Volume 9, No. 5, May - 2018 (Special Issue)
International Journal of Mathematical Archive-9(5), 2018, 63-68
Available online through www.ijma.info ISSN 2229 – 5046

SOME SUPRA MAPS VIA SUPRA $\tilde{g}$ - CLOSED SETS

[1]G. RAMKUMAR, [2]M. GILBERT RANIAND [3]A. GNANA AROCKIAM

[1,2&3]Department of Mathematics,
Arul Anandar College, Karumathur, Madurai District, Tamil Nadu, India.

E-mail:[1]ramanujam_1729@yahoo.com.[2]gil.anto@yahoo.co.in, [3]aga.arul@gmail.com.

ABSTRACT

In this paper, We introduce new class of maps called supra $\tilde{g}$ -continuous maps, supra $\tilde{g}$ - closed maps and supra $\tilde{g}$ - irresolute maps. Subsequently, we investigate several properties of these classes of maps.

2010 Mathematics Subject Classifications: *54A10, 54A20.*

Keywords and phrases: *Supra $\tilde{g}$ -closed set, supra $\tilde{g}$ -continuous map, supra $\tilde{g}$ - irresolute map, supra topological space.*

1. INTRODUCTION

In 2008, Devi *et al.* [1] introduced and studied a class of sets called supra α-open and a class of maps called sα-continuous maps between topological spaces, respectively. In 2010,Ravi et al. [10] have introduced and studied a class of sets called supra g-closed and a class of maps called supra g-continuous and supra g-closed respectively. Quite Recently G. Ramkumar *et al.* [8]have introduced and studied a class of sets called supra $\tilde{g}$ -closed. In line with the research, In this paper, We introduce new class of maps called supra $\tilde{g}$ -continuous maps, supra $\tilde{g}$ - closed maps and supra $\tilde{g}$ - irresolute maps. Subsequently, we investigate several properties of these classes of maps.

2. PRELIMINARIES

Throughout this paper (X,τ), (Y, σ) and (Z, ν) (or simply, X, Y and Z) denote topological spaces on which no separation axioms are assumed unless explicitly stated.

Definition 2.1 [5, 11]: Let X be a non-empty set. The subfamily $\mu \subseteq P(X)$ where P(X) is the power set of X is said to be a supra topology on X if $X \in \mu$ and μ is closed under arbitrary unions.

The pair (X, μ) is called a supra topological space.

The elements of μ are said to be supra open in (X, μ).

Complements of supra open sets are called supra closed sets.

Definition 2.2 [4]: A map f: X→Y is said to be
- (i) continuous if the inverse image of each open set of Y is an open set in X.
- (ii) closed if the image of each closed set of X is a closed set in Y.
- (iii) g-closed if the image of each closed set of X is a g-closed set in Y.

Definition 2.3 [1]: Let A be a subset of (X, μ). Then
- (i) The supra closure of a set A is, denoted by $cl^{\mu}(A)$, defined as $cl^{\mu}(A) = \cap$ {B : B is a supra closed and $A \subseteq B$};
- (ii) The supra interior of a set A is, denoted by $int^{\mu}(A)$, defined as $int^{\mu}(A) = \cup$ {G : G is a supra open and $A \supseteq G$}.

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Definition 2.4 [5]: Let (X, τ) be a topological space and μ be a supra topology on X. We call μ is a supra topology associated with τ if $\tau \subseteq \mu$.

Definition 2.5: Let (X, μ) be a supra topological space. A subset A of X is called
(i) supra semi-open set [1] if $A \subseteq cl^{\mu}(int^{\mu}(A))$;
(ii) supra α-open set [1, 12] if $A \subseteq int^{\mu}(cl^{\mu}(int^{\mu}(A)))$;
(iii) supra β-open set [9] if $A \subseteq cl^{\mu}(int^{\mu}(cl^{\mu}(A)))$;
(iv) supra pre-open set [12] if $A \subseteq int^{\mu}(cl^{\mu}(A))$.
The complements of the above mentioned open sets are called their respective closed sets.

