The Concircular Curvature Tensor Of The Locally Conformal Kahler Manifold

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DOI: http://dx.doi.org/10.25130/tjps.24.2019.137

ABSTRACT

In this research, we are calculated components conharmonic curvature tensor in some aspects Hermeation manifolding in particular of the Locally Conformal Kahler manifold. And we prove that this tensor possesses the classical symmetry properties of the Riemannian curvature. They also, establish relationships between the components of the tensor in this manifold.

1- Introduction

Concircular curvature tensor is invariant under concircular transformations, i.e. with conformal transformations of space keeping a harmony of functions. The concircular curvature tensor introducer will be Reminded Yano on 1940 as a tensor of type (4, 0) on n-dimensional Riemannian manifold. Conformal transformations of Riemannien structures are the important object of differential geometry, Rawah A.Z. Hassan on 2015 researched concirculac curvature tensor of nearly Kahler manifold, in this paper we investigate the "concirculac curvature tensor of locally conformal Kahler manifold".

2- Preliminaries

Let M –"smooth manifold of dimension 2n", the concircular curvature tensor introducer will be Reminded Yano as a tensor of type (4, 0) on n-dimensional Riemannian manifold. An AH -manifold is called a locally conformal Kahler manifold, if foreach point \( \mathbf{m} \in \mathbf{M} \) there exist an open neighborhood \( \mathcal{U} \) of this point and there exists \( f \in C^\infty(\mathbf{M}) \) such that \( \mathbf{U}_f \) is Kahler manifold. We will denoted to the locally conformal Kahler manifold by L.C.K.

Remark 1.2 [3]

By the Banaru's classification of AH-manifold, the L.C.K- manifold satisfies the following conditions :

\[ B^{abc} = 0, \quad \Psi^2 = a^2 d \delta^b, \quad \text{where} \quad B^{abc} \quad \text{and} \quad \Psi^2 \]

system of function on \( M \).

Theorem 1.3 [4]

The structure equations of L.C.K- manifold in the adjoint \( G \) – structure space is given by the following forms :

1. \( d\omega^a = \omega^b_\alpha \Lambda^a_b + b^c_\alpha \omega^c \Lambda^a_b \)
2. \( d\omega_a = -\omega^b_\alpha \Lambda^a_b + b^c_\alpha \omega^a \Lambda^c_b \)
3. \( d\omega^a_b = \omega^c_\alpha \Lambda^a_c + a^{bd}_c \omega^d \Lambda^a_b + \frac{1}{2} a^{c \delta}_b \omega^d \Lambda^a_b \)
4. \( d\omega^a_b = \omega^c_\alpha \Lambda^a_c + a^{bd}_c \omega^d \Lambda^a_b + \frac{1}{2} a^{c \delta}_b \omega^d \Lambda^a_b \)

Theorem 1.4 [4]

In the adjointG – structure space , the component of Riemannian curvature tensor of L.C.K- manifold are given by the following forms :

1. \( R^a_b = a^{a \delta}_b \delta^a_b + \frac{1}{2} a^{a \delta}_b \delta^a_b \)
2. \( R^a_b = -a^{a \delta}_b \delta^a_b - \frac{1}{2} a^{a \delta}_b \delta^a_b \)
3. \( R^a_b = -2a^{a \delta}_b \delta^a_b \)
4. \( R^a_b = 2a^{a \delta}_b \delta^a_b \)
5. \( R^a_b = a^{a \delta}_b - a^{a \delta}_b \delta^a_b \)

\( f \in C^\infty(\mathbf{M}) \) such that \( \mathbf{U}_f \) is Kahler manifold. We will denoted to the locally conformal Kahler manifold by L.C.K. 

Definition 1.1 [2]

An AH-manifold is called a locally conformal Kahler manifold, if foreach point \( \mathbf{m} \in \mathbf{M} \),there exist an open neighborhood \( \mathcal{U} \) of this point and there exists

\( f \in C^\infty(\mathbf{M}) \) such that \( \mathbf{U}_f \) is Kahler manifold. We will denoted to the locally conformal Kahler manifold by L.C.K. 

