Neutrosophic Semi α-Baire Spaces

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Abstract

In this paper, we introduced the concept of Neutrosophic Semi α-Baire space and some of its characterizations of Neutrosophic Semi α-Baire spaces are also studied. Here we have included several examples to illustrate the concepts.

Keywords: *Neutrosophic semi α-open set, Neutrosophic semi α-nowhere dense set, Neutrosophic semi α-first category, Neutrosophic semi α-second category and Neutrosophic semi α-Baire spaces*

1. Introduction and Preliminaries

The fuzzy set was introduced by L.A. Zadeh [15] in 1965, where each element had a degree of membership. The intuitionstic fuzzy set (Ifs for short) on a universe X was introduced by K. Atanassov [2, 3,4] in 1983 as a generalization of fuzzy set, where besides the degree of membership and the degree of non-membership of each element. The idea of "neutrosophic set" was first given by Smarandache [8,10]. Neutrosophic operations have been investigated by A.A.Salama at el. [1]. A.A.Salama and S.A.Alblowi presented the concept of Neutrosophic Topological Spaces[12].In 2000 G.B. Navalagi presented the idea of semi α-open sets in topological spaces[9].The concept of Neutrosophic semi α-open sets was given by Qays Haten Imran and Smarandache in 2017[11].The concept of Baire space in fuzzy setting was introduced and studied by G.Thangaraj and S. Anjalmose [14].The idea of neutrosophic Baire spaces are introduced by R. Dhavaseelan, S. Jafari ,R. Narmada Devi, Md. Hanif [7].

Definition 1.1. [7] A neutrosophic topology (NT) on a nonempty set X is a family T of neutrosophic sets in X satisfying the following axioms:

(i) $0_N, 1_N \in T$,

(ii) $G_1 \cap G_2 \in T$ for any $G_1, G_2 \in T$.

(iii)$\cup G_i$ for arbitrary family $\{G_i | i \in \wedge\}$.

In this case the ordered pair (X, T) or simply X is called a neutrosophic Topological Space (briefly NTS) and each Neutrosophic set in T is called a neutrosophic open set (briefly NOS). The complement A of a NOS A in X is called a neutrosophic closed set (briefly NCS) in X.

Definition 1.2. [7] Let A be a neutrosophic set in a neutrosophic topological space X. Then

Nint(A) = $\cup\{G \mid G \text{ is neutrosophic open set in } X \text{ and } G \subseteq A\}$ is called the neutrosophic interior of A;

Ncl(A) = $\cap\{G \mid G \text{ is neutrosophic closed set in } X \text{ and } G \supseteq A\}$ is called the neutrosophic closure of A.

Definition 1.3:[11] A neutrosophic set A in a neutrosophic topological space X is said to a neutrosophic Semi Open set (NSOS) if $A \subseteq Ncl(N\operatorname{int}(A))$ and neutrosophic Semi Closed set (NSCS) if $N\operatorname{int}(Ncl(A)) \subseteq A$.

Definition 1.4:[11] Let A be a neutrosophic set in a neutrosophic topological space X. Then

NSint(A) = $\cup\{G \mid G \text{ is neutrosophic semi open set in } X \text{ and } G \subseteq A\}$ is called the neutrosophic interior of A;

NScl(A) = $\cap\{G \mid G \text{ is neutrosophic semi closed set in } X \text{ and } G \supseteq A\}$ is called the neutrosophic closure of A;

Result: 1.1: Let A be a neutrosophic set in a neutrosophic topological space X. Then

NScl(A) = $A \cup N\text{int}(Ncl(A))$
NSint(A) = $A \cap Ncl(N\text{int}(A))$

Definition 1.7: [11] A neutrosophic set A in a neutrosophic topological space X is said to a Neutrosophic α-Open set(NαOS) if $A \subseteq Nint(Ncl(Nint(A)))$ and Neutrosophic α-Closed set (NαCS) if $Ncl(Nint(Ncl(A))) \supseteq A$

Definition 1.8:[11] Let A be a neutrosophic set in a neutrosophic topological space X. Then

Nαint(A) = $\cup\{G \mid G \text{ is neutrosophic } \alpha - \text{open set in } X \text{ and } G \subseteq A\}$ is called the neutrosophic interior of A;

Nαcl(A) = $\cap\{G \mid G \text{ is neutrosophic } \alpha - \text{closed set in } X \text{ and } G \supseteq A\}$ is called the neutrosophic closure of A;

Result: 1.2 Let A be a neutrosophic set in a neutrosophic topological space X. Then

Nαcl(A) = $A \cup Ncl(Nint(Ncl(A)))$
Nαint(A) = $A \cap Nint(Ncl(Nint(A)))$

Definition 1.9:[11] A neutrosophic subset A in a neutrosophic topological space (X,T) is said to a Neutrosophic Semi-α-Open set(NS α-OS) if there exist a NS α-OS B in T such that B $\subseteq$ A $\subseteq Ncl(B)$ or equivalently if $A \subseteq Ncl(N\alpha int(A))$ and Neutrosophic α-Closed set (NS α CS) if $Nint(N\alpha cl(A)) \supseteq A$.

