Neutrosophic Triplet Cosets and Quotient Groups

Mikail Bal, Moges Mekonnen Shalla and Necati Olgun *

Faculty of Arts and Sciences, Department of Mathematics, Gaziantep University, 27310 Gaziantep, Turkey; mikailbal46@hotmail.com (M.B.); moges6710@gmail.com (M.M.S.)

* Correspondence: olgun@gantep.edu.tr; Tel.: +90-536-321-4006

Received: 29 March 2018; Accepted: 17 April 2018; Published: 20 April 2018

Abstract: In this paper, by utilizing the concept of a neutrosophic extended triplet (NET), we define the neutrosophic image, neutrosophic inverse-image, neutrosophic kernel, and the NET subgroup. The notion of the neutrosophic triplet coset and its relation with the classical coset are defined and the properties of the neutrosophic triplet cosets are given. Furthermore, the neutrosophic triplet normal subgroups, and neutrosophic triplet quotient groups are studied.

Keywords: neutosophic extended triplet subgroups; neutrosophic triplet cosets; neutrosophic triplet normal subgroups; neutrosophic triplet quotient groups

1. Introduction

Neutrosophy was first introduced by Smarandache (Smarandache, 1999, 2003) as a branch of philosophy, which studied the origin, nature, and scope of neutralities, as well as their interactions with different ideational spectra: (A) is an idea, proposition, theory, event, concept, or entity; anti(A) is the opposite of (A); and (neut-A) means neither (A) nor anti(A), that is, the neutrality in between the two extremes. A notion of neutrosophic set theory was introduced by Smarandache in [1]. By using the idea of the neutrosophic theory, Kandasamy and Smarandache introduced neutrosophic algebraic structures in [2,3]. The neutrosophic triplets were first introduced by Florentin Smarandache and Mumtaz Ali [4–10], in 2014–2016. Florentin Smarandache and Mumtaz Ali introduced neutrosophic triplet groups in [6,11]. A lot of researchers have been dealing with neutrosophic triplet metric space, neutrosophic triplet vector space, neutrosophic triplet inner product, and neutrosophic triplet normed space in [12–22].

A neutrosophic extended triplet, introduced by Smarandache [7,20] in 2016, is defined as the neutral of \( x \) (denoted by \( e^{neut}(x) \) and called “extended neutral”), which is equal to the classical algebraic unitary element (if any). As a result, the “extended opposite” of \( x \) (denoted by \( e^{anti}(x) \)) is equal to the classical inverse element from a classical group. Thus, the neutrosophic extended triplet (NET) has a form \( (x, e^{neut}(x), e^{anti}(x)) \) for \( x \in N \), where \( e^{neut}(x) \in N \) is the extended neutral of \( x \). Here, the neutral element can be equal to or different from the classical algebraic unitary element, if any, such that: \( x \ast e^{neut}(x) = e^{neut}(x) \ast x = x \), and \( e^{anti}(x) \in N \) is the extended opposite of \( x \), where \( x \ast e^{anti}(x) = e^{anti}(x) \ast x = e^{neut}(x) \). Therefore, we used NET to define these new structures.

In this paper, we deal with neutrosophic extended triplet subgroups, neutrosophic triplet cosets, neutrosophic triplet normal subgroups, and neutrosophic triplet quotient groups for the purpose to develop new algebraic structures on NET groups. Additionally, we define the neutrosophic triplet image, neutrosophic triplet kernel, and neutrosophic triplet inverse image. We give preliminaries and results with examples in Section 2, and we introduce neutrosophic extended triplet subgroups in Section 3. Section 4 is dedicated to introducing neutrosophic triplet cosets, with some of their properties, and we show that neutrosophic triplet cosets are different from classical cosets. In Section 5, we introduce neutrosophic triplet normal subgroups and the neutrosophic triplet normal subgroup...
In Section 6, we define the neutrosophic triplet quotient groups and we examine the relationships of these structures with each other. In Section 7, we provide some conclusions.

2. Preliminaries

In this section, the definition of neutrosophic triplets, NETs, and the concepts of NET groups have been outlined.

2.1. Neutrosophic Triplet

Let U be a universe of discourse, and (N, *) a set included in it, endowed with a well-defined binary law *.

Definition 1 ([1–3]). A neutrosophic triplet has a form (x, neut(x), anti(x)), for x in N, where neut(x) and anti(x) ∈ N are neutral and opposite to x, which are different from the classical algebraic unitary element, if any, such that: x * neut(x) = neut(x) * x = x and x * anti(x) = anti(x) * x = neut(x), respectively. In general, x may have more than one neut’s and anti’s.

2.2. NET

Definition 2 ([4,7]). A neutrosophic extended triplet is a neutrosophic triplet, as defined in Definition 1, where the neutral of x (denoted by \( e^{\text{neut}(x)} \) and called extended neutral) is equal to the classical algebraic unitary element, if any. As a consequence, the extended opposite of x (denoted by \( e^{\text{anti}(x)} \)) is also equal to the classical inverse element from a classical group. Thus, an NET has a form \((x, e^{\text{neut}(x)}, e^{\text{anti}(x)})\), for x ∈ N, where \( e^{\text{neut}(x)} \) and \( e^{\text{anti}(x)} \) in N are the extended neutral and opposite of x, respectively, such that: x * \( e^{\text{neut}(x)} \) = \( e^{\text{neut}(x)} \) * x = x, which can be equal to or different from the classical algebraic unitary element, if any, and x * \( e^{\text{anti}(x)} \) = \( e^{\text{anti}(x)} \) * x = \( e^{\text{neut}(x)} \). In general, for each x ∈ N there are many \( e^{\text{neut}(x)} \)'s and \( e^{\text{anti}(x)} \)'s.

