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On Neutrosophic Crisp Generalized Alpha Generalized Closed Sets

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Abstract

This study reveals new concepts of neutrosophic crisp closed sets named neutrosophic crisp g -closed sets, neutrosophic crisp αg -closed sets, neutrosophic crisp $g\alpha$ -closed sets, and neutrosophic crisp $g\alpha g$ -closed sets. Furthermore, their ultimate features in neutrosophic crisp topological spaces are examined. Moreover, the consequent new concepts are introduced, such as neutrosophic crisp $g\alpha g$ -closure and neutrosophic crisp $g\alpha g$ -interior, and finding some of their characteristics.

Mathematics Subject Classification (2010): 54A05, 54B05.

Keywords: $Neu^{Cg\alpha g}$ CS; $Neu^{Cg\alpha g}$ OS; $Neu^{Cg\alpha g}$ -closure and $Neu^{Cg\alpha g}$ -interior.

1. Introduction

Salama et al. [1] presented the idea of neutrosophic crisp topological space (or simply Neu^{CTS}). Salama [2] give some concepts of neutrosophic crisp nearly open sets. Al-Hamido et al. [3] provided the interpretation of neutrosophic crisp semi- α -closed sets. Al-Obaidi et al. [4,5] provided new concepts of weakly neutrosophic crisp open functions and weakly neutrosophic crisp closed functions. PAGE et al. [6] presented the view of neutrosophic generalized homeomorphism. Imran et al. [7-9] provided neutrosophic generalized alpha generalized continuity, different kinds of weakly neutrosophic crisp continuity, and other concepts of neutrosophic crisp open sets. This paper aims to establish the notion of neutrosophic crisp $g\alpha g$ -closed sets and survey their vital elements in neutrosophic crisp topological space. Furthermore, we identify neutrosophic crisp $g\alpha g$ -closure and neutrosophic crisp $g\alpha g$ -interior and achieve several of their highlights.

2. Preliminaries

All through this work, (\mathcal{U}, ψ) (or simply \mathcal{U}) frequently implies Neu^{CTS} . For a neutrosophic crisp set \mathcal{D} in a $Neu^{CTS}(\mathcal{U}, \psi)$, we symbolize the neutrosophic crisp closure of \mathcal{D} by $Neu^c cl(\mathcal{D})$, the neutrosophic crisp interior of \mathcal{D} by $Neu^c int(\mathcal{D})$, and the neutrosophic crisp complement of \mathcal{D} by $\underline{\mathcal{D}} = \mathcal{U}_{Neu} - \mathcal{D}$, respectively.

Definition 2.1: [1]

Presume that non-empty certain fixed space \mathcal{U} has mutually exclusive subsets $\mathcal{D}_1, \mathcal{D}_2$ & \mathcal{D}_3 . A neutrosophic crisp set (or simply $Neu^C S$) \mathcal{D} with form $\mathcal{D} = \langle \mathcal{D}_1, \mathcal{D}_2, \mathcal{D}_3 \rangle$ is called an object.

Definition 2.2: [1]

A neutrosophic crisp topology (in rapid, Neu^{CT}) on $\mathcal{U} \neq \phi$ is a collection ψ of $Neu^C S$ s in \mathcal{U} comforting the rules given below:

- (i) $\phi_{Neu}, \mathcal{U}_{Neu} \in \psi$,
- (ii) $\mathcal{D}_1 \cap \mathcal{D}_2 \in \psi$ being $\mathcal{D}_1, \mathcal{D}_2 \in \psi$,
- (iii) $\bigcup \mathcal{D}_k \in \psi$ for arbitrary family $\{\mathcal{D}_k | k \in \Delta\} \subseteq \psi$.

In this situation the ordered pair (\mathcal{U}, ψ) is termed as Neu^{CTS} and each $Neu^C S$ in ψ is named as a neutrosophic crisp open set (in short, $Neu^C OS$). The complement $\underline{\mathcal{D}}$ of a $Neu^C OS$ \mathcal{D} in \mathcal{U} is recognized as neutrosophic crisp closed set (briefly, $Neu^C CS$) in \mathcal{U} .

Definition 2.3: [2]

A neutrosophic crisp subset \mathcal{D} of a $Neu^{CTS}(\mathcal{U}, \psi)$ is stated to be a neutrosophic crisp α -open set (in brief $Neu^{C\alpha} OS$) if $\mathcal{D} \subseteq Neu^c int(Neu^c cl(Neu^c int(\mathcal{D})))$ and a neutrosophic crisp α -closed set (in short $Neu^{C\alpha} CS$) if $Neu^c cl(Neu^c int(Neu^c cl(\mathcal{D}))) \subseteq \mathcal{D}$. The neutrosophic crisp α -closure of \mathcal{D} of a $Neu^{CTS}(\mathcal{U}, \psi)$ is the overlapping of the whole $Neu^{C\alpha} CS$ s that include \mathcal{D} and it is symbolized by $Neu^{C\alpha} cl(\mathcal{D})$.

Proposition 2.4: [2,10]

Every $Neu^C OS$ (resp. $Neu^C CS$) is a $Neu^{C\alpha} OS$ (resp. $Neu^{C\alpha} CS$).

3. Neutrosophic Crisp Generalized αg -Closed Sets

In this part, we characterize and analyze the neutrosophic crisp generalized αg -closed sets and several of their features.

Definition 3.1:

Let \mathcal{D} be a neutrosophic crisp subset, and let \mathfrak{M} be a $Neu^C OS$ in a $Neu^{CTS}(\mathcal{U}, \psi)$ where $\mathcal{D} \subseteq \mathfrak{M}$ then \mathcal{D} is called:

- (i) a neutrosophic crisp generalized closed set (in a word, $Neu^{Cg} CS$) if $Neu^c cl(\mathcal{D}) \subseteq \mathfrak{M}$ and the complement of a $Neu^{Cg} CS$ is a $Neu^{Cg} OS$ in (\mathcal{U}, ψ) .
- (ii) a neutrosophic crisp αg -closed set (in a word, $Neu^{C\alpha g} CS$) if $Neu^{C\alpha} cl(\mathcal{D}) \subseteq \mathfrak{M}$ and the complement of a $Neu^{C\alpha g} CS$ is a $Neu^{C\alpha g} OS$ in (\mathcal{U}, ψ) .
- (iii) a neutrosophic crisp $g\alpha$ -closed set (in a word, $Neu^{Cg\alpha} CS$) if $Neu^{C\alpha} cl(\mathcal{D}) \subseteq \mathfrak{M}$ and the complement of a $Neu^{Cg\alpha} CS$ is a $Neu^{Cg\alpha} OS$ in (\mathcal{U}, ψ) .

