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On β generalized α closed sets in Neutrosophic Topological spaces

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Abstract: In this paper a new concept of neutrosophic closed sets called neutrosophic β generalized α closed set is introduced and their properties are thoroughly studied and analyzed and also discuss their relationship between basic closed sets in neutrosophic topological spaces. Some new interesting theorems are presented using newly introduced set.

Keywords: Neutrosophic β generalized α closed sets.

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1. Introduction

The concept of intuitionistic fuzzy sets introduced by Atanassov(1), intuitionistic fuzzy topological spac by Coker(2),after that Floretin Smarandache(3) in 1999 extended the neutrosophic sets, neutrosophic topological spaces by A. A. Salama and S. A. Alblowi(9). Further the basic sets like neutrosophic open sets(N-OS), neutrosophic semi open sets(N-SOS), neutrosophic pre open sets(N-POS), neutrosophic α open sets(N- αOS), neutrosophic regular open sets(N-ROS), neutrosophic β open sets(N- βos), neutrosophic b open sets(N-bOS) are introduced in neutrosophic topological spaces and their properties are studied by various authors(8,10).

The main aim of this paper is to analyze a new concept of neutrosophic closed sets called neutrosophic β generalized α closed sets also specialized some of their basic properties with examples.

2. Preliminaries:

Here in this paper (X, τ) is the neutrosophic topological space .Also the neutrosophic interior is denoted by N-Int(A), neutrosophic closure is denoted by N-Cl(A) and

the complement of a neutrosophic set A is denoted by N-C(A) and the empty and whole sets are denoted by 0 and 1 respectively.

Definition 2.1: Let X be a non-empty fixed set. A neutrosophic set (NS) A is an object having the form A = $\{\langle x, \mu_{A(x)}, \sigma_{A(x)}, \nu_{A(x)}\rangle : x \in X\}$ where $\mu_A(x)$ represent the degree of membership , $\sigma_A(x)$ represent degree of indeterminacy and $\nu_A(x)$ represent the degree of nonmembership

Nonmembership respectively of each element $x \in X$ to the set A.

A Neutrosophic set A = $\{\langle x, \mu_{A(x)}, \sigma_{A(x)}, \nu_{A(x)}\rangle : x \in X\}$ can be identified as an ordered triple $\langle \mu_A, \sigma_A, \nu_A \rangle$ in]-0, 1+[on X.

Definition 2.2: Let A = $\langle \mu_A, \sigma_A, \nu_A \rangle$ be a NS on X, then the complement Neutrosophic-C(A) may be defined as

1. Neutrosophic -C (A) = $\{\langle x, (1-\mu_A (x)), (1- \nu_A(x)) \rangle : x \in X\}$

2. Neutrosophic -C (A) = $\{\langle x, \nu_A(x), \sigma_A(x), \mu_A (x) \rangle : x \in X\}$

3. Neutrosophic -C (A) = $\{\langle x, \nu_A(x), (1-\sigma_A(x)), \mu_A (x) \rangle : x \in X\}$

Definition 2.3: For any two neutrosophic sets A = $\{\langle x, \mu_A (x), \sigma_A(x), \nu_A(x) \rangle : x \in X\}$ and

B = $\{\langle x, \mu_B (x), \sigma_B(x), \nu_B(x) \rangle : x \in X\}$ is

1. $(A \subseteq B) \Leftrightarrow \mu_A (x) \leq \mu_B (x), \sigma_A(x) \leq \sigma_B(x)$ and $\nu_A(x) \geq \nu_B(x) \;\; \forall \;\; x \in X$

2. $(A \subseteq B) \Leftrightarrow \mu_A (x) \leq \mu_B (x), \sigma_A(x) \geq \sigma_B(x)$ and $\nu_A(x) \geq \nu_B(x) \;\; \forall \;\; x \in X$

3. $(A \cap B) \Leftrightarrow \mu_A (x) \wedge \mu_B (x), \sigma_A(x) \wedge \sigma_B(x)$ and $\nu_A(x) \vee \nu_B(x)$

4. $(A \cap B) \Leftrightarrow \mu_A (x) \wedge \mu_B (x), \sigma_A(x) \vee \sigma_B(x)$ and $\nu_A(x) \vee \nu_B(x)$

5. $(A \cup B) \Leftrightarrow \mu_A (x) \vee \mu_B (x), \sigma_A(x) \vee \sigma_B(x)$ and $\nu_A(x) \wedge \nu_B(x)$