Definition 3 ([1–3]). The element y in (N, *) is the second coordinate of a neutrosophic extended triplet (denoted as neut(y) of a neutrosophic triplet), if there are other elements exist, x and z ∈ N such that: x * y = y * x = x and x * z = z * x = y. The formed neutrosophic triplet is (x, y, z). The element z ∈ (N, *), as the third coordinate, can be defined in the same way.

Example 1. Let \( X = \{0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11\} \), enclosed with the classical multiplication law, (x) modulo 12, which is well defined on X, with the classical unitary element 1. X is an NET “weak commutative set” see “Table 1”.

<table>
<thead>
<tr>
<th>*</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>9</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>9</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>4</td>
<td>8</td>
<td>0</td>
<td>4</td>
<td>8</td>
<td>0</td>
<td>4</td>
<td>8</td>
<td>0</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>5</td>
<td>10</td>
<td>3</td>
<td>8</td>
<td>1</td>
<td>6</td>
<td>11</td>
<td>4</td>
<td>9</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>6</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>7</td>
<td>2</td>
<td>9</td>
<td>4</td>
<td>11</td>
<td>6</td>
<td>1</td>
<td>8</td>
<td>3</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>0</td>
<td>8</td>
<td>4</td>
<td>0</td>
<td>8</td>
<td>4</td>
<td>0</td>
<td>8</td>
<td>4</td>
<td>0</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
<td>9</td>
<td>6</td>
<td>3</td>
<td>0</td>
<td>9</td>
<td>6</td>
<td>3</td>
<td>0</td>
<td>9</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
<td>10</td>
<td>8</td>
<td>6</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>10</td>
<td>8</td>
<td>6</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>0</td>
<td>11</td>
<td>10</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 1. Neutrosophic triplets of (x) modulo 12.
The formed NETs of $X$ are: $(0, 0, 0), (0, 0, 1), (0, 0, 2), \ldots, (0, 0, 11), (1, 1, 1), (3, 9, 3), (3, 9, 7), (3, 9, 11), (4, 4, 4), (4, 4, 7), (4, 4, 10), (5, 1, 5), (7, 1, 7), (8, 4, 2), (8, 4, 5), (8, 4, 8), (8, 4, 11), (9, 9, 5), (9, 9, 9), (11, 1, 11)$.

Here, 2, 6, and 10 did not give rise to a neutrosophic triplet, as neut(2) = 1 and anti(2) did not exist in $Z_{12}$. In addition, neut(6) = 1, 3, 5, 7, 9, and 11, however anti(6) did not exist in $Z_{12}$. The neut(10) = 1, however anti(10) did not exist in $Z_{12}$.

**Definition 4** ([4,7]). The set $N$ is called a strong neutrosophic extended triplet set if, for any $x$ in $N$, $e_{\text{neut}}(x) \in N$ and $e_{\text{anti}}(x) \in N$ exists.

**Example 2.** The NET's of $(x)$ modulo 12 were as follows:

$(0, 0, 0), (0, 0, 1), (0, 0, 2), \ldots, (0, 0, 11), (1, 1, 1), (3, 9, 3), (3, 9, 7), (3, 9, 11), (4, 4, 4), (4, 4, 7), (4, 4, 10), (5, 1, 5), (7, 1, 7), (8, 4, 2), (8, 4, 5), (8, 4, 8), (8, 4, 11), (9, 9, 5), (9, 9, 9), (11, 1, 11)$.

**Definition 5** ([4,7]). The set $N$ is called an NET weak set if, for any $x \in N$, an NET $\left(y, e_{\text{neut}}(y), e_{\text{anti}}(y)\right)$ included in $N$ exists, such that:

\[ x = y \quad \text{or} \quad x = e_{\text{neut}}(y) \quad \text{or} \quad x = e_{\text{anti}}(y). \]

**Definition 6.** A neutrosophic extended triplet $(x, y, z)$ for $x, y, z \in N$, is called a neutrosophic perfect triplet if both $(z, y, x)$ and $(y, y, y)$ are also neutrosophic triplets.

**Example 3.** The neutrosophic perfect triplets of $(x)$ modulo 12 are described in “Table 1” as follows: Here, $(0, 0, 0), (1, 1, 1), (3, 9, 3), (4, 4, 4), (5, 1, 5), (7, 1, 7), (8, 4, 2), (8, 4, 5), (8, 4, 8), (8, 4, 11), (9, 9, 5), (9, 9, 9), (11, 1, 11)$ are neutrosophic perfect triplets of $(x)$ modulo 12.

**Definition 7.** An NET $(x, y, z)$ for $x, y, z \in N$, is called a neutrosophic imperfect triplet if at least one of $(z, y, x)$ or $(y, y, y)$ is not a neutrosophic triplet(s).

**Example 4.** The neutrosophic imperfect triplets of $(x)$ modulo 12, from the above table, were as follows:

$(0, 0, 1), (0, 0, 2), \ldots, (0, 0, 11), (3, 9, 7), (3, 9, 11), (4, 4, 7), (4, 4, 10), (8, 4, 2), (8, 4, 5), (8, 4, 11), (9, 9, 5)$.  

2.3. Neutrosophic Triplet Group (NTG)

**Definition 8** ([1–3]). Let $(N, \ast)$ be a neutrosophic strong triplet set. Then, $(N, \ast)$ is called a neutrosophic strong triplet group, if the following classical axioms are satisfied:

1. $(N, \ast)$ is well-defined, that is, for any $x, y \in N$, one has $x \ast y \in N$.
2. $(N, \ast)$ is associative, that is, for any $x, y, z \in N$, one has $x \ast (y \ast z) = (x \ast y) \ast z$.

**Example 5.** We let $Y = (Z_{12}, \times)$ be a semi-group under product 12. The neutral elements of $Z_{12}$ were 4 and 9. The elements $(8, 4, 8), (4, 4, 4), (3, 9, 3)$, and $(9, 9, 9)$ were NETs.

