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$N_{nc}\beta$-CONTINUOUS MAPS

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Abstract: In this article, we study a new types of mappings using N-neutrosophic crisp β open sets such as continuous mappings and irresolute mappings in N-neutrosophic crisp topological spaces were introduced. Also, we discussed about their properties in relation with the other continuous and irresolute mappings in N-neutrosophic crisp topological spaces. Also, we study about the concept of strongly N-neutrosophic crisp β continuous and perfectly N-neutrosophic crisp β continuous functions in N_{nc} topological spaces with their properties.

Keywords and Phrases: $N_{nc}\beta$-open sets, $N_{nc}\beta$-closed sets, $N_{nc}\beta Cts$, $N_{nc}\beta Irr$, $StN_{nc}\beta Cts$, $PeN_{nc}\beta Cts$.

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1. Introduction

The ideal concepts of neutrosophy and neutrosophic set was first presented by Smarandache [13, 14, 16] at the beginning of 21^{st} century. In 2014, the concept of neutrosophic crisp topological space presented by Salama, Smarandache and Kroumov [11]. Al-Omeri [3] also investigated neutrosophic crisp sets in the build of neutrosophic crisp topological Spaces. Also presented the definitions of neutrosophic crisp continuous mappings compact spaces. Lellis Thivagar et al. [7] introduced the concept of N_n-open (closed) sets in N-neutrosophic topological spaces. Al-Hamido [2] explore the possibilities in idea of neutrosophic crisp topological spaces into N_{nc}-topological spaces and scrutinized some of their necessary properties. F. Smarandache [15, 17] developed an extension from the neutrosophic crisp set to refined neutrosophic crisp set.

In 1983, Abd EL Monsef et al. [1] presented β- open sets in topology. Also, the equivalent notion of semi-pre open sets was independently developed by Andrijevic [5] in 1986. Vadivel et al. [19] presented β-open sets in neutrosophic crisp topological spaces via N-terms of topology.

The strong and weak forms of continuous functions are introduced by Levine in 1960 [8] and also introduced in strong continuity in topological spaces. In 1967, Naimpally [9] also discussed strongly continuous functions in a topology. In 1984, Noiri [10] discussed and studied more about supercontinuity and some strong forms of continuity. Recently, Vadivel et al. [23, 24] introduced strongly continuous functions in N_{nc} topological spaces. Perfectly continuous functions is introduced by Kohli et al. [6] in 2008 and studied their properties. Al-Omeri [4] worked on neutrosophic pre-continuous multifunctions and almost pre-continuous multifunctions in neutrosophic topological spaces. Recently, the authors [21, 22, 25, 26, 27, 28, 29] worked on some continuous and irresolute functions on N-neutrosophic crisp topological spaces and Neutrosophic topological spaces.

In this paper, we establish the concept of N-neutrosophic crisp β-continuous and N-neutrosophic crisp β-irresolute functions in N-neutrosophic crisp topological spaces and study their relation with near mappings N-neutrosophic crisp topological spaces. In addition, strongly N-neutrosophic crisp β continuous and perfectly N-neutrosophic crisp β continuous functions in N-neutrosophic crisp topological spaces are study and discuss their properties.

2. Preliminaries

Definition 2.1. [12] *For any non-empty fixed set U, a neutrosophic crisp set (briefly, ncs) K, is an object having the form $K = \langle K_1, K_2, K_3\rangle$ where K_1, K_2 & K_3 are subsets of U satisfying any one of the types*

(T1) $K_a \cap K_b = \phi$, $a \neq b$ & $\bigcup_{a=1}^{3} K_a \subset U$, $\forall a, b = 1, 2, 3.$

(T2) $K_a \cap K_b = \phi$, $a \neq b$ & $\bigcup_{a=1}^{3} K_a = U$, $\forall a, b = 1, 2, 3.$

(T3) $\bigcap_{a=1}^{3} K_a = \phi$ & $\bigcup_{a=1}^{3} K_a = U$, $\forall a = 1, 2, 3.$

Definition 2.2. [12] *Types of ncs's* $\emptyset_N$ *and* U_N *in* U *are as*

(i) $\emptyset_N$ *may be defined as* $\emptyset_N = \langle \emptyset, \emptyset, U\rangle$ *or* $\langle \emptyset, U, U\rangle$ *or* $\langle \emptyset, U, \emptyset\rangle$ *or* $\langle \emptyset, \emptyset, \emptyset\rangle$.

(ii) U_N *may be defined as* $U_N = \langle U, \emptyset, \emptyset\rangle$ *or* $\langle U, U, \emptyset\rangle$ *or* $\langle U, \emptyset, U\rangle$ *or* $\langle U, U, U\rangle$.

Definition 2.3. [12] *Let* U *be a non-empty set & the ncs's* K *&* M *in the form* $K = \langle K_{11}, K_{22}, K_{33}\rangle$, $M = \langle M_{11}, M_{22}, M_{33}\rangle$, *then*

(i) $K \subseteq M \Leftrightarrow K_{11} \subseteq M_{11}$, $K_{22} \subseteq M_{22}$ & $K_{33} \supseteq M_{33}$ *or* $K_{11} \subseteq M_{11}$, $K_{22} \supseteq M_{22}$ & $K_{33} \supseteq M_{33}$.

(ii) $K \cap M = \langle K_{11} \cap M_{11}, K_{22} \cap M_{22}, K_{33} \cup M_{33}\rangle$ *or* $\langle K_{11} \cap M_{11}, K_{22} \cup M_{22}, K_{33} \cup M_{33}\rangle$

(iii) $K \cup M = \langle K_{11} \cup M_{11}, K_{22} \cup M_{22}, K_{33} \cap M_{33}\rangle$ *or* $\langle K_{11} \cup M_{11}, K_{22} \cap M_{22}, K_{33} \cap M_{33}\rangle$

Definition 2.4. [12] *Let* $K = \langle K_1, K_2, K_3\rangle$ *a ncs on* U, *then the complement of* K *(briefly,* K^c*) may be defined in three different ways:*

(C1) $K^c = \langle {K_1}^c, {K_2}^c, {K_3}^c\rangle$, *or*

(C2) $K^c = \langle K_3, K_2, K_1\rangle$, *or*

(C3) $K^c = \langle K_3, {K_2}^c, K_1\rangle$.