6. $(A \cup B) \Leftrightarrow \mu_A (x) \vee \mu_B (x), \sigma_A(x) \wedge \sigma_B(x)$ and $\nu_A(x) \wedge \nu_B(x)$

Definition 2.4: A neutrosophic topology (NT) on a non-empty set X is a family τ of neutrosophic subsets in X satisfies the following axioms:

(NT_1) 0_N, $1_N \in \tau$

(NT_2) $G_1 \cap G_2 \in \tau$ for any $G_1, G_2 \in \tau$

(NT_3) $\cup G_i \in \tau \ \forall \ \{G_i : i \in J\} \subseteq \tau$

In this case the pair (X, τ) is a neutrosophic topological space (NTS) and any neutrosophic set in τ is known as a neutrosophic open set (N-OS) in X. A neutrosophic set A is a neutrosophic closed set (NCS) if and only if its complement N-C(A) is a neutrosophic open set in X.

Definition 2.6: A neutrosophic set A of a NTS X is said to be

(i) A neutrosophic pre-open set (NP-OS) if A ⊆ NInt(NCl(A))

(ii) A neutrosophic semi-open set (NS-OS) if A ⊆ NCl(NInt(A))

(iii) A neutrosophic α-open set (Nα-OS) if A ⊆ NInt(NCl(NInt(A)))

(iv) A neutrosophic β-open set (N β-OS) if A ⊆ N-cl(N-int(N-cl(A))).

(v) A neutrosophic regular open set (N-ROS) if N-int(N-cl(A)) = A,

(vi) A neutrosophic b open set (N-bOS) if A ⊆ N-int(N-cl(A)) ∪ N-cl(N-int(A))

Definition 2.7: A neutrosophic set A of a NTS X is said to be

(i) A neutrosophic pre-closed set (NP-CS) if NCl(NInt(A)) ⊆ A

(ii) A neutrosophic semi-closed set (NS-CS) if NInt(NCl(A)) ⊆ A

(iii) A neutrosophic α-closed set (Nα-CS) if NCl(NInt(NCl(A))) ⊆ A

(iv) A neutrosophic β-closed set (Nα-CS) if Nint(Ncl(Nint(A))) ⊆ A

(v)A neutrosophic regular closed set (N-RCS) if N-cl(N-int(A)) = A,

(vi) A neutrosophic b closed set (N-bCS) if N-int(N-cl(A)) ∩ N-cl(N-int(A)) ⊆ A

Definition 2.8:

Consider a NS A in NTS. The Neutrosophic beta interior & Neutrosophic beta closure of A are defined as

Nβint(A)= ∪ { G, G is a N-βOS in X and G ⊆A}

Nβcl(A)= ∩ { G, G is a N-βOS in X and A ⊆ K}

Remark 2.9 :

Consider a NS A in NTS, then

(1) Nβcl(A)=A Nint(Ncl(Nint(A))),

(2) Nβint(A)=A∩Ncl(Nint(Ncl(A))).

Definition 2.10:

Consider a NS A in NTS. Then it is a Neutrosophic generalized beta closed set (N-GβCS) if N-βcl(A) ⊆ U whenever A ⊆ U and U is a NOS.

3. Neutrosophic β generalized α closed sets in Topological spaces

In this section we have introduced Neutrosophic β generalized α closed sets and studied some of their properties.

Definition 3.1: An Neutrosophic set A in an NTS (X, τ) is said to be an neutrosophic β generalized α closed set (NβGαCS) if Nβcl(A) ⊆ U whenever A ⊆ U and U is an N-αOS in (X, τ).

The family of all N-βGαCSs of an NTS (X, τ) is denoted by N-βGαC(X).

Example 3.2: Let X = {a, b} and G_1 = ⟨x, (0.5_a, 0.5_b), (0.5_a, 0.5_b), (0.5_a, 0.5_b)⟩ and G_2 = ⟨x, (0.4_a, 0.3_b), (0.6_a, 0.7_d), (0.6_a, 0.7_b)⟩. Then τ = {0, G_1, G_2, 1} is an NT on X. Here

Let S = ⟨x, (0.3_a, 0.2_b), (0.7_a, 0.8_b), (0.7_a, 0.8_b)⟩ then S is called an N-βGαCS in X.

Proposition 3.3: Every Neutrosophic-CS is an Neutrosophic -βGαCS in (X, τ) but reverse process is not true in general.

