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ON $N_{NC}\mathcal{DP}^*$-SETS AND DECOMPOSITION OF CONTINUITY IN N_{NC}-TOPOLOGICAL SPACES

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ABSTRACT. The main goal of this paper is to study some new classes of sets and to obtain some new decompositions of continuity. For this aim, the notions of $N_{nc}\mathcal{DP}$ sets, $N_{nc}\mathcal{DP}\epsilon$ sets, $N_{nc}\mathcal{DP}^*$ sets, $N_{nc}\mathcal{DP}\epsilon^*$ sets, $N_{nc}e$ continuous functions, $N_{nc}\mathcal{DP}^*$ continuous functions and $N_{nc}\mathcal{DP}\epsilon^*$ continuous functions are introduced. Properties of $N_{nc}\mathcal{DP}$ sets, $N_{nc}\mathcal{DP}\epsilon$ sets, $N_{nc}\mathcal{DP}^*$ sets, $N_{nc}\mathcal{DP}\epsilon^*$ sets and the relationships between these sets and the related concepts are investigated. Finally, some new decompositions of continuity are obtained.

1. INTRODUCTION AND PRELIMINARIES

In 2008, Ekici [1] introduced the notion of e-open sets in topology. In 2020, Vadivel and John Sundar [9] N-neutrosophic δ-open, N-neutrosophic δ-semiopen and N-neutrosophic δ-preopen sets, N-neutrosophic α-continuous, N-neutrosophicsemi and N-neutrosophic pre continuous are introduced. In this paper, four new classes of sets, namely $N_{nc}\mathcal{DP}$ sets, $N_{nc}\mathcal{DP}\epsilon$ sets, $N_{nc}\mathcal{DP}^*$ sets & $N_{nc}\mathcal{DP}\epsilon^*$ sets are introduced and studied. Also, we obtain some new decompositions of continuity by using the notion of $N_{nc}e$-continuous, $N_{nc}\mathcal{DP}^*$-continuous and $N_{nc}\mathcal{DP}\epsilon^*$-continuous functions. All other undefined notions are from [2, 4–6, 8–11] and cited therein.

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2. $N_{nc}\mathcal{DP}$-SETS AND $N_{nc}\mathcal{DP}\epsilon$-SETS

Definition 2.1. Let H be an $N_{nc}s$ on a $N_{nc}ts$ $(X, N_{nc}\Gamma)$. Then H is said to be:

(i) $N_{nc}\mathcal{DP}$-set if $N_{nc}\delta\mathcal{P}cl(N_{nc}\delta\mathcal{P}int(H)) = N_{nc}int(H)$,
(ii) $N_{nc}\mathcal{DP}\epsilon$-set if $N_{nc}\delta\mathcal{P}int(N_{nc}\delta\mathcal{P}cl(H)) = N_{nc}int(H)$,
(iii) $N_{nc}\mathcal{DP}*$-set if there exists $N_{nc}o$ set A & a $N_{nc}\mathcal{DP}$-set $B \ni H = A \cap B$,
(iv) $N_{nc}\mathcal{DP}\epsilon*$-set if there exists $N_{nc}o$ set A & a $N_{nc}\mathcal{DP}\epsilon$-set $B \ni H = A \cap B$.

Theorem 2.1. The following holds for a $N_{nc}s$ H of a $N_{nc}ts$ $(X, N_{nc}\Gamma)$:

$$N_{nc}\delta\mathcal{P}int(N_{nc}\delta\mathcal{P}cl(H)) \subseteq N_{nc}\delta\mathcal{P}cl(N_{nc}\delta\mathcal{P}int(H))$$

Proof. We have $N_{nc}\delta\mathcal{P}int(N_{nc}\delta\mathcal{P}cl(H)) = N_{nc}\delta\mathcal{P}cl(H) \cap N_{nc}int\ (N_{nc}\delta cl(H)) = (H \cup N_{nc}cl(N_{nc}\delta int(H))) \cap N_{nc}int(N_{nc}\delta cl(H)) = (H \cap N_{nc}int(N_{nc}\delta cl\ (H))) \cup (\mathcal{N}_{nc}cl(N_{nc}\delta int(H)) \cap N_{nc}int(N_{nc}\delta cl(H))) \subseteq (H \cap N_{nc}int(N_{nc}\delta cl(H))) \cup N_{nc}cl\ (N_{nc}\delta int(H)) = N_{nc}\delta\mathcal{P}int(H) \cup N_{nc}cl(N_{nc}\delta int(H)) = N_{nc}\delta\mathcal{P}cl(N_{nc}\delta\mathcal{P}int(H))$. Thus, $N_{nc}\delta\mathcal{P}int(N_{nc}\delta\mathcal{P}cl(H)) \subseteq N_{nc}\delta\mathcal{P}cl(N_{nc}\delta\mathcal{P}int(H))$. □