Definition 2.5. [11] *A neutrosophic crisp topology (briefly,* ${}_{nc}t$*) on a non-empty set* U *is a family* Γ *of nc subsets of* U *satisfying*

(i) $\emptyset_N$, $U_N \in \Gamma$.

(ii) $K_1 \cap K_2 \in \Gamma \ \forall \ K_1$ & $K_2 \in \Gamma$.

(iii) $\bigcup_a K_a \in \Gamma, \ \forall \ K_a : a \in A \subseteq \Gamma$.

Then (U, Γ) *is a neutrosophic crisp topological space (briefly, ncts for short) in* U. *The neutrosophic crisp open sets (briefly, ncos) are the elements of* Γ *in* U. *A ncs* C *is neutrosophic crisp closed sets (briefly, nccs) iff its complement* C^c *is ncos.*

Definition 2.6. [2] *Let* U *be a non-empty set. Then* ${}_{nc}\Gamma_1$, ${}_{nc}\Gamma_2$, $\cdots$, ${}_{nc}\Gamma_N$ *are* N*-arbitrary crisp topologies defined on* U *and the collection* $N_{nc}\Gamma$ *is called* N_{nc}*-topology on* U *is*

$$N_{nc}\Gamma = \{A \subseteq U : A = (\bigcup_{j=1}^{N} E_j) \cup (\bigcap_{j=1}^{N} F_j),\ E_j, F_j \in {}_{nc}\Gamma_j\}$$

and it satisfies the following axioms:

(i) $\emptyset_N$, $U_N \in N_{nc}\Gamma$.

(ii) $\bigcup_{j=1}^{\infty} A_j \in N_{nc}\Gamma \ \forall \ \{A_j\}_{j=1}^{\infty} \in N_{nc}\Gamma$.

(iii) $\bigcap_{j=1}^{n} A_j \in N_{nc}\Gamma \ \forall \ \{A_j\}_{j=1}^{n} \in N_{nc}\Gamma$.

Then $(U, N_{nc}\Gamma)$ *is called a* N_{nc}*-topological space (briefly,* $N_{nc}ts$*) on* U*. The* N_{nc}*-open sets (*$N_{nc}os$*) are the elements of* $N_{nc}\Gamma$ *in* U *and the complement of* $N_{nc}os$ *is called* N_{nc}*-closed sets (*$N_{nc}cs$*) in* U*. The elements of* U *are known as* N_{nc}*-sets (*$N_{nc}s$*) on* U*.*

Definition 2.7. [2] *Let* $(U, N_{nc}\Gamma)$ *be* $N_{nc}ts$ *on* U *and* K *be an* $N_{nc}s$ *on* U*, then the* N_{nc} *interior of* K *(briefly,* $N_{nc}int(K)$*) and* N_{nc} *closure of* K *(briefly,* $N_{nc}cl(K)$*) are defined as*

$$N_{nc}int(K) = \cup\{A : A \subseteq K \ \& \ A \text{ is a } N_{nc}os \text{ in } U\}$$

$$N_{nc}cl(K) = \cap\{C : K \subseteq C \ \& \ C \text{ is a } N_{nc}cs \text{ in } U\}.$$

Definition 2.8. [2] *Let* $(U, N_{nc}\Gamma)$ *be any* $N_{nc}ts$*. Let* K *be an* $N_{nc}s$ *in* $(U, N_{nc}\Gamma)$*. Then* K *is said to be a*

(i) N_{nc}*-regular open* [18] *set (briefly,* $N_{nc}ros$*) if* $K = N_{nc}int(N_{nc}cl(K))$*.*

(ii) N_{nc}*-pre open set (briefly,* $N_{nc}\mathcal{P}os$*) if* $K \subseteq N_{nc}int(N_{nc}cl(K))$*.*

(iii) N_{nc}*-semi open set (briefly,* $N_{nc}\mathcal{S}os$*) if* $K \subseteq N_{nc}cl(N_{nc}int(K))$*.*

(iv) N_{nc}*-*α*-open set (briefly,* $N_{nc}\alpha os$*) if* $K \subseteq N_{nc}int(N_{nc}cl(N_{nc}int(K)))$*.*

(v) N_{nc}*-*γ*-open* [18] *set (briefly,* $N_{nc}\gamma os$*) set if* $K \subseteq N_{nc}cl(N_{nc}int(K)) \cup N_{nc}int(N_{nc}cl(K))$*.*

(vi) N_{nc}*-*β*-open* [19] *set (briefly,* $N_{nc}\beta os$*) if* $K \subseteq N_{nc}cl(N_{nc}int(N_{nc}cl(K)))$*.*

The complement of an $N_{nc}ros$ *(resp.* $N_{nc}\mathcal{P}os$*,* $N_{nc}\mathcal{S}os$*,* $N_{nc}\alpha os$*,* $N_{nc}\gamma os$ & $N_{nc}\beta os$*) is called an* N_{nc}*-regular (resp.* N_{nc}*-pre,* N_{nc}*-semi,* N_{nc}*-*α*,* N_{nc}*-*γ & N_{nc}*-*β*) closed set (briefly,* $N_{nc}rcs$ *(resp.* $N_{nc}\mathcal{P}cs$*,* $N_{nc}\mathcal{S}cs$*,* $N_{nc}\alpha cs$*,* $N_{nc}\gamma cs$ & $N_{nc}\beta cs$*)) in* U*.*

Definition 2.9. [20] *Let* $(U_1, N_{nc}\Gamma)$ *and* $(U_2, N_{nc}\Psi)$ *be any two* $N_{nc}ts$*'s. A map* $f : (U_1, N_{nc}\Gamma) \to (U_2, N_{nc}\Psi)$ *is said to be* N_{nc} *(resp.* N_{nc} *regular,* N_{nc} *pre,* N_{nc} *semi,* $N_{nc}\alpha$ & $N_{nc}\gamma$*) continuous (briefly,* $N_{nc}Cts$ *(resp.* $N_{nc}rCts$*,* $N_{nc}\mathcal{P}Cts$*,* $N_{nc}\mathcal{S}Cts$*,*

$N_{nc}\alpha Cts$ & $N_{nc}\gamma Cts$)) if the inverse image of every $N_{nc}os$ in $(U_2, N_{nc}\Psi)$ is a $N_{nc}os$ (resp. $N_{nc}ros$, $N_{nc}\mathcal{P}os$, $N_{nc}\mathcal{S}os$, $N_{nc}\alpha os$ & $N_{nc}\gamma os$) in $(U_1, N_{nc}\Gamma)$.