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6. \( R^\hat{a}_{bcd} = -A_{ab} + a^b \delta^a_b \), \( R^\hat{c}_{bcd} = A_{bc} - \alpha [a^b \delta^c_a] + \alpha [a^c \delta^b_a] \), \( R^\hat{d}_{bcd} = -A_{bc} + a^c \delta^b_a \)
7. \( R^\hat{a}_{bcd} = A_{bc} - \alpha [a^b \delta^c_a] + \alpha [a^c \delta^b_a] \)
8. \( R^\hat{a}_{bcd} = -A_{ab} + a^b \delta^a_b \)
9. \( R^\hat{a}_{bcd} = A_{bc} - \alpha [a^b \delta^c_a] + \alpha [a^c \delta^b_a] \)
10. \( R^\hat{a}_{bcd} = -A_{ab} + a^b \delta^a_b \), \( R^\hat{c}_{bcd} = A_{bc} - \alpha [a^b \delta^c_a] + \alpha [a^c \delta^b_a] \), \( R^\hat{d}_{bcd} = -A_{bc} + a^c \delta^b_a \)
11. \( R^\hat{a}_{bcd} = -A_{ab} + a^b \delta^a_b \), \( R^\hat{c}_{bcd} = A_{bc} - \alpha [a^b \delta^c_a] + \alpha [a^c \delta^b_a] \), \( R^\hat{d}_{bcd} = -A_{bc} + a^c \delta^b_a \)
12. \( R^\hat{a}_{bcd} = -A_{ab} + a^b \delta^a_b \), \( R^\hat{c}_{bcd} = A_{bc} - \alpha [a^b \delta^c_a] + \alpha [a^c \delta^b_a] \), \( R^\hat{d}_{bcd} = -A_{bc} + a^c \delta^b_a \)
13. \( R^\hat{a}_{bcd} = -A_{ab} + a^b \delta^a_b \), \( R^\hat{c}_{bcd} = A_{bc} - \alpha [a^b \delta^c_a] + \alpha [a^c \delta^b_a] \), \( R^\hat{d}_{bcd} = -A_{bc} + a^c \delta^b_a \)
14. \( R^\hat{a}_{bcd} = -A_{ab} + a^b \delta^a_b \), \( R^\hat{c}_{bcd} = A_{bc} - \alpha [a^b \delta^c_a] + \alpha [a^c \delta^b_a] \), \( R^\hat{d}_{bcd} = -A_{bc} + a^c \delta^b_a \)
15. \( R^\hat{a}_{bcd} = 0 \)
16. \( R^\hat{a}_{bcd} = 0 \)

We need the components of Ricci tensor of \( L.C.K \)-manifold, so we compute it as the following.

**Definition 1.5** [5]
Ricci tensor is tensor of type \((2,0)\) which is defined by \( r_{ab} = R^{cd}_{abc} = g^{cd} R_{cabd} \).

**Theorem 1.6** [6]
In the adjoint \( G \)-structure space, the component of Ricci of \( L.C.K \) manifold are given by the following forms:
1. \( r_{ab} = \alpha c_{[a[b^c d]} + \alpha (b^c d] - \alpha \delta^a_{d]} a^b \delta^c_b \) + \( \alpha \delta^a_{d]} a^b \delta^c_b \) + \( \alpha \delta^a_{d]} a^b \delta^c_b \) + \( \alpha \delta^a_{d]} a^b \delta^c_b \)
2. \( r_{ab} = -\alpha [a^b \delta^c_a] + \alpha \delta^a_{d]} a^b \delta^c_b \) + \( \alpha \delta^a_{d]} a^b \delta^c_b \) + \( \alpha \delta^a_{d]} a^b \delta^c_b \) + \( \alpha \delta^a_{d]} a^b \delta^c_b \)
3. \( r_{ab} = -\alpha [a^b \delta^c_a] + \alpha \delta^a_{d]} a^b \delta^c_b \) + \( \alpha \delta^a_{d]} a^b \delta^c_b \) + \( \alpha \delta^a_{d]} a^b \delta^c_b \) + \( \alpha \delta^a_{d]} a^b \delta^c_b \)
4. \( r_{ab} = -\alpha [a^b \delta^c_a] + \alpha \delta^a_{d]} a^b \delta^c_b \) + \( \alpha \delta^a_{d]} a^b \delta^c_b \) + \( \alpha \delta^a_{d]} a^b \delta^c_b \) + \( \alpha \delta^a_{d]} a^b \delta^c_b \)

