ISSN 2250-3153

On πg(αg)* – continuous maps and πg(αg)* - irresolute maps in Topological Spaces

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DOI: 10.29322/IJSRP.10.04.2020.p10094
http://dx.doi.org/10.29322/IJSRP.10.04.2020.p10094

Abstract : In this paper, we have introduced the concept of continuous, irresolute and homeomorphism maps of πg(αg)* closed set. Some of the fundamental properties of this set are studied. And their application also given namely, πg(αg)* –$T_{1/2}$ – space.

Keywords : πg(αg)*- closed set, πg(αg)*- continuous map, πg(αg)*-irresolute map, πg(αg)* –$T_{1/2}$ – space

1.Introduction

Levine[**5**] introduced the class of g-closed sets, a super class of closed sets in 1970. Dontchev and Noiri [19] have introduced the concept of πg-closed sets and studied their most fundamental properties in topological spaces. Also, Ekici and Noiri [21] have introduced a generalization of πg-closed sets and πg-open sets. Recently , a new class of πg(αg)*-closed sets in topological spaces introduced and studied by R.Savithiri , A.Manonmani and M.Anandhi [29]. In this paper , we have made a study on πg(αg)*- continuous map, πg(αg)*-irresolute map and πg(αg)*-homeomorphism. Also, Applications of πg(αg)*-closed sets are analyzed.

2.Preliminaries

For a subset H of a space (X,τ), cl(H) and int(H) denote the closure and the interior of H respectively. The class of all closed subsets of a space (X,τ) is denoted by C(X,τ). The smallest closed (resp. α-closed) set containing a subset H of (X,τ) is called the closure (resp. α-closure) of H and is denoted by cl(H) (resp. αcl(H)).

Definition 2.1 : 1) A π open set [21] of X is a finite union of all r-open sets in (X,τ).

2) A subset H of a space X is called α-generalized closed (briefly αg-closed) [13] if αcl(H)⊆U whenever H⊆U and U is open in X.

3) A subset H of a space X is called π- generalized closed set [21] (briefly πg-closed) if cl(H)⊆U whenever H⊆U and U is π-open in (X,τ).

4) A subset H of a space X is called **π-generalized-(αg)* closed set [29] (briefly πg(αg)*- closed set)** if αgcl(H)⊆U, whenever H⊆U and U is π open in X.

Diagram-I

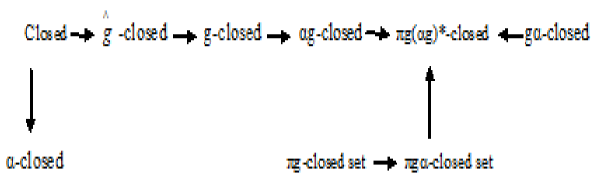


Diagram-I is obvious (see related papers).

Remark 2.2 :

π g(αg)*-closed set is independent with the following closed sets:gp-closed set, rg-closed set, s-closed set, wg-closed set,wπg-closed set, b*-closed set,b-closed set, gs-closed set, gs-closed set, gb-closed set and πgp-closed set .

3. On πg(αg)*- continuous map.

Definition 3.1:

A map θ: $(X,\tau_1) \rightarrow (Y, \tau_2)$ is called

1) continuous[5] if inverse image of every closed set of (Y, τ_2) is a closed set of (X, τ_1).

2) g-continuous[5] if the inverse image of every closed set of (Y,τ_2) is g- closed set of (X, τ_1).

3) $\hat{g}$ -continuous[4] if the inverse image of every closed set of (Y,τ_2) is $\hat{g}$ - closed set of (X, τ_1).

4) αg-continuous[13] if the inverse image of every closed set of (Y,τ_2) is αg- closed set of (X, τ_1).

5) gα-continuous[13] if the inverse image of every closed set of (Y,τ_2) is gα- closed set of (X, τ_1).

6) πg-continuous[21] if the inverse image of every closed set of (Y,τ_2) is πg- closed set of (X, τ_1).

7) πgα-continuous [25] if the inverse image of every closed set of (Y,τ_2) is πgα- closed of (X, τ_1).

8) s-continuous [6] if the inverse image of every closed set of (Y,τ_2) is s- closed set of (X, τ_1).

9) gp-continuous[23] if the inverse image of every closed set of (Y,τ_2) is gp- closed set of (X, τ_1).

