Abstract. In this paper we give a definition of harmonic curvature functions in terms of $V_n$ and define a new kind of slant helix which we call $V_n$-slant helix in $n$-dimensional Minkowski space $E^n_1$ by using the new harmonic curvature functions. Also we define a vector field $D_L$ which we call Darboux vector field of $V_n$-slant helix in $n$-dimensional Minkowski space $E^n_1$ and we give some characterizations about slant helices.

1. Introduction

Hayden gave more restrictive definition for generalized helices in [6]: If the fixed direction makes a constant angle with all the vectors of the Frenet frame then the curve is a generalized helix in $E^n$. This definition only works in the odd dimensional case. Moreover, in the same reference, it is proved that the definition is equivalent to the fact that the ratios $\frac{k_{n-1}}{k_{n-2}}, \frac{k_{n-3}}{k_{n-4}}, ..., \frac{k_2}{k_1}$ being the curvatures, are constant. This statement is related with the Lancret Theorem for generalized helices in $E^3$ (the ratio of torsion to curvature is constant).

Later, Izumiya and Takeuchi defined a new kind of helix i.e., slant helix and gave a characterization of slant helices in Euclidean 3-space $E^3$ [8]. And then Kula and Yaylı investigated spherical images; the tangent indicatrix and binormal indicatrix of a slant helix [10]. Moreover, they gave a characterization for slant helices in $E^3$: “For involute of a curve $\gamma$, $\gamma$ is a slant helix if and only if its involute is a general helix”. If a curve $\alpha$ in $E^n$, for which all the ratios $\frac{k_{n-1}}{k_{n-2}}, \frac{k_{n-3}}{k_{n-4}}, ..., \frac{k_2}{k_1}$ are constant was called ccr curves[11]. In the same reference, it is shown that in the even dimensional case, a curve has constant curvature ratios if and only if its tangent indicatrix is a geodesic in the flat torus. In 2008, Önder et al. [12] defined a new kind of slant helix in Euclidean 4-space $E^5$ which they called $B_2$-slant helix and they gave some characterizations of this slant helix in Euclidean 4-space $E^4$. Özdamar and Hacısalihoğlu defined harmonic curvature functions [13]. They generalized inclined
curves in $E^3$ to $E^n$. Gök et al. gave the definition a vector field $D$ in Euclidean $n-$space $E^n$, it is a new characterization for $V_n$-slant helix [4].

In this study, we define a new kind of slant helix in Minkowski $n-$space $E^n_1$, where we use the constant angle in between a fixed direction $X$ and the $n$th Frenet vector field $V_n$ of the curve, this means that

$$g(V_n, X) = \lambda_n \varepsilon_{n-1} = \text{constant}$$

Since $n$th Frenet vector field $V_n$ of the curve makes a constant angle with a fixed direction $X$, we call it $V_n$-slant helix in Minkowski $n-$space $E^n_1$. In this paper, at first we give a generalization of Hacsalıhoğlu’s harmonic curvature functions [13].

In this case we define a new characterization in $E^n_1$ such as:

$$\alpha : I \subset \mathbb{R} \to E^n_1$$

is a $V_n$-slant helix, then

$$\sum_{i=1}^{n-2} \varepsilon_{n-(i+2)} H^*_i = \text{constant}$$

where $H^*_i$ is $i^{th}$ harmonic curvature function in terms of $V_n$.

2. Preliminaries

Let $E^n_1$ be the $n$-dimensional pseudo-Euclidean space with index 1 endowed with the indefinite inner product given by

$$g(x, y) = -x_1y_1 + \sum_{i=2}^{n} x_iy_i,$$

where $x = (x_1, x_2, \cdots, x_n)$, $y = (y_1, y_2, \cdots, y_n)$ is the usual coordinate system. Then $v$ is said to be spacelike, timelike or null according to $g(v, v) > 0$, $g(v, v) < 0$, or $g(v, v) = 0$ and $v \neq 0$, respectively. Notice that the vector $v = 0$ is spacelike. The category into which a given tangent vector falls is called its causal character. These definitions can be generalized for curves as follows. A curve $\alpha$ in $E^n_1$ is said to be spacelike if all of its velocity vectors $\alpha'$ are spacelike, similarly for timelike and null [1].

Let us recall from [15, 7] the definition of the Frenet frame and curvatures.

