6[3,5,6,7]: A mapping f: (X,ℑ) →(Y,Γ) is said to be fuzzy almost super continuous if $f^{-1}(G)\in$ ℑ for each fuzzy set of G∈FRO(Y) .

Remark 2.6[6]: Every fuzzy super continuous mapping is fuzzy almost super continuous but the converse may not be true [7].

Definition 2.7: A fuzzy sets A of a fuzzy topological spaces (X,ℑ) is called fuzzy regular semi super open if there exists a fuzzy regular super open set O such that O ≤ A ≤ cl(O) [6]

The family of all fuzzy regular semi super open sets of a fuzzy topological (X,τ) will be denoted by FRSSO(X).

Remark 2.7: Every fuzzy regular super open set is fuzzy regular semi super open but the converse may not be true .

Definition2.8: A mapping f: (X,ℑ) →(Y,Γ) is said to be fuzzy almost super irresolute if the inverse image of every fuzzy regular semi super open set of Y is fuzzy semi super open in X. [6]

Remark 2.8: Every fuzzy super irresolute mapping is fuzzy almost super irresolute but the converse may not be true [P_6].

Definition 2.9: A fuzzy set A of a topological spaces (X,ℑ) is called fuzzy rg- super closed if cl(A)≤ U whenever A ≤ U and U is fuzzy regular super open in X .

Remark 2.9: Every fuzzy g- super closed set is fuzzy rg- super closed but its converse may not be true.

Definition 2.10: A mapping f: (X,ℑ) →(Y,Γ) is said to be fuzzy rg-super continuous if the inverse image of every fuzzy super closed set of Y is fuzzy rg- super closed set in X.

Remark 2.10: Every fuzzy g-super continuous mapping is fuzzy rg-super continuous but the converse may not be true .

III. Fuzzy rw super-closed sets

In the present section we introduce the concepts of fuzzy rw super-closed sets in fuzzy topology and obtained some of its basic properties.

Definition 3.1: A fuzzy set A of a topological spaces (X,ℑ) is called fuzzy rw super-closed if cl(A) ≤ U whenever A ≤ U and U is fuzzy regular semi super open in X.

Remark 3.1: Every fuzzy w- super closed set is fuzzy rw - super closed but its converse may not be true for,

Example 3.1: Let X= {a, b} and the fuzzy sets A and U be defined as follows:

A(a)=0.7 , A(b)=0.8, U(a)=0.7 ,U(b)=0.6

Let τ = {0, U, 1} be a fuzzy topology on X .Then A is fuzzy rw- super closed but not fuzzy w- super closed.

Remark 3.2: Every fuzzy rw- super-closed set is fuzzy rg- super closed but not conversely. For,

Example 3.2: Let X = {a, b, c, d} and the fuzzy sets O, U, V, W, and A are defined as follows:

O(a) = 1, O(b) = 0, O(c) = 0, O(d) = 0, U(a) = 0, U(b) = 1, U(c) = 0, U(d) = 0

V(a)=1, V(b) = 1, V(c) = 0, V(d) = 0, W(a) = 0, W(b) = 0, W(c) = 1, W(d) = 1

A(a) = 0, A(b) = 0, A(c) = 1, A(d) = 0 , Let τ = { 0, O, U, V, W,1} be the fuzzy topology on X. then A is rw super-closed but not rg- super closed. Thus we have the following diagram of implications:

fuzzy rw- super-closed $\Rightarrow$ fuzzy rg- super closed

$\Uparrow$ $\Uparrow$

fuzzy super closed $\Rightarrow$ fuzzy w- super closed $\Rightarrow$ fuzzy g- super closed

$\Downarrow$ $\Downarrow$ $\Downarrow$

fuzzy semi super closed $\Rightarrow$ fuzzy sg- super closed $\Rightarrow$ fuzzy gs- super closed

Theorem 3.1: Let (X,$\Im$) be a fuzzy topological spaces and A is fuzzy subset of X .Then A is fuzzy rw super-closed if and only if $\rceil(A_qF)\Rightarrow\rceil(cl(A)_qF)$ for every fuzzy regular semi super closed set F of X.