Theorem 3.2:

In a $Neu^{CTS}(\mathcal{U}, \psi)$, the subsequent arguments are valid:

- (i) Each $Neu^C CS$ is a $Neu^{Cg} CS$.
- (ii) Each $Neu^{Cg} CS$ is a $Neu^{C\alpha g} CS$.
- (iii) Each $Neu^{C\alpha} CS$ is a $Neu^{Cg\alpha} CS$.
- (iv) Each $Neu^{Cg\alpha} CS$ is a $Neu^{C\alpha g} CS$.

Proof:

- (i) Let $\mathcal{D} \subseteq \mathfrak{R}$ and \mathfrak{R} be a $Neu^C OS$ in $Neu^{CTS}(\mathcal{U}, \psi)$. Since \mathcal{D} is a $Neu^C CS$, $Neu^c cl(\mathcal{D}) \subseteq \mathcal{D}$. That is $Neu^c cl(\mathcal{D}) \subseteq \mathfrak{R}$. Hence \mathcal{D} is a $Neu^{Cg} CS$.

(ii) Let \mathfrak{D} be a Neu^{cg} CS. Then $Neu^{cl}(\mathfrak{D}) \subseteq \mathfrak{R}$ whenever $\mathfrak{D} \subseteq \mathfrak{R}$ and \mathfrak{R} is a Neu^C OS in $Neu^{CTS}(\mathfrak{U}, \psi)$. But every Neu^C OS is a Neu^{ca} OS, which implies \mathfrak{R} is a Neu^{ca} OS. Also $Neu^{ca}cl(\mathfrak{D}) \subseteq Neu^{cl}(\mathfrak{D}) \subseteq \mathfrak{R}$. Hence \mathfrak{D} is a Neu^{cag} CS.

(iii) Let \mathfrak{D} be a Neu^{ca} CS and let $\mathfrak{D} \subseteq \mathfrak{R}$ where \mathfrak{R} is a Neu^{ca} OS in $Neu^{CTS}(\mathfrak{U}, \psi)$. Since \mathfrak{D} is a Neu^{ca} CS, then $Neu^{cl}(Neu^{int}(Neu^{cl}(\mathfrak{D}))) \subseteq \mathfrak{D} \subseteq \mathfrak{R}$, since $Neu^{ca}cl(\mathfrak{D})$ is the smallest Neu^{ca} CS containing \mathfrak{D} , so, $Neu^{ca}cl(\mathfrak{D}) \subseteq \mathfrak{D} \sqcup Neu^{cl}(Neu^{int}(Neu^{cl}(\mathfrak{D}))) \subseteq \mathfrak{D} \sqcup \mathfrak{R} \subseteq \mathfrak{R}$. Hence \mathfrak{D} is a Neu^{cga} CS.

(iv) Let $\mathfrak{D} \subseteq \mathfrak{R}$ and \mathfrak{R} is a Neu^C OS in $Neu^{CTS}(\mathfrak{U}, \psi)$. Then $Neu^{ca}cl(\mathfrak{D}) \subseteq \mathfrak{R}$ as \mathfrak{D} is a Neu^{cga} CS. Since every Neu^C OS is a Neu^{ca} OS. That is $Neu^{ca}cl(\mathfrak{D}) \subseteq \mathfrak{R}$ where \mathfrak{R} is a Neu^{ca} OS. Hence \mathfrak{D} is a Neu^{cag} CS. ■

As shown in the next examples, the opposite of the beyond theorem is not valid.

Example 3.3:

Let $\mathfrak{U} = \{r_1, r_2, r_3, r_4\}$ and let $\psi = \{\phi_{Neu}, \{\{r_1\}, \phi, \phi\}, \{\{r_3, r_4\}, \phi, \phi\}, \{\{r_1, r_3, r_4\}, \phi, \phi\}, \mathfrak{U}_{Neu}\}$ be a Neu^{CT} on \mathfrak{U} . Then the Neu^C S $\{\{r_1, r_2, r_3\}, \phi, \phi\}$ is a Neu^{cg} CS but not Neu^C CS.

Example 3.4:

Let $\mathfrak{U} = \{r_1, r_2, r_3\}$ and let $\psi = \{\phi_{Neu}, \{\{r_1\}, \phi, \phi\}, \{\{r_3\}, \phi, \phi\}, \{\{r_1, r_3\}, \phi, \phi\}, \mathfrak{U}_{Neu}\}$ be a Neu^{CT} on \mathfrak{U} . Then the Neu^C S $\{\{r_3\}, \phi, \phi\}$ is a Neu^{cag} CS but not Neu^{cg} CS.

Example 3.5:

Let $\mathfrak{U} = \{s_1, s_2, s_3, s_4\}$ and let $\psi = \{\phi_{Neu}, \{\{s_1\}, \phi, \phi\}, \{\{s_2, s_4\}, \phi, \phi\}, \{\{s_1, s_2, s_4\}, \phi, \phi\}, \mathfrak{U}_{Neu}\}$ be a Neu^{CT} on \mathfrak{U} . Then the Neu^C S $\{\{s_2, s_3\}, \phi, \phi\}$ is a Neu^{cga} CS but not Neu^{ca} CS.

Example 3.6:

Let $\mathfrak{U} = \{r_1, r_2, r_3, r_4\}$ and let $\psi = \{\phi_{Neu}, \{\{r_1\}, \phi, \phi\}, \{\{r_2, r_4\}, \phi, \phi\}, \{\{r_1, r_2, r_4\}, \phi, \phi\}, \mathfrak{U}_{Neu}\}$ be a Neu^{CT} on \mathfrak{U} . Then the Neu^C S $\{\{r_1\}, \phi, \phi\}$ is a Neu^{cag} CS but not Neu^{cga} CS.