3. N-Neutrosophic Crisp β Continuous Function

Throughout this section, let $(U_1, N_{nc}\Gamma)$ and $(U_2, N_{nc}\Psi)$ be any two $N_{nc}ts$'s. Let $f : (U_1, N_{nc}\Gamma) \to (U_2, N_{nc}\Psi)$ be a function. Let K and M be an $N_{nc}s$'s in $(U_1, N_{nc}\Gamma)$.

Definition 3.1. *A function f is said to be $N_{nc}\beta$-continuous (briefly, $N_{nc}\beta Cts$) if the inverse image of every $N_{nc}os$ in $(U_2, N_{nc}\Psi)$ is a $N_{nc}\beta os$ in $(U_1, N_{nc}\Gamma)$.*

Example 3.1. Let $U = \{l_1, m_1, n_1, o_1\}$, ${}_{nc}\Gamma_1 = \{\phi_N, U_N, L, M, N\}$, ${}_{nc}\Gamma_2 = \{\phi_N, U_N\}$. $L = \langle\{l_1\}, \{\phi\}, \{m_1, n_1, o_1\}\rangle$, $M = \langle\{m_1, o_1\}, \{\phi\}, \{l_1, n_1\}\rangle$, $N = \langle\{l_1, m_1, o_1\}, \{\phi\}, \{n_1\}\rangle$, then we have $2_{nc}\Gamma = \{\phi_N, U_N, L, M, N\}$, let $f : (U, 2_{nc}\Gamma) \to (U, 2_{nc}\Gamma)$ be an identity function. Then f is a $2_{nc}\beta Cts$ function.

Theorem 3.1. *The statements are hold but the equality does not true.*

(i) Every $N_{nc}rCts$ is a $N_{nc}\beta Cts$.

(ii) Every $N_{nc}Cts$ is a $N_{nc}\beta Cts$.

(iii) Every $N_{nc}\alpha Cts$ is a $N_{nc}\beta Cts$.

(iv) Every $N_{nc}\mathcal{S}Cts$ is a $N_{nc}\beta Cts$.

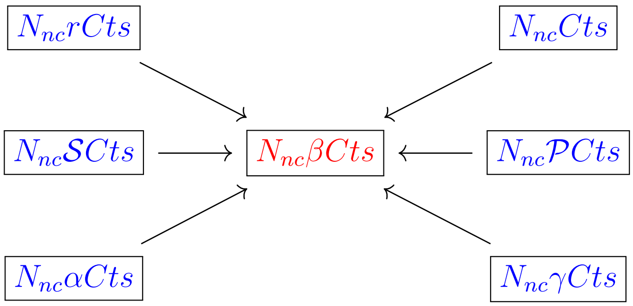
(v) Every $N_{nc}\mathcal{P}Cts$ is a $N_{nc}\beta Cts$.

(vi) Every $N_{nc}\gamma Cts$ is a $N_{nc}\beta Cts$.

Proof. (ii) Let f be a $N_{nc}Cts$ and K is a $N_{nc}os$ in U_2. Then $f^{-1}(K)$ is $N_{nc}\beta os$ in U_1. Since every $N_{nc}o$ set is $N_{nc}\beta o$ set, $f^{-1}(K)$ is $N_{nc}\beta os$ in U_1. Therefore f is $N_{nc}\beta Cts$.

The other cases are similar.

Remark 3.1. *The diagram shows $N_{nc}\beta Cts$ function in $N_{nc}ts$.*



Example 3.2. In Example 3.1, let $V = \{w_1, x_1, y_1, z_1\}$, ${}_{nc}\Psi_1 = \{\phi_N, V_N, W, X, Y\}$, ${}_{nc}\Psi_2 = \{\phi_N, V_N\}$. $W = \langle\{x_1\}, \{\phi\}, \{w_1, y_1, z_1\}\rangle$, $X = \langle\{w_1, y_1\}, \{\phi\}, \{x_1, z_1\}\rangle$, $Y = \langle\{w_1, x_1, y_1\}, \{\phi\}, \{z_1\}\rangle$, then we have $2_{nc}\Psi = \{\phi_N, V_N, W, X, Y\}$.

Define $f : (U, 2_{nc}\Gamma) \to (V, 2_{nc}\Psi)$ as $f(l_1) = x_1$, $f(m_1) = y_1$, $f(n_1) = w_1$ & $f(o_1) = z_1$, then $2_{nc}\beta Cts$ but not $2_{nc}rCts$, $2_{nc}Cts$, $2_{nc}\alpha Cts$, $2_{nc}\mathcal{P}Cts$, $2_{nc}\mathcal{S}Cts$, $2_{nc}\gamma Cts$, the set $f^{-1}(\langle\{w_1, y_1\}, \{\phi\}, \{x_1, z_1\}\rangle) = \langle\{m_1, n_1\}, \{\phi\}, \{l_1, o_1\}\rangle$ is a $2_{nc}\beta os$ but not $2_{nc}ros$, $2_{nc}os$, $2_{nc}\alpha os$, $2_{nc}\mathcal{P}os$, $2_{nc}\mathcal{S}os$, $2_{nc}\gamma os$.

Theorem 3.2. *The conditions*

(i) f is $N_{nc}\beta Cts$.

(ii) The inverse $f^{-1}(K)$ of all $N_{nc}os$ K in U_2 is $N_{nc}\beta os$ in U_1

are equivalent.

Proof. The proof is obvious, since $f^{-1}(\overline{K}) = \overline{f^{-1}(K)}$ for all $N_{nc}os$ K of U_2.

Theorem 3.3. *The conditions*

(i) $f(N_{nc}\beta cl(K)) \subseteq N_{nc}cl(f(K))$, for all ncs K in U_1.

(ii) $N_{nc}\beta cl(f^{-1}(M)) \subseteq f^{-1}(N_{nc}cl(M))$, for all ncs M in U_2

are equivalent.