Proof: Necessity: Let F be a fuzzy regular semi super closed subsets of X and $\rceil$(AqF).Then A $\leq$ 1-F and 1-F is fuzzy regular semi super open in X. Therefore cl(A) $\leq$ 1-F because A is fuzzy rw -super closed. Hence $\rceil(cl(A)_qF)$.

Sufficiency: Let U$\in$FRSSO(X) such that A $\leq$ U then $\rceil$(Aq(1-U)) and 1-U is fuzzy regular semi super closed in X. Hence by hypothesis $\rceil$(cl(A)q(1-U). Therefore cl(A)$\leq$U, Hence A is fuzzy rw super closed in X.

Theorem 3.2: Let A be a fuzzy rw- super closed set in a fuzzy topological space(X,τ) and x_β be a fuzzy point of X such that xβq(cl(int(A))) then $cl(int(x_\beta))_qA$.

Proof: If $\rceil(cl(int(x_\beta)_qA)$ then A $\leq$ 1-cl(int(x_β)) and so cl(A) $\leq$ 1-cl(int(x_β)) $\leq$ 1- x_β because A is fuzzy rw super closed in X. Hence $\rceil$($x_{\beta q}$cl(int(A))), a contradiction.

Theorem 3.3: If A and B are fuzzy rw- super closed sets in a fuzzy topological space (X,τ) then A∪B is fuzzy rg- super closed.

Proof: Let U$\in$FRSO(X) such that A ∪ B $\leq$ U. Then A $\leq$ U and B $\leq$ U , so cl(A) $\leq$ U and cl(B) $\leq$ U. Therefore cl(A) ∪ cl(B) $\leq$ cl(A ∪ B) $\leq$ U. Hence A∪B is fuzzy rw-super closed.

Remark 3.3: The intersection of any two fuzzy rw -super closed sets in a fuzzy topological space(X,τ) may not be fuzzy rw -super closed for,

Example 3.3: Let X={ a, b, c, d } and the fuzzy sets A and B are defined as follows;

A(a)=1, A(b)=1, A(c)=0, A(d)=0,

B(a)=1, B(b)=0, B(c)=1, B(d)=1,

Let $\Im$ = {0, A, B, A$\cap$B, 1} be the fuzzy topology on X .Then A and B are fuzzy rw -super closed but their intersection A $\cap$ B is not fuzzy rw -super closed.

Theorem 3.4: Let A $\leq$ B $\leq$ cl(A) and A is fuzzy rw -super closed set in a fuzzy topological space (X,τ) then B is fuzzy rw -super closed.

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Proof: Let U∈FRSO(X) such that B ≤ U. Then A ≤ U and since A is fuzzy rw- super closed. Then cl(A) ≤ U. Now B ≤ cl(A) ⇒ cl(B) ≤cl(A) ≤ U. Consequently B is fuzzy rw -super closed.

Definition 3.2: A fuzzy set A of a fuzzy topological space (X,ℑ) is called fuzzy rw -super open) if and only if 1 - A is fuzzy rw -super closed.

Remark 3.4: Every fuzzy w- super open set is fuzzy rw- super open .But converse may not be true. For the fuzzy set B defined by B(a)=0.5 and B(b)=0.7 in the fuzzy topological (X, ℑ) of example 6.1.1 is fuzzy rg- super open but not fuzzy regular super open.

Theorem 3.5: A fuzzy set A of a fuzzy rw-super open if and only if F ≤ int(A) whenever F ≤ A and F is fuzzy regular semi super open.

Proof: Obvious.

Theorem 3.6: Let A be a fuzzy rw -super open set in a fuzzy topological spaces (X,ℑ) and int (A) ≤ B ≤ A then B is fuzzy rw- super open.

Proof : Obvious .

Theorem 3.7: Let (X,ℑ) be a fuzzy topological space and FC(X) be the family of all fuzzy super closed sets of X .Then FRSSO(X) ⊆ FSC(X) if and only if every fuzzy subset of X is fuzzy rw- super closed.

