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27th October 2021

Jointly Organized by

Department of Biological Science, Physical Science and Computational Science

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A nations's growth is in proportion to education and intelligence spread among the masses. Having this idealistic vision, two great philanthropists late. S.P. Nallamuthu Gounder and Late. Arutchelver Padmabhushan Dr.N.Mahalingam formed an organization called Pollachi Kalvi Kazhagam, which started NGM College in 1957, to impart holistic education with an objective to cater to the higher educational needs of those who wish to aspire for excellence in knowledge and values. The College has achieved greater academic distinctions with the introduction of autonomous system from the academic year 1987-88. The college has been Re-Accredited by NAAC and it is ISO 9001 : 2015 Certified Institution. The total student strength is around 6000. Having celebrated its Diamond Jubilee in 2017, the college has blossomed into a premier Post-Graduate and Research Institution, offering 26 UG, 12 PG, 13 M.Phil and 10 Ph.D Programmes, apart from Diploma and Certificate Courses. The college has been ranked within Top 100 (72nd Rank) in India by NIRF 2021.

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The International conference on “Emerging Trends in Science and Technology (ETIST-2021)” is being jointly organized by Departments of Biological Science, Physical Science and Computational Science - Nallamuthu Gounder Mahalingam College, Pollachi along with ISTE, CSI, IETE, IEE & RIYASA LABS on 27th OCT 2021. The Conference will provide common platform for faculties, research scholars, industrialists to exchange and discus the innovative ideas and will promote to work in interdisciplinary mode.

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Nano $*^N$- Extremally disconnected ideal topological Spaces

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Abstract: In this paper we introduce and study the concept of Nano δI-open sets and Nano δI-continuous function to obtain Decompositions of nano αI-continuous, nano semi I-continuous in nano ideal topological spaces. Finally we introduce the notion of Nano $*^N$- Extremally disconnected ideal topological Spaces and discussd some of its properties.

Keywords : nanoδ-I-open sets,Nano weakly I-locally closed sets, Nano $*^N$- Extremally disconnected ideal topological Spaces. **2010 Subject classification:** 54A05, 54A10, 54B05

1 Introduction

Njastad [18],Levine[15],Migual cladas[17] and Mashhour et al.[16] introduced respectively the notions of α-open,semi open, regular open and pre open sets in topological spaces. The concept of ideal was first introduced by Kuratowski[8] . Hamlet and Jankovic [9]introduced and investigated further properties of ideal topological spaces. Dontchev[2] introduced the concept of pre I-continuous functions in ideal topological spaces. Hatir et. al. [4] introduced the notions of semi I-continuous and α-I-continuous functions in ideal topological spaces.In 2009, Ekici and Noiri[3] introduced and studied the concept of *- Extreamly disconnected ideal topological spaces. M.Lellis Thivagar and Carmel Richard[11],[12] introduced the notions of nano topological spaces and later they introduced the nano continuity in nano topological spaces. M.Lellis Thivagar and V.Sutha devi[13] defined the notions of nano ideal topological spaces by using nano local functions. Recently many authors[23, 5, 7, 19] introduces weaker and stronger forms of nano open sets in nano ideal topological spaces.
In this paper we introduce and study the concept of Nano δI-open sets and also we obtain Decompositions of nano continuous, nano αI-continuous, nano semi I-continuous and nano regular I-continuous functions in nano ideal topological spaces. Finally we introduce the notion of Nano $*^N$- Extremally disconnected ideal topological Spaces and discuss some of its properties.

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2 Preliminaries

Definition 2.1. *[11] Let U be a non-empty finite set of objects called the universe and R be an equivalence relation on U named as the indiscernibility relation. Elements belonging to the same equivalence class are said to be indiscernible with one another. The pair (U, R) is said to be the approximation space. Let* $X \subseteq U$.

1. *The lower approximation of X with respect to R is the set of all objects, which can be for certain classified as X with respect to R and it is denoted by* $L_R(X)$.
   That is, $L_R(X) = \bigcup\limits_{x \in U} \{R(x) : R(x) \subseteq X\}$, *where R(x) denotes the equivalence class determined by x.*

2. *The upper approximation of X with respect to R is the set of all objects, which can be possibly classified as X with respect to R and it is denoted by* $U_R(X)$. *That is,* $U_R(X) = \bigcup\limits_{x \in U} \{R(x) : R(x) \cap X \neq \phi\}$

3. *The boundary region of X with respect to R is the set of all objects, which can be classified neither as X nor as not-X with respect to R and it is denoted by* $B_R(X)$. *That is,* $B_R(X) = U_R(X) - L_R(X)$

Definition 2.2. *[11] Let U be the universe, R be an equivalence relation on U and* $\tau_R(X) = \{\phi, U, L_R(X), U_R(X),$ *where* $X \subseteq U$. *Then* $\tau_R(X)$ *satisfies the following axioms:*

1. ϕ *and U are in* $\tau_R(X)$.

2. *The union of elements of any subcollection of* $\tau_R(X)$ *is in* $\tau_R(X)$.

3. *The intersection of elements of any finite subcollection of* $\tau_R(X)$ *is in* $\tau_R(X)$.

That is, $\tau_R(X)$ *is a topology on U called the nano topology on U with respect to X. We call* $(U, \tau_R(X))$ *as the nano topological space(briefly. NTS). The elements of* $\tau_R(X)$ *are called as nano open sets (briefly. NO-sets).*

Definition 2.3. *[11] Let* $(U, \tau_R(X))$ *be a NTS, the set* $\mathcal{B} = \{U, L_R(X), B_R(X)\}$ *is the basis for* $\tau_R(X)$.

Definition 2.4. *[8] An ideal I on a topological space is a non-empty collection of subsets of X which satisfies*
1. $A \in I$ *and* $B \subseteq A$ *implies* $B \in I$.
2. $A \in I$ *and* $B \in I$ *implies* $A \cup B \in I$.