10) rg-continuous[28] if the inverse image of every closed set of $(Y,\tau_2)$is rg- closed set of (X, τ_1).

11) wg-continuous[15]if the inverse image of every closed set of(Y,τ_2) is wg-closed set of (X,τ_1).

12) wπg-continuous[15]if the inverse image of every closed set of (Y,τ_2) is wπg-closed of (X,τ_1).

13) b*-continuous[26]if the inverse image of every closed set of (Y,τ_2) is b*- closed set of (X,τ_1).

14) b-continuous[16] if the inverse image of every closed set of (Y,τ_2) is b- closed set of (X,τ_1).

15) gs-continuous[29]if the inverse image of every closed set of (Y,τ_2) is gs- closed set of (X,τ_1).

16) gb-continuous[27] if the inverse image of every closed set of (Y,τ_2) is gb-closed set of (X,τ_1).

17) πgp-continuous[24] if the inverse image of every closed set of (Y,τ_2) is πgp- closed of (X,τ_1).

18) α-continuous [11] if the inverse image of every closed set of (Y,τ_2) is α- closed set of (X,τ_1).

Definition 3.2:

A map θ: $(X, \tau_1) \rightarrow (Y, \tau_2)$ is called a **πg(αg)*-continuous** if the inverse image of every closed set of
(Y, τ_2) is πg(αg)*- closed set of (X, τ_1).

Theorem 3.3:

Every continuous map, g-continuous map, α-continuous map and αg-continuous map is πg(αg)* -continuous.

Proof:

(i) Take θ : $(X, \tau_1) \rightarrow (Y, \tau_2)$ be continuous map. Let W be closed set of (Y, τ_2) then inverse image of W is closed of (X, τ_1). Inverse image of W is πg(αg)* -closed of (X, τ_1), since closed $\rightarrow$ πg(αg)* -closed. Hence θ is πg(αg)* -continuous of (X, τ_1).

(ii) Take θ : $(X, \tau_1) \rightarrow (Y, \tau_2)$ be g-continuous map. Let W be closed set of (Y, τ_2) then inverse image of W is g-closed of (X, τ_1). Inverse image of W is πg(αg)* -closed of (X, τ_1), since g-closed $\rightarrow$ πg(αg)* -closed . Hence θ is πg(αg)* -continuous of (X, τ_1).

(iii) Take θ : $(X, \tau_1) \rightarrow (Y, \tau_2)$ be α-continuous map. Let W be closed set of (Y, τ_2) then inverse image of W is α-closed of (X, τ_1). Inverse image of W is πg(αg)* -closed of (X, τ_1), since α-closed $\rightarrow$ πg(αg)* -closed . Hence θ is πg(αg)* -continuous of (X, τ_1).

(iv) Take θ : $(X, \tau_1) \rightarrow (Y, \tau_2)$ be αg-continuous map. Let W be closed set of (Y, τ_2) then inverse image of W is αg-closed of (X, τ_1). Inverse image of W is πg(αg)* -closed of (X, τ_1),

ISSN 2250-3153

since αg-closed → πg(αg)* -closed . Hence θ is πg(αg)* -continuous of (X, τ_1).

The converse of the above theorem need not be true from the following example.

Example 3.4:

Take X = Y= {a,b,c} and τ_1 = {X,Φ,{a}}, τ_2 = {Y,Φ,{a},{b,c}}. Define θ : $(X, \tau_1) \to (Y, \tau_2)$ as θ(a) = a, θ(b) = b, θ(c) = c. Here inverse image of all τ_2^C are πg(αg)* -closed of (X, τ_1) but not closed, g-closed, α-closed and αg -closed of (X, τ_1). This implies converse not true.

Theorem 3.5:

Every $\hat{g}$ -continuous map and gα-continuous map is πg(αg)* -continuous.

Proof:

(i)Take θ : $(X, \tau_1) \to (Y, \tau_2)$ be $\hat{g}$ -continuous map. Let W be closed set of (Y, τ_2) then inverse image of W is $\hat{g}$ -closed of (X, τ_1). Inverse image of W is πg(αg)* -closed of (X, τ_1), since $\hat{g}$ -closed → πg(αg)* -closed . Hence θ is πg(αg)* -continuous of (X, τ_1).

(ii)Take θ : $(X, \tau_1) \to (Y, \tau_2)$ be gα-continuous map. Let W be closed set of (Y, τ_2) then inverse image of W is gα-closed of (X, τ_1). Inverse image of W is πg(αg)* -closed of (X, τ_1), since gα-closed → πg(αg)* -closed . Hence θ is πg(αg)* -continuous of (X, τ_1).

