

# Neutrosophic Sets and Systems

---

Volume 59 *Neutrosophic Sets and Systems*,  
Vol. 59, 2023 - Special Issue on Symbolic  
*Plithogenic Algebraic Structures*

Article 26

---

10-28-2023

## On the Representation of Some n-Plithogenic Differential Operators by Matrices

Basheer Abd Al Rida Sadiq

Follow this and additional works at: [https://digitalrepository.unm.edu/nss\\_journal](https://digitalrepository.unm.edu/nss_journal)

---

### Recommended Citation

Sadiq, Basheer Abd Al Rida. "On the Representation of Some n-Plithogenic Differential Operators by Matrices." *Neutrosophic Sets and Systems* 59, 1 (2023). [https://digitalrepository.unm.edu/nss\\_journal/vol59/iss1/26](https://digitalrepository.unm.edu/nss_journal/vol59/iss1/26)

This Article is brought to you for free and open access by UNM Digital Repository. It has been accepted for inclusion in *Neutrosophic Sets and Systems* by an authorized editor of UNM Digital Repository. For more information, please contact [disc@unm.edu](mailto:disc@unm.edu).



# On The Representation of Some n-Plithogenic Differential Operators by Matrices

Basheer Abd Al Rida Sadiq

Computer Techniques Engineering, Imam Al-Kadhumi College (IKC), Baghdad, Iraq

[basheer.abdrida@alkadhumi-col.edu.iq](mailto:basheer.abdrida@alkadhumi-col.edu.iq)

## Abstract

The main goal of this paper is to study the representation of the symbolic n-plithogenic differential operator for many different values of n by classical algebraic matrices and plithogenic matrices. We present many examples about the representation of symbolic n-plithogenic differential operators by matrices. As well as, we compute the symbolic 2-plithogenic, 3-plithogenic, and 4-plithogenic Wronskian, and anti-Wronskian.

**Keywords:** Differential operator, Wronskian, anti-Wronskian, symbolic n-plithogenic matrix

## Introduction

Symbolic n-plithogenic structures and sets are defined for the first time by Smarandache [4], as extensions of classical algebraic structures. Where they were used widely by many researchers to generalize famous algebraic structures. For example, we can see symbolic n-plithogenic rings, probability, spaces, and matrices [1-3, 5-8, 14-19].

The main results about symbolic n-plithogenic structures are the similarity between them and refined neutrosophic structures, see [9-13].

In this work, we concentrate on the analytical side of symbolic n-plithogenic algebraic structures, where we provide many examples about the applications of matrices in representing symbolic n-plithogenic differential operators. Also, we present the concept of symbolic n-plithogenic Wronskian, and anti-Wronskian,

with many computable examples. For the definitions of symbolic n-plithogenic rings and structures, check [1,6,8,19].

### Main Discussion

#### Definition:

Let  $f: 2 - SP_R \rightarrow 2 - SP_R$  be a symbolic 2-plithogenic real function, we define the symbolic 2-plithogenic differential operator as:  $D_2(f) = \dot{f}$ .

#### Definition.

Let  $f: 3 - SP_R \rightarrow 3 - SP_R$  be a symbolic 3-plithogenic real function, we define the symbolic 2-plithogenic differential operator as:  $D_3(f) = \dot{f}$ .

#### Definition.

Let  $f: 4 - SP_R \rightarrow 4 - SP_R$  be a symbolic 4-plithogenic real function, we define the symbolic 2-plithogenic differential operator as:  $D_4(f) = \dot{f}$ .

#### Definition.

Let  $f: 5 - SP_R \rightarrow 5 - SP_R$  be a symbolic 5-plithogenic real function, we define the symbolic 2-plithogenic differential operator as:  $D_5(f) = \dot{f}$ .

#### Example.

Consider  $f: 2 - SP_R \rightarrow 2 - SP_R; f(X) = X^2 + (P_1 + P_2)X - P_1$ , where  $X = x_0 + x_1P_1 + x_2P_2 \in 2 - SP_R$ , then  $D_2(f) = 2X + (P_1 + P_2)$ .