**Remark 1.7** [6]
The value of Riemannian metric \( g \) is defined by the form
1. \( g_{ab} = g_{ab} = 0 \), \( g_{ab} = \delta^a_b \), \( g_{ab} = \delta^b_a \)

**Definition 1.8** [5]
Suppose \((M,\xi,\eta)\) is an \( AH \)-manifold, the cocircular curvature of the \( L.C.K \) manifold is defined as tensor \( \mathfrak{L} \) of type \((3,1)\) by the form:
\( \mathfrak{L}_{\xi}(\mu_{\eta}) = \xi_{\mu} = -\frac{1}{n(n-1)}[\eta_{\xi} \mu_{\eta} - \eta_{\xi} \mu_{\eta}] \)
Where \( R \) is Riemannian curvature tensor, \( r \) is Ricci tensor and \( \mathfrak{L} \) is Riemannian matrix and \( \lambda \) scalar curvature.

**Theorem 1.9**
In the adjoint \( G \)-structure space, the components of the cocircular tensor of the \( L.C.K \) manifold are given by the following forms:
1. \( \mathfrak{L}_{\xi}(\mu_{\eta}) = \mathfrak{L}_{\xi}(\mu_{\eta}) = -\frac{1}{n(n-1)}[\eta_{\xi} \mu_{\eta} - \eta_{\xi} \mu_{\eta}] \)
2. \( \mathfrak{L}_{\xi}(\mu_{\eta}) = \mathfrak{L}_{\xi}(\mu_{\eta}) = -\frac{1}{n(n-1)}[\eta_{\xi} \mu_{\eta} - \eta_{\xi} \mu_{\eta}] \)
3. \( \mathfrak{L}_{\xi}(\mu_{\eta}) = \mathfrak{L}_{\xi}(\mu_{\eta}) = -\frac{1}{n(n-1)}[\eta_{\xi} \mu_{\eta} - \eta_{\xi} \mu_{\eta}] \)
4. \( \mathfrak{L}_{\xi}(\mu_{\eta}) = \mathfrak{L}_{\xi}(\mu_{\eta}) = -\frac{1}{n(n-1)}[\eta_{\xi} \mu_{\eta} - \eta_{\xi} \mu_{\eta}] \)
5. \( \mathfrak{L}_{\xi}(\mu_{\eta}) = \mathfrak{L}_{\xi}(\mu_{\eta}) = -\frac{1}{n(n-1)}[\eta_{\xi} \mu_{\eta} - \eta_{\xi} \mu_{\eta}] \)
6. \( \mathfrak{L}_{\xi}(\mu_{\eta}) = \mathfrak{L}_{\xi}(\mu_{\eta}) = -\frac{1}{n(n-1)}[\eta_{\xi} \mu_{\eta} - \eta_{\xi} \mu_{\eta}] \)
7. \( \mathfrak{L}_{\xi}(\mu_{\eta}) = \mathfrak{L}_{\xi}(\mu_{\eta}) = -\frac{1}{n(n-1)}[\eta_{\xi} \mu_{\eta} - \eta_{\xi} \mu_{\eta}] \)