NTG, in general, was not a group in the classical sense, because it might not have had a classical unitary element, nor the classical inverse elements. We considered that the neutrosophic
neutrosophic opposites replaced the classical inverse elements.

**Proposition 1 ([3]).** Let \((N, \bullet)\) be an NTG with respect to \(*\) and \(a, b, c \in N:\)

1. \(a \bullet b = a \bullet c \iff \text{neut}(a) \bullet b = \text{neut}(a) \bullet c.\)
2. \(b \bullet a = c \bullet a \iff b \bullet \text{neut}(a) = c \bullet \text{neut}(a).\)
3. If \(\text{anti}(a) \bullet b = \text{anti}(a) \bullet c,\) then \(\text{neut}(a) \bullet b = \text{neut}(a) \bullet c.\)
4. If \(b \bullet \text{anti}(a) = c \bullet \text{anti}(a),\) then \(b \bullet \text{neut}(a) = c \bullet \text{neut}(a).\)

**Theorem 1 ([3]).** Let \((N, \bullet)\) be a commutative NET, with respect to \(*\) and \(a, b \in N:\)

1. \(\text{neut}(a) \bullet \text{neut}(b) = \text{neut}(a \bullet b);\)
2. \(\text{anti}(a) \bullet \text{anti}(b) = \text{anti}(a \bullet b);\)

**Theorem 2 ([3]).** Let \((N, \bullet)\) be a commutative NET, with respect to \(*\) and \(a \in N:\)

1. \(\text{neut}(a) \bullet \text{neut}(a) = \text{neut}(a);\)
2. \(\text{anti}(a) \bullet \text{neut}(a) = \text{anti}(a) \bullet \text{anti}(a) = \text{anti}(a);\)

**Definition 9 ([3]).** An NET \((N, \bullet)\) is called to be cancellable, if it satisfies the following conditions:

1. \(\forall x, y, z \in N, x \bullet y = y \bullet z \Rightarrow y = z.\)
2. \(\forall x, y, z \in N, y \bullet x = z \bullet x \Rightarrow y = z.\)

**Definition 10 ([3]).** Let \(N\) be an NTG and \(x \in N.\) \(N\) is then called a neutro-cyclic triplet group if \(N = \langle a \rangle.\)

**Example 6.** We let \(N = (2, 4, 6)\) be an NTG with respect to \((Z_8, \cdot).\) Then, \(N\) was clearly a neutro-cyclic triplet group as \(N = \langle a \rangle.\) Therefore, 2 was the neutrosophic triplet generator of \(N.\)

### 2.4. Neutrosophic Extended Triplet Group (NETG)

**Definition 11 ([4,7]).** Let \((N, \bullet)\) be an NET strong set. Then, \((N, \bullet)\) is called an NETG, if the following classical axioms are satisfied:

1. \((N, \bullet)\) is well-defined, that is, for any \(x, y \in N,\) one has \(x \bullet y \in N.\)
2. \((N, \bullet)\) is associative, that is, for any \(x, y, z \in N,\) one has \(x \bullet (y \bullet z) = (x \bullet y) \bullet z.\)

For NETG, the neutrosophic extended neutals replaced the classical unitary element, and the neutrosophic extended opposites replaced the classical inverse elements. In the case where NETG included a classical group, then NETG enriched the structure of a classical group, since there might have been elements with more extended neutals and more extended opposites.

**Definition 12.** A permutation of a set \(X\) is a function \(\sigma: x \rightarrow x\) that is one to one and onto, that is, a bijective map. Permutation maps, being bijective, have anti neutals and the maps combine neutrally under composition of maps, which are associative. There is natural neutral permutation \(\sigma: x \rightarrow x, X = (1, 2, 3, \ldots, n),\) which is \(\sigma(k) = k.\) Therefore, all of the permutations of a set \(X = (1, 2, 3, \ldots, n)\) form an NETG under composition. This group is called the symmetric NETG \((e^{Sn})\) of degree \(n.\)
Example 7. We let $A = (1, 2, 3)$. The elements of symmetric group of $S_3$ were as follows:

$$
\sigma_0 = \begin{pmatrix} 1 & 2 & 3 \\ 1 & 2 & 3 \end{pmatrix}, \quad \sigma_1 = \begin{pmatrix} 1 & 2 & 3 \\ 2 & 3 & 1 \end{pmatrix}, \quad \sigma_2 = \begin{pmatrix} 1 & 2 & 3 \\ 3 & 1 & 2 \end{pmatrix}
$$

$$
\mu_1 = \begin{pmatrix} 1 & 2 & 3 \\ 1 & 2 & 3 \end{pmatrix}, \quad \mu_2 = \begin{pmatrix} 1 & 2 & 3 \\ 1 & 2 & 3 \end{pmatrix}, \quad \mu_3 = \begin{pmatrix} 1 & 2 & 3 \\ 1 & 2 & 3 \end{pmatrix}
$$

The operation of $S_3$ is defined in Table 2 as follows:

1. $(S_3, \circ)$ is well-defined, that is, for any $\sigma_1, \mu_1 \in S_3$, $i = 1, 2, 3$ one has $\sigma_i \circ \mu_1 \in S_3$.
2. $(S_3, \circ)$ is associative, that is, for any $\sigma_1, \mu_1, \mu_3 \in S_3$, one has the following:

$$(\sigma_1 \circ \mu_1) \circ \mu_3 = \sigma_1 \circ (\mu_1 \circ \mu_3)$$

$$(\mu_1 \circ \mu_3) = (\sigma_1 \circ \sigma_1) = \sigma_2.$$

<table>
<thead>
<tr>
<th>$\circ$</th>
<th>$\sigma_0$</th>
<th>$\sigma_1$</th>
<th>$\sigma_2$</th>
<th>$\mu_1$</th>
<th>$\mu_2$</th>
<th>$\mu_3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma_0$</td>
<td>$\sigma_0$</td>
<td>$\sigma_1$</td>
<td>$\sigma_2$</td>
<td>$\mu_1$</td>
<td>$\mu_2$</td>
<td>$\mu_3$</td>
</tr>
<tr>
<td>$\sigma_1$</td>
<td>$\sigma_1$</td>
<td>$\sigma_2$</td>
<td>$\sigma_0$</td>
<td>$\mu_2$</td>
<td>$\mu_3$</td>
<td>$\mu_1$</td>
</tr>
<tr>
<td>$\sigma_2$</td>
<td>$\sigma_2$</td>
<td>$\sigma_0$</td>
<td>$\sigma_1$</td>
<td>$\mu_3$</td>
<td>$\mu_1$</td>
<td>$\mu_2$</td>
</tr>
<tr>
<td>$\mu_1$</td>
<td>$\mu_1$</td>
<td>$\mu_2$</td>
<td>$\mu_3$</td>
<td>$\sigma_0$</td>
<td>$\sigma_2$</td>
<td>$\sigma_1$</td>
</tr>
<tr>
<td>$\mu_2$</td>
<td>$\mu_2$</td>
<td>$\mu_1$</td>
<td>$\mu_3$</td>
<td>$\sigma_1$</td>
<td>$\sigma_0$</td>
<td>$\sigma_2$</td>
</tr>
<tr>
<td>$\mu_3$</td>
<td>$\mu_3$</td>
<td>$\mu_2$</td>
<td>$\mu_1$</td>
<td>$\sigma_2$</td>
<td>$\sigma_1$</td>
<td>$\sigma_0$</td>
</tr>
</tbody>
</table>

The NET's of $S_3$ are as follows:

$$(\sigma_0, \sigma_0, \sigma_0), (\sigma_1, \sigma_0, \sigma_2), (\sigma_2, \sigma_0, \sigma_1), (\mu_1, \sigma_0, \mu_1), (\mu_2, \sigma_0, \mu_2), (\mu_3, \sigma_0, \mu_3).$$

Hence, $(S_3, \circ)$ is an NET strong group.

Definition 13 ([9–11]). Let $(N_1 \ast, N_2 \#)$ be two NETGs. A mapping $f: N_1 \to N_2$ is called a neutro-homomorphism if:

1. For any $x, y \in N_1$, we have $f(x \ast y) = f(x) \ast f(y)$
2. If $(x, \text{neut}[x], \text{anti}[x])$ is an NET from $N_1$, then,

$$f(\text{neut}[x]) = \text{neut}(f[x]) \text{ and } f(\text{anti}[x]) = \text{anti}(f[x]).$$

Example 8. We let $N_1$ be an NETG with respect multiplication modulo 6 in $(\mathbb{Z}_6, \times)$, where $N_1 = (0, 2, 4)$, and we let $N_2$ be another NETG in $(\mathbb{Z}_{10}, \times)$, where $N_2 = (0, 2, 4, 6, 8)$. We let $f: N_1 \to N_2$ be a mapping defined as $f(0) = 0, f(2) = 4, f(4) = 6$. Then, $f$ was clearly a neutro-homomorphism, because condition (1) and (2) were satisfied easily.

Definition 14. Let $f: N_1 \to N_2$ be a neutro-homomorphism from an NETG $(N_1, \ast)$ to an NETG $(N_2, \#)$. The neutrosoft image of $f$ is a subset, as follows:

$$\text{Im}(f) = \{f(g) : g \in N_1, \ast\} \text{ of } N_2.$$
Definition 15. Let \( f : N_1 \to N_2 \) be a neutro-homomorphism from an NETG \((N_1, \ast)\) to an NETG \((N_2, \circ)\) and \(B \subseteq N_2\). Then
\[
f^{-1}(B) = \{x \in N_1 : f(x) \in B\}
\]
is the neutrosophic inverse image of \(B\) under \(f\).

Definition 16. Let \( f : N_1 \to N_2 \) be a neutro-homomorphism from an NETG \((N_1, \ast)\) to an NETG \((N_2, \circ)\). The neutrosophic kernel off is a subset
\[
\ker(f) = \{x \in N_1 : f(x) = \text{neut}(x)\}
\]
of \(N_1\), where \(\text{neut}(x)\) denotes the neutral element of \(N_2\).

Example 9. We took \(D_4\), the symmetry NETG of the square, which consisted of four rotations and four reflections. We took a set of the four lines through the origin at angles 0, \(\pi/4\), \(\pi/2\), and \(3\pi/4\), numbered 1, 2, 3, 4, respectively. We let \(S_4\) be the permutation NETG of the set of four lines. Each symmetry \(s\), of the square in particular, gave a permutation \(\varphi(s)\) of the four lines. Then we defined a mapping, as follows:
\[
\Phi : D_4 \to S_4
\]
whose value at the symmetry \(s \in D_4\) was the permutation \(\varphi(s)\) of the four lines. Such a process would always define a neutro-homomorphism. We found the kernel and image of \(\varphi\). The neutral permutation of the square gave the neutral of the four lines. The rotation \((1234)\) of the square gave the permutation \((13)(24)\) of the four lines; the rotation \((13)(24)\) by 180 degrees gave the neutral permutation \(\text{neut}\) of the four lines; the rotation \((4321)\) of the square gave the permutation \((13)(24)\) of the four lines again. Thus, the neutrosophic image of the rotation NET subgroup \(R_4\) of \(D_4\) was the NET subgroup \((\text{neut}, [13][24])\) of \(S_4\). The reflections of the square were given by the compositions of the rotations of the square with a reflection, for example, the reflection \((13)\). The reflection \((13)\) of the square (in the vertical axis) gave the permutation \((24)\) of the lines. Thus, the homomorphism \(\varphi\) took the set of reflections \(R_4 \circ (13)\) to the following:
\[
\varphi(R_4) \circ \varphi(13) = (\text{neut}, [13][24] \circ [24]) = ([24], [13]).
\]
The neutrosophic image of \(\varphi\) was the union of the neutrosophic image of the rotations and the reflections, which was \(\text{Im}(\varphi) = (\text{neut}, [13][24], [13], [24]) \subseteq S_4\). In the work above, we saw that the neutrosophic kernel of \(\varphi\) was as follows:
\[
\ker(\varphi) = (\text{neut}, [13][24]) \text{ of } D_4
\]

3. Neutrosophic Extended Triplet Subgroup

In this section, a definition of the neutrosophic extended triplet subgroup and its example have been given.