Definition 1.10:[11] Let A be a neutrosophic set in a neutrosophic topological space X. Then

NSαint(A) = $\cup\{G \mid G \text{ is neutrosophic semi } \alpha - \text{open set in } X \text{ and } G \subseteq A\}$ is called the neutrosophic interior of A;

NSαcl(A) = $\cap\{G \mid G \text{ is neutrosophic semi } \alpha - \text{closed set in } X \text{ and } G \supseteq A\}$ is called the neutrosophic closure of A;

Result: 1.3 Let A be a neutrosophic set in a neutrosophic topological space X. Then

NSαcl(A) = $A \cup Nint(Ncl(Nint(Ncl(A))))$
NSαint(A) = $A \cap Ncl(Nint(Ncl(Nint(A))))$

2. Neutrosophic Semi α -nowhere dense sets

Definition 2.1.: A Neutrosophic set A in Neutrosophic topological space (X; T) is called Neutrosophic semi nowhere dense if there exists no non-zero Neutrosophic semi open set B in (X; T) such that $B \subset NScl(A)$. That is $NS\text{int}(NScl(A)) = 0_N$

Definition 2.2: Let (X, T) be a neutrosophic topological space. A neutrosophic set A in (X, T) is called Neutrosophic semi first category if A = $\bigcup_{i=1}^{\infty} A_i$ where A_i's are neutrosophic semi nowhere dense sets in (X, T). Any other neutrosophic set in (X, T) is said to be of neutrosophic semi second category.

Definition 2.3: A neutrosophic set A in neutrosophic topological space (X, T) is called neutrosophic α-dense if there exists no neutrosophic α-Closed set B in (X, T) such that $A \subset B \subset 1_N$.
That is $N\alpha cl(A) = 1_N$

Definition 2.4 A Neutrosophic set A in Neutrosophic topological space (X, T) is called Neutrosophic α-nowhere dense if there exists no non-zero Neutrosophic α -open set B in (X, T) such that $B \subset N\alpha cl(A)$.
That is $N\alpha\,\text{int}(N\alpha cl(A)) = 0_N$

Definition 2.5 A neutrosophic set A in neutrosophic topological space (X, T) is called Neutrosophic Semi α-nowhere dense if there exists no non-zero neutrosophic semi α- open set B in (X ,T) such that $B \subset NS\alpha cl(A)$ .That is $NS\alpha int\big(NS\alpha cl(A)\big) = 0_N$.

Example 2.1: Let X = {x}. Define the Neutrosophic set A, B , C and D on X as follows:

$A =< x, 0.5,0.5,0.4 >; B =< x, 0.4, 0.6, 0.8 >; C =< x, 0.4,0.5,0.8 > and\ D =< x, 0.5,0.6,0.4 >$

Then the families $T = \{0_N, 1_N, A, B, C, D\}$ is neutrosophic topology on X. Thus (X, T) is a Neutrosophic topological space. Now the sets $\overline{B}, \overline{D}$, are neutrosophic semi α-nowhere dense set

Definition 2.6 A neutrosophic set A in a neutrosophic topological space (X,T) is called neutrosophic Semi-α-dense if there exists no fuzzy Semi-α-closed set B in (X,T) such that $A \subset B \subset 1_N$. That is NSαcl(A) =1_N.

Example 2.2: Let X = {x}. Define the Neutrosophic set A, B , C and D on X as follows:

$A =< x, 0.5,0.5,0.4 >; B =< x, 0.4, 0.6, 0.8 >; C =< x, 0.4,0.5,0.8 > and\ D =< x, 0.5,0.6,0.4 >$

Then the families $T = \{0_N, 1_N, A, B, C, D\}$ is neutrosophic topology on X. Thus (X, T) is a Neutrosophic topological space. Now the sets B, D are neutrosophic semi α-dense set.