Let $\alpha : I \subset \mathbb{R} \to E^n_1$ be non-null curve in $E^n_1$. A non-null curve $\alpha(s)$ is said to be a unit speed curve if $g(\alpha'(s), \alpha'(s)) = \varepsilon_0$, ($\varepsilon_0$ being +1 or −1 according to $\alpha$ is spacelike or timelike respectively). Let $\{V_1, V_2, \ldots, V_n\}$ be the moving Frenet frame along the unit speed curve $\alpha$, where $V_i$ ($i = 1, 2, \ldots, n$) denote $i^{th}$ Frenet vector fields and $k_i$ be $i^{th}$ curvature functions of the curve ($i = 1, 2, \ldots, n-1$). Then the Frenet formulas are given as

$$\nabla_{V_i} V_1 = k_1 V_2,$$

$$\nabla_{V_i} V_i = -\varepsilon_{i-2}\varepsilon_{i-1}k_{i-1}V_{i-1} + k_i V_{i+1}, \quad 1 < i < n$$

$$\nabla_{V_i} V_n = -\varepsilon_{n-2}\varepsilon_{n-1}k_{n-1}V_{n-1}$$

where $g(V_i, V_i) = \varepsilon_{i-1}$, and $\nabla$ is the Levi-Civita connection of $E^n_1$ [7].
In this section we define $V_n$-slant helices in Minkowski $n$-space $E^n_1$ and give some characterizations by using the new harmonic curvatures $H^*_i$ for $V_n$-slant helix.

**Definition 3.1.** Let $\alpha : I \subset \mathbb{R} \to E^n_1$ be non-null curve with nonzero curvatures $k_i (i = 1, 2, ..., n)$ in $E^n_1$ and $\{V_1, V_2, ..., V_n\}$ denotes the Frenet frame of the curve $\alpha$. We call $\alpha$ as a $V_n$-slant helix in $E^n_1$ if $n$th unit vector field $V_n$ makes a constant angle with a fixed direction $X$, that is,

$$g(V_n, X) = \lambda_n \varepsilon_{n-1} = \text{constant}, \quad \lambda_n \neq 0.$$  

Therefore, $X$ is in the subspace $Sp \{V_1, V_2, ..., V_{n-1}, V_n\}$ and can be written as

$$X = \sum_{i=1}^{n} x_i V_i, \quad g(X, X) = 1.$$  

**Definition 3.2.** Let $\alpha : I \subset \mathbb{R} \to E^n_1$ be a unit speed non-null curve with nonzero curvatures $k_i (i = 1, 2, ..., n)$ in $E^n_1$. Harmonic curvature functions in terms of $V_n$ for $\alpha$ are defined by

$$H^*_i : \subset \mathbb{R} \to \mathbb{R}$$

$$H^*_0 = 0, \quad (3.1)$$

$$H^*_1 = \varepsilon_{n-3} \varepsilon_{n-2} \frac{k_{n-1}}{k_{n-2}},$$

$$H^*_i = \left( k_{n-i} H^*_{i-2} - \nabla_{V_i} H^*_{i-1} \right) \frac{\varepsilon_{n-(i+2)} \varepsilon_{n-(i+1)}}{k_{n-(i+1)}}, \quad 2 \leq i \leq n-2.$$  

**Theorem 3.3.** Let $\alpha : I \subset \mathbb{R} \to E^n_1$ be a non-null curve in $E^n_1$ arc-lengthed parameter and $X$ a unit constant vector field and $\{V_1, V_2, ..., V_n\}$ denote the Frenet frame of the curve $\alpha$, $\{H^*_1, H^*_2, ..., H^*_{n-2}\}$ denote the harmonic curvature functions of the curve $\alpha$. If $\alpha : I \subset \mathbb{R} \to E^n_1$ is a $V_n$-slant helix then we have

$$g(V_{n-(i+1)}, X) = H^*_i g(V_n, X), \quad 1 \leq i \leq n-2,$$  

where $X$ is axis of the $V_n$-slant helix.

**Proof.** We will use the induction method.

Let $i = 1$:

Since $X$ is the axis of the $V_n$-slant helix $\alpha$, we get

$$X = \lambda_1 V_1 + \lambda_2 V_2 + ... + \lambda_n V_n.$$  

From the definition of $V_n$-slant helix we have

$$g(V_n, X) = \lambda_n \varepsilon_{n-1}.$$  

A differentiation in Eq.(3.3) and the Frenet formulas give us that

$$g(V_{n-1}, X) = 0.$$  

$$
Again, differentiation in Eq.(3.4) and the Frenet formulas give
\[ g(\nabla V_i V_{n-1}, X) = 0, \]
\[ -\varepsilon_{n-3} \varepsilon_{n-2} k_{n-2} g(V_{n-2}, X) + k_{n-1} g(V_n, X) = 0, \]
\[ g(V_{n-2}, X) = \varepsilon_{n-3} \varepsilon_{n-2} \frac{k_{n-1}}{k_{n-2}} g(V_n, X) \]
\[ g(V_{n-2}, X) = H_1^* g(V_n, X), \]
respectively. Hence it is shown that the Eq.(3.2) is true for \( i = 1 \).