Definition 2.5. *[13] A NTS* $(U, \tau_R(X))$ *with an ideal I on U is called a nano ideal topological space (briefly. NITS)and denoted as* $(U, \tau_R(X), I)$.

Definition 2.6. *[13] Let*$(U, \tau_R(X), I)$ *be a NITS. A set operator* $(A)^{*N} : P(U) \rightarrow P(U)$ *is called the nano local function of I on U with respect to I on* $\tau_R(X)$ *is defined as* $(A)^{*N} = \{x \in U : U \cap A \notin I$ *; for every* $U \in \tau_R(X)\}$ *and is denoted by* $(A)^{*N}$, *where nano closure operator (briefly.* $*^N$*-closure) is defined as* $NCl^*(A) = A \cup (A)^{*N}$.

Definition 2.7. *[26] A subset S of a ideal space is called* δI*-open if* $Int(Cl^*(S)) \subseteq Cl^*(Int(S))$.
The complement of δI*-open set is called* $N\delta I$*-closed set.*

Definition 2.8. *A subset S of a NTS $(U, \tau_R(X))$ is called Nano pre - open(briefly. NP-open)[11], if $S \subseteq Nint(NCl(S))$.*

Definition 2.9. *[21] A subset A of a NITS $(U, \tau_R(X), I)$ is said to be nano I-open(briefly. NI-open) if $S \subseteq NInt((S)^{*N})$.If its complement is nano I-open called nano I-closed.*

Definition 2.10. *A subset S of a NITS $(U, \tau_R(X), I)$ is said to be*

1. *$N\alpha I$ - open [13] if $S \subseteq Nint(NCl^*(Nint(S)))$.*
2. *N S I - open [13] if $S \subseteq NCl^*(Nint(S))$.*
3. *NPI-open [5] if $S \subseteq Nint(NCl^*(S))$.*
4. *$N\beta I$ - open [24] if $S \subseteq NCl^*(Nint(NCl^*(S)))$.*
5. *NAI - open [19] if $S \subseteq NCl(Nint(S)^{*N})$.*
6. *NbI-open [24] if $S \subseteq Nint(NCl^*(S)) \cup NCl^*(Nint(S))$.*
7. *$NW\beta I$-open[7] if $S \subseteq NCl(Nint(NCl^*(S))$*
8. *NtI-set [23] if $Nint(S) = Nint(NCl^*(S))$.*
9. *NRI-open[13] if $S = Nint(NCl^*(S))$.*

Family of all $N\alpha I$-open (resp.NSI-open, NPI-open, $N\beta I$ - open) sets are denoted by $N\alpha IO(U, X)$ (resp. $NSIO(U, X)$, $NPIO(U, X), N\beta IO(U, X)$). A subset A of a NITS $(U, \tau_R(X), I)$ is said to be $N\alpha I$-closed (resp. NSI-closed, NPI-closed,N βI -closed, NAI-closed, NbI-closed, $NW\beta I$-closed, NRI-closed), if its complement is N αI-open (resp. NSI-open ,N PI-open, $N\beta I$ - open, NAI-open, NbI-open, $NW\beta I$-open, NRI-open).

Definition 2.11. *[22] A subset S of a NITS is called Nano *-closed(briefly. $*^N$-closed)(resp. Nano *-perfect(briefly.$*^N$-perfect)) if $A^{*N} \subseteq A$(resp. $A^{*N} = A$).*

Definition 2.12. *[12] Let $(U, \tau_R(X))$ and $(V, \tau'_R(Y))$ be two NTS. A mapping $\sigma : (U, \tau_R(X)) \to (V, \tau'_R(Y))$ is said to be nano continuous(resp. Nano pre continuous[25](briefly. NP-continuous)) if the inverse image of every NO-set in $(V, \tau'_R(Y))$ is NO-set(NP-open set) in $(U, \tau_R(X))$*

Definition 2.13. *[19] Let $(U, \tau_R(X), I)$ be NITS. A mapping $\sigma : (U, \tau_R(X), I) \to (V, \tau_{R'}(Y))$ is said to be nano almost-I-continuous (briefly. NAI-continuous)if $\sigma^{-1}(T)$ is NAI-open set in $(U, \tau_R(X), I)$ for every NO-set T in $(V, \tau_{R'}(Y))$.*

Definition 2.14. *[21] A mapping $\sigma : (U, \tau_R(X), I) \to (V, \tau_{R'}(Y))$ is called nano I-continuous (briefly. NI-continuous)if $\sigma^{-1}(T)$ is NI-open set in $(U, \tau_R(X), I)$ for every NO-set T in $(V, \tau_{R'}(Y))$.*

Definition 2.15. *[6] A mapping $\sigma : (U, \tau_R(X), I) \to (V, \tau_{R'}(Y))$ is said to be N αI-continuous (resp.,N SI-continuous, NPI-continuous) if $\sigma^{-1}(T)$ is NαI-open (resp., NSI-open, NPI-open) set in $(U, \tau_R(X), I)$ for every NO-set T in $(V, \tau_{R'}(Y))$.*

Definition 2.16. *[11] A NTS $(U, \tau_R(X))$ is called Nano extremally disconnected topological space (briefly. N.E.D space)if nano closure of each NO-set is a NO-set.*

Theorem 2.17. *[20] A subset S of NITS is NWILC-set if and only if there exist a NO-set T such that $S = T \cap NCl^*(S)$.*

3 Nano δI-open sets

Definition 3.1. *A subset S of a NITS$(U, \tau_R(X), I)$ is said to be Nano δI-open (briefly.NδI-open) if $Nint(NCl^*(S)) \subseteq NCl^*(Nint(S))$.*
The complement of $N\delta I$-open set is called $N\delta I$-closed set.
The family of all $N\delta I$-open (resp. $N\delta I$-closed) subsets of U is denoted by $N\delta IO(U, X)$(resp.$N\delta IC(U, X)$).