Proof: Necessity: Suppose that FRSO(X) ⊆ FC(X) and that A ≤ U ∈ FRSSO(X) then cl(A) ≤ cl(U) = U and A is fuzzy rw -super closed.

Sufficiency: Suppose that every fuzzy subset of X is fuzzy rw- super closed .If U∈FRSSO(X) then since U ≤ U and U is fuzzy rw - super closed, cl(U) ≤ U and U ∈ FC(X).Thus FRSO(X) ⊆ FC(X).

Theorem 3.8: Let A be a fuzzy w- super closed set in a fuzzy topological space (X,ℑ) and f: (X,ℑ) →(Y, σ) is a fuzzy almost super irresolute and fuzzy super closed mappings then f(A) is fuzzy rw - super closed in Y.

Proof: If f(A)≤G where G∈FRSSO(Y).Then A≤ f^{-1}(G) ∈FSSO(X) and hence cl(A) ≤ f^{1}(G),because A is a fuzzy w- super closed in X. Since f is fuzzy super closed, f(cl(A)) is a fuzzy super closed set in Y. It follows that cl(f(A)) ≤ cl(f(cl(A))) =f(cl(A)) ≤ G.Thus cl(f(A)≤G and f(A) is a fuzzy rw –super closed set in Y.

Definition 3.2: A mapping f: (X,ℑ) → (Y,σ) is said to be fuzzy regular semi super irresolute if the inverse image of each fuzzy regular semi super open in X.

Theorem 3.9: Let A be the fuzzy rw -super closed set in a fuzzy topological space (X,ℑ) and f: (X,ℑ) →(Y,σ) is a fuzzy regular semi super irresolute and fuzzy super closed mapping then f(A) is fuzzy rw super closed sets in Y.

Proof: If f(A) ≤ G where G∈FRSO(Y) then A ≤ f^{-1}(G) ∈ FRSO(X) and hence cl(A) ≤ f^{-1}(G) because A is fuzzy rw -super-closed in X. Since f is fuzzy closed f(cl(A)) is a fuzzy closed set in Y. It follows that cl(f(A))≤ cl(f cl(A)) = f(cl(A)) ≤ G thus cl(f(A)) ≤ G and f(A) is fuzzy
rw -super closed sets in Y.

Definition 3.3: A collection {G_α: α∈Λ} of fuzzy rw- super open sets in a fuzzy topological space (X, ℑ) is called a fuzzy rw- super open cover of a fuzzy set A of X if A ≤ ∪ { G_α :α ∈ Λ }.

Definition 3.4: A fuzzy set of a topological space (X,ℑ) is said to be fuzzy rw -super compact if every fuzzy rw –super open cover of X has a finite sub cover.

Definition 3.5: A fuzzy topological space (X, ℑ) is said to be fuzzy rw- super compact relative to X, if for every collection { G_α:α∈Λ } of fuzzy rw -super open subsets of X such that A ≤ ∪ {$G_{\alpha j}$:αj ∈ Λ_0}.

Definition 3.6: A crisp subset of A of a fuzzy topological space (X, ℑ) is said to be fuzzy rw –super compact if A is fuzzy rw- super compact as a fuzzy subspace of X.

Theorem 3.10: Fuzzy rw-super closed crisp subsets of a fuzzy rw –super compact space are fuzzy rw- super compact relative to X.

Proof: Let A be a fuzzy rw super-closed crisp set off a fuzzy rw- super compact space (X, ℑ) .Then 1 - A is fuzzy rw –super open in X .Let G = {G_α:$\alpha\in\Lambda$}. Be a cover of A fuzzy rw- super open sets in X .Then the family{G, 1-A} is a fuzzy rg- super open in X is fuzzy rw –super compact.it had sub cover { $G_{\alpha 1}$ $G_{\alpha 2}$ $G_{\alpha 3 \ldots\ldots}$$G_{\alpha n}$}. If the sub cover contain 1-A, we discard it thus we have obtained a finite fuzzy rg-open sub cover of A is fuzzy rw -super-compact relative to X.