We now assume the Eq.(3.2) is true for the first \( i - 1 \). Then we have
\[ g(V_{n-i}, X) = H_{i-1}^* g(V_n, X). \] (3.5)

A differentiation in Eq.(3.5) and the Frenet formulas give us that
\[ -\varepsilon_{n-i-2} \varepsilon_{n-i-1} k_{n-i-1} g(V_{n-i-1}, X) + k_{n-i} g(V_{n-i+1}, X) = \nabla V_i H_{i-1}^* g(V_n, X). \]
Since we have the induction hypothesis, \( g(V_{n-i+1}, X) = H_{i-2}^* g(V_n, X) \), we get
\[ (k_{n-i} H_{i-2} - \nabla V_i H_{i-1}^*) \frac{\varepsilon_{n-(i+2)} \varepsilon_{n-(i+1)}}{k_{n-(i+1)}} g(V_n, X) = g(V_{n-(i+1)}, X), \]
which gives
\[ g(V_{n-(i+1)}, X) = H_i^* g(V_n, X). \]

**Theorem 3.4.** Let \( \alpha : I \subset \mathbb{R} \rightarrow E_1^n \) be a non-null curve in \( E_1^n \) arc-lengthed parameter and \( X \) a unit constant vector field and \( \{V_1, V_2, ..., V_n\} \) and \( \{H_1^*, H_2^*, ..., H_n^*\} \) denote the Frenet frame and the harmonic curvature functions of the curve \( \alpha \), respectively. If \( \alpha : I \subset \mathbb{R} \rightarrow E_1^n \) is a \( V_n \)-slant helix then we have
\[ X = g(V_n, X) \left( \sum_{i=1}^{n-2} H_i^* V_{n-(i+1)} \varepsilon_{n-(i+2)} + \varepsilon_{n-1} V_n \right). \]

**Proof.** If the axis of \( V_n \)-slant helix \( \alpha \) in \( E_1^n \) is \( X \), then we can write
\[ X = \sum_{i=1}^{n} \lambda_i V_i. \]

By using the Theorem(3.3) we get
\[ \lambda_1 = \varepsilon_0 H_{n-2}^* g(V_n, X), \]
\[ \lambda_2 = \varepsilon_1 H_{n-3}^* g(V_n, X), \]
\[ \vdots \]
\[ \lambda_{n-2} = \varepsilon_{n-3} H_1^* g(V_n, X), \]
\[ \lambda_{n-1} = 0, \]
\[ \lambda_n = \varepsilon_{n-1} g(V_n, X). \]
Thus we can easily obtain that
\[ X = g(V_n, X) \left( \sum_{i=1}^{n-2} H_i^* V_{n-(i+1)} \varepsilon_{n-(i+2)} + \varepsilon_{n-1} V_n \right). \]

\[ \square \]

**Theorem 3.5.** Let \( \alpha : I \subset \mathbb{R} \rightarrow E^n_1 \) be a non-null curve in \( E^n_1 \) arc-lengthed parameter, \( X \) be a unit constant vector field and \( \{V_1, V_2, \ldots, V_n\} \), \( \{H_1^*, H_2^*, \ldots, H_{n-2}^*\} \) denote the Frenet frame and the harmonic curvature functions of the curve \( \alpha \), respectively.

If \( \alpha : I \subset \mathbb{R} \rightarrow E^n_1 \) is a \( V_n \)-slant helix, then
\[
\sum_{i=1}^{n-2} \varepsilon_{n-(i+2)} H_i^* = \text{constant}.
\]

**Proof.** Let \( \alpha \) be a \( V_n \)-slant helix with the arc length parameter \( s \). Since \( X \) is a unit vector field, by using Theorem (3.4) we obtain
\[
(g(V_n, X))^2 \left( \varepsilon_{n-1} + \sum_{i=1}^{n-2} \varepsilon_{n-(i+2)} H_i^* \right) = 1. 
\]
Thus we get
\[
\sum_{i=1}^{n-2} \varepsilon_{n-(i+2)} H_i^* = \frac{1 - \varepsilon_{n-1} \lambda_n^2}{\lambda_n^2}.
\]
for some non-zero constant \( \lambda_n \), which completes the proof. \( \square \)