Theorem 3.7:

In a $Neu^{CTS}(\mathfrak{U}, \psi)$, the subsequent arguments are valid:

- (i) Each Neu^C OS is a Neu^{cg} OS.
- (ii) Each Neu^{cg} OS is a Neu^{cag} OS.
- (iii) Each Neu^{ca} OS is a Neu^{cga} OS.
- (iv) Each Neu^{cga} OS is a Neu^{cag} OS.

Proof:

(i), (ii), (iii) and (iv) are understandable. ■

Definition 3.8:

Let \mathfrak{D} be a neutrosophic crisp subset, and \mathfrak{M} be a Neu^{cag} OS in a $Neu^{CTS}(\mathfrak{U}, \psi)$ where $\mathfrak{D} \subseteq \mathfrak{M}$, then \mathfrak{D} is titled a neutrosophic crisp generalized αg -closed set (in brief, $Neu^{cga}g$ CS) if $Neu^{cl}(\mathfrak{D}) \subseteq \mathfrak{M}$ and the family of the whole $Neu^{cga}g$ CSs of a $Neu^{CTS}(\mathfrak{U}, \psi)$ is symbolized by $Neu^{cga}gC(\mathfrak{U})$.

Theorem 3.9:

In a $Neu^{CTS}(\mathfrak{U}, \psi)$, the subsequent arguments are valid:

- (i) Each Neu^C CS is a $Neu^{cga}g$ CS.
- (ii) Each $Neu^{cga}g$ CS is a Neu^{cg} CS.
- (iii) Each $Neu^{cga}g$ CS is a Neu^{cag} CS.
- (iv) Each $Neu^{cga}g$ CS is a Neu^{cga} CS.

Proof:

(i) Let \mathfrak{D} be a Neu^C CS and \mathfrak{M} be any Neu^{cag} OS in a $Neu^{CTS}(\mathfrak{U}, \psi)$ including \mathfrak{D} . Then $Neu^{cl}(\mathfrak{D}) = \mathfrak{D} \subseteq \mathfrak{M}$. Therefore, \mathfrak{D} is a $Neu^{cga}g$ CS.

(ii) Let \mathfrak{D} be a $Neu^{cga}g$ CS and \mathfrak{M} be any Neu^C OS in a $Neu^{CTS}(\mathfrak{U}, \psi)$ including \mathfrak{D} . According to theorem (3.7), \mathfrak{M} is a Neu^{cag} OS in (\mathfrak{U}, ψ) . Because \mathfrak{D} is a $Neu^{cga}g$ CS, we get $Neu^{cl}(\mathfrak{D}) \subseteq \mathfrak{M}$. Therefore, \mathfrak{D} is a Neu^{cg} CS.

(iii) Let \mathcal{D} be a Neu^{Cgag} CS and \mathfrak{M} be any Neu^C OS in a $Neu^{CTS}(\mathcal{U}, \psi)$ including \mathcal{D} . According to theorem (3.7), \mathfrak{M} is a Neu^{Cag} OS in (\mathcal{U}, ψ) . Because \mathcal{D} is a Neu^{Cgag} CS, we get $Neu^{Ccl}(\mathcal{D}) \subseteq Neu^Ccl(\mathcal{D}) \subseteq \mathfrak{M}$. Therefore, \mathcal{D} is a Neu^{Cag} CS.

(iv) Let \mathcal{D} be a Neu^{Cgag} CS and \mathfrak{M} be any $Neu^{C\alpha}$ OS in a $Neu^{CTS}(\mathcal{U}, \psi)$ including \mathcal{D} . According to theorem (3.7), \mathfrak{M} is a Neu^{Cag} OS in (\mathcal{U}, ψ) . Because \mathcal{D} is a Neu^{Cgag} CS, we get $Neu^{Ccl}(\mathcal{D}) \subseteq Neu^Ccl(\mathcal{D}) \subseteq \mathfrak{M}$. Therefore, \mathcal{D} is a $Neu^{Cg\alpha}$ CS. ■

The next examples show that the reverse of the beyond theorem is not reasonable.

Example 3.10:

Let $\mathcal{U} = \{s_1, s_2, s_3, s_4\}$ and let $\psi = \{\phi_{Neu}, \langle\{s_1\}, \phi, \phi\rangle, \langle\{s_2, s_4\}, \phi, \phi\rangle, \langle\{s_1, s_2, s_4\}, \phi, \phi\rangle, \mathcal{U}_{Neu}\}$ be a Neu^{CT} on \mathcal{U} . Then the $Neu^CS \langle\{s_1, s_2, s_3\}, \phi, \phi\rangle$ is a Neu^{Cgag} CS but not Neu^C CS.

Example 3.11:

Let $\mathcal{U} = \{s_1, s_2, s_3, s_4, s_5\}$ and let $\psi = \{\phi_{Neu}, \langle\{s_4\}, \phi, \phi\rangle, \langle\{s_1, s_2\}, \phi, \phi\rangle, \langle\{s_1, s_2, s_4\}, \phi, \phi\rangle, \mathcal{U}_{Neu}\}$ be a Neu^{CT} on \mathcal{U} . Then the $Neu^CS \langle\{s_1, s_3, s_4\}, \phi, \phi\rangle$ is a Neu^{Cg} CS but not Neu^{Cgag} CS.

Example 3.12:

Let $\mathcal{U} = \{r_1, r_2, r_3, r_4\}$ and let $\psi = \{\phi_{Neu}, \langle\{r_1\}, \phi, \phi\rangle, \langle\{r_2, r_4\}, \phi, \phi\rangle, \langle\{r_1, r_2, r_4\}, \phi, \phi\rangle, \mathcal{U}_{Neu}\}$ be a Neu^{CT} on \mathcal{U} . Then the $Neu^CS \langle\{r_1, r_3\}, \phi, \phi\rangle$ is a $Neu^{Cg\alpha}$ CS. Therefore, it is Neu^{Cag} CS, but it is not Neu^{Cgag} CS.

Definition 3.13:

A neutrosophic crisp subset \mathcal{D} of a $Neu^{CTS}(\mathcal{U}, \psi)$ is termed a neutrosophic crisp generalized ag-open set (in brief, Neu^{Cgag} OS) iff $\mathcal{U}_{Neu} - \mathcal{D}$ is a Neu^{Cgag} CS. The collection of the whole Neu^{Cgag} OSs of a $Neu^{CTS}(\mathcal{U}, \psi)$ is signified by $Neu^{Cgag}O(\mathcal{U})$.