Theorem 3.2. *Let S be a subset of a NITS $(U, \tau_R(X), I)$, then the following are hold.*

1. *Every NO-set is a $N\delta I$-open set.*
2. *Every $N\alpha I$-open set is a $N\delta I$-open set.*
3. *Every NSI-open set is a $N\delta I$-open set.*
4. *Every NtI-set is a $N\delta I$-open set.*

Proof: (1). Let S be a NO-set.
Since $Nint(NCl^*((S))) \subseteq NCl^*(S) = NCl^*(Nint(S))$.
Thus S is $N\delta I$-open.
(2). Since S is a $N\alpha I$-open set,
$S \subseteq Nint(NCl^*(Nint(S))) \subseteq NCl^*(Nint(S))$.
Now, $NCl^*(S) \subseteq NCl^*(NCl^*(Nint(S))) = (NCl^*(Nint(S)))$.
Also we have, $Nint(NCl^*(S)) \subseteq NCl^*(S) \subseteq NCl^*(Nint(S))$.
Thus, $Nint(NCl^*(S) \subseteq NCl^*(Nint(S))$.
Therefore S is $N\delta I$-open.
(3) Let S be a NSI-open set, $S \subseteq NCl^*(Nint(S))$.
Since $Nint(NCl^*((S))) \subseteq NCl^*(S) \subseteq NCl^*(NCl^*(Nint(S))) = NCl^*(Nint(S))$.
Thus S is $N\delta I$-open.
(4). Since S is a NtI-set,
$Nint(S) = Nint(NCl^*(S))$.
Therefore, $Nint(NCl^*(S)) = Nint(S) \subseteq NCl^*(Nint(S))$.
i.e., $Nint(NCl^*(S)) \subseteq NCl^*(Nint(S))$.
Thus S is $N\delta I$-open .

Remark 3.3. *Converses of the above theorem need not be true as shown in the following example.*

Example 3.4. *Let $U = \{a_1, a_2, a_3, a_4\}$ be the universe $X = \{a_1, a_4\}$, $U/R = \{\{a_3\}, \{a_4\}, \{a_1, a_2\}\}$, $\tau_R(X) = \{\{\phi, \{a_4\}, \{a_1, a_2\}, \{a_1, a_2, a_4\}, U\}$with an ideal $I = \{\phi, \{a_1\}\}$.*
(i). The set $\{a_1\}$is a NδI- open set but not a NαI-open set.
(ii). The set $\{a_1, a_2, a_4\} \in N\delta IO(U, X)$ but $\{a_1, a_2, a_4\} \notin NtI(U, X)$.
(iii).The set $\{a_1, a_3, a_4\} \in N\delta IO(U, X)$ but not a NO-set.

Theorem 3.5. *Let S be both NPI-open and $N\delta I$- open sets in NITS $(U, \tau_R(X), I)$ then S is a NSI-open set in $(U, \tau_R(X), I)$.*

Proof: Let S be both NPI-open and $N\delta I$-open sets in $(U, \tau_R(X), I)$.
Then $S \subseteq Nint(NCl^*(S)) \subseteq NCl^*(Nint(S))$.
Thus S is a NSI-open set.

Theorem 3.6. *Let S and T be two subsets of a NITS* $(U, \tau_R(X), I)$*. If S is a* $N\delta I$*-open set and* $S \subseteq T \subseteq NCl^*(S)$ *then T is a* $N\delta I$*-open set.*

Proof: Suppose that $S \subseteq T \subseteq NCl^*(S)$ and let S is $N\delta I$-open set in $(U, \tau_R(X), I)$.
Then we have, $Nint(NCl^*(S)) \subseteq NCl^*(Nint(S))$.
Since $S \subset T$,$NCl^*(Nint(S)) \subseteq NCl^*(Nint(T))$.
Since $T \subseteq NCl^*(S)$, $NCl^*(T) \subseteq NCl^*(S)$.
Now, $Nint(NCl^*(T)) \subseteq Nint(NCl^*(S))$.
By hypothesis, $Nint(NCl^*(T)) \subseteq Nint(NCl^*(S)) \subseteq NCl^*(Nint(S)) \subseteq NCl^*(Nint(T))$.
Thus, T is a $N\delta I$-open set.

Theorem 3.7. *[13] In a NITS* $(U, \tau_R(X), I)$*,every* NRI*-open set is a NO-set.*

Theorem 3.8. *In a NITS* $(U, \tau_R(X), I)$*,every* NRI*-open set is* $N\alpha I$*-open(*NSI*-open,*NPI*-open ,* $N\delta I$*-open,* NtI*-set).*

Proof: Proof is obvious.

Remark 3.9. *The converses of Theorem 3.8 need not be true as shown in the following example.*

Example 3.10. *Let* $U = \{a_1, a_2, a_3, a_4\}$ *be the universe with* $U/R = \{\phi, \{a_1\}, \{a_4\}, \{a_2, a_4\}\}$ *and* $X = \{a_1, a_2\}$*,* $I = \{\phi, \{a_1\}\}$*. Now,* $\tau_R(X) = \{\phi, \{a_1\}, \{a_2, a_4\}, \{a_1, a_2, a_4\}, U\}$*.*
(i) *The set* $\{a_1, a_2, a_4\}$ *is* $N\alpha I$*-open set,* NSI*-open set ,*NPI*-open set,*$N\delta I$*-open set. But not a* NRI*-open set.*
(ii) $\{a_2, a_3, a_4\}$ *are* NtI*-set but not a* NRI*-open set.*

Theorem 3.11. *Let S be a subset of NITS* $(U, \tau_R(X), I)$ *, then the following are equivalent.*

1. *S is a* $N\alpha I$*-open set .*
2. *S is both* $N\delta I$*-open set and* NPI*-open set.*