Theorem 2.2. Let H be a $N_{nc}s$ on a $N_{nc}ts$ $(X, N_{nc}\Gamma)$. The following hold:

(i) if H is a $N_{nc}\mathcal{DP}$ set, then it is a $N_{nc}\mathcal{DP}\epsilon$ set,
(ii) if H is a $N_{nc}\mathcal{DP}\epsilon$ set, then it is $N_{nc}ec$,
(iii) if H is a $N_{nc}\mathcal{DP}$ set, then it is $N_{nc}\delta\mathcal{P}c$. But not conversely.

Proof.

(i) Let H be a $N_{nc}\mathcal{DP}$ set. Then, by Theorem 2.1, $N_{nc}int(H) \subseteq N_{nc}int\ (N_{nc}\delta\mathcal{P}cl(H)) \subseteq N_{nc}\delta\mathcal{P}int(N_{nc}\delta\mathcal{P}cl(H)) \subseteq N_{nc}\delta\mathcal{P}cl(N_{nc}\delta\mathcal{P}int(H)) = N_{nc}int(H)$. Thus, $N_{nc}\delta\mathcal{P}int(N_{nc}\delta\mathcal{P}cl(H)) = N_{nc}int(H)$ and hence H is a $N_{nc}\mathcal{DP}\epsilon$ set.
(ii) Let H be a $N_{nc}\mathcal{DP}\epsilon$ set. Then, $H \supseteq N_{nc}int(H) = N_{nc}\delta\mathcal{P}int;\ (N_{nc}\delta\mathcal{P}cl(H)) = N_{nc}\delta\mathcal{P}cl(H) \cap N_{nc}int(N_{nc}\delta cl(H)) = (H \cup N_{nc}cl(N_{nc}\delta int(H))) \cap N_{nc}int(N_{nc}\delta cl(H)) \supseteq N_{nc}cl(N_{nc}\delta int(H)) \cap N_{nc}int(N_{nc}\delta cl(H))$. Hence, H is $N_{nc}ec$.
(iii) Let H be a $N_{nc}\mathcal{DP}$ set. Then we obtain $H \supseteq N_{nc}int(H) = N_{nc}\delta\mathcal{P}cl(N_{nc}\delta\mathcal{P}\ int(H)) = N_{nc}\delta\mathcal{P}int(H) \cup N_{nc}cl(N_{nc}\delta int(H)) \supseteq N_{nc}cl(N_{nc}\delta int(H))$. Since $N_{nc}\delta\ \mathcal{P}cl(N_{nc}\delta\mathcal{P}int(H)) = N_{nc}\delta\mathcal{P}int(H) \cup N_{nc}cl(N_{nc}\delta\mathcal{P}int(H))$. Thus, H is $N_{nc}\delta\mathcal{P}c$.

□

Example 1. Let $X = \{z_5, z_4, z_1, z_2, z_3\}$, ${}_{nc}\Gamma_1 = \{X_n, \phi_n, C, B, A\}$, ${}_{nc}\Gamma_2 = \{\phi_n, X_n\}$. $A = \langle\{z_3\}, \{\phi\}, \{z_5, z_4, z_1, z_2\}\rangle$, $B = \langle\{z_2, z_1\}, \{\phi\}, \{z_4, z_3, z_5\}\rangle$, $C = \langle\{z_2, z_1, z_3\}, \{\phi\}, \{z_5, z_4\}\rangle$, then we have $2_{nc}\Gamma = \{\phi_n, X_n, C, B, A\}$. Then:

(i) $\langle\{z_5, z_4, z_3\}, \{\phi\}, \{z_2, z_1\}\rangle$ is a $2_{nc}\mathcal{DP}\epsilon$ set and $2_{nc}\delta\mathcal{P}c$ set but not $2_{nc}\mathcal{DP}$ set.

(ii) $\langle\{z_1\}, \{\phi\}, \{z_5, z_4, z_3, z_2\}\rangle$ is a $2_{nc}ecs$ but not $2_{nc}\mathcal{DP}\epsilon$ set.

Remark 2.1. Every

(i) $N_{nc}\mathcal{DP}$ set is a $N_{nc}\mathcal{DP}^*$ set,

(ii) $N_{nc}\mathcal{DP}\epsilon$ set is a $N_{nc}\mathcal{DP}\epsilon^*$ set,

(iii) $N_{nc}\mathcal{DP}^*$ set is a $N_{nc}\mathcal{DP}\epsilon^*$ set,

(iv) $N_{nc}o$ set is a $N_{nc}\mathcal{DP}^*$ set and so a $N_{nc}\mathcal{DP}\epsilon^*$ set.