Definition 17. Given an NETG \((N, \ast)\), a subset \(H\) is called an NET subgroup of \(N\), if it forms an NETG itself under \(\ast\). Explicitly, this means the following:

1. The extended neutral element \(e_{\text{neut}}(x)\) lies in \(H\).
2. For any \(x, y \in H\), \(x \ast y \in H\) (\(H\) is closed under \(\ast\)).
3. If \(x \in H\), then \(e_{\text{anti}}(x) \in H\) (\(H\) has extended opposites).

We wrote \(H \leq N\) whenever \(H\) was an NET subgroup of \(N\). \(\emptyset \neq H \subseteq N\), satisfying (2) and (3) of Definition 17, would be an NET subgroup, as we took \(x \in H\) and then (2) gave \(e_{\text{anti}}(x) \in H\), after which (3) gave \(x \ast e_{\text{anti}}(x) = e_{\text{neut}}(x) \in H\).
**Example 10.** We let \( S_4 = (\text{neut}, \sigma_1, \sigma_2, \ldots, \sigma_9, \tau_1, \tau_2, \ldots, \tau_8, \delta_1, \delta_2, \ldots, \delta_6) \) with \( \sigma_1 = (1234), \sigma_2 = (13)(24), \sigma_3 = (1432), \sigma_4 = (1243), \sigma_5 = (14)(23), \sigma_6 = (1342), \sigma_7 = (1324), \sigma_8 = (12)(34), \sigma_9 = (1432), \tau_1 = (234), \tau_2 = (243), \tau_3 = (134), \tau_4 = (143), \tau_5 = (124), \tau_6 = (142), \tau_7 = (123), \tau_8 = (132), \delta_1 = (12), \delta_2 = (13), \delta_3 = (14), \delta_4 = (23), \delta_5 = (24), \delta_6 = (34). \) The trivial neutrosophic extended subgroups of \( S_4 \) are the neutral elements, and the non-trivial neutrosophic extended subgroups \( S_4 \) of order 2 were as follows: (neut, \( \sigma_2 \)), (neut, \( \sigma_3 \)), (neut, \( \sigma_6 \)), (neut, \( \delta_1 \)), (neut, \( \delta_2 \)), (neut, \( \delta_3 \)), (neut, \( \delta_4 \)), (neut, \( \delta_5 \)), (neut, \( \delta_6 \)), and the neutrosophic extended subgroups, \( S_4 \), of order 3 were as follows:

\[
\begin{align*}
L_{11} &= \langle \tau_1 \rangle = \langle \tau_2 \rangle = (\text{neut}, \tau_1, \tau_2) \\
L_{12} &= \langle \tau_3 \rangle = \langle \tau_{14} \rangle = (\text{neut}, \tau_3, \tau_4) \\
L_{13} &= \langle \tau_5 \rangle = \langle \tau_6 \rangle = (\text{neut}, \tau_5, \tau_6) \\
L_{14} &= \langle \tau_7 \rangle = \langle \tau_8 \rangle = (\text{neut}, \tau_7, \tau_8)
\end{align*}
\]

It was straightforward to find the neutrosophic extended subgroups of order 4, 6, 8, and 12 of \( S_4 \).

**4. Neutrosophic Triplet Cosets**

In this section, the neutrosophic triplet coset and its properties have been outlined. Furthermore, the difference between the neutrosophic triplet coset and the classical one have been given.

**Definition 18.** Let \( N \) be an NETG and \( H \subseteq N \). \( \forall x \in N \), the set \( xH/h \in H \), is denoted by \( xH \), analogously, as follows:

\[ Hx = hx/h \in H \]

and

\[ (xH)\text{anti}(x) = (xh)\text{anti}(x)/h \in H. \]

When \( h \leq N \), \( xH \) is called the left neutrosophic triplet coset of \( H \in N \) containing \( x \), and \( Hx \) is called the right neutrosophic triplet coset of \( H \in N \) containing \( x \). In this case, the element \( x \) is called the neutrosophic triplet coset representative of \( xH \) or \( Hx \). \( |xH| \) and \( |Hx| \) are used to denote the number of elements in \( xH \) or \( Hx \), respectively.

**Example 11.** When \( N = S_3 \) and \( H = \langle [1], [12] \rangle \), the “Table 3” lists the left and right neutrosophic triplet \( H \)-cosets of every element of the NETG.

<table>
<thead>
<tr>
<th>( g )</th>
<th>( gH )</th>
<th>( Hg )</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>[1], [12]</td>
<td>![Image]</td>
</tr>
<tr>
<td>(12)</td>
<td>[1], [12]</td>
<td>![Image]</td>
</tr>
<tr>
<td>(13)</td>
<td>[13], [123]</td>
<td>![Image]</td>
</tr>
<tr>
<td>(23)</td>
<td>[23], [132]</td>
<td>![Image]</td>
</tr>
<tr>
<td>(123)</td>
<td>[13], [123]</td>
<td>![Image]</td>
</tr>
<tr>
<td>(132)</td>
<td>[23], [132]</td>
<td>![Image]</td>
</tr>
</tbody>
</table>