Proof: (1) $\Rightarrow$ (2)
Let S be a $N\alpha I$-open set .
Then $S \subseteq Nint(NCl^*(Nint(S))) \subseteq Nint(NCl^*(S))$ and S is $N\delta I$open by theorem 3.2(ii). Thus S is both $N\delta I$-open set and NPI-open set.
(2) $\Rightarrow$ (1)
Let S be a NPI-open set and $N\delta I$-open set.
We have, $S \subseteq Nint(NCl^*(S))$ and $Nint(NCl^*(S)) \subseteq NCl^*(Nint(S))$. Thus $S \subseteq NCl^*(Nint(S))$
Then, $S \subseteq Nint(NCl^*(S)) \subseteq Nint(NCl^*(NCl^*(Nint(S)))) \subseteq Nint(NCl^*(Nint(S)))$.
Hence $S \subseteq Nint(NCl^*(Nint(S)))$. Thus S is a $N\alpha I$-open set.

Remark 3.12. *The notions of* NPI*-open set and* $N\delta I$*-open set are independent.*

Example 3.13. *Let* $U = \{a_1, a_2, a_3, a_4\}$ *be the universe* $X = \{a_1, a_4\}$*,* $U/R = \{\{a_3\}, \{a_4\}, \{a_1, a_2\}\}$*,* $\tau_R(X) = \{\{\phi, \{a_4\}, \{a_1, a_2\}, \{a_1, a_2, a_4\}\}$*with an ideal* $I = \{\phi, \{a_1\}\}$*. Then the set* $\{a_2\}$ *is a* NPI*-open set but not* $N\delta I$*-open. And the set* $\{a_3\}$ *is a* $N\delta I$*-open set but not* NPI*-open.*

Theorem 3.14. *Let S be a subset of a NITS* $(U, \tau_R(X), I)$*, then the following are equivalent.*

1. *S is a NSI-open set .*

2. *S is both $N\delta I$-open and $N\beta I$-open.*

Proof: (1) $\Rightarrow$ (2) Let S be a NSI-open set in $(U, \tau_R(X), I)$. By Theorem 3.2, S is $N\delta I$-open . Since $S \subseteq NCl^*(Nint(S)) \subseteq NCl^*(Nint(NCl^*(S)))$. Thus S is $N\beta I$-open.
(2) $\Rightarrow$ (1) Let S be $N\delta I$-open and $N\beta I$-open, we have $Nint(NCl^*(S)) \subseteq NCl^*(Nint(S))$. Thus we obtain that $NCl^*(Nint(NCl^*(S))) \subseteq NCl^*(NCl^*(Nint(S))) = NCl^*(Nint(S))$. Since S is $N\beta I$-open, we have $S \subseteq NCl^*(Nint(NCl^*(S))) \subseteq NCl^*(NCl^*(Nint(S))) = NCl^*(Nint(S))$. Hence S is a NSI-open set.

Remark 3.15. *The notions of $N\beta I$-open set and $N\delta I$-open set are independent.*

Example 3.16. *Let $U = \{a_1, a_2, a_3, a_4\}$ be the universe $X = \{a_1, a_4\}$, $U/R = \{\{a_3\}, \{a_4\}, \{a_1, a_2\}\}$, $\tau_R(X) = \{\{\phi, \{a_4\}, \{a_1, a_2\}, \{a_1, a_2, a_4\}\}$with an ideal $I = \{\phi, \{a_1\}\}$. Then the set $\{a_2\}$ is $N\beta I$-open but not $N\delta I$-open. And the set $\{a_3\}$is $N\delta I$-open but not $N\beta I$-open.*

Theorem 3.17. *Let S be a subset of a NITS $(U, \tau_R(X), I)$, then the following are equivalent.*

1. *S is a NRI-open set.*

2. *S is a NO-set and NtI-set.*

Proof: (1) $\Rightarrow$ (2) obviously true by the Theorem 3.7 and Theorem 3.8 .
(2) $\Rightarrow$ (1) suppose that S is a NO-set and NtI-set.
Then $S = Nint(S)$ and $Nint(S) = Nint(NCl^*(S))$.
Thus $S = Nint(NCl^*(S))$. Hence S is a NRI-open set.

Remark 3.18. *The notions of NO-set and NtI-set are independent.*

Example 3.19. *Let $U = \{a_1, a_2, a_3, a_4\}$ be the universe $X = \{a_1, a_4\}$, $U/R = \{\{a_3\}, \{a_4\}, \{a_1, a_2\}\}$, $\tau_R(X) = \{\{\phi, \{a_4\}, \{a_1, a_2\}, \{a_1, a_2, a_4\}\}$with an ideal $I = \{\phi, \{a_1\}\}$. Then the set $\{a_1, a_2, a_4\}$ is a NO-set but not NtI-set and $\{a_1\}$ is a NtI-set but not a NO-set.*

Definition 3.20. *A subset S of a NITS is called*

1. *Nano weakly I-locally closed set[20](briefly. NWILC-set) if $S = P \cup Q$, where P is a NO-set and Q is a $*^N$-closed set.*

2. *Nano locally closed set[1](briefly. NLC-set) if $S = P \cup Q$, where P is a NO-set and Q is a NC-set.*

3. *Nano I-locally closed set(briefly. NILC-set) if $S = P \cup Q$, where P is a NO-set and Q is a $*^N$-perfect.*

Theorem 3.21. *In a NITS $(U, \tau_R(X), I)$,*

1. *Every NLC-set is a NWILC-set.*

2. *Every NILC-set is a NWILC-set.*

Proof: Proof is obvious from the definitions.