**Definition 3.6.** If \( X \) is the axis of \( V_n \)-slant helix \( \alpha \) in \( E^n_1 \), then from Theorem (3.4) we can write
\[
X = g(V_n, X) \left( \sum_{i=1}^{n-2} H_i^* V_{n-(i+1)} \varepsilon_{n-(i+2)} + \varepsilon_{n-1} V_n \right)
\]
where \( g(V_n, X) = \lambda_n \varepsilon_{n-1} = \text{constant} \). And then we can define a new vector field as
\[
D_L = \varepsilon_0 H_{n-2}^* V_1 + \varepsilon_1 H_{n-3}^* V_2 + \ldots + \varepsilon_{n-3} H_1^* V_{n-2} + \varepsilon_{n-1} V_n
\]
which is an axis of the \( V_n \)-slant helix \( \alpha \).

**Theorem 3.7.** Let \( \alpha : I \subset \mathbb{R} \rightarrow E^n_1 \) be a non-null curve in \( E^n_1 \) arc-lengthed parameter, \( X \) be a unit constant vector field and \( \{V_1, V_2, \ldots, V_n\} \) and \( \{H_1^*, H_2^*, \ldots, H_{n-2}^*\} \) denote the Frenet frame and the harmonic curvature functions for \( V_n \)-slant helix \( \alpha \), respectively. Then \( \alpha \) is a \( V_n \)-slant helix if and only if \( D_L \) is a constant vector field.

**Proof.** Suppose that \( \alpha \) is a \( V_n \)-slant helix in \( E^n_1 \) and \( X \) is the axis of \( \alpha \). From Theorem (3.4), we get
\[
X = g(V_n, X) \left( \sum_{i=1}^{n-2} H_i^* V_{n-(i+1)} \varepsilon_{n-(i+2)} + \varepsilon_{n-1} V_n \right).
\]
From the Eq.(3.3) \( g(V_n, X) \) is a constant and so \( D_L \) is a constant vector field.
Conversely, since $D_L$ is a constant vector field then we can write that

$$X = g(V_n, X)D_L$$

and then

$$g(X, X) = g(V_n, X)g(X, D_L)$$

or since $X$ is a unit vector field, we have

$$g(V_n, X) = \frac{1}{g(X, D_L)}$$

where $g(X, D_L) = \text{constant}$. So, $g(V_n, X)$ is constant and thus $\alpha$ is a $V_n$-slant helix.

**Corollary 1.** Let $\alpha$ be a unit speed curve in $E^3_1$, $\{V_1, V_2, V_3\}$ and $\{k_1, k_2\}$ denote the Frenet frame and curvature functions of the curve $\alpha$, respectively. Then $\alpha$ is a $V_3$-slant helix if and only if $\frac{k_2}{k_1} = \text{constant}$.

**Proof.** Let $\alpha$ be $V_3$-slant helix in $E^3_1$, from Theorem(3.7) for $n = 3$,

$$D_L = \varepsilon_1 \frac{k_2}{k_1} V_1 + \varepsilon_2 V_3 = \text{constant}$$

(3.8)

Differentiation in (3.8) gives

$$\nabla_{V_1} D_L = \varepsilon_1 \left( \frac{k_2}{k_1} \right)' V_1 = 0,$$

or $\frac{k_2}{k_1} = \text{constant}$.

Conversely, if $\frac{k_2}{k_1}$ is constant, $\nabla_{V_1} D_L = 0$ and $D_L = \text{constant}$. From Theorem(3.7) $\alpha$ is a $V_3$-slant helix, which completes the proof. $\square$

**Corollary 2.** Let $\alpha$ be a non-degenerate $W$-curve i.e., all curvatures of the curve are constant in $E^3_1$, $\{V_1, V_2, V_3\}$, $\{k_1, k_2\}$ denote the Frenet frame and curvature functions of the curve $\alpha$, respectively. In this case the curve $\alpha$ is a $V_3$-slant helix.

**Proof.** It is obvious from Corollary 1. $\square$

**Corollary 3.** Let $\alpha$ be a non-degenerate $W$-curve i.e., all curvatures of the curve are constant in $E^4_1$, $\{V_1, V_2, V_3, V_4\}$, $\{k_1, k_2, k_3\}$ denote the Frenet frame and curvature functions of the curve $\alpha$, respectively. In this case the curve $\alpha$ is not a $V_4$-slant helix i.e., $B_2$-slant helix.