Proof. (i) Since $N_{nc}cl(f(K))$ is a $N_{nc}cs$ in U_2 and f is $N_{nc}\beta Cts$, then f^{-1} $(N_{nc}$ $cl(f(K)))$ is $N_{nc}\beta c$ in U_1. Now, since $K \subseteq f^{-1}$ $(N_{nc}$ $cl(f(K)))$, $N_{nc}\beta cl(K) \subseteq f^{-1}(N_{nc}cl(f(K)))$. Therefore, $f(N_{nc}\beta cl(K)) \subseteq N_{nc}cl(f(K))$.
(ii) By replacing K with M in (i), we obtain $f(N_{nc}\beta cl(f^{-1}(M))) \subseteq N_{nc}cl(f(f^{-1}(M)))$ $\subseteq N_{nc}cl(M)$. Hence, $N_{nc}\beta cl(f^{-1}(M)) \subseteq f^{-1}(N_{nc}cl(M))$.

Remark 3.2. *If f is $N_{nc}\beta Cts$, then*

(i) $f(N_{nc}\beta cl(K))$ is not necessarily equal to $N_{nc}cl(f(K))$ where $K \subseteq U_1$.

(ii) $N_{nc}\beta cl(f^{-1}(M))$ *is not necessarily equal to* $f^{-1}(N_{nc}cl(M))$ *where* $M \subseteq U_2$.

Example 3.3. Let $U = \{l_1, m_1, n_1, o_1, p_1\}$, ${}_{nc}\Gamma_1 = \{\phi_N, U_N, L, M, N\}$, ${}_{nc}\Gamma_2 = \{\phi_N, U_N\}$. $L = \langle\{n_1\}, \{\phi\}, \{l_1, m_1, o_1, p_1\}\rangle$, $M = \langle\{l_1, m_1\}, \{\phi\}, \{n_1, o_1, p_1\}\rangle$, $N = \langle\{l_1, m_1, n_1\}, \{\phi\}, \{o_1, p_1\}\rangle$, then we have $2_{nc}\Gamma = \{\phi_N, U_N, L, M, N\}$. Let $f : (U, 2_{nc}\Gamma) \to (U, 2_{nc}\Gamma)$ be an identity function and f is a $2_{nc}\beta Cts$.

(i) Let $K = \langle\{l_1, m_1\}, \{\phi\}, \{n_1, o_1, p_1\}\rangle \subseteq U$. Then $f(2_{nc}\beta cl(K)) = f(2_{nc}\beta\ cl(\langle \{l_1, m_1\}, \{\phi\}, \{n_1, o_1, p_1\}\rangle)) = f(\langle\{l_1, m_1\}, \{\phi\}, \{n_1, o_1, p_1\}\rangle) = \langle\{l_1, m_1\}, \{\phi\}, \{n_1, o_1, p_1\}\rangle$. But $2_{nc}cl(f(K)) = 2_{nc}cl(f(\langle\{l_1, m_1\}, \{\phi\}, \{n_1, o_1, p_1\}\rangle)) = 2_{nc}cl(\langle\{l_1, m_1\}, \{\phi\}, \{n_1, o_1, p_1\}\rangle) = \langle\{l_1, m_1, o_1, p_1\}, \{\phi\}, \{n_1\}\rangle$. Thus $f(2_{nc}\beta cl(K)) \neq 2_{nc}cl(f(K))$.

(ii) Let $M = \langle\{l_1\}, \{\phi\}, \{m_1, n_1, o_1, p_1\}\rangle \subseteq U$. Then $2_{nc}\beta cl(f^{-1}(M)) \subseteq 2_{nc}\beta cl(f^{-1}(\langle \{l_1\}, \{\phi\}, \{m_1, n_1, o_1, p_1\}\rangle)) = 2_{nc}\beta cl(\langle\{l_1\}, \{\phi\}, \{m_1, n_1, o_1, p_1\}\rangle)$. But $f^{-1}(2_{nc}cl(M)) = f^{-1}(2_{nc}cl(\langle\{l_1\}, \{\phi\}, \{m_1, n_1, o_1, p_1\}\rangle)) = f^{-1}(U) = U$. Thus $2_{nc}\beta cl(f^{-1}(M)) \neq f^{-1}(2_{nc}cl(M))$.

Theorem 3.4. *If f is $N_{nc}\beta Cts$, then $f^{-1}(N_{nc}int(M)) \subseteq N_{nc}\beta int(f^{-1}(M))$, for all ncs M in U_2.*

Proof. If f is $N_{nc}\beta Cts$ and $M \subseteq U_2$. $N_{nc}int(M)$ is $N_{nc}o$ in U_2 and hence, $f^{-1}(N_{nc}int(M))$ is $N_{nc}\beta o$ in U_1. Therefore $N_{nc}\beta int(f^{-1}(N_{nc}int(M))) = f^{-1}(N_{nc}int(M))$. Also, $N_{nc}int(M) \subseteq M$, implies that $f^{-1}(N_{nc}int(M)) \subseteq f^{-1}(M)$. Therefore $N_{nc}\beta\ int(f^{-1}(N_{nc}int(M))) \subseteq N_{nc}\beta int(f^{-1}(M))$. That is $f^{-1}(N_{nc}int(M)) \subseteq N_{nc}\beta int(f^{-1}(M))$.

Conversely, let $f^{-1}(N_{nc}int(M)) \subseteq N_{nc}\beta int(f^{-1}(M))$ for all subset M of U_2. If M is $N_{nc}o$ in U_2, then $N_{nc}int(M) = M$. By assumption, $f^{-1}(N_{nc}int(M)) \subseteq N_{nc}\beta int(f^{-1}(M))$. Thus $f^{-1}(M) \subseteq N_{nc}\beta int(f^{-1}(M))$. But $N_{nc}\beta int\ (f^{-1}(M)) \subseteq f^{-1}(M)$. Therefore $N_{nc}\beta int(f^{-1}(M)) = f^{-1}(M)$. That is, $f^{-1}(M)$ is $N_{nc}\beta o$ in U_1, for all $N_{nc}os$ M in U_2. Therefore f is $N_{nc}\beta Cts$ on U_1.