Consider  $g: 3 - SP_R \rightarrow 3 - SP_R; g(X) = X^2 + P_3X + P_3 + P_2$ , where  $X = x_0 + x_1P_1 + x_2P_2 + x_3P_3 \in 3 - SP_R$ , then  $D_3(g) = 2X + P_3$ .

Consider  $h: 4 - SP_R \rightarrow 4 - SP_R; h(X) = X^3 + (P_1 + P_4)X - 1$ , where  $X = x_0 + x_1P_1 + x_2P_2 + x_3P_3 + x_4P_4 \in 4 - SP_R$ , then  $D_3(h) = 3X^2 + P_1 + P_4$ .

#### Example.

Consider  $D_2$  the symbolic 2-plithogenic differential operator on the space of symbolic 2-plithogenic quadratic polynomials  $\{aX^2 + bX + c; a, b, c, X \in 2 - SP_R\}$ , then:

$$\begin{cases} D_2(X^2) = 2X = 2x_0 + 2x_1P_1 + 2x_2P_2 = 0X^2 + 2X + 0.1 \\ D_2(X) = 1 = 0X^2 + 0.X + 1.1 \\ D_2(1) = 0 = 0X^2 + 0.X + 0.1 \end{cases}$$

Hence  $[D_2] = \begin{pmatrix} 0 & 0 & 0 \\ 2 & 0 & 0 \\ 1 & 1 & 0 \end{pmatrix}$ .

**Example.**

Consider  $D_3, D_4, D_5$  be the symbolic 3-plithogenic, 4-plithogenic, 5-plithogenic differential operators on the spaces of cubic symbolic 30plithogenic, 4-plithogenic, and 5-plithogenic spaces.

$$L_1 = \{aX^3 + bX^2 + bX + d; a, b, c, d, X \in 3 - SP_R\}$$

$$L_2 = \{aX^3 + bX^2 + bX + d; a, b, c, d, X \in 4 - SP_R\}$$

$$L_3 = \{aX^3 + bX^2 + bX + d; a, b, c, d, X \in 5 - SP_R\}$$

$$\text{Then } D_n(X^3) = 3X^2 = 0.X^3 + 3X^2 + 0.X + 0.1.$$

$$D_n(X^2) = 2X = 0.X^3 + 0.X^2 + 2.X + 0.1.$$

$$D_n(X) = 1 = 0.X^3 + 0.X^2 + 0.X + 1.1.$$

$$D_n(1) = 0 = 0.X^3 + 0.X^2 + 0.X + 0.1$$

For all  $3 \leq n \leq 5$ , hence:

$$[D_n] = \begin{pmatrix} 0 & 0 & 0 & 0 \\ 3 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 1 & 1 \end{pmatrix}$$

**Example.**

For  $\sin X = \sin(x_0 + x_1P_1 + x_2P_2), \cos X = \cos(x_0 + x_1P_1 + x_2P_2)$ .

We have:

$$\begin{cases} D_2(\sin X) = \cos X = 0.\sin X + 1.\cos X + 0.1 \\ D_2(\cos X) = -\sin X = -1.\sin X + 0.\cos X + 0.1 \\ D_2(1) = 0 = 0.\sin X + 0.\cos X + 0.1 \end{cases}$$

Hence  $[D_2] = \begin{pmatrix} 0 & -1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}$ .

For  $\sin X = \sin(x_0 + x_1P_1 + x_2P_2 + x_3P_3), \cos X = \cos(x_0 + x_1P_1 + x_2P_2 + x_3P_3)$ .

We have:

$$\begin{cases} D_3(\sin X) = \cos X \\ D_3(\cos X) = -\sin X \\ D_3(1) = 0 \end{cases}$$

Hence  $[D_3] = \begin{pmatrix} 0 & -1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}$ .

For  $\sin X = \sin(x_0 + x_1P_1 + x_2P_2 + x_3P_3 + x_4P_4)$ ,  $\cos X = \cos(x_0 + x_1P_1 + x_2P_2 + x_3P_3 + x_4P_4)$ .