The converse of the above theorem need not be true from the following example.

Example 3.6:

Take X = Y= {a,b,c} and τ_1 = {X,Φ,{c},{b,c}}, τ_2 = {Y,Φ,{a},{b,c}}. Define θ : $(X, \tau_1) \to (Y, \tau_2)$ as θ(a) = a, θ(b) = b, θ(c) = c. Here inverse image of all τ_2^C are πg(αg)* -closed of (X, τ_1) but not gα-closed and $\hat{g}$ -closed of (X, τ_1). This implies converse not true.

Theorem 3.7:

Every πg-continuous map is πg(αg)* -continuous.

Proof:

Take θ: $(X, \tau_1) \to (Y, \tau_2)$ be πg-continuous map. Let W be closed set of (Y, τ_2) then inverse image of W is πg-closed of (X, τ_1). Inverse image of W is πg(αg)* -closed of (X, τ_1), since πg-closed → πg(αg)* -closed . Hence θ is πg(αg)* -continuous of (X, τ_1).

The converse of the above theorem need not be true from the following example.

Example 3.8:

Take X = Y= {a,b,c,d} and τ_1 = {X,Φ,{a},{b},{a,b},{b,c},{a,b,c}}, τ_2 = {Y,Φ,{a},{a,b,d}}. Define θ : $(X, \tau_1) \to (Y, \tau_2)$ as θ(a) = a, θ(b) = b, θ(c) = c, θ(d)=d. Here inverse image of all τ_2^C are πg(αg)* -closed of (X, τ_1) but not πg -closed of (X, τ_1). This implies converse not true.

Theorem 3.9:

Every πgα-continuous map is πg(αg)* –continuous but not converse.

Proof:

Take θ : $(X, \tau_1) \to (Y, \tau_2)$ be πgα-continuous map. Let W be closed set of (Y, τ_2) then inverse image of W is πgα-closed of (X, τ_1). Inverse image of W is πg(αg)* -closed of (X, τ_1), since πgα-closed → πg(αg)* -closed . Hence θ is πg(αg)* -continuous of (X, τ_1).

Remark 3.10:

The composition of two πg(αg)*-continuous map is need not be a πg(αg)*-continuous map.

Example:3.11

Take X = Y= Z={a,b,c} and τ_1 = {X,Φ,{a},{b},{a,b}}, τ_2 = {Y,Φ,{a},{a,b}} and τ_3 = {Y,Φ,{a},{b,c}}. Define θ : $(X, \tau_1) \to (Y, \tau_2)$ and h : $(Y, \tau_2) \to (Z, \tau_3)$ be an identity maps. Let θ and h be a πg(αg)*-continuous maps. . But $(h \circ \theta)^{-1}$({a}) = θ^{-1} (h^{-1}({a}))={a} is not πg(αg)*-closed of (X, τ_1). Hence h o θ is not πg(αg)*-continuous.

Theorem 3.12:

A map θ: $(X, \tau_1) \to (Y, \tau_2)$ is πg(αg)*-continuous and h : $(Y, \tau_2) \to (Z, \tau_3)$ is continuous , then h o θ : $(X, \tau_1) \to (Z, \tau_3)$ is πg(αg)*-continuous.

Proof:

Take W be any closed set in (Z, τ_3) and.so h^{-1} of W is closed of (Y, τ_2), Since h is continuous. $(h \circ \theta)^{-1}(W) = \theta^{-1}(h^{-1}(W))$ is πg(αg)*-closed (X, τ_1), Since θ is πg(αg)*-continuous . Hence h o θ is πg(αg)*-continuous.

Theorem 3.13:

A map θ: $(X, \tau_1) \to (Y, \tau_2)$ is πg(αg)*-continuous if and only if inverse image of every open set in

ISSN 2250-3153

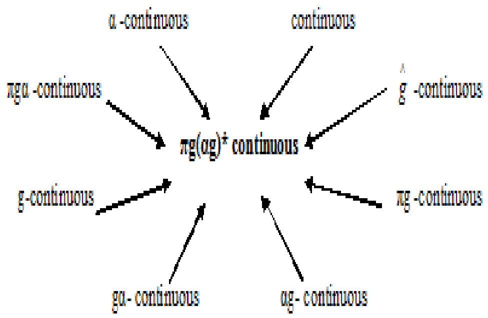
(Y, τ_2) is $\pi g(\alpha g)^*$- open set in (X, τ_1).