IV. FUZZY RW-SUPER CONTINUOUS MAPPINGS

In the present section we introduce the concept of fuzzy regular super w-Super continuous mappings in fuzzy topology and obtained some of its basic properties.

Definition 4.1: A fuzzy set A of topological spaces (X,ℑ) is called fuzzy regular w- super continuous mapping (written as fuzzy rw - super continuous mapping) if the inverse image of every fuzzy closed set of Y is fuzzy rw –super closed in X.

Theorem 4.2:A mapping f: (X,ℑ)→(Y,σ) is fuzzy rw-super continuous if and only if the inverse image of every fuzzy super open set of Y is fuzzy rw- super open in X.

Proof: It is obvious because $f^{-1}(1-A) = 1-f^{-1}(A)$ for every fuzzy set A of Y.

Remark 4.2: Every fuzzy w-super continuous mapping is rw -super continuous but its converse may not be true for,

Example 4.1: Let X={a,b} and Y={x,y}the fuzzy sets U and V be defined as follows;

U(a)=0.7 , U(b)=0.6

V(x)=0.2 , V(y)=0.2

Let ℑ = {0, U, 1 } and σ={0,V,1}be a fuzzy topology on X and Y respectively .Then the mapping f: (X, τ)→(Y,σ) defined by f(a)= x and f(b) = y is fuzzy rw- super continuous mapping but not fuzzy w-super continuous mapping.

Remark 4.2: Every fuzzy rw -super continuous mapping is rg-super continuous but its converse may not be true for,

Example 4.2: Let X = {a, b} and Y = {x, y}the fuzzy sets U and V be defined as follows;

U(a)=0.7, U(b)=0.6

V(x)=0.2, V(y)=0.2

Let ℑ = {0,U,1} and σ = {0, V, 1}be a fuzzy topology on X and Y respectively .Then the mapping f: (X,ℑ)→(Y,σ) defined by f(a)=x and f(b)=y is fuzzy rw- super continuous mapping but not fuzzy w-super continuous mapping.

Theorem 4.2: If f: (X,ℑ)→(Y,σ) is fuzzy w-super continuous then for each fuzzy point x_β of X and each fuzzy open set B, $f(x_\beta)\in B$ then there exists a fuzzy rw –super open set A such that $x_\beta\in A$ and $f(A)\leq B$.

Proof: Let x_β be fuzzy point of X and B be a fuzzy open set such that $f(x_\beta) \in B$ put $B= f^{-1}(A)$, then by the hypothesis A is a fuzzy rw-super open set of X such that $x_\beta\in A$ and $f(A)=f(f^{-1}(B)) \leq B$.

Theorem 4.3: If f: (X,ℑ)→(Y,σ) is fuzzy rw super continuous then for each fuzzy point x_β of X and each fuzzy open set B of Y such that, $f(x_\beta)_q B$ then there exists a fuzzy rw –super open set A such that $x_{\beta q}A$ and $f(A) \leq B$.

Proof: Let x_β be fuzzy point of X and B be a fuzzy super open set such that $f(x_\beta)_q B$ put $B= f^{-1}(A)$,then by the hypothesis A is a fuzzy rw- super open set of X such that $x_\beta qA$ and $f(A) = f(f^{-1}(B)) \leq B$.

Definition 4.2: Let (X, ℑ) be a fuzzy topological .The rw –super closure of the fuzzy set A of X denoted by rw –super cl(A) is defined as follows rw- super cl(A) = inf{B: B ≥ A , B is fuzzy rw- super closed set of X}.

Remark 4.3: It is clear that A≤ rw –super cl(A)≤cl(A) for any fuzzy set A of X.

Theorem 4.4: If f: (X,ℑ)→(Y,σ) is fuzzy rw -super continuous then f(rw –super cl(A)) ≤cl(f(A)) for every fuzzy set A of X.