**Proposition 1.10**
The cocircular curvature of \( L.C.K \) manifold satisfies all the properties the algebraic:
1. \( \mathfrak{L}(\mu_{\eta}) = -\mathfrak{L}(\eta_{\xi}) \)
2. \( \mathfrak{L}(\mu_{\eta}) = -\mathfrak{L}(\eta_{\xi}) \)
3. \( \mathfrak{L}(\mu_{\eta}) = -\mathfrak{L}(\eta_{\xi}) \)
4. \( \mathfrak{L}(\mu_{\eta}) = -\mathfrak{L}(\eta_{\xi}) \)

**proof:**
We shall prove just (1) the rest is as proof in the same way 1) $C(LCK)(X_a, X_b, X_c, X_d) = R(X_a, X_b, X_c, X_d) - \frac{1}{n(n-1)} \{g(X_a, X_c) R(X_b, X_d) - g(X_a, X_d) R(X_b, X_c)\}
\quad = -R(X_a, X_b, X_c, X_d) + \frac{1}{n(n-1)} \{g(X_a, X_c) R(X_b, X_d) - g(X_a, X_d) R(X_b, X_c)\} = -R(X_a, X_b, X_c, X_d)
$ Properties are similarly proved:
2) $C(LCK)(X_a, X_b, X_c, X_d) = -R(X_a, X_b, X_c, X_d)$
3) $C(LCK)(X_a, X_b, X_c, X_d) + R(X_a, X_b, X_c, X_d) = 0$
4) $C(LCK)(X_a, X_b, X_c, X_d) = -R(X_a, X_b, X_c, X_d)$ $X_i \in X(M), i = 1, 2, 3, 4$
(1),(2),(3) and (4) is called an algebra curvature tensor of (L.C.K.) manifolds.
The cocircular curvature of (L.C.K.) manifolds looks like
$R(X_a, X_b) X_c = R(X_a, X_b) X_c - \frac{1}{n(n-1)} \{< X_b, X_c > \}$
Where $Q = r$.
By definition of a spectrum tensor.
$R(X_a, X_b) X_c = R(X_a, X_b) X_c - \frac{1}{n(n-1)} \{< X_b, X_c > \}$
$X_a \neq < X_a, X_b > QX_a$

Definition 1.11

$LCK-$ manifold for which $C_i(LCK) = 0$ is $LCK-$manifold of class $C_i(LCK), i = 0, 1, \ldots, 7$.
The manifold of class $C_0(LCK)$ characterized by a condition $C_a^{bcd}(LCK) = 0$, or $C_a^{bcd} = 0$, $[C(LCK)(\epsilon_a, \epsilon_b)] \epsilon_c = 0$.
As $\sigma$ - a projector on $D_j^\perp$, that
$\sigma = [C(LCK)(\epsilon_a, \epsilon_b, \epsilon_c)] \epsilon_d = 0$.

Removing the brackets can be received:

$C(LCK)(X_a, X_b) X_c - C(LCK)(X_a, X_b) X_c - C(LCK)(X_a, X_b) X_c - C(LCK)(X_a, X_b) X_c = -C(LCK)(X_a, X_b) X_c - jC(LCK)(X_a, X_b) X_c - jC(LCK)(X_a, X_b) X_c - jC(LCK)(X_a, X_b) X_c = 0$

Thus $LCK-$ manifold of class $C_0(LCK)$ characterized by identity 2)

$LCK-$ manifold of class $C_0(LCK)$ characterized by identity
$C(LCK)(X_a, X_b) X_c - C(LCK)(X_a, X_b) X_c - C(LCK)(X_a, X_b) X_c = -C(LCK)(X_a, X_b) X_c - jC(LCK)(X_a, X_b) X_c - jC(LCK)(X_a, X_b) X_c - jC(LCK)(X_a, X_b) X_c = 0$

As $\sigma$ - a projector on $D_j^\perp$, that
$\sigma = [C(LCK)(\epsilon_a, \epsilon_b, \epsilon_c)] \epsilon_d = 0$.