First of all, cosets were not usually neutrosophic extended triplet subgroups (some did not even contain the extended neutral). In addition, since \( (13) \neq H(13) \), a particular element could have different left and right neutrosophic triplet \( H \)-cosets. Since \( (13)H = H(13) \), different elements could have the same left neutrosophic triplet \( H \)-cosets.
Example 12. We calculated the neutrosophic triplet cosets of $N = (Z_4, +)$ under addition and let $H = (0, 2)$. The elements $(0, 0, 0), (0, 0, 1), (0, 0, 2), (0, 0, 3), (1, 1, 1)$, and $(3, 3, 3)$ were NET’s of $Z_4$ and the classical cosets of $N$ were as follows:

$$H = H + 0 = H + 2 = (0, 2).$$

and

$$H + 1 = H + 3 = (1, 3).$$

Here, 2 did not give rise to NET, because the neut’s of 2 were 1 and 3, however there were no anti’s. Therefore, we could not obtain the neutrosophic triplet coset of $N$. In general, classical cosets were not neutrosophic triplet cosets, because they might not have satisfied the NET conditions.

Similarly to Definition 16, we could define neutrosophic triplet cosets as follows:

Definition 19. Let $N$ be a neutrosophic triplet group and $H \leq N$. We defined a relation $\equiv \ell(modH)$ on $N$ as follows:

if $x_1, x_2 \in N$ and $\text{anti}(x_1)x_2 \in N$, Then

$$x_1 = \ell x_2(modH)$$

Or, equivalently, if there exists an $h \in H$, such that:

$$\text{anti}(x_1) \ast x_2 = h$$

That is, if $x_2 = x_1h$ for some $h \in H$.

Proposition 2. The relation $\equiv \ell(modH)$ is a neutrosophic triplet equivalence relation. The neutrosophic triplet equivalence class containing $x$ is the set $xH = xh/h \in H$.

Proof.

1. $\forall x \in N_1$, $\text{anti}(x) \ast x = \text{neut}(x) \in H$. Hence, $x = \ell x_1(modH)$ and $\equiv \ell(modH)$ is reflexive.

2. If $x = \ell x_2(modH)$, then $\text{anti}(x_1) \ast x_2 \in H$. However, since an anti of an element of $H$ is also in $H$, $\text{anti}(\text{anti}[x_1] \ast x_2) = \text{anti}(x_2) \ast \text{anti}(\text{anti}[x_1]) = \text{anti}(x_2) \ast x_1 \in H$. Thus, $x_2 = \ell x_1(modH)$, hence $\equiv \ell(modH)$ is symmetric.

3. Finally, if $x_1 = \ell x_2(modH)$ and $x_2 = \ell x_3(modH)$, then $\text{anti}(x_1) \ast x_2 \in H$ and $\text{anti}(x_2) \ast x_3 \in H$. Since $H$ is closed under taking products, $\text{anti}(x_1)x_2\text{anti}(x_2)x_3 = \text{anti}(x_1)x_3 \in H$. Hence, $x_1 = \ell x_3(modH)$ so that $\equiv \ell(modH)$ is transitive. Thus, $\equiv \ell(modH)$ is a neutrosophic triplet equivalence relation.

4.1. Properties of Neutrosophic Triplet Cosets

Lemma 1. Let $H \leq N$ and let $x, y \in N$. Then,

1. $x \in xH$.
2. $xH = H \iff x \in H$.
3. $xH = yH \iff x \in yH$.
4. $xH = yH$ or $xH \cap yH = \emptyset$.
5. $xH = yH \iff \text{anti}(x)y \in H$.
6. $xH = Hx \iff H = (xH)\text{anti}(x)$.
7. $xH \subseteq N \iff x \in H$.
8. $(xy)H = x(yH)$ and $H(xy) = (Hx)y$.
9. $|xH| = |yH|$.
Proof.

(1) \( x = x(neut(x)) \in xH \)
(2) \( \Rightarrow \) Suppose \( xH = H \). Then \( x = x(neut(x)) \in xH = H \).

\( \Leftarrow \) Now assume \( x \) in \( H \). Since \( H \) is closed, \( xH \subseteq H \).

Next, also assume \( h \notin H \), so \( \text{anti}(x)h \in H \), since \( H \leq N \). Then,

\[
    h = \text{neut}(x)h = x * \text{anti}(x)h = x(\text{anti}[x])h \in xH,
\]

So \( H \subseteq xH \). By mutual inclusion, \( xH = h \).

(3) \( xH = yH \)
\[
    \Rightarrow x = x(neut(x)) \in xH = yH.
\]
\( \Leftarrow \) \( x \in yH \Rightarrow x = yh, \) where \( h \in H \Rightarrow h \in H, xH = (yh)H = y(hH) = yH. \)

(4) Suppose that \( xH \cap yH \neq \emptyset \). Then, \( \exists a \in xH \cap yH \Rightarrow \exists h_1, h_2 \in H \) \( \exists a = xh_1 \)
and
\[
    a = yh_2. \text{ Thus, } x = a(\text{anti}(h_1)) = yh_2(\text{anti}h_1) \text{ and } xH = yh_2(\text{anti}(h_1))H = yh_2(\text{anti}(h_1)) = yH \text{ by (2) of Lemma 1.}
\]

(5) \( xH = yH \Leftrightarrow H = \text{anti}(x)yH \Leftrightarrow (2) \text{ of Lemma 1, } \text{anti}(x)y \in H. \)

(6) \( xH = Hx \Leftrightarrow (xH)\text{anti}(x) = (Hx)\text{anti}(x) = H(x * \text{anti}(x)) = H \Leftrightarrow xH(\text{anti}(x)) = H. \)

(7) \( (\text{That is, } xH = H) \)
Suppose thay \( xH \) is a neutrosophic extended triplet subgroup of \( N \). Then
\( xH \) contains the identity, so \( xH = H \) by (3) of Lemma 1, which holds \( \Leftrightarrow x \in H \) by (2) of Lemma 1.