Proposition 3.14:

Let (\mathcal{U}, ψ) be a Neu^{CTS} . If any Neu^C OS in (\mathcal{U}, ψ) , then it is a Neu^{Cgag} OS.

Proof:

Let \mathcal{D} be a Neu^C OS in a $Neu^{CTS}(\mathcal{U}, \psi)$, then $\mathcal{U}_{Neu} - \mathcal{D}$ is a Neu^C CS in (\mathcal{U}, ψ) . According to theorem (3.9), point (i), $\mathcal{U}_{Neu} - \mathcal{D}$ is a Neu^{Cgag} CS. Therefore, \mathcal{D} is a Neu^{Cgag} OS in (\mathcal{U}, ψ) . ■

Proposition 3.15:

Let (\mathcal{U}, ψ) be a Neu^{CTS} . If any Neu^{Cgag} OS is in (\mathcal{U}, ψ) , then it is a Neu^{Cg} OS.

Proof:

Let \mathcal{D} be a Neu^{Cgag} OS in a $Neu^{CTS}(\mathcal{U}, \psi)$, then $\mathcal{U}_{Neu} - \mathcal{D}$ is a Neu^{Cgag} CS in (\mathcal{U}, ψ) . According to theorem (3.9), point (ii), $\mathcal{U}_{Neu} - \mathcal{D}$ is a Neu^{Cg} CS. Therefore, \mathcal{D} is a Neu^{Cg} OS in (\mathcal{U}, ψ) . ■

Theorem 3.16:

In a $Neu^{CTS}(\mathcal{U}, \psi)$, the next arguments are valid:

- (i) Each Neu^{Cgag} OS is a Neu^{Cag} OS.
- (ii) Each Neu^{Cgag} OS is a $Neu^{Cg\alpha}$ OS.

Proof:

Analogous to the beyond proposition. ■

Proposition 3.17:

If \mathcal{D} and \mathfrak{R} are Neu^{Cgag} CSs in a $Neu^{CTS}(\mathcal{U}, \psi)$, then $\mathcal{D} \sqcup \mathfrak{R}$ is a Neu^{Cgag} CS.

Proof:

Let \mathcal{D} and \mathfrak{R} be Neu^{Cgag} CSs in a $Neu^{CTS}(\mathcal{U}, \psi)$ and let \mathfrak{M} be any Neu^{Cag} OS including \mathcal{D} and \mathfrak{R} . Then $\mathcal{D} \sqcup \mathfrak{R} \subseteq \mathfrak{M}$. Then $\mathcal{D} \subseteq \mathfrak{M}$ and $\mathfrak{R} \subseteq \mathfrak{M}$. Since \mathcal{D} and \mathfrak{R} are Neu^{Cgag} CSs, $Neu^Ccl(\mathcal{D}) \subseteq \mathfrak{M}$ and $Neu^Ccl(\mathfrak{R}) \subseteq \mathfrak{M}$. Now, $Neu^Ccl(\mathcal{D} \sqcup \mathfrak{R}) = Neu^Ccl(\mathcal{D}) \sqcup Neu^Ccl(\mathfrak{R}) \subseteq \mathfrak{M}$ and so $Neu^Ccl(\mathcal{D} \sqcup \mathfrak{R}) \subseteq \mathfrak{M}$. Hence, $\mathcal{D} \sqcup \mathfrak{R}$ is a Neu^{Cgag} CS. ■

Proposition 3.18:

If \mathcal{D} and \mathfrak{R} are Neu^{Cgag} OSs in a $Neu^{CTS}(\mathcal{U}, \psi)$, then $\mathcal{D} \sqcap \mathfrak{R}$ is a Neu^{Cgag} OS.

Proof:

Let \mathcal{D} and \mathcal{R} be $Neu^{cga}OS$ s in a $Neu^{CTS}(\mathcal{U}, \psi)$. Then $\mathcal{U}_{Neu} - \mathcal{D}$ and $\mathcal{U}_{Neu} - \mathcal{R}$ are $Neu^{cga}CS$ s. According to proposition (3.17), $(\mathcal{U}_{Neu} - \mathcal{D}) \sqcup (\mathcal{U}_{Neu} - \mathcal{R})$ is a $Neu^{cga}CS$. Subsequently, $(\mathcal{U}_{Neu} - \mathcal{D}) \sqcup (\mathcal{U}_{Neu} - \mathcal{R}) = \mathcal{U}_{Neu} - (\mathcal{D} \sqcap \mathcal{R})$. Therefore, $\mathcal{D} \sqcap \mathcal{R}$ is a $Neu^{cga}OS$. ■

Proposition 3.19:

If a $Neu^CS \mathcal{D}$ is $Neu^{cga}CS$ in a $Neu^{CTS}(\mathcal{U}, \psi)$, then $Neu^ccl(\mathcal{D}) - \mathcal{D}$ includes no non-empty Neu^CS in (\mathcal{U}, ψ) .

Proof:

Let \mathcal{D} be a $Neu^{cga}CS$ in a $Neu^{CTS}(\mathcal{U}, \psi)$ and let \mathcal{F} be any Neu^CS in (\mathcal{U}, ψ) s.t. $\mathcal{F} \subseteq Neu^ccl(\mathcal{D}) - \mathcal{D}$. Since \mathcal{D} is a $Neu^{cga}CS$, we have $Neu^ccl(\mathcal{D}) \subseteq \mathcal{U}_{Neu} - \mathcal{F}$. This implies $\mathcal{F} \subseteq \mathcal{U}_{Neu} - Neu^ccl(\mathcal{D})$. Then $\mathcal{F} \subseteq Neu^ccl(\mathcal{D}) \cap (\mathcal{U}_{Neu} - Neu^ccl(\mathcal{D})) = \phi_{Neu}$. Thus, $\mathcal{F} = \phi_{Neu}$. Hence, $Neu^ccl(\mathcal{D}) - \mathcal{D}$ contains no non-empty Neu^CS in (\mathcal{U}, ψ) . ■

Proposition 3.20:

A $Neu^CS \mathcal{D}$ is $Neu^{cga}CS$ in a $Neu^{CTS}(\mathcal{U}, \psi)$ iff $Neu^ccl(\mathcal{D}) - \mathcal{D}$ includes no non-empty $Neu^{cga}CS$ in (\mathcal{U}, ψ) .