Remark 3.3. *If f is $N_{nc}\beta Cts$, then $N_{nc}\beta int(f^{-1}(M))$ is not necessarily equal to $f^{-1}(N_{nc}\ int(M))$ where $M \subseteq U_2$.*

Example 3.4. In Example 3.3, f is a $2_{nc}\beta Cts$. Let $M = \langle\{l_1, n_1\}, \{\phi\}, \{m_1, o_1, p_1\}\rangle \subseteq U$. Then $2_{nc}\beta int(f^{-1}(M)) \subseteq 2_{nc}\beta int(f^{-1}(\langle\{l_1, n_1\}, \{\phi\}, \{m_1, o_1, p_1\}\rangle)) = 2_{nc}\beta\ int(\langle \{l_1, n_1\}, \{\phi\}, \{m_1, o_1, p_1\}\rangle) = \langle\{l_1, n_1\}, \{\phi\}, \{m_1, o_1, p_1\}\rangle$. But $f^{-1}(2_{nc}int(M)) = f^{-1}(2_{nc}int(\langle\{l_1, n_1\}, \{\phi\}, \{m_1, o_1, p_1\}\rangle)) = f^{-1}(\langle\{n_1\}, \{\phi\}, \{l_1, m_1, o_1, p_1\}\rangle) = \langle\{n_1\}, \{\phi\}, \{l_1, m_1, o_1, p_1\}\rangle$. Thus $2_{nc}\beta int(f^{-1}(M)) \neq f^{-1}(2_{nc}int(M))$.

Theorem 3.5. *The statements*

(i) *f is a $N_{nc}\beta Cts$ function.*

(ii) *For every $N_{nc}P$ $p_{(p_1,p_2,p_3)} \in U_1$ and each ncs K of $f(p_{(p_1,p_2,p_3)})$, there exists an $N_{nc}\beta os$ M such that $p_{(p_1,p_2,p_3)} \in M \subseteq f^{-1}(K)$.*

(iii) *For every N_{nc} point $p_{(p_1,p_2,p_3)} \in U_1$ and each ncs K of $f(p_{(p_1,p_2,p_3)})$, there exists an $N_{nc}\beta os$ M such that $p_{(p_1,p_2,p_3)} \in M$ and $f(M) \subseteq K$*

are equivalent.

Proof. (i) $\Rightarrow$ (ii): If $p_{(p_1,p_2,p_3)}$ is an $N_{nc}P$ in U_1 and if K is an ncs of $f(p_{(p_1,p_2,p_3)})$, then $\exists$ an $N_{nc}os$ W in U_2 such that $f(p_{(p_1,p_2,p_3)}) \in W \subset K$. Thus, f is a $N_{nc}\beta Cts$, $M = f^{-1}(W)$ is an $N_{nc}\beta os$ and $p_{(p_1,p_2,p_3)} \in f^{-1}(f(p_{(p_1,p_2,p_3)})) \subseteq f^{-1}(W) = M \subseteq f^{-1}(K)$. Thus, (ii) is a valid statement.
(ii) $\Rightarrow$ (iii): Let $p_{(p_1,p_2,p_3)}$ be an $N_{nc}P$ in U_1 and let K be an ncs of $f(p_{(p_1,p_2,p_3)})$. Then $\exists$ an $N_{nc}\beta os$ K such that $p_{(p_1,p_2,p_3)} \in M \subseteq f^{-1}(K)$ by (ii). Thus, we have $p_{(p_1,p_2,p_3)} \in M$ and $f(M) \subseteq f(f^{-1}(K)) \subseteq K$. Hence, (iii) is valid.
(iii) $\Rightarrow$ (i): Let M be an $N_{nc}os$ in U_2 and let $p_{(p_1,p_2,p_3)} \in f^{-1}(M)$. Then, $f(p_{(p_1,p_2,p_3)}) \in f(f^{-1}(M)) \subset M$. Since M is an $N_{nc}os$, M is an ncs of $f(p_{(p_1,p_2,p_3)})$. Therefore, from (iii), $\exists$ an $N_{nc}\beta os$ K such that $p_{(p_1,p_2,p_3)}$ and $f(K) \subseteq M$. This implies that $p_{(p_1,p_2,p_3)} \in K \subseteq f^{-1}(f(K)) \subseteq f^{-1}(M)$. Therefore, we know that $f^{-1}(M)$ is an $N_{nc}\beta os$ in U_1. Thus, f is a $N_{nc}\beta Cts$ function.

4. N-Neutrosophic Crisp β Irresolute Functions

In this section, we introduce the concept of N-neutrosophic crisp β irresolute function in $N_{nc}ts$. Also, we discuss the relation with $N_{nc}\beta Cts$ function.

Definition 4.1. *Let $(U_1, N_{nc}\Gamma)$ and $(U_2, N_{nc}\Psi)$ be two $N_{nc}ts$'s. A function $f : (U_1, N_{nc}\Gamma) \to (U_2, N_{nc}\Psi)$ is called N-neutrosophic crisp β irresolute (briefly, N_{nc} β Irr) function if the inverse image of every $N_{nc}\beta o$ set in U_2 is $N_{nc}\beta o$ in U_1.*

Theorem 4.1. *Let $(U_1, N_{nc}\Gamma)$ and $(U_2, N_{nc}\Psi)$ be two $N_{nc}ts$'s. A function $f : (U_1, N_{nc}\Gamma) \to (U_2, N_{nc}\Psi)$ is $N_{nc}\beta Irr$ iff the inverse image of every $N_{nc}\beta c$ set in U_2 is $N_{nc}\beta c$ in U_1.*

Proof. Let A be any $N_{nc}\beta c$ set in U_2. Then A^c is $N_{nc}\beta o$ set in U_2. Since f is $N_{nc}\beta Irr$, $f^{-1}(A^c)$ is $N_{nc}\beta o$ set in U_1 and $f^{-1}(A^c) = [f^{-1}(A)]^c$ which implies that is $f^{-1}(A)$ is $N_{nc}\beta c$ set in U_1.

Conversely, let B be any $N_{nc}\beta o$ set in U_2. Then B^c is $N_{nc}\beta c$ set in U_2. Thus $f^{-1}(B^c)$ is $N_{nc}\beta c$ set in U_1 and $f^{-1}(B^c) = [f^{-1}(B)]^c$ which implies that is $f^{-1}(B)$ is $N_{nc}\beta c$ set in U_1. Hence $f : (U_1, N_{nc}\Gamma) \to (U_2, N_{nc}\Psi)$ is $N_{nc}\beta Irr$.