But not conversely.

Example 2. Let $X = \{z_4, z_3, z_1, z_2\}$, ${}_{nc}\Gamma_1 = \{\phi_n, X_n, D, C, B, A\}$, ${}_{nc}\Gamma_2 = \{\phi_n, X_n, F, E\}$. $A = \langle\{z_4\}, \{\phi\}, \{z_3, z_2, z_1\}\rangle$, $B = \langle\{z_4, z_1\}, \{\phi\}, \{z_3, z_2\}\rangle$, $C = \langle\{z_2, z_1, z_4\}, \{\phi\}, \{z_3\}\rangle$, $D = \langle\{z_4, z_1, z_3\}, \{\phi\}, \{z_2\}\rangle$, $E = \langle\{z_1\}, \{\phi\}, \{z_3, z_4, z_2\}\rangle$, $F = \langle\{z_2, z_1\}, \{\phi\}, \{z_4, z_3\}\rangle$, then we have $2_{nc}\Gamma = \{\phi_n, X_n, F, E, A, D, B, C\}$. Then:

(i) $\langle\{z_4, z_1\}, \{\phi\}, \{z_3, z_2\}\rangle$ is a $2_{nc}\mathcal{DP}^*$ set but not $2_{nc}\mathcal{DP}$ set.

(ii) $\langle\{z_4, z_1, z_2\}, \{\phi\}, \{z_3\}\rangle$ is a $2_{nc}\mathcal{DP}\epsilon^*$ set but not $2_{nc}\mathcal{DP}\epsilon$ set.

Example 3. Let $X = \{z_4, z_3, z_1, z_2\}$, ${}_{nc}\Gamma_1 = \{X_n, \phi_n, C, A, B\}$, ${}_{nc}\Gamma_2 = \{X_n, \phi_n\}$. $A = \langle\{z_2\}, \{\phi\}, \{z_4, z_1, z_3\}\rangle$, $B = \langle\{z_3\}, \{\phi\}, \{z_4, z_1, z_2\}\rangle$, $C = \langle\{z_2, z_3\}, \{\phi\}, \{z_4, z_1\}\rangle$, then we have $2_{nc}\Gamma = \{\phi_n, X_n, C, B, A\}$. Then:

(i) $\langle\{z_4, z_2, z_1\}, \{\phi\}, \{z_3\}\rangle$ is a $2_{nc}\mathcal{DP}\epsilon^*$ set but not $2_{nc}\mathcal{DP}^*$ set.

(ii) $\langle\{z_4, z_1\}, \{\phi\}, \{z_3, z_2\}\rangle$ is a $2_{nc}\mathcal{DP}^*$ set and $2_{nc}\mathcal{DP}\epsilon^*$ set but not $2_{nc}os$.

Theorem 2.3. Let H be an $N_{nc}s$ on a $N_{nc}ts$ $(X, N_{nc}\Gamma)$. Then H is

(i) $N_{nc}o$,

(ii) $N_{nc}\alpha o$ and a $N_{nc}\mathcal{DP}^*$ set,

(iii) $N_{nc}\delta\mathcal{P}o$ & a $N_{nc}\mathcal{DP}^*$ set,

(iv) $N_{nc}eo$ & a $N_{nc}\mathcal{DP}^*$ set,

(v) $N_{nc}\alpha o$ & a $N_{nc}\mathcal{DP}\epsilon^*$ set,

(vi) $N_{nc}\mathcal{P}o$ & a $N_{nc}\mathcal{DP}\epsilon^*$ set,

(vii) $N_{nc}\delta\mathcal{P}o$ & a $N_{nc}\mathcal{DP}\epsilon^*$ set

are equivalent.