Proof: Let S be an N-CS in X. Let we take S ⊆ U where U is said to be an N-αOS in X. As N-βcl(S) ⊆ N-cl(S) = S ⊆ U by hypothesis, we have N-βcl(S) ⊆ U. Thus S is an N-βGαCS in (X, τ).

Example 3.4: Let X = {a, b}, G_1 = ⟨x, (0.5_a, 0.5_b), (0.5_a, 0.5_b), (0.5_a, 0.5_b)⟩ and G_2 = ⟨x, (0.4_a, 0.3_b), (0.6_a, 0.7_d), (0.6_a, 0.7_b)⟩. Then τ = {0, G_1, G_2, 1} is an NT on X.

Here we take S = ⟨x, (0.3$_a$, 0.2$_b$), (0.7$_a$, 0.8$_b$), (0.7$_a$, 0.8$_b$)⟩ is an (N)-βGαCS but it not an (N)-CS in (X, τ) since N-cl(S) = $G_1^c \neq$ S.

Proposition 3.5: Every Neutrosophic -SCS is an Neutrosophic -βGαCS in (X, τ) but reverse process is not true in general.

Proof: Let A be an N-SCS in X. Let we take A ⊆ U and U is said to be an N-αOS in X. As N-βeta closure(A) ⊆ N-semi closure(A) = A ⊆ U by hypothesis, we have N-βeta closure (A) ⊆ U. Then A is called an N-βGαCS in (X, τ).

Example 3.6: Let X = {a, b}, G_1 = ⟨x, (0.5$_a$, 0.5$_b$), (0.5$_a$, 0.5$_b$), (0.5$_a$, 0.5$_b$)⟩ and G_2 = ⟨x, (0.4$_a$, 0.3$_b$), (0.6$_a$, 0.7$_b$), (0.6$_a$, 0.7$_b$)⟩. Then τ = {0, G_1, G_2, 1} is an NT on X.

Here we take a point S = ⟨x, (0.3$_a$, 0.2$_b$), (0.7$_a$, 0.8$_b$), (0.7$_a$, 0.8$_b$)⟩ which satisfy N-βGαCS but does not satisfy N-SCS in (X, τ) since N-int(N-cl(S)) = N-int(G_1^c) = $G_1 \nsubseteq$ S.

Proposition 3.7: Every Neutrosophic-PCS is an Neutrosophic -βGαCS in (X, τ) but reverse process is not true in general.

Proof: Let A be an N-PCS in X. Let we take A ⊆ U and U is said to be an N-αOS in X. As N-βeta closure(A) ⊆ N-Pre closure(A) = A ⊆ U by hypothesis, we have N-βeta closure (A) ⊆ U. Then A is called an N-βGαCS in (X, τ).

Example 3.8: Let X = {a, b}, G_1 = ⟨x, (0.5$_a$, 0.6$_b$), (0.5$_a$, 0.4$_b$), (0.5$_a$, 0.4$_b$)⟩ and G_2 = ⟨x, (0.4$_a$, 0.3$_b$), (0.6$_a$, 0.7$_b$), (0.6$_a$, 0.7$_b$) ⟩. Then τ = {0, G_1, G_2, 1} is an NT on X. Here we take A = ⟨x, (0.4$_a$, 0.3$_b$), (0.6$_a$, 0.7$_b$), (0.6$_a$, 0.7$_b$)⟩ which satisfy N-βGαCS but does not satisfy N-PCS in (X, τ) as N-cl(N-int(A)) = N-cl(G_2) = $G_1^c \nsubseteq$ A.

Proposition 3.9: Every Neutrosophic-αCS is an Neutrosophic-βGαCS in (X, τ) but not conversely in general.

Proof: Let A be an N-αCS in X. Let as assume A ⊆ U and U is said to be an N-αOS in X. As N-βcl(A) ⊆ N-αcl(A) = A ⊆ U by hypothesis, we have N-βcl(A) ⊆ U. Then A is an N-βGαCS in (X, τ).

Example 3.10: Let X = {a, b}, G_1 = ⟨x, (0.5a, 0.5b), (0.5a, 0.5b), (0.5a, 0.5b)⟩ and G_2 = ⟨x, (0.4a, 0.3b), (0.6a, 0.7b), (0.6a, 0.7b) ⟩. Then τ = {0, G_1, G_2, 1} is an IFT on X. Here we take S = ⟨x, (0.3a, 0.2b), (0.7a, 0.8b), (0.7a, 0.8b)⟩ which satisfy N-βGαCS but does not satisfy N-αCS in (X, τ) since N-cl(N-int(N-cl(S))) = N-cl(N-int(G_1^c)) = N-cl(G_1) = $G_1^c \nsubseteq$ S.