Proof:

Let \mathcal{D} be a $Neu^{cga}CS$ in a $Neu^{CTS}(\mathcal{U}, \psi)$ and let \mathcal{S} be any $Neu^{cga}CS$ in (\mathcal{U}, ψ) s.t. $\mathcal{S} \subseteq Neu^ccl(\mathcal{D}) - \mathcal{D}$. Since \mathcal{D} is a $Neu^{cga}CS$, we have $Neu^ccl(\mathcal{D}) \subseteq \mathcal{U}_{Neu} - \mathcal{S}$. This implies $\mathcal{S} \subseteq \mathcal{U}_{Neu} - Neu^ccl(\mathcal{D})$. Then $\mathcal{S} \subseteq Neu^ccl(\mathcal{D}) \cap (\mathcal{U}_{Neu} - Neu^ccl(\mathcal{D})) = \phi_{Neu}$. Thus, \mathcal{S} is empty. On the other hand, imagine that $Neu^ccl(\mathcal{D}) - \mathcal{D}$ includes no non-empty $Neu^{cga}CS$ in (\mathcal{U}, ψ) . Allow $\mathcal{D} \subseteq \mathcal{M}$ and \mathcal{M} is $Neu^{cga}OS$. If $Neu^ccl(\mathcal{D}) \subseteq \mathcal{M}$ then $Neu^ccl(\mathcal{D}) \cap (\mathcal{U}_{Neu} - \mathcal{M})$ is non-empty. Because $Neu^ccl(\mathcal{D})$ is Neu^CS and $\mathcal{U}_{Neu} - \mathcal{M}$ is $Neu^{cga}CS$, we get $Neu^ccl(\mathcal{D}) \cap (\mathcal{U}_{Neu} - \mathcal{M})$ as non-empty $Neu^{cga}CS$ of $Neu^ccl(\mathcal{D}) - \mathcal{D}$, which is a conflict. Consequently, $Neu^ccl(\mathcal{D}) \not\subseteq \mathcal{M}$. Therefore, \mathcal{D} is a $Neu^{cga}CS$. ■

Theorem 3.21:

If \mathcal{D} is a $Neu^{cga}OS$ and a $Neu^{cga}CS$ in a $Neu^{CTS}(\mathcal{U}, \psi)$, then \mathcal{D} is a Neu^CS in (\mathcal{U}, ψ) .

Proof:

Assume that \mathcal{D} is a $Neu^{cga}OS$ and a $Neu^{cga}CS$ in a $Neu^{CTS}(\mathcal{U}, \psi)$ then $Neu^ccl(\mathcal{D}) \subseteq \mathcal{D}$ and since $\mathcal{D} \subseteq Neu^ccl(\mathcal{D})$. Therefore, $Neu^ccl(\mathcal{D}) = \mathcal{D}$. Hence, \mathcal{D} is a Neu^CS . ■

Theorem 3.22:

If \mathcal{D} is a $Neu^{cga}CS$ in a $Neu^{CTS}(\mathcal{U}, \psi)$ and $\mathcal{D} \subseteq \mathcal{R} \subseteq Neu^ccl(\mathcal{D})$, then \mathcal{R} is a $Neu^{cga}CS$ in (\mathcal{U}, ψ) .

Proof:

Suppose that \mathcal{D} is a $Neu^{cga}CS$ in a $Neu^{CTS}(\mathcal{U}, \psi)$. Let \mathcal{M} be a $Neu^{cga}OS$ in (\mathcal{U}, ψ) s.t. $\mathcal{R} \subseteq \mathcal{M}$. Then $\mathcal{D} \subseteq \mathcal{M}$. Since \mathcal{D} is a $Neu^{cga}CS$, it follows that $Neu^ccl(\mathcal{D}) \subseteq \mathcal{M}$. Now, $\mathcal{R} \subseteq Neu^ccl(\mathcal{D})$ implies $Neu^ccl(\mathcal{R}) \subseteq Neu^ccl(Neu^ccl(\mathcal{D})) = Neu^ccl(\mathcal{D})$. Thus, $Neu^ccl(\mathcal{D}) \subseteq \mathcal{M}$. Hence, \mathcal{R} is a $Neu^{cga}CS$. ■

Theorem 3.23:

If \mathcal{D} is a $Neu^{cga}OS$ in a $Neu^{CTS}(\mathcal{U}, \psi)$ and $Neu^cint(\mathcal{D}) \subseteq \mathcal{R} \subseteq \mathcal{D}$, then \mathcal{R} is a $Neu^{cga}OS$ in (\mathcal{U}, ψ) .

Proof:

Suppose that \mathcal{D} is a $Neu^{cga}OS$ in a $Neu^{CTS}(\mathcal{U}, \psi)$ and $Neu^cint(\mathcal{D}) \subseteq \mathcal{R} \subseteq \mathcal{D}$. Then $\mathcal{U}_{Neu} - \mathcal{D}$ is a $Neu^{cga}CS$ and $\mathcal{U}_{Neu} - \mathcal{D} \subseteq \mathcal{U}_{Neu} - \mathcal{R} \subseteq Neu^ccl(\mathcal{U}_{Neu} - \mathcal{D})$. Then $\mathcal{U}_{Neu} - \mathcal{R}$ is a $Neu^{cga}CS$ corresponding to theorem (3.22). Hence, \mathcal{R} is a $Neu^{cga}OS$. ■

Theorem 3.24:

A $Neu^CS \mathcal{D}$ is $Neu^{cga}OS$ iff $\mathcal{P} \subseteq Neu^cint(\mathcal{D})$ where \mathcal{P} is a $Neu^{cga}CS$ and $\mathcal{P} \subseteq \mathcal{D}$.