Definition 2.6: Let (X, μ) be a supra topological space. A subset A of X is called
i) supra g-closed [10]if $cl^{\mu}(A) \subseteq U$ whenever $A \subseteq U$ and U is supra open in X
ii) supra ω-closed (= supra $\hat{g}$ -closed) [7]if $cl^{\mu}(A) \subseteq U$ whenever $A \subseteq U$ and U is supra semi-open in X.
iii) supra *g closed[6] if $cl^{\mu}(A) \subseteq U$ whenever $A \subseteq U$ and U is supra ω –open in X.
iv) supra#gs closed[7] if $scl^{\mu}(A) \subseteq U$ whenever $A \subseteq U$ and U is supra *g–open in X.
v) supra $\tilde{g}$ - closed[8] if $cl^{\mu}(A) \subseteq U$ whenever $A \subseteq U$ and U is supra #gs –open in X.
The complements of the above mentioned open sets are called their respective closed sets.

Definition 2.7: Let (X, τ) and (Y, σ) be two topological spaces with $\tau \subseteq \mu$. A map $f : (X, \mu) \to (Y, \sigma)$ is called
a) supra continuous [1] if the inverse image of each open set of Y is a supra open set in X.
b) g-continuous [10] if the inverse image of each closed set of Y is a supra g-closed set in X.
c) supra ω -continuous [7] if the inverse image of each closed set of Y is a supra ω -closed set in X.
d) supra #gs-continuous [7] if the inverse image of each closed set of Y is a supra #gs-closed set in X.

3. SUPRA $\tilde{g}$ - MAPS

Definition 3.1: Let (X,μ) be a supra topological space. $A \subseteq X$ then

i) Supra $\tilde{g}$ -closure of A is denoted by $cl^{\mu}_{\tilde{g}}(A)$, defined by the intersection of all supra $\tilde{g}$ -closed sets containing A

(i.e) $cl^{\mu}_{\tilde{g}}(A) = \bigcap$ {F, $A \subseteq F$ and F is supra $\tilde{g}$ -closed}

ii) Supra $\tilde{g}$ - interior of A is denoted by $int^{\mu}_{\tilde{g}}(A)$, defined by the union of all supra $\tilde{g}$ -open sets contained in A.

(i.e) $int^{\mu}_{\tilde{g}}(A) = \bigcup$ { F, $A \subseteq F$ and F is supra $\tilde{g}$ -open}

Remark 3.2: For the subsets A, B of a supra topological space (X,μ), the following statements hold.

i) $cl^{\mu}_{\tilde{g}}(A)$ is the smallest supra $\tilde{g}$ -closed set containing A.

ii) A is supra $\tilde{g}$ -closed if and only if $cl^{\mu}_{\tilde{g}}(A)$ =A.

iii) If $A \subseteq B$ then $cl^{\mu}_{\tilde{g}}(A) \subseteq cl^{\mu}_{\tilde{g}}(B)$.

iv) $cl^{\mu}_{\tilde{g}}(A) \cup cl^{\mu}_{\tilde{g}}(B) \subseteq cl^{\mu}_{\tilde{g}}(A \cup B)$.

v) $X \setminus int^{\mu}_{\tilde{g}}(A) = cl^{\mu}_{\tilde{g}}(A^c)$.

vi) $int^{\mu}_{\tilde{g}}(int^{\mu}_{\tilde{g}}(A)) = int^{\mu}_{\tilde{g}}(A)$.

vii) $X \setminus cl^{\mu}_{\tilde{g}}(A) = int^{\mu}_{\tilde{g}}(A^c)$.

viii) If $A \subseteq B$ then $int^{\mu}_{\tilde{g}}(A) \subseteq int^{\mu}_{\tilde{g}}(B)$

ix) $int^{\mu}_{\tilde{g}}(A) \cup int^{\mu}_{\tilde{g}}(B) \subseteq int^{\mu}_{\tilde{g}}(A \cup B)$

x) $int^{\mu}_{\tilde{g}}(A) \cap int^{\mu}_{\tilde{g}}(B) \supseteq int^{\mu}_{\tilde{g}}(A \cap B)$

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Lemma 3.3: Let (X, τ) be topological space $\tau \subseteq \mu$. For any $A \subseteq X$, $int^{\mu}(A) \subseteq int^{\mu}_{\tilde{g}}(A) \subseteq A$.

Proof: Since every supra open set is supra $\tilde{g}$ -open.