**Proof.** Let $\alpha$ be a non-degenerate $W$-curve i.e., all curvatures of the curve are constant in $E^4_1$. From the Definition(3.2) and Definition(3.6) we can write

$$D_L = -\varepsilon_1 \frac{1}{k_1} \left( \frac{k_3}{k_2} \right)' + \varepsilon_2 \frac{k_3}{k_2} V_2 + \varepsilon_3 V_4.$$
where \( k_1, k_2 \) and \( k_3 \) are curvatures of the curve. If all curvatures of the curve are constants, i.e., the curve is a \( W \)-curve, then we get

\[
D_L = \varepsilon_2 \frac{k_3}{k_2} V_2 + \varepsilon_3 V_4.
\]

If we take the derivative of \( W \) we get

\[
\nabla W D_L = -\varepsilon_0 \varepsilon_1 \varepsilon_2 \frac{k_1 k_3}{k_2} V_1.
\]

Since \( \alpha \) is a non-degenerate curve, we obtain that \( \nabla W D_L \neq 0 \) or \( D_L \) is constant vector field. So, from Theorem (3.7) the curve is not \( V_4 \)-slant helix i.e., \( B_2 \)-slant helix.

**Corollary 4.** Let \( \alpha \) be a non-degenerate curve in \( E^4_1 \). If the curve \( \alpha \) is a \( V_4 \)-slant helix i.e., \( B_2 \)-slant helix then,

\[
\left[ \frac{1}{k_1} \left( \frac{k_3}{k_2} \right) \right]' + \varepsilon_0 \varepsilon_1 k_1 \frac{k_3}{k_2} = 0.
\]

**Proof.** Let \( \alpha \) be \( V_4 \)-slant helix i.e., \( B_2 \)-slant helix. From Theorem(3.5) for \( n = 4 \), we have \( \varepsilon_1 H_1^2 + \varepsilon_0 H_2^2 = \text{constant} \). By using the Definition(3.2)

\[
\varepsilon_1 \left( \frac{k_3}{k_2} \right)^2 + \varepsilon_0 \left[ \frac{1}{k_1} \left( \frac{k_3}{k_2} \right) \right]' = \text{constant}.
\]

By taking the derivative of Eq.(3.9) we obtain

\[
\left[ \frac{1}{k_1} \left( \frac{k_3}{k_2} \right) \right]' + \varepsilon_0 \varepsilon_1 k_1 \frac{k_3}{k_2} = 0.
\]

**Theorem 3.8.** Let \( \alpha \) be a non-degenerate curve in \( E^{2m+1}_1 \), and \( \{ H_1^*, H_2^*, \ldots, H_{2m-1}^* \} \) be the harmonic curvature functions of the curve \( \alpha \). If the ratios \( k_2, k_4, k_6, \ldots, k_{2m-2}, k_{2m-1} \) are constant, then we have for \( 2 \leq i \leq m \)

\[
H_{2i-2}^* = 0
\]

and

\[
H_{2i-1}^* = \frac{k_{2m}}{k_{2m-1}} \frac{k_{2m-2}}{k_{2m-3}} \cdots \frac{k_{2m+1-2(i-1)}}{k_{2m+1-(2i-1)}} \varepsilon_{2m-1} \varepsilon_{2m-2} \varepsilon_{2m+1-2i}.
\]

**Proof.** We apply the induction method for the proof.

Let \( i = 1 \):
From Definition (3.2) we may write

\[ H_2^* = (k_{2m-1}H_0^* - \nabla V_1 H_1^) \frac{\varepsilon_{2m-3}\varepsilon_{2m-2}}{k_{2m-2}} \]

\[ H_2^* = \left( -\varepsilon_{2m-2}\varepsilon_{2m-1} \right) ^j \frac{\varepsilon_{2m-3}\varepsilon_{2m-2}}{k_{2m-2}} \]

where \( \frac{k_{2m}}{k_{2m-1}} = \text{constant} \), so

\[ H_2^* = 0, \]

and again Definition (3.2) gives us

\[ H_3^* = (k_{2m-2}H_1^* - \nabla V_1 H_2^* \frac{\varepsilon_{2m-3}}{k_{2m-3}}) \]