Theorem 4.2. *Let $(U_1, N_{nc}\Gamma)$ and $(U_2, N_{nc}\Psi)$ be two $N_{nc}ts$'s. And let $f : U_1 \to U_2$, Every $N_{nc}\beta Irr$ is a $N_{nc}\beta Cts$. But not converse.*

Proof. Let V be a $N_{nc}\beta o$ set in U_2. Since every $N_{nc}\beta o$ set is $N_{nc}o$ set in U_2. Since f is $N_{nc}\beta Irr$, $f^{-1}(V)$ is $N_{nc}\beta o$ in U_1. Therefore f is $N_{nc}\beta Cts$.

Example 4.1. Let $U = \{l_1, m_1, n_1, o_1, p_1\} = V$, ${}_{nc}\Gamma_1 = \{\phi_N, U_N, L, M, N\}$, ${}_{nc}\Gamma_2 = \{\phi_N, U_N\}$. $L = \langle\{n_1\}, \{\phi\}, \{l_1, m_1, o_1, p_1\}\rangle$, $M = \langle\{l_1, m_1\}, \{\phi\}, \{n_1, o_1, p_1\}\rangle$, $N = \langle\{l_1, m_1, n_1\}, \{\phi\}, \{o_1, p_1\}\rangle$, then we have $2_{nc}\Gamma = \{\phi_N, U_N, L, M, N\}$. ${}_{nc}\Psi_1 = \{\phi_N, V_N, O, P, Q\}$, ${}_{nc}\Psi_2 = \{\phi_N, V_N\}$. $O = \langle\{l_1, m_1\}, \{\phi\}, \{n_1, o_1, p_1\}\rangle$, $P = \langle\{n_1, o_1\}, \{\phi\}, \{l_1, m_1, p_1\}\rangle$, $Q = \langle\{l_1, m_1, n_1, o_1\}, \{\phi\}, \{p_1\}\rangle$, then we have $2_{nc}\Psi = \{\phi_N, V_N, O, P, Q\}$.

Define $h : (U, 2_{nc}\Gamma) \to (V, 2_{nc}\Psi)$ as $h(l_1) = l_1$, $h(m_1) = m_1$, $h(n_1) = n_1$, $h(o_1) = p_1$ & $h(p_1) = p_1$, then $2_{nc}\beta Cts$ mapping but not $2_{nc}\beta Irr$ mapping, the set $h^{-1}(\langle\{m_1, o_1, p_1\}, \{\phi\}, \{l_1, n_1\}\rangle) = \langle\{m_1, o_1, p_1\}, \{\phi\}, \{l_1, n_1\}\rangle$ is a $2_{nc}\beta os$ in V but not $2_{nc}\beta os$ in U.

Theorem 4.3. *Let* $f : (U_1, N_{nc}\Gamma) \to (U_2, N_{nc}\Psi)$ *be a function. Then the following are equivalent:*

(i) f *is* $N_{nc}\beta Irr$.

(ii) $N_{nc}\beta cl(f^{-1}(B)) \subseteq f^{-1}(N_{nc}\beta cl(B))$ *for every ncs* B *of* U_2.

(iii) $f(N_{nc}\beta cl(A)) \subseteq N_{nc}\beta cl(f(A))$ *for every ncs* A *of* U_1.

(iv) $f^{-1}(N_{nc}\beta int(B)) \subseteq N_{nc}\beta int(f^{-1}(B))$ *for every ncs* B *of* U_2.

Proof. (i) $\Rightarrow$ (ii): Let B be any *ncs* in U_2. Then by Proposition 3.1 in [19] (xi), $N_{nc}\beta cl(B)$ is $N_{nc}\beta c$ in U_2. Since f is $N_{nc}\beta Irr$, $f^{-1}(N_{nc}\beta cl(B))$ is $N_{nc}\beta c$ in U_1. Then $N_{nc}\beta cl(f^{-1}(N_{nc}\beta cl(B))) = f^{-1}(N_{nc}\beta cl(B))$. By Proposition 3.1 in [19] (ii) and (iv), $N_{nc}\beta cl(f^{-1}(B)) \subseteq N_{nc}\beta cl(f^{-1}(N_{nc}\beta cl(B))) = f^{-1}(N_{nc}\beta cl(B))$. This proves (ii).
(ii) $\Rightarrow$ (iii): Let A be any *ncs* in U_1. Then $f(A) \subseteq U_2$. By (ii), $N_{nc}\beta cl(f^{-1}(f(A))) \subseteq f^{-1}(N_{nc}\beta cl(f(A)))$. But $N_{nc}\beta cl(A) \subseteq N_{nc}\beta cl\ (f^{-1}(f(A)))$, $N_{nc}\beta cl(A) \subseteq f^{-1}\ (N_{nc}\beta cl\ (f(A)))$. That implies, $f(N_{nc}\beta cl(A)) \subseteq N_{nc}\beta cl(f(A))$.
(iii) $\Rightarrow$ (i): Let F be any $N_{nc}\beta c$ set in U_2. Then $f^{-1}(F) = f^{-1}(N_{nc}\beta cl(F))$. By (iii), $f(N_{nc}\beta cl(f^{-1}(F))) \subseteq N_{nc}\beta cl(f(f^{-1}(F))) \subseteq N_{nc}\beta cl(F) = F$. That implies, $(N_{nc}\beta cl(f^{-1}(F))) \subseteq f^{-1}(F)$. But $f^{-1}(F) \subseteq N_{nc}\beta cl(f^{-1}(F))$, $N_{nc}\beta cl(f^{-1}(F)) = f^{-1}(F)$ and so $f^{-1}(F)$ is $N_{nc}\beta c$ set U_1. Therefore f is $N_{nc}\beta Irr$.
(i) $\Rightarrow$ (iv): Let B any *ncs* in U_2. By Proposition 3.1 in [19] (xii), $N_{nc}\beta int(B)$ is $N_{nc}\beta o$ in U_2. Since f is $N_{nc}\beta Irr$, $f^{-1}(N_{nc}\beta int(B))$ is $N_{nc}\beta o$ in U_1. Then $f^{-1}(N_{nc}\beta int(B)) = N_{nc}\beta int(f^{-1}(N_{nc}\beta int(B))) \subseteq N_{nc}\beta int(f^{-1}(B))$.
(iv) $\Rightarrow$ (i): Let V be any $N_{nc}\beta c$ in U_2. Then by (iv), $f^{-1}(V) = f^{-1}(N_{nc}\beta int(V)) \subseteq$

$N_{nc}\beta int(f^{-1}(V))$. But, $N_{nc}\beta int(f^{-1}(V)) \subseteq f^{-1}(V), N_{nc}\beta int(f^{-1}(V)) = f^{-1}(V)$ and by Proposition 3.1 in [19] (x), $f^{-1}(V)$ is $N_{nc}\beta o$. Thus f is $N_{nc}\beta Irr$.