We have:

$c$

$$\text{Hence } [D_4] = \begin{pmatrix} 0 & -1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}.$$

**Example.**

For  $\{1, X, X^2, X^3, X^4\}$ ;  $X = x_0 + x_1P_1 + x_2P_2$ , we have:

$$\begin{cases} D_2(X^4) = 4X^3 \\ D_2(X^3) = 3X^2 \\ D_2(X^2) = 2X \\ D_2(X) = 1 \\ D_2(1) = 0 \end{cases}$$

$$\text{Hence } [D_2] = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 \\ 4 & 0 & 0 & 0 & 0 \\ 0 & 3 & 0 & 0 & 0 \\ 0 & 0 & 2 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \end{pmatrix}$$

For  $X = x_0 + \sum_{i=1}^5 x_iP_i$ , we have:

$$\begin{cases} D_5(X^4) = 4X^3 \\ D_5(X^3) = 3X^2 \\ D_5(X^2) = 2X \\ D_5(X) = 1 \\ D_5(1) = 0 \end{cases}$$

$$\text{Hence } [D_5] = \begin{pmatrix} 0 & 0 & 0 & 0 & 0 \\ 4 & 0 & 0 & 0 & 0 \\ 0 & 3 & 0 & 0 & 0 \\ 0 & 0 & 2 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \end{pmatrix}$$

**Example.**

Consider  $A = \{1, e^X, e^{2X}\}$ , where  $X = x_0 + x_1P_1 + x_2P_2$ ,  $B = \{1, e^Y, e^{2Y}\}$ , where  $Y = y_0 + y_1P_1 + y_2P_2 + y_3P_3$ ,  $C = \{1, e^Z, e^{2Z}\}$ , where  $Z = z_0 + z_1P_1 + z_2P_2 + z_3P_3 + z_4P_4$ ,  $D = \{1, e^T, e^{2T}\}$ , where  $T = t_0 + \sum_{i=1}^5 t_iP_i$ , then:

$$\begin{cases} D_2(1) = 0 \\ D_2(e^X) = e^X \\ D_2(e^{2X}) = 2e^{2X} \end{cases}$$

$$\text{Hence } [D_3] = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 2 \end{pmatrix}.$$

$$\begin{cases} D_3(1) = 0 \\ D_3(e^Y) = e^Y \\ D_3(e^{2Y}) = 2e^{2Y} \end{cases}$$

$$\text{Hence } [D_3] = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 2 \end{pmatrix}.$$

$$\begin{cases} D_4(1) = 0 \\ D_4(e^Z) = e^Z \\ D_4(e^{2Z}) = 2e^{2Z} \end{cases}$$

$$\text{Hence } [D_4] = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 2 \end{pmatrix}.$$

$$\begin{cases} D_5(1) = 0 \\ D_5(e^T) = e^T \\ D_5(e^{2T}) = 2e^{2T} \end{cases}$$

$$\text{Hence } [D_5] = \begin{pmatrix} 0 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 2 \end{pmatrix}.$$

### Another possible representation.

We have shown that symbolic n-plithogenic differential operators can be represented by classical real matrices, now we will try to explain how they can be represented by plithogenic matrices.

### Example.

Consider  $\{1, X, X^2\}$ ;  $X = x_0 + x_1P_1 + x_2P_2$ , with  $D_2$  the symbolic 2-plithogenic differential operator, then:

$$\begin{cases} D_2(1) = 0 = 0 \cdot x_0 + 0 \cdot x_1P_1 + 0 \cdot x_2P_2 \\ D_2(X) = 1 \\ D_2(X^2) = 2X \end{cases}$$

The basis  $\{1, X, X^2\}$  can be represented as follows:

$$B_1 = \{1, x_0, x_0^2\}, B_2 = \{1, (x_0 + x_1), (x_0 + x_1)^2\}, B_3 \\ = \{1, (x_0 + x_1 + x_2), (x_0 + x_1 + x_2)^2\}$$