Removing the brackets can be received:

$C(LCK)(X_a, X_b) X_c - C(LCK)(X_a, X_b) X_c - C(LCK)(X_a, X_b) X_c - C(LCK)(X_a, X_b) X_c = -C(LCK)(X_a, X_b) X_c - jC(LCK)(X_a, X_b) X_c - jC(LCK)(X_a, X_b) X_c - jC(LCK)(X_a, X_b) X_c = 0$

Thus $LCK-$ manifold of class $C_0(LCK)$ characterized by identity

Theorem 1.12

$LCK-$ manifold of class $C_0(LCK)$ characterized by identity

$C(LCK)(X_a, X_b) X_c - C(LCK)(X_a, X_b) X_c - C(LCK)(X_a, X_b) X_c = -C(LCK)(X_a, X_b) X_c - jC(LCK)(X_a, X_b) X_c - jC(LCK)(X_a, X_b) X_c - jC(LCK)(X_a, X_b) X_c = 0$

The basic invariants cocircular (L.C.K.) manifold will be named.
\( C(LCK) = C_3(LCK) \)

\( C_2(LCK) \)

\( C_1(LCK) = C_3(LCK) \)

\( C_0(LCK) = C_2(LCK) \)

\( C_0(LCK) = C_1(LCK) \)

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\( C_0(LCK) = C_0(LCK) \)
From (7) and (8) we get
\[ \cdots \cdots \cdots (10) \]
From (9) and (10) we get
\[ \cdots \cdots \cdots (11) \]
From (10) and (11) we get
\[ \cdots \cdots \cdots (12) \]
From (9) and (12) we get \( C_1(LCK) = C_2(LCK) \)

Now we shall prove (iii)

\[ C_2(LCK) = \]
\[ C(LCK)(X_a,X_b)X_c + C(LCK)(X_a,X_b)X_c - J(C(LCK)(X_a,X_b))X_c - J(C(LCK)(X_a,X_b))X_c \]
\[ - J(C(LCK)(X_a,X_b))X_c \]
\[ \cdots \cdots \cdots (13) \]

From (13) and (14) we get
\[ \cdots \cdots \cdots (15) \]
From (11) and (15) we get
\[ \cdots \cdots \cdots (16) \]
From (15) and (16) we get \( C_2(LCK) = C_3(LCK) \)

Now we shall prove (iv)

\[ C_3(LCK) = \]
\[ C(LCK)(X_a,X_b)X_c - C(LCK)(X_a,X_b)X_c + J(C(LCK)(X_a,X_b))X_c - J(C(LCK)(X_a,X_b))X_c \]
\[ \cdots \cdots \cdots (17) \]
From (16) and (17) we get
\[ \cdots \cdots \cdots (18) \]
From (15) and (18) we get \( C_2(LCK) = C_4(LCK) \)
From (19) and (20) we get
\[
\text{(21)}
\]
From (22) and (23) we get
\[
\text{(24)}
\]

\textbf{Theorem 1.15}

Let \( \bar{C}(LCK) \) be a locally conformal Kahler manifold, then the following statements are equivalent:
1) \( S - \) structure of class \( \tilde{C}_3(LCK) \)
2) \( \bar{C}_0(LCK) = 0 \)
3) On space of the adjoint \( G - \) structure identities \( C(LCK)_{\bar{b}d\bar{c}d} = 0 \) are fair.

\textbf{Proof:}

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تتسير الانحناء الدائري في منطوي كوهمر المتطابق محليا
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الملخص
في هذا البحث تم احتساب مركبات تتسير الانحناء الدائري في بعض أصناف المنطوي الهرميتي التقريبي وعلى وجه الخصوص منطوي كوهمر الكونغوري المحلي، مع برهنة ان هذا التتسير يمتلك خصائص التناظر الكلاسيكي لتنسير الانحاء الريماني، إضافة إلى ايجاد علاقات بين مركبات التنسير في هذا المنطوي.