Proof:

Suppose that $\mathcal{P} \subseteq Neu^cint(\mathcal{D})$ where \mathcal{P} is a $Neu^{cga}CS$ and $\mathcal{P} \subseteq \mathcal{D}$. Then $\mathcal{U}_{Neu} - \mathcal{D} \subseteq \mathcal{U}_{Neu} - \mathcal{P}$ and $\mathcal{U}_{Neu} - \mathcal{P}$ is a $Neu^{cga}OS$ by theorem (3.16). Now, $Neu^ccl(\mathcal{U}_{Neu} - \mathcal{D}) = \mathcal{U}_{Neu} - Neu^cint(\mathcal{D}) \subseteq \mathcal{U}_{Neu} - \mathcal{P}$. Then $\mathcal{U}_{Neu} - \mathcal{D}$ is a $Neu^{cga}CS$. Hence, \mathcal{D} is a $Neu^{cga}OS$.

Conversely, let \mathfrak{D} be a $Neu^{Cgag}OS$ and \mathfrak{P} be a $Neu^{Cgag}CS$ and $\mathfrak{P} \subseteq \mathfrak{D}$. Then $\mathfrak{U}_{Neu} - \mathfrak{D} \subseteq \mathfrak{U}_{Neu} - \mathfrak{P}$. Since $\mathfrak{U}_{Neu} - \mathfrak{D}$ is a $Neu^{Cgag}CS$ and $\mathfrak{U}_{Neu} - \mathfrak{P}$ is a $Neu^{Cag}OS$, we have $Neu^{Ccl}(\mathfrak{U}_{Neu} - \mathfrak{D}) \subseteq \mathfrak{U}_{Neu} - \mathfrak{P}$. Then $\mathfrak{P} \subseteq Neu^{Cint}(\mathfrak{D})$. ■

Remark 3.25:

The later chart illustrates the virtual among the separate sorts of Neu^C CS:

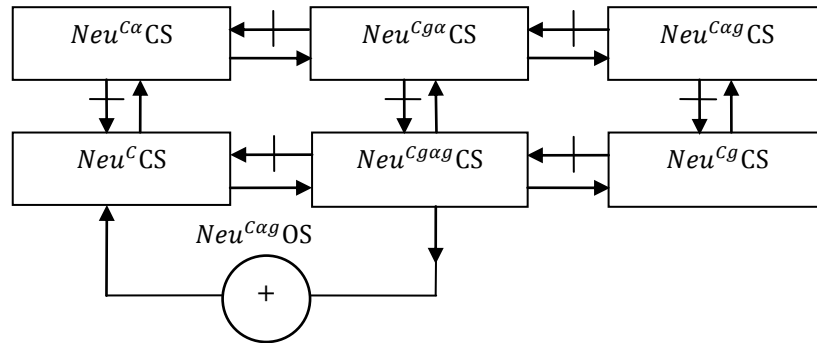


Figure 1: The later

4. Neutrosophic Crisp gag -Closure and Neutrosophic Crisp gag -Interior

We stand for neutrosophic crisp gag -closure and neutrosophic crisp gag -interior and achieve several of their highlights in this sector.

Definition 4.1:

The overlapping of the whole $Neu^{Cgag}CS$ s in a $Neu^{CTS}(\mathfrak{U}, \psi)$ including \mathfrak{D} is termed neutrosophic crisp gag -closure of \mathfrak{D} , and it is symbolized by $Neu^{Cgagcl}(\mathfrak{D})$.

Definition 4.2:

The union of all $Neu^{Cgag}OS$ s in a $Neu^{CTS}(\mathfrak{U}, \psi)$ included in \mathfrak{D} is termed neutrosophic crisp gag -interior of \mathfrak{D} , and it is symbolized by $Neu^{Cgagint}(\mathfrak{D})$.

Theorem 4.3:

Let \mathfrak{D} be any Neu^CS in a $Neu^{CTS}(\mathfrak{U}, \psi)$. Then the next issues stand:

- (i) $Neu^{Cgagint}(\mathfrak{D}) = \mathfrak{D}$ iff \mathfrak{D} is a $Neu^{Cgag}OS$.
- (ii) $Neu^{Cgagcl}(\mathfrak{D}) = \mathfrak{D}$ iff \mathfrak{D} is a $Neu^{Cgag}CS$.
- (iii) $Neu^{Cgagint}(\mathfrak{D})$ is the biggest $Neu^{Cgag}OS$ included in \mathfrak{D} .
- (iv) $Neu^{Cgagcl}(\mathfrak{D})$ is the fewest $Neu^{Cgag}CS$ including \mathfrak{D} .

Proof:

(i), (ii), (iii) and (iv) are obvious. ■

Proposition 4.4:

Let \mathfrak{D} be any Neu^CS in a $Neu^{CTS}(\mathfrak{U}, \psi)$. Then the next issues stand:

- (i) $Neu^{Cgagint}(\mathfrak{U}_{Neu} - \mathfrak{D}) = \mathfrak{U}_{Neu} - (Neu^{Cgagcl}(\mathfrak{D}))$,
- (ii) $Neu^{Cgagcl}(\mathfrak{U}_{Neu} - \mathfrak{D}) = \mathfrak{U}_{Neu} - (Neu^{Cgagint}(\mathfrak{D}))$.

Proof:

- (i) By definition, $Neu^{Cgagcl}(\mathfrak{D}) = \bigcap \{\mathfrak{R} : \mathfrak{D} \subseteq \mathfrak{R}, \mathfrak{R} \text{ is a } Neu^{Cgag}CS\}$
 $\mathfrak{U}_{Neu} - (Neu^{Cgagcl}(\mathfrak{D})) = \mathfrak{U}_{Neu} - \bigcap \{\mathfrak{R} : \mathfrak{D} \subseteq \mathfrak{R}, \mathfrak{R} \text{ is a } Neu^{Cgag}CS\}$
 $= \bigcup \{\mathfrak{U}_{Neu} - \mathfrak{R} : \mathfrak{D} \subseteq \mathfrak{R}, \mathfrak{R} \text{ is a } Neu^{Cgag}CS\}$

$$\begin{aligned}
&= \sqcup \{ \mathfrak{M} : \mathfrak{U}_{Neu} - \mathfrak{D} \sqsupseteq \mathfrak{M}, \mathfrak{M} \text{ is a } Neu^{Cgag}OS \} \\
&= Neu^{Cgag}int(\mathfrak{U}_{Neu} - \mathfrak{D}).
\end{aligned}$$

(ii) The validation is the same as (i). ■

Theorem 4.5:

Let \mathfrak{D} and \mathfrak{R} be two Neu^C SS in a $Neu^{CTS}(\mathfrak{U}, \psi)$. Then the following properties hold:

- (i) $Neu^{Cgag}cl(\phi_{Neu}) = \phi_{Neu}$, $Neu^{Cgag}cl(\mathfrak{U}_{Neu}) = \mathfrak{U}_{Neu}$.
- (ii) $\mathfrak{D} \sqsubseteq Neu^{Cgag}cl(\mathfrak{D})$.
- (iii) $\mathfrak{D} \sqsubseteq \mathfrak{R} \Rightarrow Neu^{Cgag}cl(\mathfrak{D}) \sqsubseteq Neu^{Cgag}cl(\mathfrak{R})$.
- (iv) $Neu^{Cgag}cl(\mathfrak{D} \sqcap \mathfrak{R}) \sqsubseteq Neu^{Cgag}cl(\mathfrak{D}) \sqcap Neu^{Cgag}cl(\mathfrak{R})$.
- (v) $Neu^{Cgag}cl(\mathfrak{D} \sqcup \mathfrak{R}) = Neu^{Cgag}cl(\mathfrak{D}) \sqcup Neu^{Cgag}cl(\mathfrak{R})$.
- (vi) $Neu^{Cgag}cl(Neu^{Cgag}cl(\mathfrak{D})) = Neu^{Cgag}cl(\mathfrak{D})$.

Proof:

(i) and (ii) are apparent.

(iii) By part (ii), $\mathfrak{R} \sqsubseteq Neu^{Cgag}cl(\mathfrak{R})$. Since $\mathfrak{D} \sqsubseteq \mathfrak{R}$, we have $\mathfrak{D} \sqsubseteq Neu^{Cgag}cl(\mathfrak{R})$. But $Neu^{Cgag}cl(\mathfrak{R})$ is a Neu^{Cgag} CS. Thus $Neu^{Cgag}cl(\mathfrak{R})$ is a Neu^{Cgag} CS containing \mathfrak{D} . Since $Neu^{Cgag}cl(\mathfrak{D})$ is the smallest Neu^{Cgag} CS containing \mathfrak{D} , we have $Neu^{Cgag}cl(\mathfrak{D}) \sqsubseteq Neu^{Cgag}cl(\mathfrak{R})$.

(iv) We know that $\mathfrak{D} \sqcap \mathfrak{R} \sqsubseteq \mathfrak{D}$ and $\mathfrak{D} \sqcap \mathfrak{R} \sqsubseteq \mathfrak{R}$. Therefore, by part (iii), $Neu^{Cgag}cl(\mathfrak{D} \sqcap \mathfrak{R}) \sqsubseteq Neu^{Cgag}cl(\mathfrak{D})$ and $Neu^{Cgag}cl(\mathfrak{D} \sqcap \mathfrak{R}) \sqsubseteq Neu^{Cgag}cl(\mathfrak{R})$. Hence $Neu^{Cgag}cl(\mathfrak{D} \sqcap \mathfrak{R}) \sqsubseteq Neu^{Cgag}cl(\mathfrak{D}) \sqcap Neu^{Cgag}cl(\mathfrak{R})$.

(v) Since $\mathfrak{D} \sqsubseteq \mathfrak{D} \sqcup \mathfrak{R}$ and $\mathfrak{R} \sqsubseteq \mathfrak{D} \sqcup \mathfrak{R}$, it follows from part (iii) that $Neu^{Cgag}cl(\mathfrak{D}) \sqsubseteq Neu^{Cgag}cl(\mathfrak{D} \sqcup \mathfrak{R})$ and $Neu^{Cgag}cl(\mathfrak{R}) \sqsubseteq Neu^{Cgag}cl(\mathfrak{D} \sqcup \mathfrak{R})$. Hence $Neu^{Cgag}cl(\mathfrak{D}) \sqcup Neu^{Cgag}cl(\mathfrak{R}) \sqsubseteq Neu^{Cgag}cl(\mathfrak{D} \sqcup \mathfrak{R})$. (1)

Since $Neu^{Cgag}cl(\mathfrak{D})$ and $Neu^{Cgag}cl(\mathfrak{R})$ are Neu^{Cgag} CSs, $Neu^{Cgag}cl(\mathfrak{D}) \sqcup Neu^{Cgag}cl(\mathfrak{R})$ is also Neu^{Cgag} CS by proposition (3.17). Also $\mathfrak{D} \sqsubseteq Neu^{Cgag}cl(\mathfrak{D})$ and $\mathfrak{R} \sqsubseteq Neu^{Cgag}cl(\mathfrak{R})$ implies that $\mathfrak{D} \sqcup \mathfrak{R} \sqsubseteq Neu^{Cgag}cl(\mathfrak{D}) \sqcup Neu^{Cgag}cl(\mathfrak{R})$. Thus $Neu^{Cgag}cl(\mathfrak{D}) \sqcup Neu^{Cgag}cl(\mathfrak{R})$ is a Neu^{Cgag} CS containing $\mathfrak{D} \sqcup \mathfrak{R}$. Since $Neu^{Cgag}cl(\mathfrak{D} \sqcup \mathfrak{R})$ is the smallest Neu^{Cgag} CS containing $\mathfrak{D} \sqcup \mathfrak{R}$, we have $Neu^{Cgag}cl(\mathfrak{D} \sqcup \mathfrak{R}) \sqsubseteq Neu^{Cgag}cl(\mathfrak{D}) \sqcup Neu^{Cgag}cl(\mathfrak{R})$. (2)

From (1) and (2), we have $Neu^{Cgag}cl(\mathfrak{D} \sqcup \mathfrak{R}) = Neu^{Cgag}cl(\mathfrak{D}) \sqcup Neu^{Cgag}cl(\mathfrak{R})$.