Any quadratic polynomial  $P(X) = aX^2 + bX + c$ ;  $a, b, c, X \in 2 - SP_R$ , with:

$$\begin{cases} a = a_0 + a_1P_1 + a_2P_2 \\ b = b_0 + b_1P_1 + b_2P_2 \\ c = c_0 + c_1P_1 + c_2P_2 \\ X = x_0 + x_1P_1 + x_2P_2 \end{cases}$$

$$\begin{aligned} P(X) &= aX^2 + bX + c \\ &= (a_0x_0^2 + b_0x_0 + c_0) \\ &\quad + P_1[(a_0 + a_1)(x_0 + x_1)^2 - a_0x_0^2 + (b_0 + b_1)(x_0 + x_1) - b_0x_0 + c_1] \\ &\quad + P_2[(a_0 + a_1 + a_2)(x_0 + x_1 + x_2)^2 - (a_0 + a_1)(x_0 + x_1)^2 \\ &\quad + (b_0 + b_1 + b_2)(x_0 + x_1 + x_2) - (b_0 + b_1)(x_0 + x_1) + c_2] \\ &= q_1(x_0) + P_1[q_2(x_0 + x_1) - q_1(x_0)] \\ &\quad + P_2[q_3(x_0 + x_1 + x_2) - q_2(x_0 + x_1)] \end{aligned}$$

Hence,  $D_2(P(X)) = D_2(q_1) + P_1[D_2(q_2) - D_2(q_1)] + P_2[D_2(q_3) - D_2(q_2)]$ , hence:

$$\begin{aligned} [D_2] &= \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 2 \\ 0 & 1 & 0 \end{pmatrix} + P_1 \left[ \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 2 \\ 0 & 1 & 0 \end{pmatrix} \right] + P_2 \left[ \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 2 \\ 0 & 1 & 0 \end{pmatrix} \right] \\ &= \begin{pmatrix} 0 & 0 & 0 \\ 0 & 0 & 2 + 2P_1 + 2P_2 \\ 0 & 1 + P_1 + P_2 & 0 \end{pmatrix} \end{aligned}$$

**The symbolic plithogenic Wronskian.**

Consider the following functions independent set:

$E = \{f_1, \dots, f_n\}$ , their wronskian is defined as follows:

$$W(E) = \begin{vmatrix} f_1 & \dots & f_n \\ \dot{f}_1 & \dots & \dot{f}_n \\ \vdots & \vdots & \vdots \\ f_1^{(n-1)} & \dots & f_n^{(n-1)} \end{vmatrix}$$

We show some examples for finding the symbolic n-plithogenic Wronskian.

**Example.**

Consider  $E_1 = \{e^X, e^{2X}; X = x_0 + x_1P_1 + x_2P_2\}$ ,  $E_2 = \{1, \sin X, \cos X; X = x_0 + x_1P_1 + x_2P_2 + x_3P_3\}$ ,  $E_3 = \{1, \tan X; X = x_0 + x_1P_1 + x_2P_2 + x_3P_3 + x_4P_4\}$ ,  $E_4 = \{1, X, X^2, X^3; X = x_0 + \sum_{i=1}^5 x_iP_i\}$ , we have:

$$\begin{aligned} W(E_1) &= \begin{vmatrix} D_2^{(0)}(e^X) & D_2^{(0)}(e^{2X}) \\ D_2(e^X) & D_2(e^{2X}) \end{vmatrix} = \begin{vmatrix} e^{x_0+x_1P_1+x_2P_2} & e^{2x_0+2x_1P_1+2x_2P_2} \\ e^{x_0+x_1P_1+x_2P_2} & 2e^{2x_0+2x_1P_1+2x_2P_2} \end{vmatrix} \\ &= e^{3x_0+3x_1P_1+3x_2P_2} \end{aligned}$$