Proposition 2.1. If A is a Neutrosophic semi nowhere dense set in (X, T), then $\overline{A}$ is a Neutrosophic semi α -dense set in (X, T)

Definition 2.7. Let (X, T) be a neutrosophic topological space. A neutrosophic set A in (X, T) is called neutrosophic Semi α-first category set if A = $\bigcup_{i=1}^{\infty} A_i$, where A_i' s are neutrosophic Semi α- nowhere dense sets in (X, T). A neutrosophic set which is not Semi α-first category is called a neutrosophic Semi α-second category set in (X, T).

Example 2.3: Let X = {a, b}. Define the Neutrosophic set A, B and C on X as follows:

$$A = \left\langle x, \left(\frac{a}{0.2}, \frac{b}{0.4}\right), \left(\frac{a}{0.2}, \frac{b}{0.4}\right), \left(\frac{a}{0.5}, \frac{b}{0.6}\right) \right\rangle, \quad B = \left\langle x, \left(\frac{a}{0.6}, \frac{b}{0.2}\right), \left(\frac{a}{0.6}, \frac{b}{0.2}\right), \left(\frac{a}{0.3}, \frac{b}{0.4}\right) \right\rangle$$

$C = \left\langle x, \left(\frac{a}{0.3}, \frac{b}{0.4}\right), \left(\frac{a}{0.3}, \frac{b}{0.4}\right), \left(\frac{a}{0.4}, \frac{b}{0.4}\right) \right\rangle$

Then the families $T = \{0_N, 1_N, A, B, A \cup B\}$ is neutrosophic topology on X. Thus (X, T) is a Neutrosophic topological space. Now the sets $, \overline{B}, \overline{A \cup B}$ are Neutrosophic α-nowhere dense sets in (X, T) and $(\overline{B}) \cup (\overline{A \cup B}) = \overline{B}$, $\overline{B}$ is neutrosophic Semi α-first category set.

Proposition 2.2. Let (X, T) be a neutrosophic topological space. If A is a neutrosophic α-dense set in (X, T), then A is neutrosophic semi α-dense in (X, T).

Proof: Let (X, T) be a neutrosophic topological space. If A is a neutrosophic α -dense implies that N αcl(A) = 1_N . That is $A \cup Ncl\left(Nint\left(Ncl(A)\right)\right) = 1_N$. Clearly $Ncl(Nint(Ncl(A))) = 1_N$. Now $Nint(Ncl\left(Nint\left(Ncl(A)\right)\right)) = Nint\left(1_N\right) = 1_N$. So $\cup\, Nint(Ncl\left(Nint\left(Ncl(A)\right)\right)\right) = A \cup 1_N = 1_N$. This implies $NS\alpha cl(A) = 1_N$. Hence A is Neutrosophic semi α-dense in (X, T).

Proposition 2.3. Let (X, T) be a neutrosophic topological space. If A is a neutrosophic semi-dense set in (X, T), then A is neutrosophic semi α-dense in (X, T).

Proof: Let (X, T) be a neutrosophic topological space. If A is a neutrosophic semi dense implies that NScl(A) = 1_N . That is $A \cup \left(Nint\left(Ncl(A)\right)\right) = 1_N$. Clearly $(Ncl(A)) = 1_N$. Now $Nint(Ncl\left(Nint\left(Ncl(A)\right)\right)) = Nint\left(1_N\right) = 1_N$. So $A \cup Nint(Ncl\left(Nint\left(Ncl(A)\right)\right)\right) = A \cup 1_N = 1_N$ .This implies $NS\alpha cl(A) = 1_N$. Hence A is Neutrosophic semi α-dense in (X, T).

Proposition 2.4. Let (X, T) be a neutrosophic topological space. If A is a neutrosophic α- nowhere dense set in (X, T), then A is neutrosophic semi α- nowhere dense in (X, T) only if $A \subseteq B$ where B is not open.

Proof: Let (X, T) be a neutrosophic topological space. If A is a neutrosophic α- nowhere dense, there exist no neutrosophic α- open set B $\neq 0$ such that $B \subset N\alpha cl(A)$. Since B is not neutrosophic α- open $N\alpha int(B) \neq B$. So $Ncl(N\alpha int(B)) \neq Ncl(B)$. Clearly B$\not\subset Ncl(B)$. Therefore $B \not\subset Ncl(N\alpha int(B))$. This implies B is not neutrosophic semi α- open. Now $B \subset N\alpha cl(A)$ gives$A \cup Ncl\left(Nint\left(Ncl(A)\right)\right) \supset B$. That is either A $\supset B$ or $Ncl\left(Nint\left(Ncl(A)\right)\right) \supset B$. Suppose that $Ncl\left(Nint\left(Ncl(A)\right)\right) \supset B$ then $A \subseteq B$. Since B is not α –open $Nint(Ncl\left(Nint\left(Ncl(A)\right)\right) \supset Nint(B) \supset B$.So $Nint(Ncl\left(Nint\left(Ncl(A)\right)\right) \supset B$. $A \cup Nint(Ncl\left(Nint\left(Ncl(A)\right)\right) \supset A \cup B = B$. This implies $NS\alpha cl(A) \supset B$. Hence A is neutrosophic semi α- nowhere dense in (X, T).