Definition 3.4: Let (X, τ) and (Y, σ) be two topological space with $\tau \subseteq \mu$ and $\sigma \subseteq \lambda$. A map f: (X, μ)→(Y, λ) is said to be

i) Supra $\tilde{g}$ -continuous if $f^{-1}(V)$ is supra $\tilde{g}$ -closed in X for every closed set V of Y.
ii) Supra $\tilde{g}$ -irresolute if $f^{-1}(V)$ is supra $\tilde{g}$ -closed in X for every supra $\tilde{g}$ -closed set V of Y.
iii) Supra $\tilde{g}$ -closed [resp. supra $\tilde{g}$ -open] if f(V) is supra $\tilde{g}$ -closed [resp. supra $\tilde{g}$ -open] in Y for every closed set [resp. open] V of X.
iv) Supra $\tilde{g}^{*}$-continuous if $f^{-1}(V)$ is supra $\tilde{g}$ -closed in X for every supra closed set V of Y.
v) Supra $\tilde{g}^{*}$-closed if f(V) is supra $\tilde{g}$ -closed in Y for every supra closed set V of X.

Theorem 3.5: Let (X, τ) and (Y, σ) be two topological space with $\tau \subseteq \mu$ and $\sigma \subseteq \lambda$. A map f:(X,μ)→(Y,λ) is supra $\tilde{g}^{*}$-closed if and only if $cl^{\mu}_{\tilde{g}}(f(A)) \subseteq f(cl^{\mu}(A))$ for every subset A of X.

Proof: Suppose that f is supra $\tilde{g}^{*}$-closed and $A \subseteq X$. Then $f(cl^{\mu}(A))$ is supra $\tilde{g}$ -closed in Y. We have $f(A) \subseteq f(cl^{\mu}(A))$ and by Remark 3.2 $cl^{\mu}_{\tilde{g}}(f(A)) \subseteq cl^{\mu}_{\tilde{g}}(f(cl^{\mu}(A)) = f(cl^{\mu}(A))$.

Conversely, Let A be any supra closed in X. By hypothesis and Remark 3.2 we have $A=cl^{\mu}(A)$ and so $f(A)=f(cl^{\mu}(A)) \supseteq cl^{\mu}_{\tilde{g}}(f(A))$. Therefore, $f(A)= cl^{\mu}_{\tilde{g}}(f(A))$. Hence f(A) is supra $\tilde{g}$ -closed in Y and hence f is supra $\tilde{g}$ -closed.

Theorem 3.6: Let (X, τ) and (Y, σ) be two topological space with $\tau \subseteq \mu$ and $\sigma \subseteq \lambda$. A map f:(X, μ)→(Y, λ) is a supra $\tilde{g}^{*}$-closed mapping, then for each subset A of X, $cl^{\lambda}(int^{\lambda}f(A)) \subseteq f(cl^{\mu}(A))$.

Proof: Let f be a supra $\tilde{g}^{*}$-closed map and $A \subseteq X$. Since $cl^{\mu}(A)$ is a supra closed set in X. We have $f(cl^{\mu}(A))$ is supra $\tilde{g}$ -closed and hence supra pre-closed. Therefore $cl^{\lambda}(int^{\lambda}(f(cl^{\mu}(A))) \subseteq f(cl^{\mu}(A))$ (i.e) $cl^{\lambda}(int^{\lambda}f(A)) \subseteq f(cl^{\mu}(A))$.

Theorem 3.7: Let (X, τ) and (Y, σ) be two topological space with $\tau \subseteq \mu$ and $\sigma \subseteq \lambda$. A map f:(X, τ)→(Y, λ) is a supra $\tilde{g}$ -closed if and only if for each subset S of Y for each open set U containing $f^{-1}(S)$ there is supra $\tilde{g}$ -open set V of Y such that $S \subseteq V$ and $f^{-1}(V) \subseteq U$.

Proof: Suppose that f is a supra $\tilde{g}$ -closed map. Let $S \subseteq Y$ and U be an open set of X such that $f^{-1}(S) \subseteq U$. Thus V=Y\f(X\U) is a supra $\tilde{g}$ -open set containing S such that $f^{-1}(V) \subseteq U$.

