INTUITIONISTIC FUZZY I-CONVERGENT DIFFERENCE SEQUENCE SPACES DEFINED BY COMPACT OPERATOR

Esra Kamber
Sakarya University, Institute of Science and Technology
Sakarya, Turkey

Abstract. In this paper, we have introduced and studied the intuitionistic fuzzy I-convergent difference sequence spaces \( I^{(\mu, \nu)}(T, \Delta) \) and \( I^{T(\mu, \nu)}(T, \Delta) \) used by compact operator. Also, we have introduced a new concept, called closed ball in these spaces. With the help of these notions, we have established a new topological space and investigated some topological properties in intuitionistic fuzzy I-convergent difference sequence spaces \( I^{(\mu, \nu)}(T, \Delta) \) and \( I^{T(\mu, \nu)}(T, \Delta) \) used by compact operator.

Key words: intuitionistic fuzzy space, compact operator, topological space.

1. Introduction

Fuzzy set theory introduced by Zadeh [1] has been applied in various fields of mathematics such as the theory of functions [2] and the approximation theory [3]. Fuzzy topology plays an important role in fuzzy theory. It copes with such conditions where the classical theories break down. The intuitionistic fuzzy normed space and intuitionistic fuzzy \( n \)-normed space which were introduced in [4]-[5] are the most contemporary improvements in fuzzy topology. Recently, the definition of I-convergence in intuitionistic fuzzy zweier I-convergent sequence spaces and intuitionistic fuzzy zweier I-convergent double sequence spaces have been studied in [10]-[14].

The notion of statistical convergence was given by Steinhaus [15] and Fast [16] using the definition of density of the set of natural numbers. Many years later,
statistical convergence was discussed by many researchers in the theory of fourier analysis, ergodic theory and number theory. Related studies can be found in [32]-[36]. Some statistical convergence types in intuitionistic fuzzy normed spaces and intuitionistic fuzzy n-normed spaces were studied in [6]-[9] and [28]-[37]. As an extended definition of statistical convergence, definition of I-convergence was introduced by Kostyrko, Salat and Wilczynski [17] by using the idea of I of subsets of the set of natural numbers. Recently, I- and I∗- convergence of double sequences have been studied by Das et. al. [18].

New sequence spaces were introduced by means of various matrix transformations in [24]-[32]. Kızmaz [21] defined the difference sequence spaces with the difference matrix as follows:

\[ X(\Delta) = \{ x = (x_k) : \Delta x \in X \} \]

for \( X = l_\infty, c, c_0 \), where \( \Delta x_k = x_k - x_{k+1} \) and \( \Delta \) denotes the difference matrix \( \Delta = (\Delta_{nk}) \) defined by

\[
\Delta_{nk} = \begin{cases} 
(-1)^{n-k}, & \text{if } n \leq k \leq n+1, \\
0, & \text{if } 0 \leq k < n.
\end{cases}
\]

Recently, Kamber has studied intuitionistic fuzzy difference sequence spaces and intuitionistic fuzzy difference double sequence spaces in [26] and [27].

In this paper, we introduce the intuitionistic fuzzy I-convergent difference sequence spaces \( I^{\mu,\nu}(T, \Delta) \) and \( I^{0,\mu,\nu}(T, \Delta) \) using by compact operator and investigate some topological properties of these new spaces.

2. Basic definitions

In this section, we give some definitions and notations which will be used for this study.

**Definition 2.1.** [19] A binary operation \( \ast : [0, 1] \times [0, 1] \to [0, 1] \) is said to be a continuous t-norm if it satisfies the following conditions:

(i) \( \ast \) is associative and commutative,

(ii) \( \ast \) is continuous,

(iii) \( a \ast 1 = a \) for all \( a \in [0, 1] \),

(iv) \( a \ast b \leq c \ast d \) whenever \( a \leq c \) and \( b \leq d \) for each \( a, b, c, d \in [0, 1] \).

**Definition 2.2.** [19] A binary operation \( \circ : [0, 1] \times [0, 1] \to [0, 1] \) is said to be a continuous t-conorm if it satisfies the following conditions:

(i) \( \circ \) is associative and commutative,

(ii) \( \circ \) is continuous,
(iii) $a \circ 0 = a$ for all $a \in [0, 1]$.
(iv) $a \circ b \leq c \circ d$ whenever $a \leq c$ and $b \leq d$ for each $a, b, c, d \in [0, 1]$.