Proposition 3.11: Every Neutrosophic-bCS is an Neutrosophic-βGαCS in (X, τ) but reverse process is not true in general.

Proof: Let A be an NbCS in X. Let as assume A ⊆ U and U is said to be an N-αOS in X. As N-βcl(A) ⊆ N-bcl(A) = A ⊆ U by hypothesis, we have N-βcl(A) ⊆ U. Then A is an N-βGαCS in (X, τ).

Example 3.12: Let X = {a, b}, G_1 = ⟨x, (0.5a, 0.3b), (0.5a, 0.7b), (0.5a, 0.7b)⟩ and G_2 = ⟨x, (0.4a, 0.3b), (0.6a, 0.7b), (0.6a, 0.7b)⟩. Then τ = {0, G_1, G_2, 1} is an NT on X. Here we assume A = ⟨x, (0.4a, 0.6b), (0.4a, 0.4b), (0.4a, 0.4b)⟩ which satisfy N-βGαCS but does not satisfy N-bCS in (X, τ) since N-int(N-cl(A)) ∩ N-cl(N-int(A)) = G_1 ∩ G_1^c = $G_1 \nsubseteq$ A.

Proposition 3.13: Every Neutrosophic-RCS is an Neutrosophic-βGαCS in (X, τ) but reverse process is not true in general.

Proof: Let A be an N-RCS in X. Then A is an N-CS as every N-RCS is an N-CS, A is an N-βGαCS in (X, τ).

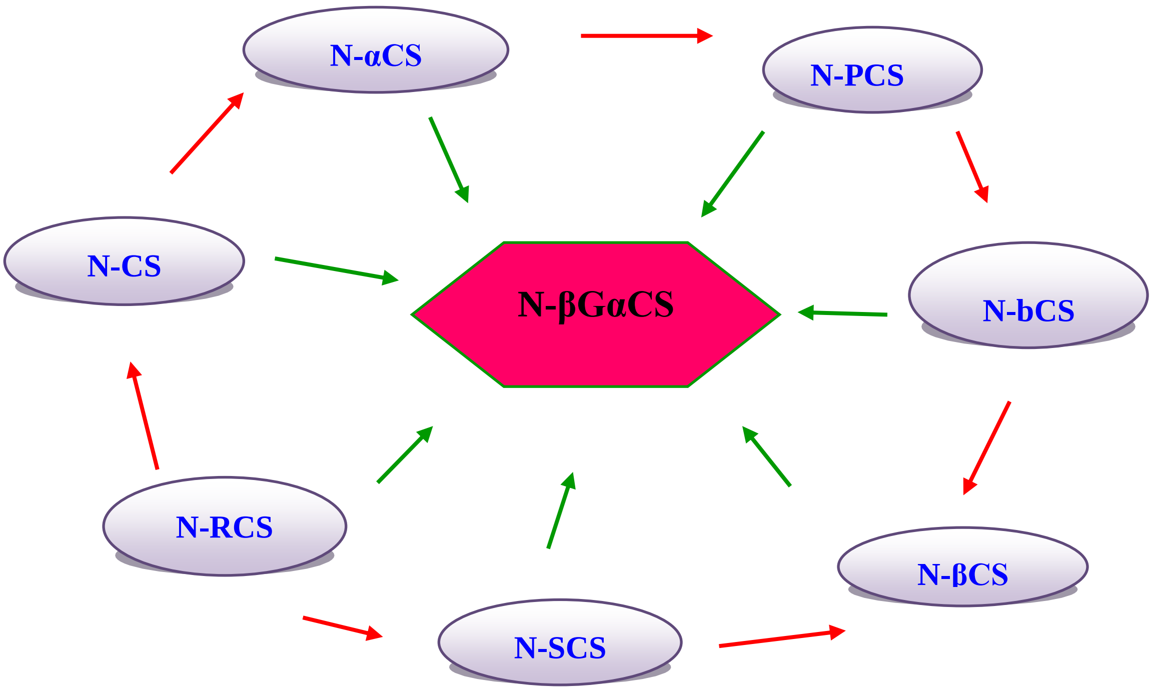
Example 3.14: Let X = {a, b}, G_1 = ⟨x, (0.5a, 0.6b), (0.5a, 0.4b), (0.5a, 0.4b)⟩ and G_2 = ⟨x, (0.4a, 0.3b), (0.6a, 0.7b), (0.6a, 0.7b)⟩. Then τ = {0, G_1, G_2, 1} is an NT on X. Here we take A = ⟨x, (0.4a, 0.3b), (0.6a, 0.7b)⟩ which satisfy N-βGαCS but does not satisfy N-RCS in (X, τ) as N-cl(N-int(A)) = N-cl(G_2) = $G_1^c \neq$ A.