Conversely, suppose that F is a closed set of X. Then $f^{-1}(Y\setminus f(F)) \subseteq X\setminus F$ and X\F is open. By hypothesis, there exist a supra $\tilde{g}$ -open set V of Y such that $Y\setminus(f(F)) \subseteq V$ and $f^{-1}(V) \subseteq X\setminus F$. Therefore $F \subseteq X\setminus f^{-1}(V)$,
Hence $Y\setminus V \subseteq f(F) \subseteq f(X\setminus f^{-1}(V)) \subseteq Y\setminus V$ which implies f(F)=Y\V. Since Y\V is supra $\tilde{g}$ -closed, f(F) is supra $\tilde{g}$ -closed set in Y and thus f is supra $\tilde{g}$ -closed map.

Theorem 3.8: Let (X, τ) and (Y, σ) be two topological space with $\tau \subseteq \mu$ and $\sigma \subseteq \lambda$. A map f:(X, μ)→(Y, λ) is a supra #gs-irresolute and supra $\tilde{g}^{*}$-closed and A is a supra $\tilde{g}$ -closed subset of X, Then f(A) is supra $\tilde{g}$ -closed.

Proof: Let U be a supra #gs-open in Y such that $f(A) \subseteq U$. Since f is supra #gs-irresolute. $f^{-1}(U)$ is a supra #gs-open set containing A. Hence $cl^{\mu}(A) \subseteq f^{-1}(U)$ as A is supra $\tilde{g}$ -closed in X. Since f is supra $\tilde{g}^{*}$-closed. $f(cl^{\mu}(A))$ is a supra $\tilde{g}$ -closed set containing in the supra #gs-open set U, which implies that $cl^{\mu}(f(cl^{\mu}(A))) \subseteq U$ and hence $cl^{\mu}(f(A)) \subseteq U$. Therefore f(A) supra $\tilde{g}$ -closed set.

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Remark 3.9: The composition of two supra $\tilde{g}$ -closed maps need not be supra $\tilde{g}$ -closed.

Corollary 3.10: Let (X, τ), (Y, σ) and (Z, η) be three topological space with $\tau\subseteq\mu$, $\sigma\subseteq\lambda$ and $\upsilon\subseteq\eta$. A map f:(X, μ)→(Y, λ) be a supra $\tilde{g}$ -closed map and g:(Y, λ)→(Z, η) be a supra $\tilde{g}^*$-closed and supra #gs-irresolute map then their composition gof: (X, τ)→(Z, η) is supra $\tilde{g}$ -closed.

Proof: Let A be a closed set of X. Since f is supra $\tilde{g}$ -closed, f(A) is supra $\tilde{g}$ -closed set in Y. Since g is both supra #gs-irresolute and supra $\tilde{g}$ -closed by Theorem 3.8, g(f(A))=(gof)(A) is supra $\tilde{g}$ -closed in Z and therefore gof is supra $\tilde{g}$ -closed.

Definition 3.11: A Supra topological (X, μ) is said to be

1) Supra $T_{\tilde{g}}$ -space if every supra $\tilde{g}$ -closed subset of X is supra closed in X.
2) Supra $T_{1/2}$-space if every supra g-closed subset of X is supra closed in X.
3) Supra semi* $T_{1/2}$-space if every supra $\hat{g}$ -closed subset of X is supra closed in X.
4) Supra $T_{1/2}^*$-space if every supra g-closed subset of X is closed in X.
5) Supra semi$T_{1/2}^{**}$-space if every supra $\hat{g}$ -closed subset of X is closed in X.

Preposition 3.12: Let (X, τ), (Y, σ) and (Z, υ) be three topological space with $\tau\subseteq\mu$, $\sigma\subseteq\lambda$ and $\upsilon\subseteq\eta$. If f:(X,μ)→(Y,λ) and g:(Y, λ)→(Z, η) are supra $\tilde{g}^*$-closed and Y is a supra $T_{\tilde{g}}$ -space, then their composition gof: (X,μ)→(Z, η) is supra $\tilde{g}^*$-closed map.

Proof: Let A be supra closed set of X. Then f(A) is supra $\tilde{g}$ -closed in Y. Since Y is $T_{\tilde{g}}$ -space f(A) is supra closed in Y and g is supra $\tilde{g}^*$-closed then g(f(A)) is supra $\tilde{g}^*$-closed set in Z that is (gof)(A) is supra $\tilde{g}$ -closed in Z and so gof is supra $\tilde{g}$ -closed.

Definition 3.13: Let (X, τ) and (Y, σ) be two topological space with $\tau\subseteq\mu$ and $\sigma\subseteq\lambda$. A map f: (X, μ)→(Y, λ) is called supra g^*-closed if f(V) is supra g-closed in X for every supra closed V in Y.