$$W(E_2) = \begin{vmatrix} 1 & \sin\left(x_0 + \sum_{i=1}^3 x_i P_i\right) & \cos\left(x_0 + \sum_{i=1}^3 x_i P_i\right) \\ 0 & \cos\left(x_0 + \sum_{i=1}^3 x_i P_i\right) & -\sin\left(x_0 + \sum_{i=1}^3 x_i P_i\right) \\ 0 & -\sin\left(x_0 + \sum_{i=1}^3 x_i P_i\right) & -\cos\left(x_0 + \sum_{i=1}^3 x_i P_i\right) \end{vmatrix} = -\cos^2\left(x_0 + \sum_{i=1}^3 x_i P_i\right)$$

$$W(E_3) = \begin{vmatrix} 1 & \tan\left(x_0 + \sum_{i=1}^4 x_i P_i\right) \\ 0 & 1 + \tan^2\left(x_0 + \sum_{i=1}^4 x_i P_i\right) \end{vmatrix} = 1 + \tan^2\left(x_0 + \sum_{i=1}^4 x_i P_i\right)$$

$$W(E_4) = \begin{vmatrix} 1 & x_0 + \sum_{i=1}^5 x_i P_i & \left(x_0 + \sum_{i=1}^5 x_i P_i\right)^2 & \left(x_0 + \sum_{i=1}^5 x_i P_i\right)^3 \\ 0 & 1 & 2\left(x_0 + \sum_{i=1}^5 x_i P_i\right) & 3\left(x_0 + \sum_{i=1}^5 x_i P_i\right) \\ 0 & 0 & 2 & 6\left(x_0 + \sum_{i=1}^5 x_i P_i\right) \\ 0 & 0 & 0 & 6 \end{vmatrix} = 12$$

**Example.**

Consider  $E_1 = \{\ln X, e^X; X = x_0 + \sum_{i=1}^5 x_i P_i\}$ ,  $E_2 = \{\ln X, \sqrt{X}; X = x_0 + \sum_{i=1}^4 x_i P_i\}$ ,  $E_3 = \{e^X, \sin X; X = x_0 + \sum_{i=1}^3 x_i P_i\}$ , then:

$$W(E_1) = \begin{vmatrix} \ln X & e^X \\ \frac{1}{X} & e^X \end{vmatrix} = e^{x_0 + \sum_{i=1}^5 x_i P_i} \left[ \ln\left(x_0 + \sum_{i=1}^5 x_i P_i\right) - \frac{1}{x_0 + \sum_{i=1}^5 x_i P_i} \right]$$

$$W(E_2) = \begin{vmatrix} \ln X & \sqrt{X} \\ \frac{1}{X} & \frac{1}{2\sqrt{X}} \end{vmatrix} = \frac{\ln X}{2\sqrt{X}} - \frac{1}{\sqrt{X}} = \frac{\ln X - 2}{2\sqrt{X}}$$

$$= \frac{1}{\sqrt{x_0 + \sum_{i=1}^4 x_i P_i}} \left[ \ln\left(x_0 + \sum_{i=1}^4 x_i P_i\right) - 2 \right]$$

$$W(E_3) = \begin{vmatrix} e^X & \sin X \\ e^X & \cos X \end{vmatrix} = e^{x_0 + \sum_{i=1}^3 x_i P_i} \left[ \cos\left(x_0 + \sum_{i=1}^3 x_i P_i\right) - \sin\left(x_0 + \sum_{i=1}^3 x_i P_i\right) \right]$$

**Symbolic n-plithogenic anti-Wronskian.**

Let  $E = \{f_1, \dots, f_n\}$  be a set of n functions, then:



$$AW(E) = \begin{vmatrix} f_1 & f_2 & \dots & f_n \\ \int f_1 & \int f_2 & \dots & \vdots \\ \int \left( \int f_1 \right) & \vdots & \dots & \vdots \\ \vdots & \vdots & \vdots & \vdots \\ \underbrace{\int f_1}_{n-1 \text{ times}} & \underbrace{\int f_2}_{n-1 \text{ times}} & \dots & \underbrace{\int f_n}_{n-1 \text{ times}} \end{vmatrix}$$

Now, we will clarify how (AW) can be computed.