Proposition 3.15: Every Neutrosophic-βCS is an Neutrosophic-βGαCS in (X, τ) but reverse process is not true in general.

Proof: Let A be an N-βCS in X. Let as assume A ⊆ U and U is said to be an N-αOS in X. Now N-βcl(A) = A ⊆ U, by hypothesis. Therefore we have N-βcl(A) ⊆ U. Hence A is an N-βGαCS in (X, τ).

Example 3.16: Let X = {a, b}, G_1 = ⟨x, (0.5_a, 0.3_b), (0.5_a, 0.7_b), (0.5_a, 0.7_b)⟩ and G_2 = ⟨x, (0.4_a, 0.3_b), (0.6_a, 0.7_b), (0.6_a, 0.7_b)⟩. Then τ = {0, G_1, G_2, 1} is an NT on X. Here A = ⟨x, (0.4_a, 0.6_b), (0.4_a, 0.4_b), (0.4_a, 0.4_b)⟩ which satisfy N-βGαCS but does not satisfy N-βCS in (X, τ) as N-int(N-cl(N-int(A))) = N-int(N-cl(G_2)) = N-int(G_1^c) = $G_1 \nsubseteq$ A.

In the following diagram, we have provided the relation between various types of neutrosophic closedness.



Remark 3.17: The union of any two N-βGαCSs is not an N-βGαCS in general as seen in the following example.

Example 3.18: Let us assume X = {a, b}, G_1 = ⟨x, (0.5_a, 0.6_b), (0.5_a, 0.4_b), (0.5_a, 0.4_b)⟩, G_2 = ⟨x, (0.2_a, 0.3_b), (0.8_a, 0.7_b), (0.8_a, 0.7_b)⟩ and G_3 = ⟨x, (0.6_a, 0.7_b), (0.4_a, 0.3_b), (0.4_a, 0.3_b)⟩. Then τ be {0, G_1, G_2, G_3, 1} is an Neutrosophic Topology on X.

The NSs A = ⟨x, (0.1_a, 0.5_b), (0.9_a, 0.5_b), (0.9_a, 0.5_b)⟩, B = ⟨x, (0.5_a, 0.2_b), (0.5_a, 0.8_b), (0.5_a, 0.8_b)⟩ are N-βGαCSs in (X, τ). But A ∪ B is not an N-βGαCS as A ∪ B = ⟨x, (0.5_a, 0.5_b), (0.5_a, 0.5_b), (0.5_a, 0.5_b)⟩ ⊆ G_1 but N-βcl(A ∪ B) = ⟨x, (0.6_a, 0.7_b), (0.4_a, 0.3_b), (0.4_a, 0.3_b)⟩ ⊈ G_1.

Remark 3.19: The intersection of any two N-βGαCSs is not an N-βGαCS in general as seen in the following example.

Example 3.20: Let X = {a, b}, G_1 = ⟨x, (0.5_a, 0.6_b), (0.5_a, 0.4_b), (0.5_a, 0.4_b)⟩, G_2 = ⟨x, (0.2_a, 0.3_b), (0.8_a, 0.7_b), (0.8_a, 0.7_b)⟩ and G_3 = ⟨x, (0.6_a, 0.7_b), (0.4_a, 0.3_b), (0.4_a, 0.3_b)⟩. Then τ = {0, G_1, G_2, G_3, 1} is an NT on X. The IFSs A = ⟨x, (0.5_a, 0.8_b), (0.5_a, 0.2_b), (0.5_a, 0.2_b)⟩, B = ⟨x, (0.8_a, 0.6_b), (0.2_a, 0.4_b)⟩ are N-βGαCSs in (X, τ). But A ∩ B is not an N-βGαCS as A ∩ B = ⟨x, (0.5_a, 0.6_b), (0.5_a, 0.4_b), (0.5_a, 0.4_b)⟩ ⊆ G_1 but N-βcl(A ∩ B) = ⟨x, (0.6_a, 0.7_b), (0.4_a, 0.3_b), (0.4_a, 0.3_b)⟩ ⊈ G_1.