**Definition 2.3.** [4] The five-tuple $(X, \mu, \nu, *, \circ)$ is said to be intuitionistic fuzzy normed linear space (or shortly IFNLS) is where $X$ is a linear space over a field $F$, $*$ is a continuous $t$-norm, $\circ$ is a continuous $t$-conorm, $\mu, \nu$ are fuzzy sets on $X \times (0, \infty)$, $\mu$ denotes the degree of membership and $\nu$ denotes the degree of nonmembership of $(x, t) \in X \times (0, \infty)$ satisfying the following conditions for every $x, y \in X$ and $s, t > 0$:

(i) $\mu(x, t) + \nu(x, t) \leq 1$,
(ii) $\mu(x, t) > 0$,
(iii) $\mu(x, t) = 1$ if and only if $x = 0$,
(iv) $\mu(\alpha x, t) = \mu(x, \frac{t}{|\alpha|})$ if $\alpha \neq 0$,
(v) $\mu(x, t) * \mu(y, s) \leq \mu(x + y, t + s)$,
(vi) $\mu(x, \cdot) : (0, \infty) \to [0, 1]$ is continuous,
(vii) $\lim_{t \to \infty} \mu(x, t) = 1$ and $\lim_{t \to 0} \mu(x, t) = 0$,
(viii) $\nu(x, t) < 1$,
(ix) $\nu(x, t) = 0$ if and only if $x = 0$,
(x) $\nu(\alpha x, t) = \nu(x, \frac{t}{|\alpha|})$ if $\alpha \neq 0$,
(xi) $\nu(x, t) \circ \nu(y, s) \geq \nu(x + y, s + t)$,
(xii) $\nu(x, \cdot) : (0, \infty) \to [0, 1]$ is continuous,
(xiii) $\lim_{t \to \infty} \nu(x, t) = 0$ and $\lim_{t \to 0} \nu(x, t) = 1$.

In this case $(\mu, \nu)$ is called intuitionistic fuzzy norm.

**Example 2.1.** [4] Let $(X, \| \cdot \|)$ be a normed space, and let $a \ast b = ab$ and $a \circ b = \min\{a + b, 1\}$ for all $a, b \in [0, 1]$. For all $x \in X$ and every $t > 0$, consider

$$
\mu(x, t) := \frac{t}{t + \|x\|} \text{ and } \nu(x, t) := \frac{\|x\|}{t + \|x\|}.
$$

Then $(X, \mu, \nu, \ast, \circ)$ is an IFNLS.

**Definition 2.4.** [4] Let $(X, \mu, \nu, \ast, \circ)$ be an IFNLS. A sequence $x = (x_k)$ in $X$ is convergent to $L \in X$ with respect to the intuitionistic fuzzy norm $(\mu, \nu)$ if, for every $\varepsilon > 0$ and $t > 0$, there exists $k_0 \in \mathbb{N}$ such that $\mu(x_k - L, t) > 1 - \varepsilon$ and $\nu(x_k - L, t) < \varepsilon$ for all $k \geq k_0$ where $k \in \mathbb{N}$. It is denoted by $(\mu, \nu) - \lim x = L$. 
Theorem 2.1. [20] Let \((X, \mu, \nu, *, \circ)\) be an IFNLS. Then, a sequence \(x = (x_k)\) in \(X\) is convergent to \(L \in X\) if and only if
\[
\lim_{k \to \infty} \mu(x_k - L, t) = 1 \quad \text{and} \quad \lim_{k \to \infty} \nu(x_k - L, t) = 0.
\]

Definition 2.5. [17] If \(X\) is a non-empty set, then a family of sets \(I \subset P(X)\) is called an ideal in \(X\) if and only if
\begin{enumerate}
\item \(\emptyset \in I\),
\item for each \(A, B \in I\) implies that \(A \cup B \in I\), and
\item for each \(A \in I\) and \(B \subset A\) we have \(B \in I\),
\end{enumerate}
where \(P(X)\) is the power set of \(X\).

Definition 2.6. [17] If \(X\) is a non-empty set, then a non-empty family of sets \(F \subset P(X)\) is called a filter on \(X\) if and only if
\begin{enumerate}
\item \(\emptyset \notin F\),
\item for each \(A, B \in F\) implies that \(A \cap B \in F\), and
\item for each \(A \in F\) and \(B \supset A\), we have \(B \in F\).
\end{enumerate}

An ideal \(I\) is called non-trivial if \(I \neq \emptyset\) and \(X \notin I\). A non-trivial ideal \(I \subset P(X)\) is called an admissible ideal in \(X\) if and only if \(\{\{x\} : x \in X\} \subseteq I\).