Proposition 2.5: If A is a neutrosophic semi-nowhere dense set in a neutrosophic topological space (X, T) then $NS\alpha int(A) = 0_N$

Proof: Let A be a Neutrosophic semi-nowhere dense set in (X, T). Then, we have NSint (NScl (A)) = 0_N.

Now A $\subseteq$ NScl(A) we have NSint(A) $\subseteq$ NSint(NScl(A))= 0_N. Hence NSint(A)= 0_N.That is $A \cap Ncl(Nint(A)) = 0_N$. This implies $Ncl(Nint(A)) = 0_N$.So we have $A \cap Ncl\left(Nint\left(Ncl(Nint(A))\right)\right) = 0_N$.

Hence $NS\alpha int(A) = 0_N$

Proposition 2.6: If A is a neutrosophic α -nowhere dense set in a neutrosophic topological space (X, T) then $NS\alpha int(A) = 0_N$

Proof: Let A be a neutrosophic α -nowhere dense set in (X, T). Then, we have Nαint (Nαcl (A)) = 0_N.

Now A $\subseteq$ Nαcl(A) we have Nαint(A) $\subseteq$ Nαint(Nαcl(A))= 0_N. Hence Nαint(A)= 0_N.

That is $A \cap Nint(Ncl(Nint(A))) = 0_N$. This implies $Nint(Ncl(Nint(A))) = 0_N$.

So we have $A \cap Ncl\left(Nint\left(Ncl(Nint(A))\right)\right) = 0_N$. Hence $NS\alpha int(A) = 0_N$

Proposition 2.7:[1] For any neutrosophic subset A of a neutrosophic topological space (X, T), then

$(i)\ Nint\left(NS\alpha int(A)\right) = NS\alpha int\left(Nint(A)\right) = Nint(A)$
$(ii)\ N\alpha int\left(NS\alpha int(A)\right) = NS\alpha int\left(\alpha Nint(A)\right) = N\alpha int(A)$

Proposition 2.8 Let (X, T) be a neutrosophic topological space. If A is a neutrosophic semi α-nowhere dense set and neutrosophic α-closed set in (X, T), then A is a neutrosophic α-nowhere dense set in (X, T).

Proof: Let A be a neutrosophic semi α-nowhere dense set in (X, T), then by proposition (2.6), $NS\alpha int(A) = 0_N$.Now $N\alpha int\left(NS\alpha int(A)\right) = N\alpha int(0_N) = 0_N$. By proposition (2.7), for a neutrosophic subset A

$N\alpha int\left(NS\alpha int(A)\right) = NS\alpha int\left(N\alpha int(A)\right) = N\alpha int(A)$, this implies $N\alpha int(A) = 0_N$. Here A is neutrosophic α-closed set and so $N\alpha cl(A) = A \Longrightarrow N\alpha int(N\alpha cl(A)) = N\alpha int(A) = 0_N$

Hence A is a neutrosophic α-nowhere dense set in (X, T).

Proposition 2.9: Let (X, T) be a neutrosophic topological space. If A is a neutrosophic semi α-nowhere dense set and neutrosophic closed set in (X, T),then A is a neutrosophic nowhere dense set in (X, T).

Proof: Let A be a neutrosophic semi α-nowhere dense set in (X, T), then by proposition (2.6), $NS\alpha int(A) = 0_N$.Now $Nint\left(NS\alpha int(A)\right) = Nint(0_N) = 0_N$. By proposition (2.7), for a neutrosophic subset A

$N\alpha int\left(NS\alpha int(A)\right) = NS\alpha int\left(Nint(A)\right) = Nint(A)$, this implies $Nint(A) = 0_N$. Here A is neutrosophic closed set and so $Ncl(A) = A \Longrightarrow Nint(Ncl(A)) = Nint(A) = 0_N$

Hence A is a neutrosophic nowhere dense set in (X, T).

3. Neutrosophic Semi α-Baire space

Motivated by the concept of neutrosophic Baire space introduced in [9] we shall now define:

Definition 3.1. Let (X, T) be a neutrosophic topological space. Then (X, T) is called a Neutrosophic Semi α-Baire space if $NS\alpha\, int\left(\bigcup_{i=1}^{\infty} A_i\right) = 0_N$, where A*i* ’s are neutrosophic semi α- nowhere dense sets in (X,T).