Conversely, if \( x \in H \), then \( xH = H \leq N \) by (2) of Lemma 1.

(8) \( (xy)H = x(yH) \) and \( H(xy) = (Hx)\text{anti}(x) = H(x * \text{anti}(x)) = H \Leftrightarrow xH(\text{anti}(x)) = H. \)

(9) \( (\text{Find a map } \alpha: xH \rightarrow xH \text{ that is one to one and onto}) \)
Consider \( \alpha: xH \rightarrow xH \) defined by \( \alpha(xh) = yh. \) This is clearly onto \( yH. \) Suppose \( \alpha(xh_1) \)
\( = \alpha(xh_2). \) Then \( yh_1 = yh_2 \Rightarrow h_1 = h_2 \) by left cancellation \( \Rightarrow xh_1 = xh_2, \) therefore \( \alpha \) is one to one.

Since \( \alpha \) provides a one to one correspondence between \( xH \) and \( yH, |xH| = |yH|. \)

In classical group theory, cosets were used in the construction of vitali sets (a type of non-measurable set), and in computational group theory cosets were used to decode received data in linear error-correcting codes, to prove Lagrange’s theorem. The neutrosophic triplet coset plays a similar role in the theory of neutrosophic extended triplet group, as in the classical group theory. Neutrosophic triplet cosets could be used in areas, such as neutrosophic computational modelling, to prove Lagrange’s theorem in the neutrosophic extended triplet, etc.

4.2. The Index and Lagrange’s Theorem: \( |H| \text{ divides } |N| \)

**Theorem 3** If \( N \) is a finite neutrosophic extended triplet group and \( H \leq N \), then \( |H| / |N|. \) Moreover, the number of the distinct left neutrosophic triplet cosets of \( H \) in \( N \) is \( |N|/|H|. \)
6. Neutrosophic Triplet Quotient (Factor) Groups

The notion of quotient (factor) groups was one of the central concepts of classical group theory

\[ |N| = |x_1H| + |x_2H| + \ldots + |x_rH| = r|H|. \]

Therefore: \[ |x_iH| = |xH| \] for \( i = 1, 2, \ldots, r \). \( \square \)

**Example 13.** We let \( H = \langle 11 \rangle, \langle 12 \rangle \), it had three left neutrosophic triplet cosets in \( S_3 \), see example 11, \[ [S_3:H] = 3 = \langle H, [13]H, [23]H \rangle = \langle H, [13]H, [23]H \rangle. \]

5. Neutrosophic Triplet Normal Subgroups

In this section, the neutrosophic triplet normal subgroup and neutrosophic triplet normal subgroup test have been outlined.

**Definition 20.** A neutrosophic extended triplet subgroup \( H \) of a neutrosophic extended triplet group \( N \) is called a neutrosophic triplet normal subgroup of \( N \), if \( xH = Hx, \forall x \in N \) and we denote it as \( H \trianglelefteq N \).

**Example 14.** The set \( A_n = \sigma \in S_n | \sigma \text{ was even} \) was even a normal subgroup of \( S_n \). It was called the alternating neutrosophic extended triplet group on \( n \) letters. It was enough to notice that \( A_n = \ker(\text{sgn}) \). Since \( |S_n| = n! \), thus,

\[ |A_n| = n!/2. \]

\[ S_n/A_n = n!/n!/2 = 2. \]

**Neutrosophic Triplet Normal Subgroup Test**

**Theorem 4** A neutrosophic extended triplet subgroup \( H \) of \( N \) is normal in \( N \) if, and only if, \( \text{anti}(x)Hx \subseteq H \), \( \forall x \in N \).

**Proof.** Let \( H \) be a neutrosophic extended triplet subgroup of \( N \). Suppose \( H \) is neutrosophic extended triplet subgroup of \( N \). Then \( \forall x \in N, y \in H : \exists z \in H : xy = zx. \) Thus \( (xy)\text{anti}(x) = z \in H \) implying \( (xH)\text{anti}(x) \subseteq H \). \( \square \)

Conversely, suppose \( \forall x \in N : (xH)\text{anti}(x) \subseteq H \). Then for \( n \not\in N \), we have \( (nH)\text{anti}(n) \subseteq H \), which implies \( nH \subseteq H \). Also, for \( \text{anti}(n) \not\in N \), we have \( \text{anti}(n)H(\text{anti}[\text{anti}(n)]) = \text{anti}(n)Hn \subseteq H \), which implies \( Hn \subseteq nH \). Therefore, \( nH = Hn \), meaning that \( H \trianglelefteq N \).

**Example 15.** We let \( f: N \rightarrow H \) be a neutro-homomorphism from a neutrosophic extended triplet group \( N \) to a neutrosophic extended triplet group \( H \), \( \text{Ker} f \trianglelefteq N \).

1. If \( \forall a, b \in \text{ker} f \), we had to show that \( a[\text{anti}(b)] \in \text{ker} f \). This meant that \( \text{ker} f \) was a neutrosophic extended triplet subgroup of \( N \). If \( a \in \text{ker} f \), then

\[ f(a) = \text{neut}_H(1) \]

and

\[ b \in \text{ker} f, \] then

\[ f(b) = \text{neut}_H(1) \]

Then, we showed that \( f(\text{anti}(b)) = \text{neut}_H(1) \) (f is neutro-homomorphism)
6. Neutrosophic Triplet Quotient (Factor) Groups

The notion of neutrosophic extended triplet group has been introduced in this paper, and quotient groups play a similar role in the theory of neutrosophic extended triplet group theory. Quotient groups are defined for neutrosophic extended triplet groups, and a neutrosophic triplet quotient group is obtained for a given neutrosophic extended triplet group. The quotient group is defined as the set of all left neutrosophic triplet cosets of a subgroup.