Theorem 3.22. *Let $S \subset U$ in NITS$(U, \tau_R(X), I)$, the following are equivalent.*

1. *S is NO-set.*

2. *S is a $N\alpha I$-open set and NWILC-set.*

3. *S is a NPI-open set and NWILC-set.*

Proof:(1) $\implies$ (2) $\implies$ (3) is obvious.
(3) $\implies$ (1). Let S be a NWILC-set in $(U, \tau_R(X), I)$ then $S = P \cap Q$ where P is NO-set and Q is $*^N$-closed set. Since S is NPI-open set, we have $S \subseteq Nint(NCl^*(S)) = Nint(NCl^*(P \cap Q)) = Nint(NCl^*(P) \cap NCl^*(Q))$. Now Q is $*^N$-closed set we have $S \subseteq Nint(NCl^*(P)) \cap Nint(Q)$. Now $S = P \cap S \subseteq P \cap Nint(NCl^*(P)) \cap Nint(Q)$. Since P is a NO-set, $S \subseteq Nint(P \cap NCl^*(P)) \cap Nint(Q) = Nint(P) \cap Nint(Q) = Nint(P \cap Q) = Nint(S)$. Thus S is NO-set.

Remark 3.23. *In a NITS,*

1. *The notions of $N\alpha I$-open sets and NWILC-sets are independent.*

2. *The notions of NPI-open sets and NWILC-sets are indipentent.*

Example 3.24. *In example 3.19,the set $\{a_3\}$ is NWILC- set but not $N\alpha I$-open and NPI-open set and the set $\{a_2, a_3, a_4\}$ is a NPI-open set but not NWILC- set.*

Example 3.25. *Let $U = \{a_1, a_2, a_3, a_4\}$ be the Universe set with $U/R = \{\{a_1, a_2\}, \{a_2\}, \{a_3\}\}$ and $X = \{a_1, a_4\}$. The nano topology $\tau_{R(X)} = \{\phi, \{a_1, a_4\}, U\}$ with Ideal $I = \{\phi, \{a_1\}\}$.Then the set $\{a_1, a_2, a_4\}$ is a $N\alpha I$-open set but not a NWILC- set.*

4 Nano $*^N$- Extremally disconnected ideal topological Spaces

Definition 4.1. *A NITS $(U, \tau_R(X), I)$ is called Nano $*^N$-Extremally disconnected ideal topological space (briefly. $*^N$-E.D space) if the $*^N$-closure of every NO-set is a NO-set in $(U, \tau_R(X), I)$.*

Example 4.2. *Let $U = \{a_1, a_2, a_3, a_4\}$ be the Universe set with $U/R = \{\{a_1, a_2\}, \{a_2\}, \{a_3\}\}$ and $X = \{a_1, a_4\}$. The nano topology $\tau_{R(X)} = \{\phi, \{a_1, a_4\}, U\}$ with Ideal $I = \{\phi, \{a_1\}\}$ is Nano $*^N$-Extremally disconnected space.*

Note 4.3. *Let $(U, \tau_R(X), I)$ be a NITS and if $I = \tau_R(X)$ then it is a $*^N$-E.D space.*

Theorem 4.4. *Let $(U, \tau_R(X), I)$ be a NITS and $I = \{\phi\}$. Then $(U, \tau_R(X), I)$ is a $*^N$-E.D space if and only if $(U, \tau_R(X), I)$ is N.E.D space.*

Proof : If $I = \{\phi\}$,then we know that $NCl^*(S) = NCl(S)$. So we obtain $NCl^*(S) = NCl(S) \in \tau_R(X)$ for every $S \in \tau_R(X)$.Thus $(U, \tau_R(X), I)$ is $*^N$-E.D space if and only if $(U, \tau_R(X), I)$ is N.E.D space.

Theorem 4.5. *For a NITS $(U, \tau_R(X), I)$, the following are equivalent.*

1. *$(U, \tau_R(X), I)$ is $*^N$- E.D space.*

2. *$Nint^*(S)$ is a NC-set for every NC-set S of U.*

3. *$NCl^*(Nint(S)) \subseteq Nint(NCl^*(S))$ for every subset S of U.*

4. *Every NSI-open set is a NPI-open set.*

5. $*^N$*-closure of every* $N\beta I$*-open set is a NO-set in U.*

6. *Every* $N\beta I$*-open set is a NPI-open set.*

7. *For any set S in U is a* $N\alpha I$*-open set if and only if S is a NSI-open set.*

Proof :(1) $\Longrightarrow$ (2). Let S be a NC- set in U. Now $U-S$ is NO-set in U. By (1), $NCl^*(U-S) = U - Nint^*(S)$ is a NO-set in U.Thus $Nint^*(S)$ is NC-set in U.
(2) $\Longrightarrow$ (3). Let S be any set and $U - Nint(S)$ is a NC-set in U. By (2), $Nint^*(U - Nint(S)) = U - NCl^*(Nint(S))$ is NC-set in U then $NCl^*(Nint(S))$is a NO-set in U. Thus $NCl^*(Nint(S)) = Nint(NCl^*(Nint(S))) \subseteq Nint(NCl^*(S))$.
(3) $\Longrightarrow$ (4). Let S be a NSI-open set , $S \subseteq NCl^*(Nint(S)) \subseteq Nint(NCl^*(S))$. Thus S is a NPI-open set.
(4) $\Longrightarrow$ (5). We know that every NSI-open set is a $N\beta I$-open set in U. Suppose that $NCl^*(S)$ is a NSI-open set , by (4) $NCl^*(S)$ is a NPI-open set. Then $NCl^*(S) \subseteq Nint(NCl^*(S))$. Now $Nint(NCl^*(S)) \subset NCl^*(S)$, we have $NCl^*(S) = Nint(NCl^*(S))$ is a NO-set in U.
(5) $\Longrightarrow$ (6). Let $NCl^*(S)$ be a $N\beta I$-open set in U. By (5), $S \subseteq NCl^*(S) = Nint(NCl^*(S))$. Thus S is a NPI-open set.
(6) $\Longrightarrow$ (7). Every $N\alpha I$-open set is a NSI-open set. Conversly suppose that S be a NSI-open set in U. We know that every NSI-open set is a $N\beta I$-open set. By (6), S is a NPI-open set. Since S is both NSI-open set and NPI-open set then it is a $N\alpha I$-open set.
(7) $\Longrightarrow$ (1). Suppose that $NCl^*(S)$ is a NSI-open set and by (7), $NCl^*(S)$ is a $N\alpha I$-open set in U. Then $NCl^*(S) \subseteq Nint(NCl^*(Nint(NCl^*(S)))) \subseteq Nint(NCl^*(NCl^*(S))) \subseteq Nint(NCl^*(S))$. Since $Nint(NCl^*(S)) \subseteq NCl^*(S)$, we have $NCl^*(S) = Nint(NCl^*(S))$.Thus $NCl^*(S)$ is a NO-set.