(vi) Since $Neu^{Cgag}cl(\mathfrak{D})$ is a Neu^{Cgag} CS, we have by theorem (4.3) part (ii), $Neu^{Cgag}cl(Neu^{Cgag}cl(\mathfrak{D})) = Neu^{Cgag}cl(\mathfrak{D})$. ■

Theorem 4.6:

Let \mathfrak{D} and \mathfrak{R} be two Neu^C SS in a $Neu^{CTS}(\mathfrak{U}, \psi)$. Then the following properties hold:

- (i) $Neu^{Cgag}int(\phi_{Neu}) = \phi_{Neu}$, $Neu^{Cgag}int(\mathfrak{U}_{Neu}) = \mathfrak{U}_{Neu}$.
- (ii) $Neu^{Cgag}int(\mathfrak{D}) \sqsubseteq \mathfrak{D}$.
- (iii) $\mathfrak{D} \sqsubseteq \mathfrak{R} \Rightarrow Neu^{Cgag}int(\mathfrak{D}) \sqsubseteq Neu^{Cgag}int(\mathfrak{R})$.
- (iv) $Neu^{Cgag}int(\mathfrak{D} \sqcap \mathfrak{R}) = Neu^{Cgag}int(\mathfrak{D}) \sqcap Neu^{Cgag}int(\mathfrak{R})$.
- (v) $Neu^{Cgag}int(\mathfrak{D} \sqcup \mathfrak{R}) \sqsupseteq Neu^{Cgag}int(\mathfrak{D}) \sqcup Neu^{Cgag}int(\mathfrak{R})$.
- (vi) $Neu^{Cgag}int(Neu^{Cgag}int(\mathfrak{D})) = Neu^{Cgag}int(\mathfrak{D})$.

Proof:

(i), (ii), (iii), (iv), (v) and (vi) are apparent. ■

Definition 4.7:

A $Neu^{CTS}(\mathfrak{U}, \psi)$ is called a neutrosophic crisp $T_{\frac{1}{2}}$ -space (in short, $Neu^CT_{\frac{1}{2}}$ -space) if each Neu^{Cg} CS in it is a Neu^C CS.

Definition 4.8:

A $Neu^{CTS}(\mathfrak{U}, \psi)$ is called a neutrosophic crisp T_{gag} -space (in short, Neu^CT_{gag} -space) if each Neu^{Cgag} CS in it is a Neu^C CS.

Proposition 4.9:

Every $Neu^CT_{\frac{1}{2}}$ -space is a Neu^CT_{gag} -space.

Proof:

Let (\mathcal{U}, ψ) be a $Neu^CT_{\frac{1}{2}}$ -space and let \mathcal{D} be a Neu^{Cgag} CS in \mathcal{U} . Then \mathcal{D} is a Neu^{Cg} CS, by theorem (3.9) part (ii). Since (\mathcal{U}, ψ) is a $Neu^CT_{\frac{1}{2}}$ -space, then \mathcal{D} is a Neu^C CS in \mathcal{U} . Hence (\mathcal{U}, ψ) is a $Neu^{CT_{gag}}$ -space. ■

The next instance reveals that the overhead proposition's converse is not reasonable.

Example 4.10:

Let $\mathcal{U} = \{s_1, s_2, s_3\}$ and let $\psi = \{\phi_{Neu}, \langle\{s_1\}, \phi, \phi\rangle, \langle\{s_2, s_3\}, \phi, \phi\rangle, \mathcal{U}_{Neu}\}$ be a Neu^{CT} on \mathcal{U} . Then (\mathcal{U}, ψ) is a $Neu^{CT_{gag}}$ -space but not $Neu^{CT_{\frac{1}{2}}}$ -space.

Proposition 4.11:

For a $Neu^{CTS}(\mathcal{U}, \psi)$, the following statements are equivalent:

- (i) (\mathcal{U}, ψ) is a $Neu^{CT_{gag}}$ -space.
- (ii) Every singleton of a $Neu^{CTS}(\mathcal{U}, \psi)$ is either Neu^{Cag} CS or Neu^C OS.

Proof:

(i) \Rightarrow (ii) Assume that for some $u \in \mathcal{U}$ the $Neu^CS \langle\{u\}, \phi, \phi\rangle$ is not a Neu^{Cag} CS in a $Neu^{CTS}(\mathcal{U}, \psi)$. Then the only Neu^{Cag} OS containing $\mathcal{U}_{Neu} - \langle\{u\}, \phi, \phi\rangle$ is the space \mathcal{U} itself and $\mathcal{U}_{Neu} - \langle\{u\}, \phi, \phi\rangle$ is a Neu^{Cgag} CS in (\mathcal{U}, ψ) . By assumption $\mathcal{U}_{Neu} - \langle\{u\}, \phi, \phi\rangle$ is a Neu^C CS in (\mathcal{U}, ψ) or equivalently $\langle\{u\}, \phi, \phi\rangle$ is a Neu^C OS.

(ii) \Rightarrow (i) Let \mathcal{D} be a Neu^{Cgag} CS in (\mathcal{U}, ψ) and let $u \in Neu^Ccl(\mathcal{D})$. By assumption $\langle\{u\}, \phi, \phi\rangle$ is either Neu^{Cag} CS or Neu^C OS.

Case(1). Suppose $\langle\{u\}, \phi, \phi\rangle$ is a Neu^{Cag} CS. If $u \notin \mathcal{D}$, then $Neu^Ccl(\mathcal{D}) - \mathcal{D}$ contains a non-empty Neu^{Cag} CS $\langle\{u\}, \phi, \phi\rangle$ which is a contradiction. Therefore $u \in \mathcal{D}$.

Case(2). Suppose $\langle\{u\}, \phi, \phi\rangle$ is a Neu^C OS. Since $u \in Neu^Ccl(\mathcal{D})$, $\langle\{u\}, \phi, \phi\rangle \cap \mathcal{D} \neq \phi_{Neu}$ and therefore $Neu^Ccl(\mathcal{D}) \subseteq \mathcal{D}$ or equivalently \mathcal{D} is a Neu^C CS in a $Neu^{CTS}(\mathcal{U}, \psi)$. ■

5. Conclusion

The sense of Neu^{Cgag} CS distinguished employing Neu^{Cag} CS creates a Neu^{CT} and remains among the idea of Neu^C CS and the idea of Neu^{Cg} CS. The Neu^{Cgag} CS can be utilized to derive a new decomposition of Neu^{Cgag} -continuity and new Neu^{Cgag} -separation axioms.

Funding: There is no external grant for this work.

Acknowledgments: The authors are appreciative of the referees for their constructive comments.

Conflicts of Interest: There are no conflicts of interest declared by the authors.

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