Proof: Let A be a fuzzy set of X. Then cl(f(A)) is a fuzzy super closed set of Y. Since f is fuzzy rw -super continuous f^{-1}(cl(f(A))) is fuzzy rw –super closed in X. Clearly A ≤ f^{-1}(cl(f(A))) therefore ,rw -super cl(A) ≤ rw -super cl(f^{-1}(cl(f(A)))) = f^{-1}(cl(f(A))) ,hence f(rw -super cl(A)) ≤ cl(f(A)).

Remark 4.4: The converse of the theorem 6.2.2 is not true .

Definition 4.3: A fuzzy topological space (X,ℑ) is said to be fuzzy rw- super-$T_{1/2}$ if every fuzzy rw- super closed set in X is fuzzy super closed in X.

Theorem 4.5: Let f be a mapping from a fuzzy rw super-$T_{1/2}$ space (X,ℑ) to a fuzzy topological space (Y,σ) then the following condition are equivalent:

(a) f is fuzzy super continuous.

(b) f is fuzzy w- super continuous.

(c) f is fuzzy rw -super continuous.

Proof: Obvious.

Theorem 4.6: If f: (X,ℑ)→(Y,σ) is fuzzy rw- super continuous and g:(Y,σ)→(Z,η) is fuzzy super continuous .Then gof : (X,ℑ) →(Z,η) is fuzzy rw -super continuous.

Proof: If A is fuzzy closed in Z then f^{-1}(A) is fuzzy closed in Y because g is fuzzy super continuous. Therefore $(gof)^{-1}$=f^{-1}(g-1(A)) is fuzzy rw –super closed in X. Hence gof is fuzzy rw- super continuous.

Theorem 4.7: If f: (X,ℑ)→(Y,σ) and g: (Y,σ)→(Z,η) are two fuzzy rw-super continuous mapping and (Y,σ) is fuzzy rw- super-$T_{1/2}$ super continuous. Then gof: (X, τ)→(Z,η) is fuzzy rw -super continuous.

Proof: Obvious.

Theorem 4.8: A fuzzy rw -super continuous image of a fuzzy rw –super compact space is fuzzy compact.

Proof: Let f: (X,ℑ)→(Y,σ) be a fuzzy rw -super continuous mapping from a fuzzy rw –super compact space (X,τ) on to a fuzzy topological space (Y,σ). Let { A_i: i∈Λ } be a fuzzy super open cover of Y, then {$f^{-1}(A_i)$: i∈Λ} is a fuzzy rw –super open cover of X. Since X is fuzzy rw- super compact it has a finite sub cover, say {$f^{-1}(A_1)$, $f^{-1}(A_2)$, $f^{-1}(A_3)$… $f^{-1}(A_n)$} since f is onto {A_1, A_2… ,A_n} is a fuzzy super open cover of Y so (Y,σ) is fuzzy compact.

Definition 4.4:A fuzzy topological space (X,ℑ) is fuzzy rw – super connected if there is no proper fuzzy set of X which is both fuzzy rw- super open and fuzzy rw- super closed.

Remark 4.5: Every fuzzy rw- super connected space is fuzzy super connected but he converse may not be true. For;

Example 4.4: Let X={a, b} and A be defined as follows, A(a)=0.5,A(b)=0.7.Let ℑ={0, A, 1} be topology on X, then (X, ℑ) is fuzzy super connected but not fuzzy rw- super connected.

Theorem 4.10: If (X,ℑ) fuzzy rw- super- $T_{1/2}$ connected if and only if it is fuzzy rw- super connected.

Proof: Obvious.

Theorem 4.10: If f: (X,ℑ)→(Y,σ) fuzzy rw- super continuous surjection and X is fuzzy rw -super connected then Y is fuzzy super connected.

Proof: Suppose Y is not fuzzy super connected .Then there exists a proper fuzzy set A of Y which is both fuzzy super open and fuzzy super closed, therefore f^{-1}(G) is proper fuzzy set of X, which is both fuzzy rw- super open and fuzzy rw –super closed, because f is fuzzy rw -super continuous surjection. Hence, X is not fuzzy rw- super connected, which is a contradiction

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