Theorem 4.6. *Let* $(U, \tau_R(X), I)$ *be a NITS. Then the following Properties are equivalent.*

1. $(U, \tau_R(X), I)$ *is a* $*^N$*-E.D. Space.*

2. *Every NRI-open subset of* $(U, \tau_R(X), I)$ *is a* $*^N$*-closed set in* $(U, \tau_R(X), I)$.

3. *Every NRI-closed subset of* $(U, \tau_R(X), I)$ *is a* $*^N$*-open set in* $(U, \tau_R(X), I)$.

Proof :(1) $\Longrightarrow$ (2). Let $(U, \tau_R(X), I)$ be a $*^N$-E.D space. Let S be a NRI-open subset of $(U, \tau_R(X), I)$, then $S = Nint(NCl^*(S))$. Let S is a NO-set,then $NCl^*(S)$ is a NO-set. Thus $S = Nint(NCl^*(S)) = NCl^*(S)$, is a $*^N$-closed set.
(2) $\Longrightarrow$ (1). Suppose every NRI-open subset of U is a $*^N$-closed subset of U. Since $Nint(NCl^*(S))$ is a NRI-open set in U then it is a $*^N$-closed subset of U. This implies $NCl^*(S) \subseteq NCl^*(Nint(NCl^*(S))) = Nint(NCl^*(S))$ .Thus $NCl^*(S) = Nint(NCl^*(S))$ is a NO-set in $(U, \tau_R(X), I)$.Hence $(U, \tau_R(X), I)$ is a $*^N$-E.D space.
(3) $\Longleftrightarrow$ (1). Proof is obvious.

Theorem 4.7. *For a* $*^N$*-E.D. Space* $(U, \tau_R(X), I)$,*then*

1. *If S and T are NRI-closed sets then* $S \cap T$ *is a NRI- closed set.*

2. *If S and T are NRI-open sets then* $S \cup T$ *is a NRI-open set.*

Proof :. (1). Let S and T are NRI-open sets and $(U, \tau_R(X), I)$ be a $*^N$-E.D. Space. Now S and T are closed then by Theorem 4.5, $Nint^*(S)$ and $Nint^*(T)$ are NC-sets in U. Then $S \cap T = NCl(Nint^*(S)) \cap NCl(Nint^*(T)) = Nint^*(S) \cap Nint^*(T) = Nint^*(S \cap T) \subseteq NCl(Nint^*(S \cap T))$.
On the other hand, we have $NCl(Nint^*(S \cap T)) = NCl(Nint^*(S)) \cap (Nint^*(T))$
$\subseteq NCl(Nint^*(S)) \cap NCl(Nint^*(T)) = S \cap T$. Hence $S \cap T$ is a NRI-closed set.
(2). Proof follows from case(1)

Theorem 4.8. *For a NITS $(U, \tau_R(X), I)$ then the following properties are equivalent*

1. *$(U, \tau_R(X), I)$ is a $*^N$-E.D. Space*
2. *For every NSI-open subset S of U then $NCl^*(S)$ is a NO-set.*
3. *For every NPI-open subset S of U then $NCl^*(S)$ is a NO-set.*
4. *For every NRI-open subset S of U then $NCl^*(S)$ is a NO-set.*

Proof :. (1) $\Longrightarrow$ (2) and (1) $\Longrightarrow$ (3). Let S be a NSI-open(resp. NPI-open) subset of U. We know that every NSI-open (resp. NPI-open) set is a $N\beta I$-open set. By Theorem 4.5, $NCl^*(S)$ is a NO-set.
(2) $\Longrightarrow$ (4) and (3) $\Longrightarrow$ (4).Let S be a NRI-open set in U. We know that every NRI-open set is NSI-open and NPI-open. By Theorem 4.5, $NCl^*(S)$ is a NO-set.
(4) $\Longrightarrow$ (1) Suppose that for every NRI-open subset S of U then $NCl^*(S)$ is a NO-set in U.Let $S = Nint(NCl^*(S))$ is NRI-open subset of U then $NCl^*(Nint(NCl^*(S))$ is a NO-set in U. Now $NCl^*(S) \subseteq NCl^*(Nint(NCl^*(S)) = Nint(NCl^*(Nint(NCl^*(S))) = Nint(NCl^*(S))$. This implies that $NCl^*(S)$ is a NO-set in U.