**Definition 21.** Let $N$ be a neutrosophic extended triplet group and $H$ be a neutrosophic triplet normal subgroup of $N$. Then, the neutrosophic triplet quotient group $N/H$ is the set of all left neutrosophic triplet cosets of $H$ in $N$, that is, $N/H = \{xH : x \in N \}$.

Theorem 5. A neutrosophic triplet subgroup $H$ of $N$ is a neutrosophic triplet normal subgroup of $N$ if, and only if, each left neutrosophic triplet coset of $H$ in $N$ is a right neutrosophic triplet coset of $H$. 

**Proof.** Let $H$ be a neutrosophic triplet normal subgroup of $N$, then $xH(anti(x)) = H$, $\forall x \in N \Rightarrow xH(anti(x))x = Hx$, $\forall x \in N \Rightarrow xH = Hx$, $\forall x \in N$, since each left neutrosophic triplet coset $xH$ is the right neutrosophic triplet coset $Hx$. □

Conversely, let each left neutrosophic triplet coset of $H$ in $N$ be a right neutrosophic triplet coset of $H$ in $N$. This means that if $x$ is any element of $N$, then the left neutrosophic triplet coset $xH$ is also a right neutrosophic triplet coset of $H$. However, $x$ is a left neutrosophic triplet coset and needs to contain one common element before they are identical. Therefore, $Hx$ is the unique right neutrosophic triplet coset which is equal to the left neutrosophic triplet coset $xH$. Therefore, we have $xH = Hx$, $\forall x \in N \Rightarrow xH(anti(x)) = Hx(anti(x))$, $\forall x \in N \Rightarrow xH(anti(x)) = H$, $\forall x \in N$, since $H$ is a neutrosophic triplet normal subgroup of $N$.

6. Neutrosophic Triplet Quotient (Factor) Groups

The notion of quotient (factor) groups was one of the central concepts of classical group theory and played an important role in the study of the general structure of groups. Just as in a classical group theory, quotient groups played a similar role in the theory of neutrosophic extended triplet group. In this section, we have introduced the notion of neutrosophic triplet quotient group and its relation to the neutrosophic extended triplet group.

**Definition 21.** If $N$ is a neutrosophic extended triplet group and $H \trianglelefteq N$ is a neutrosophic triplet normal subgroup, then the neutrosophic triplet quotient group $N/H$ has elements $xH: x \in N$, the neutrosophic triplet cosets of $H$ in $N$, and an operation of $(xH)(yH) = (xy)H$.

**Example 16.** Let's find all of the possible neutrosophic triplet quotient groups for the dihedral group $D_3$. $D_3 = \{1, r, r^2, s, sr, sr^2\}$, where $r^3 = s^2 = rsrs = 1$. A quotient set $D_3/N$ is a neutrosophic triplet group if, and only if, $N \trianglelefteq D_3$. Then, all of neutrosophic triplet normal subgroups are $D_3$ itself. We always have the trivial ones $D_3/D_3 = 1 \cong 1$ and $D_3/1 \cong D_3$. The subgroup $\langle r \rangle = \langle r^2 \rangle = \langle 1, r, r^2 \rangle$ is that of index 2 and thus is...
normal. Therefore, $D_3/(r)$ is also a neutrosophic triplet quotient group. If $N \trianglelefteq D_3$ is a different neutrosophic triplet normal subgroup, then $\langle N \rangle = 2$, so either $N = \langle s \rangle$, $N = \langle sr \rangle$, or $N = \langle sr^2 \rangle$. However, none of them are normal, since $(sr)s(anti(sr)) = sr^2$ not in $\langle s \rangle$. Hence, the only non-trivial neutrosophic triplet quotient group is $D_3/(r)$.

**Theorem 6** Let $N$ be a neutrosophic extended triplet group and $H$ be a neutrosophic triplet normal subgroup of $N$. In the set $N/H = xH, x \in N$ is a neutrosophic extended triplet group under the operation of $(xH)(yH) = xyH$.

**Proof.** $N/H \times N/H \rightarrow N/H$

1. $xH = x'H$ and $yH = y'H$

   $xH = x'H$ and $yH = y'H$

   $xH = x'H$ and $yH = y'H$.

2. The neutral, for any $x \in H$, is $\text{neut}(x)H = H$. That is, $xH = H = xH \ast \text{neut}(x)H = x \ast \text{neut}(x)H = xH$.

3. An anti of a neutrosophic triplet coset $xH$ is $\text{anti}(x)H$, since $xH \ast \text{anti}(x)H = (x \ast \text{anti}(x)H) = \text{neut}(x)H = H$.

4. Associativity, $(xH)zH = (xy)HzH = (xy)zH = xH(zy)H = xH(zyH), \forall x, y, z \in N$. $\square$

**7. Conclusions**

The main theme of this paper was to introduce the neutrosophic extended triplets and then to utilize these neutrosophic extended triplets in order to introduce the neutrosophic triplet cosets, neutrosophic triplet normal subgroup, and finally, the neutrosophic triplet quotient group. We also studied some interesting properties of these newly created structures and their application to neutrosophic extended triplet group. We further defined the neutrosophic kernel, neutrosophic-image, and inverse image for neutrosophic extended triplets. As a further generalization, we created a new field of research, called Neutrosophic Triplet Structures (namely, the neutrosophic triplet cosets, neutrosophic triplet normal subgroup, and neutrosophic triplet quotient group).

**Author Contributions:** All authors have contributed equally to this paper. The individual responsibilities and contribution of all authors can be described as follows: the idea of this whole paper was put forward by Mikail Bal, he also completed the preparatory work of the paper. Mogeek Mekonnen Shalla analyzed the existing work of symmetry 292516 neutrosophic triplet coset and quotient group and wrote part of the paper. The revision and submission of this paper was completed by Necati Olgun.

**Conflicts of Interest:** The authors declare no conflict of interest.

**References and Note**


© 2018 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (http://creativecommons.org/licenses/by/4.0/).