Proof.
(i) $\Rightarrow$ (ii) Obvious, since every $N_{nc}o$ set is $N_{nc}\alpha o$ $\&$ a $N_{nc}\mathcal{DP}^*$ set.
(ii) $\Rightarrow$ (iii) $\&$ (iii) $\Rightarrow$ (iv) are obvious.
(i) $\Rightarrow$ (v) Obvious, since every $N_{nc}o$ set is $N_{nc}\alpha o$ and a $N_{nc}\mathcal{DP}\epsilon^*$ set.
(v) $\Rightarrow$ (vi) $\&$ (vi) $\Rightarrow$ (vii) are obvious.
(iv) $\Rightarrow$ (i) Let H be $N_{nc}eo$ and a $N_{nc}\mathcal{DP}^*$ set. Then there exists $N_{nc}o$ set A and a $N_{nc}\mathcal{DP}$ set B such that $H = A\cap B$. Also, we obtain $H \subseteq N_{nc}\delta\mathcal{P}cl(N_{nc}\delta\mathcal{P}int(A\cap B)) \subseteq N_{nc}\delta\mathcal{P}int(A) \cap N_{nc}\delta\mathcal{P}cl(N_{nc}\delta\mathcal{P}int(B)) = N_{nc}int(B) \cap (N_{nc}\delta\mathcal{P}int(A) \cup N_{nc}cl(N_{nc}\delta int(A))) \subseteq N_{nc}int(B)\cap(N_{nc}\delta\mathcal{P}int(A)\cup N_{nc}cl(N_{nc}int(A))) = N_{nc}cl(A)\cap N_{nc}int(B)$. Since $H \subseteq N_{nc}cl(A) \cap N_{nc}int(B) \cap A = N_{nc}int(B) \cap A$, $H = A \cap N_{nc}int(B)$ and hence H is $N_{nc}o$.
(vii) $\Rightarrow$ (i) Let H be a $N_{nc}\delta\mathcal{P}o$ set and a $N_{nc}\mathcal{DP}\epsilon^*$ set. Then there exists $N_{nc}o$ set A $\&$ a $N_{nc}\mathcal{DP}\epsilon$ set $B \ni H = A\cap B$. Also, we have $H \subseteq N_{nc}\delta\mathcal{P}int(N_{nc}\delta\mathcal{P}cl(H)) = N_{nc}\delta\mathcal{P}int(N_{nc}\delta\mathcal{P}cl(A\cap B)) \subseteq N_{nc}\delta\mathcal{P}int(N_{nc}\delta\mathcal{P}cl(A))\cap N_{nc}\delta\mathcal{P}int(N_{nc}\delta\mathcal{P}cl(B)) = N_{nc}\delta\mathcal{P}int(N_{nc}\delta\mathcal{P}cl(A)) \cap N_{nc}int(B) = (N_{nc}\delta\mathcal{P}cl(A) \cap N_{nc}int(N_{nc}\delta cl(A))) \cap N_{nc} int(B) \subseteq N_{nc}int(N_{nc}\delta cl(A)) \cap N_{nc}int(B)$. Since $H \subseteq N_{nc}int(N_{nc}\delta cl(A)) \cap N_{nc} int(B) \cap A = A \cap N_{nc}int(B)$, $H = A \cap N_{nc}int(B)$ and hence H is $N_{nc}o$. $\square$

3. Decompositions of continuity

Definition 3.1. Let $(X, N_{nc}\Gamma)$ $\&$ $(Y, N_{nc}\Psi)$ be $N_{nc}ts$'s. A map $f : (X, N_{nc}\Gamma) \to (Y, N_{nc}\Psi)$ is said to be $N_{nc}e$ (resp. $N_{nc}\delta$-almost, $N_{nc}\mathcal{DP}^*$ and $N_{nc}\mathcal{DP}\epsilon^*$)-continuous (briefly, $N_{nc}eCts$ (resp. $N_{nc}\delta aCts$, $N_{nc}\mathcal{DP}^*Cts$ and $N_{nc}\mathcal{DP}\epsilon^*Cts$)) if the inverse image of every $N_{nc}os$ in $(Y, N_{nc}\Psi)$ is a $N_{nc}eos$ (resp. $N_{nc}\delta\mathcal{P}os$, $N_{nc}\mathcal{DP}^*s$ and $N_{nc}\mathcal{DP}\epsilon^*s$) in $(X, N_{nc}\Gamma)$.

Remark 3.1. Let $f : (X, N_{nc}\Gamma) \to (Y, N_{nc}\Psi)$ be a function. Then:

(i) $N_{nc}\delta aCts \to N_{nc}eCts \leftarrow N_{nc}\delta\mathcal{S}Cts$,
(ii) If f is $N_{nc}Cts$, then it is $N_{nc}\mathcal{DP}^*Cts$,
(iii) If f is $N_{nc}\mathcal{DP}^*Cts$, then it is $N_{nc}\mathcal{DP}\epsilon^*Cts$.

These implications are not reversible as shown.