Preposition 3.14: Let (X, τ), (Y, σ) and (Z, υ) be three topological space with $\tau\subseteq\mu$, $\sigma\subseteq\lambda$ and $\upsilon\subseteq\eta$. A map f:(X, μ)→(Y, λ) be a supra $\tilde{g}^*$-closed map and g:(Y,λ)→(Z,η) be a supra g^*-closed and Y is supra $T_{\tilde{g}}$ -space then their composition gof: (X, μ)→(Z, η) is supra g^*-closed.

Proof: Similar to Proposition 3.12.

Preposition 3.15: Let (X, τ), (Y, σ) and (Z, υ) be three topological space with $\tau\subseteq\mu$, $\sigma\subseteq\lambda$ and $\upsilon\subseteq\eta$. A map f:(X, μ)→(Y, λ) be a closed map and g:(Y,λ)→(Z,η) be a supra $\tilde{g}$ -closed map then their composition gof: (X, μ)→(Z,η) is supra $\tilde{g}$ -closed.

Proof: Similar to Proposition 3.12.

Theorem 3.16: Let (X, τ), (Y, σ) and (Z, υ) be three topological space with $\tau\subseteq\mu$, $\sigma\subseteq\lambda$ and $\upsilon\subseteq\eta$. Let f:(X, μ)→(Y,λ) and g:(Y, λ)→(Z, η) be two mappings such that gof: (X, μ)→(Z, η) is supra $\tilde{g}$ -closed mapping then the following statements are true if

i) f is a supra continuous and surjective, then g is supra $\tilde{g}^*$-closed.
ii) g is a supra $\tilde{g}$ -irresollute and injective, then f is supra $\tilde{g}$ -closed.
iii) f is supra g-continuous, surjective and X is supra $T_{1/2}^*$-space, then g is supra $\tilde{g}$ -closed.
iv) f is supra $\tilde{g}$ -continuous, surjective and X is supra semi $T_{1/2}^{**}$-space, then g is supra $\tilde{g}$ -closed.

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Proof:

(i) Let A be a closed set of Y. Since f is continuous $f^{-1}(A)$ is closed in X and since gof is supra $\tilde{g}$ -closed, $(gof)(f^{-1}(A))$ is supra $\tilde{g}$ -closed in Z. Therefore g(A) is supra $\tilde{g}$ -closed in Z, since f is surjective. Therefore, g is supra $\tilde{g}$ -closed map.

(ii) Let B be closed in X. Since gof is supra $\tilde{g}$ -closed, (gof)(B) is supra $\tilde{g}$ -closed in Z. $g^{-1}((gof)(B))$ is supra $\tilde{g}$ -closed in Y. i.e, f(B) is supra $\tilde{g}$ -closed in Y, since g is injective.
Thus, f is supra $\tilde{g}$ -closed map.

(iii) Let A be a closed set of Y. Since f is supra $\tilde{g}$ -continuous, $f^{-1}(A)$ is supra $\tilde{g}$ -closed in X.
Since X is a supra $T_{½}^{*}$-space $f^{-1}(A)$ is closed in X and so as in (i) g is supra $\tilde{g}$ -closed map.

(iv) Let A be a closed set of Y. Since f is supra $\tilde{g}$ -continuous, $f^{-1}(A)$ is is supra $\tilde{g}$ -closed set in X. Since every supra $\tilde{g}$ -closed set is supra $\hat{g}$ -closed and X is supra semi $T_{½}^{**}$-space. $f^{-1}(A)$ is closed in X and so as in (i) g is a supra $\tilde{g}$ -closed map.

Definition 3.17: Let (X, τ) and (Y, σ) be two topological space with $\tau \subseteq \mu$, $\sigma \subseteq \lambda$. A map $f:(X,\mu)\to(Y,\lambda)$ is said to be

i) Supra strongly $\tilde{g}$ -continuous if $f^{-1}(V)$ is open in X for every supra $\tilde{g}$ -open V in Y.

ii) Supra strongly $\tilde{g}^{*}$-continuous if $f^{-1}(V)$ is supra open in X for every supra $\tilde{g}$ -open V in Y.