Theorem 4.4. *If $f : (U_1, N_{nc}\Gamma) \to (U_2, N_{nc}\Psi)$ and $g : (U_2, N_{nc}\Psi) \to (U_3, N_{nc}\tau)$ are $N_{nc}\beta Irr$ function, then their composition $g \circ f : (U_1, N_{nc}\Gamma) \to (U_3, N_{nc}\tau)$ is also $N_{nc}\beta Irr$.*

Proof. Let V be a $N_{nc}\beta o$ set in U_3. Since g is a $N_{nc}\beta Irr$ function, $g^{-1}(V)$ is $N_{nc}\beta o$ in U_2. Since f is a $N_{nc}\beta Irr$ function, $f^{-1}(g^{-1}(V)) = (g \circ f)^{-1}(V)$ is $N_{nc}\beta o$ in U_1. Therefore $g \circ f$ is $N_{nc}\beta Irr$.

Theorem 4.5. *If $f : (U_1, N_{nc}\Gamma) \to (U_2, N_{nc}\Psi)$ is $N_{nc}\beta Irr$ and $g : (U_2, N_{nc}\Psi) \to (U_3, N_{nc}\tau)$ are $N_{nc}\beta Cts$ function then their composition $g \circ f : (U_1, N_{nc}\Gamma) \to (U_3, N_{nc}\tau)$ is also $N_{nc}\beta Cts$.*

Proof. Let V be a $N_{nc}o$ set in U_3. Since g is a $N_{nc}\beta Cts$ function, $g^{-1}(V)$ is $N_{nc}\beta o$ in U_2. Since f is a $N_{nc}\beta Irr$ function, $f^{-1}(g^{-1}(V)) = (g \circ f)^{-1}(V)$ is $N_{nc}\beta o$ in U_1. Therefore $g \circ f$ is $N_{nc}\beta Cts$.

5. Strongly $N_{nc}\beta$ Continuous and Perfectly $N_{nc}\beta$ Continuous Functions

In this section, we introduce the concept of strongly N-neutrosophic crisp β continuous and perfectly N-neutrosophic crisp β continuous functions in $N_{nc}ts$ and we discuss the relation with the above-mentioned functions.

Definition 5.1. *Let $(U_1, N_{nc}\Gamma)$ and $(U_2, N_{nc}\Psi)$ be two $N_{nc}ts$'s. A function $f : (U_1, N_{nc}\Gamma) \to (U_2, N_{nc}\Psi)$ is called strongly N-neutrosophic crisp β continuous (briefly, $StN_{nc}\beta Cts$) function if the inverse image of every $N_{nc}\beta o$ set in U_2 is $N_{nc}o$ in U_1.*

Definition 5.2. *Let $(U_1, N_{nc}\Gamma)$ and $(U_2, N_{nc}\Psi)$ be two $N_{nc}ts$'s. A function $f : (U_1, N_{nc}\Gamma) \to (U_2, N_{nc}\Psi)$ is called a perfectly N-neutrosophic crisp continuous (briefly, $PeN_{nc}Cts$) function if the inverse image of every $N_{nc}o$ set in U_2 is N-neutrosophic crisp clopen (i.e both $N_{nc}o$ and $N_{nc}c$) (briefly, $N_{nc}clo$) in U_1.*

Definition 5.3. *Let $(U_1, N_{nc}\Gamma)$ and $(U_2, N_{nc}\Psi)$ be two $N_{nc}ts$'s. A function $f : (U_1, N_{nc}\Gamma) \to (U_2, N_{nc}\Psi)$ is called a perfectly N-neutrosophic crisp β continuous (briefly, $PeN_{nc}\beta Cts$) function if the inverse image of every $N_{nc}\beta o$ set in U_2 is N-neutrosophic crisp clopen (i.e both $N_{nc}o$ and $N_{nc}c$) (briefly, $N_{nc}clo$) in U_1.*

Theorem 5.1. *Let $(U_1, N_{nc}\Gamma)$ and $(U_2, N_{nc}\Psi)$ be two $N_{nc}ts$'s and $f : (U_1, N_{nc}\Gamma) \to (U_2, N_{nc}\Psi)$ be a function. Then*

(i) If f is $PeN_{nc}\beta Cts$, then f is $PeN_{nc}Cts$.

(ii) If f is $StN_{nc}\beta Cts$, then f is $N_{nc}Cts$.

Proof. (i) Let $f : (U_1, N_{nc}\Gamma) \to (U_2, N_{nc}\Psi)$ be $PeN_{nc}\beta Cts$. Let V be a $N_{nc}o$ set in U_2. Since f is $PeN_{nc}\beta Cts$, $f^{-1}(V)$ is $N_{nc}clo$ in U_1. Therefore f is $PeN_{nc}Cts$.
(ii) Let $f : (U_1, N_{nc}\Gamma) \to (U_2, N_{nc}\Psi)$ be $StN_{nc}\beta Cts$. Let G be a $N_{nc}o$ set in U_2. Since f is $StN_{nc}\beta Cts$, $f^{-1}(G)$ is $N_{nc}o$ in U_1. Therefore f is $N_{nc}Cts$.

Theorem 5.2. *Let $f : (U_1, N_{nc}\Gamma) \to (U_2, N_{nc}\Psi)$ be $StN_{nc}\beta Cts$ and A be $N_{nc}o$ in U_1. Then the restriction, $f_A : A \to U_2$ is $StN_{nc}\beta Cts$.*
Proof. Let V be any $N_{nc}\beta o$ set in U_2. Since f is $StN_{nc}\beta Cts$, $f^{-1}(V)$ is $N_{nc}o$ in U_1. But $f_A^{-1}(V) = A \cap f^{-1}(V)$. Since A and $f^{-1}(V)$ are $N_{nc}o$, $f_A^{-1}(V)$ is $N_{nc}o$ in A. Hence f_A is $StN_{nc}\beta Cts$.