Theorem 4.9. *Let $(U, \tau_R(X), I)$ be a $*^N$-E.D. space and $I = \{\phi\}$, then the following are hold.*

1. *Every $NW\beta I$-open set is NP-open .*
2. *Let S be a NI-open set if and only if S be a NAI-open set.*

Proof :(1). Let S be a NWβI-open set in $*^N$-E.D. space $(U, \tau_R(X), I)$. Then $S \subseteq NCl(Nint(NCl^*(S)))$. Now, $S \in \tau_R(X)$,we have $NCl^*(S) \in \tau_R(X)$. Since $NCl^*(S)$ is a NO-set in U, $NCl^*(S) = Nint(NCl^*(S))$. This implies $S \subseteq NCl^*(S) = Nint(NC^*(NCl(Nint(NCl^*(S))))) \subseteq Nint(NCl^*(NCl(NCl^*(S))))$. Since $I = \{\phi\}$, we have,$S \subseteq Nint(NCl(S))$. Thus S is NP- open.
(2). Suppose that S is NI-open then $S \subseteq Nint(S^{*N})$. Now we have,$S \subseteq Nint(S^{*N}) \subseteq NCl(Nint(S^{*N}))$. Thus S is NAI-open. Conversly suppose that S is NAI-open then $S \subseteq NCl(Nint(S^{*N}))$. Since $(U, \tau_R(X), I)$ is $*^N$-E.D. space , $S \in \tau_R(X)$ then $NCl^*(S) \in \tau_R(X)$. Now,$S \subseteq NCl^*(S) = Nint(NCl^*(S))$.
This implise that $S \subseteq NCl^*(S) \subseteq Nint(NCl^*(NCl(Nint(S^{*N}))))$.
Now $I = \{\phi\}$, we have $S \subseteq Nint(NCl(Nint(S^{*N}))) \subseteq Nint(NCl(S^{*N}))$. Since $S^{*N} = NCl(S^{*N}) = NCl^*(S*N)$, $S \subseteq Nint(S^{*N})$. Thus S is NI-open.

Theorem 4.10. *A Subset S of $*^N$- E.D. space $(U, \tau_R(X), I)$. Then the following are equivalent.*

1. *S is a NO-set*
2. *S is $N\alpha I$-open and NWILC-set.*
3. *S is NSI-open and NWILC-set.*

4. *S is NPI-open and NWILC-set.*

5. *S is NbI-open and NWILC-set.*

6. *S is $N\beta I$-open and NWILC-set.*

Proof:(1) $\implies$ (2).Since every NO-set is $N\alpha I$-open and NWILC-set.
(2) $\implies$ (3). Since every $N\alpha I$-open set is NPI-open, proof is obvious.
(3) $\implies$ (4). Since $(U, \tau_R(X), I)$ is a $*^N$-E.D. space and by Theorem4.5, proof is obvious.
(4) $\implies$ (5). Since every NPI-open set is NbI-open, proof is obvious.
(5) $\implies$ (6). Since every NbI-open set is $N\beta I$-open, proof is obvious.
(6) $\implies$ (1). Suppose that S is $N\beta I$-open and NWILC-set, then $S \subseteq NCl^*(Nint(NCl^*(S)))$ and by Theorem 2.17, we have $S = T \cap NCl^*(S)$. This implies that $S \subseteq T \cap NCl^*(NCl^*(Nint(NCl^*(S)))) = T \cap NCl^*(Nint(NCl^*(S)))$. Now using Theorem 4.5, There exists a NO-set T such that $S \subseteq T \cap Nint(NCl^*(NCl^*(S))) = T \cap Nint(NCl^*(S))$. Now $S \subseteq Nint(T) \cap Nint(NCl^*(S)) = Nint(T \cap NCl^*(S) = Nint(S)$. Thus S is a No-set.

Theorem 4.11. *A Subset S of $*^N$- E.D. space $(U, \tau_R(X), I)$. Then the following are equivalent.*

1. *S is a NO-set*

2. *S is $N\alpha I$-open and NILC-set.*

3. *S is NSI-open and NILC-set.*

4. *S is NPI-open and NILC-set.*

5. *S is NbI-open and NILC-set.*

6. *S is $N\beta I$-open and NILC-set.*

Proof: Proof follows from Theorem 3.21 and Theorem 4.10.

Theorem 4.12. *A Subset S of $*^N$- E.D. space $(U, \tau_R(X), I)$. Then the following are equivalent.*

1. *S is a NO-set*

2. *S is $N\alpha I$-open and NLC-set.*

3. *S is NSI-open and NLC-set.*

4. *S is NPI-open and NLC-set.*

5. *S is NbI-open and NLC-set.*

6. *S is $N\beta I$-open and NLC-set.*

Proof: Proof follows from Theorem 3.21 and Theorem 4.10.

5 Decompositions of some stronger and weaker forms of nano continuous mappings

Definition 5.1. *A map $\sigma : (U, \tau_R(X), I) \to (V, \tau_{R'}(Y))$ is said to be NRI-continuous (resp. $N\delta I$-continuous, NtI-continuous, NbI-continuous, $N\beta I$-continuous, NILC-continuous, NWILC-continuous) if $\sigma^{-1}(T)$ is NRI-open(resp. $N\delta I$-open ,NtI-set, NbI-open, $N\beta I$-open, NILC-set, NWILC-set) in $(U, \tau_R(X), I)$ for every NO-set T in $(V, \tau_{R'}(Y))$.*

Definition 5.2. *[1] A mapping $\sigma : (U, \tau_R(X), I) \to (V, \tau_{R'}(Y))$ is called NLC-continuous if $\sigma^{-1}(T)$ is NLC-set in $(U, \tau_R(X), I)$ for every NO-set set T in $(V, \tau_{R'}(Y))$.*

Theorem 5.3. *In a NITS, a mapping $\sigma : (U, \tau_R(X), I) \to (V, \tau_{R'}(Y))$ the following are hold.*

1. *Every $N\alpha I$-continuous mapping is $N\delta I$-continuous.*
2. *Every NtI-continuous mapping is $N\delta I$-continuous.*
3. *Every nano continuous mapping is $N\delta I$-continuous.*

Proof: It is immediate from Theorem 3.2.

Theorem 5.4. *If $\sigma : (U, \tau_R(X), I) \to (V, \tau_{R'}(Y))$ is both NPI-continuous and $N\delta I$-continuous then it is NSI-continuous.*

Proof: Let T be a NO-set in $(V, \tau_{R'}(Y))$. Since σ is NPI-continuous and $N\varepsilon I$-continuous, $\sigma^{-1}(T)$ is both $N\delta I$-open and NPI-open. By Theorem 3.5, $\sigma^{-1}(T)$ is NSI-open. Thus, σ is NSI-continuous.