Theorem 3.18: Let (X, τ), (Y, σ) and (Z, υ) be three topological space with $\tau \subseteq \mu$, $\sigma \subseteq \lambda$ and $\upsilon \subseteq \eta$. Let $f:(X, \mu)\to(Y, \lambda)$ and $g:(Y, \lambda)\to(Z, \eta)$ be two mappings such that their composition $gof: (X, \mu)\to(Z, \eta)$ be a supra $\tilde{g}$ -closed mapping. If g is strongly $\tilde{g}$ -continuous and injective, then f is closed.

Proof: Let D be a closed set of X. Since gof is supra $\tilde{g}$ -closed, (gof)(D) is supra $\tilde{g}$ -closed in Z. Since g is supra strongly $\tilde{g}$ -continuous $g^{-1}((gof)(D))$ is closed in Y, f(D) is closed in Y, since g is injective. Therefore f is closed map.

Theorem 3.19: Let (X, τ) and (Y, σ) be two topological space with $\tau \subseteq \mu$, $\sigma \subseteq \lambda$. Any bijection map $f:(X, \mu)\to(Y, \lambda)$ the following statements are equivalent

(i) f^{-1}: $(Y, \lambda)\to(X,\mu)$ is supra $\tilde{g}$ -continuous

(ii) f is supra $\tilde{g}$ -open map and

(iii) f is supra $\tilde{g}$ -closed map

Proof:

i) $\Rightarrow$ ii): Let U be open set of X. Then by assumption $(f^{-1})^{-1}(U) = f(U)$ is supra $\tilde{g}$ -open in Y and so f is supra $\tilde{g}$ -open.

ii) $\Rightarrow$ iii): Let F be a closed set of X. The F^c is open in X. By assumption $f(F^c)$ is supra $\tilde{g}$ -open in Y. i.e, $f(F^c) = (f(F))^c$ is supra $\tilde{g}$ -open in Y and therefore f(F) is supra $\tilde{g}$ -closed in Y. Hence f is supra $\tilde{g}$ -closed.

iii) $\Rightarrow$ i): Let F be closed set in X. By assumption f(F) is supra $\tilde{g}$ -closed in Y.

But $f(F) = (f^{-1})^{-1}(F)$ and therefore f^{-1} is supra $\tilde{g}$ -continuous.

Theorem 3.20: Let (X,τ) and (Y,σ) be two topological space with $\tau \subseteq \mu$ and $\sigma \subseteq \lambda$. A map $f:(X,\mu)\to(Y,\lambda)$ is Supra $\tilde{g}$ -open if and only if for any subset B of Y and for any closed set S containing $f^{-1}(B)$, there exist Supra $\tilde{g}$ -closed set A of Y containing B such that $f^{-1}(A) \subseteq S$.

Proof: Similar to Theorem 3.7

Definition 3.21: Let (X,τ) and (Y,σ) be two topological space with $\tau \subseteq \mu$ and $\sigma \subseteq \lambda$. A map $f:(X,\mu)\to(Y,\lambda)$ is said to be supra $\tilde{g}^{**}$-closed map if f(V) is Supra $\tilde{g}$ -closed in Y for every supra $\tilde{g}$ -closed set V in X.

Preposition 3.22: Let (X, τ) and (Y, σ) be two topological space with $\tau \subseteq \mu$ and $\sigma \subseteq \lambda$. A map f:(X, μ)→(Y, λ) is said to be Supra $\tilde{g}^{**}$-closed if and only if $cl^{\mu}_{\tilde{g}}(f(A)) \subseteq f(cl^{\mu}_{\tilde{g}}(A))$ for every subset A of X.

Proof: Similar to Theorem 3.5.

Theorem 3.23: Let (X,τ) and (Y,σ) be two topological space with $\tau \subseteq \mu$, $\sigma \subseteq \lambda$. For any bijection map f:(X,μ)→(Y,λ) the following statements are equivalent

i) f^{-1}: (Y,λ)→(X,μ) is supra $\tilde{g}$ -irresolute

ii) f is supra $\tilde{g}^{**}$-open map and

iii) f is supra $\tilde{g}^{**}$-closed map

Proof: Similar to Theorem 3.19

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Source of support: Proceedings of National Conference March 1st - 2018, On "Recent Advances in Pure and Applied Mathematics (RAPAM - 2018)", Organized by Department of Mathematics, Arul Anandar College (Autonomous), Madurai. Tamilnadu, India.