Theorem 5.3. *Every $PeN_{nc}\beta Cts$ is $StN_{nc}\beta Cts$.*
Proof. Let $f : (U_1, N_{nc}\Gamma) \to (U_2, N_{nc}\Psi)$ be $PeN_{nc}\beta Cts$ and V be $N_{nc}\beta o$ in U_2. Since f is $PeN_{nc}\beta Cts$, $f^{-1}(V)$ is $N_{nc}clo$ in U_1. That is, $f^{-1}(V)$ is both $N_{nc}o$ and $N_{nc}c$ in U_1. Hence f is $StN_{nc}\beta Cts$.

Theorem 5.4. *If $f : (U_1, N_{nc}\Gamma) \to (U_2, N_{nc}\Psi)$ and $g : (U_2, N_{nc}\Psi) \to (U_3, N_{nc}\tau)$ are $StN_{nc}\beta Cts$, then their composition $g \circ f : (U_1, N_{nc}\Gamma) \to (U_3, N_{nc}\tau)$ is also $StN_{nc}\beta Cts$.*
Proof. Let V be a $N_{nc}\beta o$ set in U_3. Since g is a $StN_{nc}\beta Cts$ function, $g^{-1}(V)$ is $N_{nc}o$ in U_2. Since f is a $StN_{nc}\beta Cts$ function, $f^{-1}(g^{-1}(V)) = (g \circ f)^{-1}(V)$ is $N_{nc}o$ in U_1. Therefore $g \circ f$ is $StN_{nc}\beta Cts$.

Theorem 5.5. *If $f : (U_1, N_{nc}\Gamma) \to (U_2, N_{nc}\Psi)$ and $g : (U_2, N_{nc}\Psi) \to (U_3, N_{nc}\tau)$ are $PeN_{nc}\beta Cts$, then their composition $g \circ f : (U_1, N_{nc}\Gamma) \to (U_3, N_{nc}\tau)$ is also $PeN_{nc}\beta Cts$.*
Proof. Let V be a $N_{nc}\beta o$ set in U_3. Since g is a $PeN_{nc}\beta Cts$ function, $g^{-1}(V)$ is $N_{nc}clo$ in U_2. That is $g^{-1}(V)$ is both $N_{nc}o$ and $N_{nc}c$. Since f is a $PeN_{nc}\beta Cts$ function, $f^{-1}(g^{-1}(V)) = (g\circ f)^{-1}(V)$ is $N_{nc}clo$ in U_1. Therefore $g\circ f$ is $PeN_{nc}\beta Cts$.

Theorem 5.6. *Let $f : (U_1, N_{nc}\Gamma) \to (U_2, N_{nc}\Psi)$ and $g : (U_2, N_{nc}\Psi) \to (U_3, N_{nc}\tau)$ be functions. Then,*

(i) If g is $StN_{nc}\beta Cts$ and f is $N_{nc}\beta Cts$, then $g \circ f$ is $N_{nc}\beta Irr$.

(ii) If g is $PeN_{nc}\beta Cts$ and f is $N_{nc}Cts$, then $g \circ f$ is $StN_{nc}\beta Cts$.

(iii) If g is $StN_{nc}\beta Cts$ and f is $PeN_{nc}\beta Cts$, then $g \circ f$ is $PeN_{nc}\beta Cts$.

(iv) If g is $N_{nc}\beta Cts$ and f is $StN_{nc}\beta Cts$, then $g \circ f$ is $N_{nc}Cts$.

Proof. (i) Let V be a $N_{nc}\beta o$ set in U_3. Since g is a $StN_{nc}\beta Cts$ function, $g^{-1}(V)$ is $N_{nc}o$ in U_2. Since f is a $N_{nc}\beta Cts$ function, $f^{-1}(g^{-1}(V)) = (g \circ f)^{-1}(V)$ is $N_{nc}\beta o$

in U_1. Hence $g \circ f$ is $N_{nc}\beta Irr$.
(ii) Let V be a $N_{nc}\beta o$ set in U_3. Since g is a $PeN_{nc}\beta Cts$ function, $g^{-1}(V)$ is $N_{nc}clo$ in U_2. That is, $g^{-1}(V)$ is both $N_{nc}o$ and $N_{nc}c$. Since f is a $N_{nc}Cts$, $f^{-1}(g^{-1}(V)) = (g \circ f)^{-1}(V)$ is $N_{nc}o$ in U_1. Therefore $g \circ f$ is $StN_{nc}\beta Cts$.
(iii) Let V be a $N_{nc}\beta o$ set in U_3. Since g is a $StN_{nc}\beta Cts$ function, $g^{-1}(V)$ is $N_{nc}o$ in U_2. Since f is a $PeN_{nc}\beta Cts$ function, $f^{-1}(g^{-1}(V)) = (g \circ f)^{-1}(V)$ is $N_{nc}clo$ in U_1. Hence $g \circ f$ is $PeN_{nc}\beta Cts$.
(iv) Let V be a $N_{nc}o$ set in U_3. Since g is a $N_{nc}\beta Cts$ function, $g^{-1}(V)$ is $N_{nc}\beta o$ in U_2. Since f is a $StN_{nc}\beta Cts$ function, $f^{-1}(g^{-1}(V)) = (g \circ f)^{-1}(V)$ is $N_{nc}o$ in U_1. Therefore $g \circ f$ is $N_{nc}Cts$.

6. Conclusion

We have discussed about a N-neutrosophic crisp β-continuous mappings in N-neutrosophic crisp topological spaces and also their relationship with near mappings in this article. And, N-neutrosophic crisp β-irresolute functions is also introduced and studied some of their properties with example. Also, studied about the concept of strongly N-neutrosophic crisp β continuous and perfectly N-neutrosophic crisp β continuous functions in N-neutrosophic crisp topological spaces. This can be extended to N-neutrosophic crisp β-open mappings, N-neutrosophic crisp β-closed mappings, N-neutrosophic crisp β-homeomorphism and also a contra field of N-neutrosophic crisp β functions in N-neutrosophic crisp topological spaces.

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