By using \( H_2^* = 0 \) and Definition (3.2) we can write

\[ H_2^* = \frac{k_{2m}}{k_{2m-1}} \frac{k_{2m-2}}{k_{2m-3}} \varepsilon_{2m-1} \varepsilon_{2m-2} \varepsilon_{2m-3} \varepsilon_{2m-4} \]

Let us assume that Theorem 3.8 is true for the case \( i = p \), then we may write that

\[ H_{2p+1} = 0 \]

and

\[ H_{2p+1} = \frac{k_{2m}}{k_{2m-1}} \frac{k_{2m-2}}{k_{2m-3}} \varepsilon_{2m-1} \varepsilon_{2m-2} \varepsilon_{2m-3} \varepsilon_{2m-4} \]

Definition (3.2) gives us \( H_{2p} = 0 \) and

\[ H_{2p+1} = (k_{2m-2}H_{2p-1}^* - \nabla V_1 H_{2p}^*) \frac{\varepsilon_{2m-2} \varepsilon_{2m-1} \varepsilon_{2m-3} \varepsilon_{2m-4}}{k_{2m-2p-1}} \]

By using \( H_{2p} = 0 \) and Definition (3.2) we can write

\[ H_{2p+1} = \frac{k_{2m}}{k_{2m-1}} \frac{k_{2m-2}}{k_{2m-3}} \varepsilon_{2m-1} \varepsilon_{2m-2} \varepsilon_{2m-3} \varepsilon_{2m-4} \]

which completes the proof. \( \square \)

**Definition 3.9.** Let \( \alpha \) be a non-degenerate curve in \( E_1^{2m+1} \), and \( \{ H_1^*, H_2^*, \ldots, H_{2m-1}^* \} \) be the harmonic curvature functions of the curve \( \alpha \). If the ratios \( \frac{k_2}{k_1}, \frac{k_3}{k_2}, \ldots, \frac{k_{2m-2}}{k_{2m-3}}, \frac{k_{2m}}{k_{2m-1}} \) are constant, then the curve \( \alpha \) is called \( V_n \)–slant helix in the sense of Hayden, where \( 2 \leq i \leq m \).

**Corollary 5.** Let \( \alpha \) be a non-degenerate curve in \( E_1^{2m+1} \), and \( \{ H_1^*, H_2^*, \ldots, H_{2m-1}^* \} \) be the harmonic curvature functions of the curve \( \alpha \). If the ratios \( \frac{k_2}{k_1}, \frac{k_3}{k_2}, \ldots, \frac{k_{2m-2}}{k_{2m-3}}, \frac{k_{2m}}{k_{2m-1}} \) are constant, then from Theorem (3.7) and Theorem (3.8) we can easily see that the axis of a \( V_n \)–slant helix in the sense of Hayden \( \alpha \) is

\[ D_{V_n} = \varepsilon_{0} H_{2m-1}^* V_1 + \varepsilon_{2} H_{2m-3}^* V_3 + \ldots + \varepsilon_{2m-2} H_1^* V_{2m-1} + \varepsilon_{2m} V_{2m+1}. \]
V_n - SLANT HELIX IN $E^n_1$

Proof. According to Definition (3.6) for $n = 2m + 1$ we have

$$D_L = \epsilon_0 H_{2m-1}^* V_1 + \epsilon_1 H_{2m-2}^* V_2 + \cdots + \epsilon_{2m-2} H_{1}^* V_{2m-1} + \epsilon_{2m} V_{2m+1}$$

where from Theorem(3.8) we get

$$D_L = \epsilon_0 H_{2m-1}^* V_1 + \epsilon_2 H_{2m-3}^* V_3 + \cdots + \epsilon_{2m-2} H_{1}^* V_{2m-1} + \epsilon_{2m} V_{2m+1},$$

which completes the proof.

ÖZET: Bu çalışmada $E^n_1$ n-boyutlu Minkowski uzayında yeni tanımlanlan Harmonik eğrilik fonksiyonları yardımcıyla $V_n$ - slant helis adını verdiği yeni bir slant helis tanımlanmış ve bu helisin $V_n$ cinsinden Harmonik eğrilik fonksiyonları verilmiştir. Ayrıca $E^n_1$ n-boyutlu Minkowski uyazında $V_n$ - slant helis eğrisi boyunca $D_L$ ile gösterilen bir vektör alanı tanımlanmış ve bunu $V_n$ - slant helis Darboux vektör alanı denilmiştir. Bu vektör alanı sayesinde slant helislerin yeni bazı karakterizasyonları verilmiştir.

References


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