**Example.**

Consider  $E_1 = \{1, X, X^2; X = x_0 + \sum_{i=1}^2 x_i P_i\}$ ,  $E_2 = \{e^X, e^{2X}; X = x_0 + \sum_{i=1}^3 x_i P_i\}$ ,  $E_3 = \{\sin X, \cos X; X = x_0 + \sum_{i=1}^4 x_i P_i\}$ , then:

$$\begin{aligned} AW(E_1) &= \begin{vmatrix} 1 & X & X^2 \\ X & \frac{1}{2}X^2 & \frac{1}{3}X^3 \\ \frac{1}{2}X^2 & \frac{1}{6}X^3 & \frac{1}{12}X^4 \end{vmatrix} \\ &= 1 \cdot \begin{vmatrix} \frac{1}{2}X^2 & \frac{1}{3}X^3 \\ \frac{1}{6}X^3 & \frac{1}{12}X^4 \end{vmatrix} - X \begin{vmatrix} X & \frac{1}{3}X^3 \\ \frac{1}{2}X^2 & \frac{1}{12}X^4 \end{vmatrix} + X^2 \begin{vmatrix} X & \frac{1}{2}X^2 \\ \frac{1}{2}X^2 & \frac{1}{6}X^3 \end{vmatrix} \\ &= \left(\frac{1}{24} - \frac{1}{18}\right)X^6 - X \left(\frac{1}{12} - \frac{1}{6}\right)X^5 + X^2 \left(\frac{1}{6} - \frac{1}{4}\right)X^4 \\ &= X^6 \left(\frac{1}{24} - \frac{1}{18} - \frac{1}{12} + \frac{1}{6} + \frac{1}{6} - \frac{1}{4}\right) = X^6 \left(\frac{1}{24} + \frac{8}{24} - \frac{6}{24} - \frac{2}{24} - \frac{1}{18}\right) \\ &= X^6 \left(\frac{1}{24} - \frac{1}{18}\right) = -\frac{1}{72} \left(x_0 + \sum_{i=1}^3 x_i P_i\right) \end{aligned}$$

$$AW(E_2) = \begin{vmatrix} e^X & e^{2X} \\ e^X & \frac{1}{2}e^{2X} \end{vmatrix} = \frac{1}{2}e^X e^{2X} - e^X e^{2X} = -\frac{1}{2}e^{3X} = -\frac{1}{2}e^{(x_0 + \sum_{i=1}^3 x_i P_i)}$$

$$\begin{aligned}
AW(E_3) &= \begin{vmatrix} \sin X & \cos X & 1 \\ -\cos X & -\sin X & X \\ -\sin X & -\cos X & \frac{1}{2}X^2 \end{vmatrix} \\
&= \sin X \cdot \begin{vmatrix} \sin X & X \\ -\cos X & \frac{1}{2}X^2 \end{vmatrix} - \cos X \begin{vmatrix} -\cos X & X \\ -\sin X & \frac{1}{2}X^2 \end{vmatrix} + 1 \cdot \begin{vmatrix} -\cos X & \sin X \\ -\sin X & -\cos X \end{vmatrix} \\
&= \sin X \left( \frac{1}{2}X^2 \sin X + X \cos X \right) - \cos X \left( -\frac{1}{2}X^2 \cos X + X \sin X \right) \\
&\quad + (\cos^2 X + \sin^2 X) \\
&= \frac{1}{2}X^2 \sin^2 X + X \cos X \sin X + \frac{1}{2}X^2 \cos^2 X - X \cos X \sin X + 1 \\
&= \frac{1}{2}X^2(1) + 1 = \frac{1}{2} \left( x_0 + \sum_{i=1}^4 x_i P_i \right) + 1
\end{aligned}$$

## Conclusion

In this paper, we have studied the representation of the symbolic n-plithogenic differential operator for many different values of n by classical algebraic matrices and plithogenic matrices. We presented many examples about the representation of symbolic n-plithogenic differential operators by matrices. As well as, we computed the symbolic 2-plithogenic, 3-plithogenic, and 4-plithogenic Wronskian, and anti-Wronskian.