Proof:

Take θ: $(X, \tau_1) \rightarrow (Y, \tau_2)$ be $\pi g(\alpha g)^*$ -continuous map and W be open set in (Y, τ_2) then W^c is closed in (Y, τ_2) . Inverse image of W^c is $\pi g(\alpha g)^*$ -closed of (X, τ_1) since θ is $\pi g(\alpha g)^*$ -continuous . But $\theta^{-1}(W^c) = (\theta^{-1}(W))^c$. Hence inverse image of W is $\pi g(\alpha g)^*$ -open of (X, τ_1).

Conversely, Assume, For every open set W of (Y, τ_2), inverse image of W is $\pi g(\alpha g)^*$ -open of (X, τ_1). If W of (Y, τ_2) be a closed set, then W^c of (Y, τ_2) be a open set. By assumption , inverse image of W^c of (X, τ_2) be a $\pi g(\alpha g)^*$-open set of (X, τ_1). But $\theta^{-1}(W^c) = (\theta^{-1}(W))^c$. Hence inverse image of W is $\pi g(\alpha g)^*$ -closed of (X, τ_1). This implies θ is $\pi g(\alpha g)^*$-continuous

Diagram -II



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4. On $\pi g(\alpha g)^*$- open map.

Definition 4.1:

A map θ: $(X, \tau_1) \rightarrow (Y, \tau_2)$ is called a **$\pi g(\alpha g)^*$-open map** if the image of every open set of (X, τ_1) is $\pi g(\alpha g)^*$- open set of (Y, τ_2).

Theorem 4.2:

Every open map, g-open map, $\hat{g}$ -open map ,α-open map, αg-open map, gα-open map , πg–open map and πgα –open map is $\pi g(\alpha g)^*$ –open map.

Proof:

Follows from the fact that "Every open set, g-open set, $\hat{g}$ -open set ,α-open set, αg-open set, gα-open set , πg–open set and πgα –open set is $\pi g(\alpha g)^*$ –open set".

The converse of the above theorem need not be true from the following example.

Example 4.3:

Take X = Y= {a,b,c} and τ_1 = {X,Φ,{a},{b,c}}, τ_2 = {Y,Φ,{a}}. Define $\theta : (X, \tau_1) \rightarrow (Y, \tau_2)$ as $\theta(a) = a$, $\theta(b) = b$, $\theta(c) = c$. Here W={b,c} be a open set of (X, τ_1) . But image of W is $\pi g(\alpha g)^*$ –open set of (Y, τ_2) but not open set, g-open set, α-open set, αg-open set of (Y, τ_2) . This implies converse of above theorem not true.

5. On $\pi g(\alpha g)^*$- irresolute map.

Definition 5.1:

A map θ: $(X, \tau_1) \rightarrow (Y, \tau_2)$ is called a **$\pi g(\alpha g)^*$-irresolute** if the inverse image of every $\pi g(\alpha g)^*$-closed set of (Y, τ_2) is $\pi g(\alpha g)^*$- closed set of (X, τ_1).

Theorem 5.2:

Every $\pi g(\alpha g)^*$ –irresolute map is $\pi g(\alpha g)^*$ -continuous map.

Proof:

Take a map $\theta : (X, \tau_1) \rightarrow (Y, \tau_2)$ be $\pi g(\alpha g)^*$ –irresolute map. Let W be closed set of (Y, τ_2) then W be a $\pi g(\alpha g)^*$ – closed set of (Y, τ_2), since closed $\rightarrow$ $\pi g(\alpha g)^*$ –closed. But inverse image of W is $\pi g(\alpha g)^*$ -closed of (X, τ_1). Hence θ is $\pi g(\alpha g)^*$ -continuous.

The converse of the above theorem need not be true from the following example.

Example 5.3:

Take X = Y= {a,b,c} and τ_1 = {X,Φ,{a},{b},{a,b}}, τ_2 = {Y,Φ,{a},{a,b}}. Define $\theta : (X, \tau_1) \rightarrow (Y, \tau_2)$ as $\theta(a) = a$, $\theta(b) = b$, $\theta(c) = c$, $\theta(d)=d$. Here inverse image of all τ_2^C are of $\pi g(\alpha g)^*$ -closed of (X, τ_1) so θ is $\pi g(\alpha g)^*$ –continuous. But inverse image of all $\pi g(\alpha g)^*$ -closed of (Y, τ_2) are not $\pi g(\alpha g)^*$ -closed of (X, τ_1) so θ is not $\pi g(\alpha g)^*$ – irresolute map.