Example 3.1: Let X = {a, b}. Define the Neutrosophic set A, B,C and D on X as follows:

$A = \left\langle x, \left(\frac{a}{0.5}, \frac{b}{0.2}\right), \left(\frac{a}{0.5}, \frac{b}{0.2}\right), \left(\frac{a}{0.3}, \frac{b}{0.4}\right) \right\rangle$, $B = \left\langle x, \left(\frac{a}{0.3}, \frac{b}{0.4}\right), \left(\frac{a}{0.3}, \frac{b}{0.4}\right), \left(\frac{a}{0.6}, \frac{b}{0.5}\right) \right\rangle$

$C = \left\langle x, \left(\frac{a}{0.3}, \frac{b}{0.4}\right), \left(\frac{a}{0.3}, \frac{b}{0.4}\right), \left(\frac{a}{0.2}, \frac{b}{0.5}\right) \right\rangle$, $D = \left\langle x, \left(\frac{a}{0.3}, \frac{b}{0.4}\right), \left(\frac{a}{0.5}, \frac{b}{0.4}\right), \left(\frac{a}{0.5}, \frac{b}{0.2}\right) \right\rangle$

Then the family $T = \{0_N, 1_N, A, B, A \cup B\}$ is neutrosophic topology on X. Thus (X, T) is a Neutrosophic topological space. Now the sets $\overline{A}, \overline{A \cup B}$ are Neutrosophic semi α-nowhere dense sets in (X, T) and $NS\alpha \operatorname{int}[(\overline{A}) \cup (\overline{A \cup B})] = NS\alpha \operatorname{int}(D) = 0_N$, Hence the neutrosophic topological space (X,T) is neutrosophic semi α-Baire space.

Proposition 3.2:
Every neutrosophic Baire space is neutrosophic semi α -Baire space.

Example 3.2
Let X = {a, b}. Define the Neutrosophic set A, B and C on X as follows:

$A = \left\langle x, \left(\frac{a}{0.2}, \frac{b}{0.4}\right), \left(\frac{a}{0.2}, \frac{b}{0.4}\right), \left(\frac{a}{0.5}, \frac{b}{0.6}\right) \right\rangle$, $B = \left\langle x, \left(\frac{a}{0.6}, \frac{b}{0.2}\right), \left(\frac{a}{0.6}, \frac{b}{0.2}\right), \left(\frac{a}{0.3}, \frac{b}{0.4}\right) \right\rangle$

$C = \left\langle x, \left(\frac{a}{0.3}, \frac{b}{0.4}\right), \left(\frac{a}{0.3}, \frac{b}{0.4}\right), \left(\frac{a}{0.4}, \frac{b}{0.4}\right) \right\rangle$,

Then the family $T = \{0_N, 1_N, A, B, A \cup B\}$ is neutrosophic topology on X. Thus (X, T) is a Neutrosophic topological space. Now the sets $\overline{B}, \overline{A \cup B}$ are Neutrosophic nowhere dense and Neutrosophic semi α-nowhere dense sets in (X, T).

Here $N \operatorname{int}[(\overline{B}) \cup (\overline{A \cup B})] = N \operatorname{int}(\overline{A \cup B}) = 0_N$. Hence the neutrosophic topological space (X,T) is Neutrosophic Baire space.

But $NS\alpha \operatorname{int}[(\overline{B}) \cup (\overline{A \cup B})] = NS\alpha \operatorname{int}(\overline{A \cup B}) = 0_N$ So the neutrosophic topological space (X,T) is Neutrosophic semi α-Baire space

Proposition 3.3: Every neutrosophic semi α -Baire space in not to be a neutrosophic Baire space.

Consider the **example 3.1:**
The sets $\overline{A}, \overline{A \cup B}$ are Neutrosophic nowhere dense sets in (X, T), But

$$N \operatorname{int}[(\overline{A}) \cup (\overline{A \cup B})] = N \operatorname{int}(D) \neq 0_N .$$

Hence the neutrosophic topological space (X, T) is not neutrosophic Baire space.

Proposition 3.4: Every neutrosophic semi α -Baire space in not to be a neutrosophic Baire space.

Consider the **example 3.1:**
The sets $\overline{A}, \overline{A \cup B}$ are Neutrosophic semi nowhere dense sets in (X, T), But

$$NS \operatorname{int}[(\overline{A}) \cup (\overline{A \cup B})] = NS \operatorname{int}(D) \neq 0_N .$$

Hence the neutrosophic topological space (X, T) is not neutrosophic Semi Baire space

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