## References

1. Nader Mahmoud Taffach , Ahmed Hatip., "A Review on Symbolic 2-Plithogenic Algebraic Structures " Galoitica Journal Of Mathematical Structures and Applications, Vol.5, 2023.
2. Nader Mahmoud Taffach , Ahmed Hatip.," A Brief Review on The Symbolic 2-Plithogenic Number Theory and Algebraic Equations ", Galoitica Journal Of Mathematical Structures and Applications, Vol.5, 2023.
3. Merkepçi, H., and Abobala, M., " On The Symbolic 2-Plithogenic Rings", International Journal of Neutrosophic Science, 2023.
4. Smarandache, F., " Introduction to the Symbolic Plithogenic Algebraic Structures (revisited)", Neutrosophic Sets and Systems, vol. 53, 2023.

5. Taffach, N., " An Introduction to Symbolic 2-Plithogenic Vector Spaces Generated from The Fusion of Symbolic Plithogenic Sets and Vector Spaces", Neutrosophic Sets and Systems, Vol 54, 2023.
6. Ben Othman, K., Albasheer, O., Nadweh, R., Von Shtawzen, O., and Ali, R., "On The Symbolic 6-Plithogenic and 7-Plithogenic Rings", Galoitica Journal of Mathematical Structures and Applications, Vol.8, 2023.
7. Merkepci, H., and Rawashdeh, A., " On The Symbolic 2-Plithogenic Number Theory and Integers ", Neutrosophic Sets and Systems, Vol 54, 2023.
8. Albasheer, O., Hajjari, A., and Dalla, R., " On The Symbolic 3-Plithogenic Rings and Their Algebraic Properties", Neutrosophic Sets and Systems, Vol 54, 2023.
9. Abobala, M., On Refined Neutrosophic Matrices and Their Applications In Refined Neutrosophic Algebraic Equations, Journal Of Mathematics, Hindawi, 2021
10. Olgun, N., Hatip, A., Bal, M., and Abobala, M., " A Novel Approach To Necessary and Sufficient Conditions For The Diagonalization of Refined Neutrosophic Matrices", International Journal of neutrosophic Science, Vol. 16, pp. 72-79, 2021.
11. Abobala, M., and Zeina, M.B., " A Study Of Neutrosophic Real Analysis By Using One Dimensional Geometric AH-Isometry", Galoitica Journal Of Mathematical Structures And Applications, Vol.3, 2023.
12. Bisher Ziena, M., and Abobala, M., " On The Refined Neutrosophic Real Analysis Based on Refined Neutrosophic Algebraic AH-Isometry", Neutrosophic Sets and Systems, vol. 54, 2023.
13. M. B. Zeina and M. Abobala, "A Novel Approach of Neutrosophic Continuous Probability Distributions using AH-Isometry with Applications in Medicine," in *Cognitive Intelligence with Neutrosophic Statistics in Bioinformatics*, Elsevier, 2023.

14. Ali, R., and Hasan, Z., " An Introduction To The Symbolic 3-Plithogenic Modules ", Galoitica Journal Of Mathematical Structures and Applications, vol. 6, 2023.
15. M. B. Zeina, N. Altounji, M. Abobala, and Y. Karmouta, "Introduction to Symbolic 2-Plithogenic Probability Theory," *Galoitica: Journal of Mathematical Structures and Applications*, vol. 7, no. 1, 2023.
16. Rawashdeh, A., "An Introduction To The Symbolic 3-plithogenic Number Theory", Neoma Journal Of Mathematics and Computer Science, 2023.
17. Ben Othman, K., "On Some Algorithms For Solving Symbolic 3-Plithogenic Equations", Neoma Journal Of Mathematics and Computer Science, 2023.
18. Ben Othman, K., Von Shtawzen, O., Khaldi, A., and Ali, R., "On The Concept Of Symbolic 7-Plithogenic Real Matrices", *Pure Mathematics For Theoretical Computer Science*, Vol.1, 2023.
19. Ben Othman, K., Von Shtawzen, O., Khaldi, A., and Ali, R., "On The Symbolic 8-Plithogenic Matrices", *Pure Mathematics For Theoretical Computer Science*, Vol.1, 2023.