Theorem 5.4:

A map θ: $(X, \tau_1) \rightarrow (Y, \tau_2)$ is $\pi g(\alpha g)^*$-irresolute and h : $(Y, \tau_2) \rightarrow (Z, \tau_3)$ is $\pi g(\alpha g)^*$- continuous , then h o θ : $(X, \tau_1) \rightarrow (Z, \tau_3)$ is $\pi g(\alpha g)^*$-continuous.

Proof:

Take W be any closed set of (Z, τ_3) and.so h^{-1} of W is $\pi g(\alpha g)^*$-closed of (Y, τ_2), Since h is $\pi g(\alpha g)^*$-continuous. $(h \circ \theta)^{-1}(W) = \theta^{-1}(h^{-1}(W))$ is $\pi g(\alpha g)^*$-closed of (X, τ_1), Since θ is $\pi g(\alpha g)^*$- irresolute. Hence h o θ is $\pi g(\alpha g)^*$-continuous.

Theorem 5.5:

ISSN 2250-3153

A map θ: $(X, \tau_1) \rightarrow (Y, \tau_2)$ is $\pi g(\alpha g)^*$-irresolute and h : $(Y, \tau_2) \rightarrow (Z, \tau_3)$ is $\pi g(\alpha g)^*$- irresolute , then h o θ : $(X, \tau_1) \rightarrow (Z, \tau_3)$ is $\pi g(\alpha g)^*$-irresolute.

Proof:

Take W be any $\pi g(\alpha g)^*$-closed set of (Z, τ_3) and.so h^{-1} of W is $\pi g(\alpha g)^*$-closed of (Y, τ_2), Since h is $\pi g(\alpha g)^*$-irresolute. $(h \circ \theta)^{-1}(W) = \theta^{-1}(h^{-1}(W))$ is $\pi g(\alpha g)^*$-closed of (X, τ_1), Since θ is $\pi g(\alpha g)^*$- irresolute. Hence h o θ is $\pi g(\alpha g)^*$-irresolute.

Theorem 5.6:

A map θ: $(X, \tau_1) \rightarrow (Y, \tau_2)$ is $\pi g(\alpha g)^*$-irresolute if and only if inverse image of every $\pi g(\alpha g)^*$- open set in (Y, τ_2) is $\pi g(\alpha g)^*$- open set in (X, τ_1).

Proof:

Similar to Theorem 3.13.

6. On $\pi g(\alpha g)^*$ - homeomorphisms.

Definition 6.1:

A bijective map θ: $(X, \tau_1) \rightarrow (Y, \tau_2)$ is called a **$\pi g(\alpha g)^*$-homeomorphism** if a map is both $\pi g(\alpha g)^*$ –continuous and $\pi g(\alpha g)^*$ –open.

Remark 6.2:

For a bijective map θ: $(X, \tau_1) \rightarrow (Y, \tau_2)$, the following statement are equivalent:

(i) θ^{-1} is $\pi g(\alpha g)^*$ –continuous , (ii) θ is $\pi g(\alpha g)^*$ –open , (iii) θ is $\pi g(\alpha g)^*$ –closed .

Theorem 6.3:

Every homeomorphism is a $\pi g(\alpha g)^*$ –homeomorphism.

Proof :

Follows from the fact that "Every continuous map is $\pi g(\alpha g)^*$ –continuous map and Every open map is $\pi g(\alpha g)^*$ –open map".

The converse of the above theorem need not be true from the following example.

Example 6.4:

Take X = Y= {a,b,c} and τ_1 = {X,Φ,{a},{b},{a,b}}, τ_2 = {Y,Φ,{a},{a,b}}.

Define θ : $(X, \tau_1) \rightarrow (Y, \tau_2)$ as bijective map. Now θ is $\pi g(\alpha g)^*$ – homeomorphism but not a homeomorphim, Since θ ({b})={b} is not in open set of (Y, τ_2) .

Remark 6.5:

The composition of two $\pi g(\alpha g)^*$-homeomorphism map is need not be a $\pi g(\alpha g)^*$-homeomorphism map.