Example 4. Let $X = \{z_5, z_4, z_1, z_2, z_3\} = Y$, ${}_{nc}\Gamma_1 = \{\phi_n, X_n, B, A, C\}$, ${}_{nc}\Gamma_2 = \{\phi_n, X_n\}$. $A = \langle\{z_3\}, \{\phi\}, \{z_5, z_2, z_4, z_1\}\rangle$, $B = \langle\{z_2, z_1\}, \{\phi\}, \{z_4, z_5, z_3\}\rangle$, $C =$

$\langle\{z_3, z_2, z_1\}, \{\phi\}, \{z_5, z_4\}\rangle$, then we have $2_{nc}\Gamma = \{\phi_n, X_n, C, B, A\}$. Define $f : (X, 2_{nc}\Gamma) \to (Y, 2_{nc}\Psi)$ as:

(i) $f(z_1) = z_3$, $f(z_2) = z_4$, $f(z_3) = z_1$, $f(z_4) = z_2$ & $f(z_5) = z_5$, then f is $2_{nc}eCts$ but not $N_{nc}\delta aCts$, the set $f^{-1}(\langle\{z_1, z_2\}, \{\phi\}, \{z_5, z_4, z_3\}\rangle) = \langle\{z_4, z_3\}, \{\phi\}, \{z_5, z_2, z_1\}\rangle$ is a $2_{nc}eos$ but not $2_{nc}\delta\mathcal{P}os$.

(ii) $f(z_4) = z_4$, $f(z_3) = z_2$, $f(z_2) = z_3$, $f(z_1) = z_1$ & $f(z_5) = z_5$, then f is $2_{nc}eCts$ but not $N_{nc}\delta\mathcal{S}Cts$, the set $f^{-1}(\langle\{z_2, z_1\}, \{\phi\}, \{z_5, z_4, z_3\}\rangle) = \langle\{z_3, z_1\}, \{\phi\}, \{z_5, z_4, z_2\}\rangle$ is a $2_{nc}eos$ but not $2_{nc}\delta\mathcal{S}os$.

Example 5. Let $X = \{z_4, z_2, z_3, z_1\} = Y$, ${}_{nc}\Gamma_1 = \{\phi_n, X_n, C, B, A\}$, ${}_{nc}\Gamma_2 = \{\phi_n, X_n\}$. $A = \langle\{z_2\}, \{\phi\}, \{z_4, z_1, z_3\}\rangle$, $B = \langle\{z_3\}, \{\phi\}, \{z_4, z_1, z_2\}\rangle$, $C = \langle\{z_3, z_2\}, \{\phi\}, \{z_4, z_1\}\rangle$, then we have $2_{nc}\Gamma = \{\phi_n, X_n, C, B, A\}$. Define $f : (X, 2_{nc}\Gamma) \to (Y, 2_{nc}\Psi)$ as:

(i) $f(z_1) = z_2$, $f(z_2) = z_1$, $f(z_3) = z_4$ & $f(z_4) = z_3$, then f is $2_{nc}\mathcal{DP}^*Cts$ but not $2_{nc}Cts$, the set $f^{-1}(\langle\{z_2\}, \{\phi\}, \{z_4, z_1, z_3\}\rangle) = \langle\{z_1\}, \{\phi\}, \{z_4, z_2, z_3\}\rangle$ is a $2_{nc}\mathcal{DP}^*$ set but not $2_{nc}os$.

(ii) $f(z_4) = z_4$, $f(z_3) = z_3$, $f(z_2) = z_1$ & $f(z_1) = z_2$, then f is $2_{nc}\mathcal{DP}\epsilon^*Cts$ but not $2_{nc}\mathcal{DP}^*Cts$, the set $f^{-1}(\langle\{z_3, z_2\}, \{\phi\}, \{z_4, z_1\}\rangle) = \langle\{z_3, z_1\}, \{\phi\}, \{z_4, z_2\}\rangle$ is a $2_{nc}\mathcal{DP}\epsilon^*$ set but not $2_{nc}\mathcal{DP}^*$ set.

Theorem 3.1. Let $f : (X, N_{nc}\Gamma) \to (Y, N_{nc}\Psi)$. The following are equivalent:

(i) f is $N_{nc}Cts$

(ii) f is $N_{nc}\alpha Cts$ and $N_{nc}\mathcal{DP}^*Cts$

(iii) f is $N_{nc}\delta aCts$ and $N_{nc}\mathcal{DP}^*Cts$

(iv) f is $N_{nc}eCts$ and $N_{nc}\mathcal{DP}^*Cts$

(v) f is $N_{nc}\alpha Cts$ and $N_{nc}\mathcal{DP}\epsilon^*Cts$

(vi) f is $N_{nc}\mathcal{P}Cts$ and $N_{nc}\mathcal{DP}\epsilon^*Cts$

(vii) f is $N_{nc}\delta aCts$ and $N_{nc}\mathcal{DP}\epsilon^*Cts$.

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