Theorem 5.5. *Let $\sigma : (U, \tau_R(X), I) \to (V, \tau_{R'}(Y))$ is NRI-continuous then σ is $N\alpha I$-continuous(NSI-continuous, $N\delta I$- continuous, Nt-I-continuous).*

Proof: Proof is immediate from the Theorem 3.8.

Remark 5.6. *The converses of the above theorem need not be true as shown in the following example.*

Example 5.7. *Let $U = \{a_1, a_2, a_3, a_4\}$ be the universe with $U/R = \{\phi, a_1\}, \{a_3\}, \{a_2, a_4\}\}$ and $X = \{a_1, a_2\}$, $I = \{\phi, \{a_1\}\}$. Now, $\tau_R(X) = \{\phi, \{a_1\}, \{a_2, a_4\}, \{a_1, a_2, a_4\}, U\}$. and $V = \{a_1, a_2, a_3\}$with $V/R' = \{\{a_1\}\{a_2, a_4\}\}$,$Y = \{a_1\}$and $\tau_{R'}(Y) = \{\phi, \{a_1\}, V\}$.*
(i)Define a map $\sigma : (U, \tau_R(X), I) \to (V, \tau_{R'}(Y))$ $\sigma(a_1) = \sigma(a_2) = \sigma(a_4) = a_1$ and $\sigma(a_3) = a_2$ then σ is $N\alpha I$-continuous, NSI-continuous, NPI-continuous, $N\delta I$- continuous but not NRI-continuous.
(ii)Define a map $\sigma : (U, \tau_R(X), I) \to (V, \tau_{R'}(Y))$ $\sigma(a_2) = \sigma(a_3) = \sigma(a_4) = a_1$ and $\sigma(a_1) = a_2$ then σ is N tI-continuous but not NR I-continuous.

Theorem 5.8. *A mapping $\sigma : (U, \tau_R(X), I) \to (V, \tau_{R'}(Y))$ is $N\alpha I$-continuous if and only if σ is both $N\delta I$-continuous and NP I-continuous.*

Proof: Proof follows immediately from Theorem 3.11.

Theorem 5.9. *A mapping $\sigma : (U, \tau_R(X), I) \to (V, \tau_{R'}(Y))$ is NSI-continuous if and only if σ is both $N\delta I$-continuous and $N\beta I$-continuous.*

Proof: Proof follows immediately from Theorem 3.14.

Theorem 5.10. *A mapping $\sigma : (U, \tau_R(X), I) \rightarrow (V, \tau_{R'}(Y))$ is NRI-continuous if and only if σ is both nano continuous and NtI-continuous.*

Proof: Proof follows immediately from Theorem 3.17.

Theorem 5.11. *For a mapping $\sigma : (U, \tau_R(X), I) \rightarrow (V, \tau_{R'}(Y))$,then the following are equivalent.*

1. *Nano continuous.*
2. *$N\alpha I$-continuous set and $NWILC$-continuous.*
3. *NPI-continuous and $NWILC$-continuous.*

Proof: Proof follows immediately from Theorem 3.22.

Theorem 5.12. *Let $(U, \tau_R(X), I)$ $*^N$-E.D. space. Then the mapping $\sigma : (U, \tau_R(X), I) \rightarrow (V, \tau_{R'}(Y))$ is*

1. *NPI-continuous if and only if $N\beta$ I-continuous.*
2. *NPI-continuous if and only if NSI-continuous.*
3. *$N\alpha$I-continuous if and only if NSI-continuous .*

Proof: Proof follows from Theorem 4.5.

Theorem 5.13. *If the mapping $\sigma : (U, \tau_R(X), I) \rightarrow (V, \tau_{R'}(Y))$ and $(U, \tau_R(X), I)$ is $*^N$- E.D. space then the following properties are equivalent.*

1. *σ is nano continuous*
2. *σ is $N\alpha I$-continuous and $NWILC$-continuous.*
3. *σ is NSI-continuous and $NWILC$-continuous.*
4. *$\sigma$is NPI-continuous and $NWILC$-continuous.*
5. *σ is NbI-continuous and $NWILC$-continuous.*
6. *σ is $N\beta I$-continuous and $NWILC$-continuous.*

Proof: Proof is immediate from Theorem 4.10.

Theorem 5.14. *If the mapping $\sigma : (U, \tau_R(X), I) \rightarrow (V, \tau_{R'}(Y))$ and $(U, \tau_R(X), I)$ is $*^N$- E.D. space then the following properties are equivalent.*

1. *σ is nano continuous*
2. *σ is $N\alpha I$-continuous and $NILC$-continuous.*
3. *σ is NSI-continuous and $NILC$-continuous.*
4. *$\sigma$is NPI-continuous and $NILC$-continuous.*

5. *σ is NbI-continuous and $NILC$-continuous.*

6. *σ is $N\beta I$-continuous and $NILC$-continuous.*

Proof: Proof is immediate from Theorem 4.11.

Theorem 5.15. *If the mapping $\sigma : (U, \tau_R(X), I) \to (V, \tau_{R'}(Y))$ and $(U, \tau_R(X), I)$ is $*^N$- E.D. space then the following properties are equivalent.*

1. *σ is nano continuous*

2. *σ is $N\alpha I$-continuous and NLC-continuous.*

3. *σ is NSI-continuous and NLC-continuous.*

4. *$\sigma$is NPI-continuous and NLC-continuous.*

5. *σ is NbI-continuous and NLC-continuous.*

6. *σ is $N\beta I$-continuous and NLC-continuous.*

Proof: Proof is immediate from Theorem 4.12.

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