Example 6.6 :

Take X = Y= Z={a,b,c} and τ_1 = {X,Φ,{a},{b},{a,b}}, τ_2 = {Y,Φ,{a},{a,b}} and τ_3 = {Y,Φ,{a},{b,c}}. Define θ : $(X, \tau_1) \rightarrow (Y, \tau_2)$ and h : $(Y, \tau_2) \rightarrow (Z, \tau_3)$ be an identity maps. Let θ and h be a $\pi g(\alpha g)^*$-homeomorphism maps. . But $(h \circ \theta)^{-1}(\{a\}) = \theta^{-1}(h^{-1}(\{a\}))=\{a\}$ is not $\pi g(\alpha g)^*$-closed of (X, τ_1). Hence h o θ is not $\pi g(\alpha g)^*$-homeomorphism, Since h o θ is not a $\pi g(\alpha g)^*$-continuous map.

Theorem 6.7:

If map θ: $(X, \tau_1) \rightarrow (Y, \tau_2)$ is bijective $\pi g(\alpha g)^*$ -continuous map, then following statement are equivalent:

(i) θ is $\pi g(\alpha g)^*$ –homeomorphism , (ii) θ is $\pi g(\alpha g)^*$ –open , (iii) θ is $\pi g(\alpha g)^*$ –closed .

Proof :

Follows from Remark 6.2.

7. Applications of $\pi g(\alpha g)^*$-closed set.

Definition 7.1:

1)A topological space (X,τ) is called $T_{1/2}$ - space [5] if every g- closed in (X,τ) is closed in (X,τ).

2) A topological space (X,τ) is called T_b - space [14] if every gs-closed in (X,τ) is closed in (X,τ).

3) A topological space (X,τ) is called ${}_{\alpha}T_b$ -space[17] if every αg-closed in (X,τ) is closed in (X,τ).

Definition 7.2:

A topological space (X, τ) is called **$\pi g(\alpha g)^*$ –$T_{1/2}$ - space** if every $\pi g(\alpha g)^*$ - closed set of (X, τ) is closed of (X, τ).

Theorem 7.3:

Every $\pi g(\alpha g)^*$ –$T_{1/2}$ – space is a $T_{1/2}$ – space.

Proof :

Assume that (X, τ) is a $\pi g(\alpha g)^*$ –$T_{1/2}$ – space. Let H be a g-closed set. But every g-closed set is a $\pi g(\alpha g)^*$-closed. By assumption, (X, τ) is a $T_{1/2}$ – space.

Theorem 7.4:

Every $\pi g(\alpha g)^*$ –$T_{1/2}$ – space is a ${}_{\alpha}T_b$ - space.

Proof :

Assume that (X, τ) is a $\pi g(\alpha g)^*$ –$T_{1/2}$ – space. Let H be a αg-closed set. But every αg-closed set is a $\pi g(\alpha g)^*$-closed. By assumption, (X, τ) is a ${}_{\alpha}T_b$ - space.

Remark 7.5 :

$\pi g(\alpha g)^*$ –$T_{1/2}$ – space andT_b – space are independent spaces

Theorem 7.6:

A space (X, τ) is a πg(αg)* –$T_{1/2}$ – space if and only if every singleton of X is either π-closed set or αg –open.

Proof :

Assume that (X, τ) is a πg(αg)* –$T_{1/2}$ – space. Let y be an element in X and {y} is not in π-closed, then X-{y} is not in π-open and then X-{y} is πg(αg)* –closed. By assumption , X-{y} is αg-closed. Hence {y} is αg-open. The converse is similar.

Theorem 7.7:

A map θ: (X, τ_1) →(Y, τ_2) and h : (Y, τ_2) →(Z, τ_3) be two maps and if θ is αg-irresolute and h is a πg(αg)* –continuous and Y is a πg(αg)* –$T_{1/2}$ – space, then h o θ : (X, τ_1) →(Z, τ_3) is αg-continuous.

Proof :

Take W be any closed set in (Z, τ_3) . Here (Y, τ_2) is a πg(αg)* –$T_{1/2}$ – space and h^{-1} of W is πg(αg)*-closed of (Y, τ_2), Since h is πg(αg)*-continuous. But $(h \circ \theta)^{-1}(W) = \theta^{-1}(h^{-1}(W))$ is αg-closed (X, τ_1), Since θ is αg- irresolute. Hence h o θ is αg-continuous.

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