Proposition 3.21: Let (X, τ) be an NTS. Then for every A ∈ N-βGαC(X) and for every B ∈ NS(X), A ⊆ B ⊆ N-βcl(A) ⇒B ∈ N-βGαC(X).

Proof: Let B ⊆ U and also U be an N-α open set in X. Then since A ⊆ B, A ⊆ U. By hypothesis B ⊆ N-βcl(A). Therefore N-βcl(B) ⊆ N-βcl(N-βcl(A)) = N-βcl(A) ⊆ U, since A is an N-βGαCS in X. Hence B ∈ N-βGαC(X).

Proposition 3.22: If R is an N-αOS and an N-βGαCS in (X, τ), then R is an N-βCS in (X, τ).

Proof: Since R ⊆ R and R is an N-αOS in X, by hypothesis N-βcl(R) ⊆ R. But R ⊆ N-βcl(R). Therefore N-βcl(R) = R. Then R is an N-βCS in (X, τ).

Proposition 3.23: Let H ⊆ R ⊆ X where R is said to be an N-αOS and it is an N-βGαCS in X. Then H is an N-βGαCS in R if and only if H is an N-βGαCS in X.

Proof: Necessity: Let as assume J be an N-αOS in X and F ⊆ J. Also let H be an N-βGαCS in R. Then clearly H ⊆ R ∩ J and R ∩ J is an N-αOS in A. Hence neutrosophic beta closure of H in R, N-βcl_R(H) ⊆ R ∩ J and by Proposition 3.22, R is an N-βCS. Therefore N-βcl(R) = R. Now neutrosophic beta closure of H in X, N-βcl(H) ⊆ N-βcl(H) ∩ N-βcl(R) = N-βcl(H) ∩ R = N-βcl$_R$(H) ⊆ R ∩ J ⊆ J, that is N-βcl(H) ⊆ R, whenever H ⊆ R. Hence H is called N-βGαCS in X.

Sufficiency: Let V be an N-αOS in A, such that F ⊆ V. Since A is an N-αOS in X, V is an N-αOS in X. Therefore N-βcl(F) ⊆ V, as F is an N-βGαCS in X. Thus, N-βcl$_A$(F) = N-βcl(F) ∩ A ⊆ V ∩ A ⊆ V. Hence F is an N-βGαCS in A.

Proposition 3.24: An NS A is both an N-OS and an N-βGαCS if and only if A is an N-ROS in X.

Proof: Necessity: Let A be both an N-OS and an N-βGαCS in X. Then A is an N-αOS and an N-βGαCS. By Proposition 3.22, A is an N-βCS and N-int(N-cl(N-int(A))) ⊆ A. Since A is an N-OS, N-int(A) = A. Therefore N-int(N-cl(A)) ⊆ A. Since A is an N-OS, it is an N-POS. Hence A ⊆ N-int(N-cl(A)). Therefore A = N-int(N-cl(A)) and A is an N-ROS in X.

Sufficiency: Let A be an N-ROS in X then A= N-int(N-cl(A)). Since every N-ROS is an N-OS, A is an N-OS. We know N-int(N-cl(N-int(A))) = N-int(N-cl(A)) = A ⊆ A. Therefore A is an Neutrosophic β Closed set in X, and by Proposition 3.15, A is an N-βGαCS in X.

Proposition 3.25: Let (X, τ) be an NTS. Then N-βC(X) = N-βGαC(X) if every IFS in (X, τ) is an N-αOS in X.
Proof: Suppose that every NS in (X, τ) is an N-αOS in X. Let A ∈ N-βGαC(X). Then A is also an N-αOS by hypothesis. We know that A is an N-βCS. Therefore A ∈ N-βC(X).
Hence N-βGαC(X) ⊆ N-βC(X) ⟶ (i)
Let A ∈ N-βC(X). Then by Proposition 3.15, A is an N-βGαCS and A ∈ N-βGαC(X). Hence N-βC(X) ⊆ N-βGαC(X) ⟶ (ii). From (i) and (ii) N-βC(X) = N-βGαC(X).

Proposition 3.26: Let R be an N-αOS and an N-βGαCS of (X, τ). Then R ∩ F is an N-βGαCS of (X, τ) where F is an N-CS of X.

Proof: Suppose that R is an N-αOS and an N-βGαCS of (X, τ), then by Proposition 3.22, R is an N-βCS. But F is an N-CS in X. Hence R ∩ F is an N-βCS as every N-CS is an N-βCS. Then R ∩ F is an N-βGαCS in X.

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