A relation between the concepts of an ideal and a filter is given by the following proposition:

Proposition 2.1. [17] Let \(I \subset P(X)\) be a non-trivial ideal. Then the class \(F = F(I) = \{M \subset X : M = X - A, \text{ for some } A \in I\}\) is a filter on \(X\). \(F = F(I)\) is called the filter associated with the ideal \(I\).

Definition 2.7. [25] Let \(I \subset P(\mathbb{N})\) be a non-trivial ideal and \((X, \mu, \nu, *, \circ)\) be an IFNLS. Then a sequence \(x = (x_k)\) in \(X\) is said to be \(I\)-convergent to \(L \in X\) with respect to the intuitionistic fuzzy linear norm \((\mu, \nu)\) if, for every \(\varepsilon > 0\) and \(t > 0\), the set
\[
\{k \in \mathbb{N} : \mu(x_k - L, t) \leq 1 - \varepsilon \quad \text{or} \quad \nu(x_k - L, t) \geq \varepsilon\} \in I.
\]
In this case, we write \(I(\mu, \nu) - \lim x = L\).

Definition 2.8. [14] Let \(X\) and \(Y\) be two normed linear spaces and \(T : D(T) \to Y\) be a linear operator, where \(D \subset X\). Then the operator \(T\) is said to be bounded, if there exists a positive real \(k\) such that \(||Tx|| \leq k||x||\), for all \(x \in D(T)\). The set of all bounded linear operators \(B(X, Y)\) is a normed linear space normed by \(||T|| = \sup ||Tx|| (x \in X, ||x|| = 1)\) and \(B(X, Y)\) is a Banach space if \(Y\) is a Banach space.
Definition 2.9. [14] Let $X$ and $Y$ be two normed linear spaces. An operator $T : X \to Y$ is said to be a compact linear operator (or completely continuous linear operator,) if

(i) $T$ is linear,

(ii) $T$ maps every bounded sequence $(x_k)$ in $X$ onto a sequence $(T(x_k))$ in $Y$ which has a convergent subsequence. The set of all compact linear operator $C(X,Y)$ is a closed subspace of $B(X,Y)$ and $C(X,Y)$ is Banach space, if $Y$ is a Banach space.

3. Weighted Norlund-Euler $\lambda$-statistical convergence in IFNLS

In this paper, we defined a variant of ideal convergent sequence spaces called intuitionistic fuzzy ideal difference convergent sequence spaces using by compact operator and investigated some topological properties of these spaces.

Intuitionistic fuzzy $I$-convergent difference sequence spaces using by compact operator are introduced as:

$$I^{(\mu, \nu)}(T, \Delta) = \{(x_k) \in I^{(\mu, \nu)}(T, \Delta) : \{k \in \mathbb{N} : \mu(T(\Delta x_k) - L, t) \leq 1 - \varepsilon \text{ or } v(T(\Delta x_k) - L, t) \geq \varepsilon \} \in I\},$$

and

$$I^0(\mu, \nu)(T, \Delta) = \{(x_k) \in I^{(\mu, \nu)}(T, \Delta) : \{k \in \mathbb{N} : \mu(T(\Delta x_k), t) \leq 1 - \varepsilon \text{ or } v(T(\Delta x_k), t) \geq \varepsilon \} \in I\}.$$
Let define the set \( A_3 = A_1 \cup A_2 \). Hence \( A_3 \in I \). It follows that \( A_3 \) is a non-empty set in \( F(I) \). We will prove that for every \((x_k),(y_k) \in I^{(\mu,v)}(T,\Delta)\),

\[
A_3^c \subset \{ k \in \mathbb{N} : \mu \left( T(\Delta x_k) - L_1, t/2|\alpha| \right) > 1 - \varepsilon \mbox{ and } v \left( T(\Delta x_k) - L_1, t/2|\alpha| \right) < \varepsilon \} \subset F(I),
\]

and

\[
A_2^c = \{ k \in \mathbb{N} : \mu \left( T(\Delta y_k) - L_2, t/2|\beta| \right) > 1 - \varepsilon \mbox{ and } v \left( T(\Delta y_k) - L_2, t/2|\beta| \right) < \varepsilon \} \subset F(I).
\]

Then, \( 1 - \varepsilon \geq \mu \left( (\alpha T(\Delta x_m) + \beta L_1(\Delta y_m)) - (\alpha L_1 + \beta L_2), t \right) \geq \mu \left( T(\Delta x_m) - L_1, t/2|\alpha| \right) \mu \left( T(\Delta y_m) - L_2, t/2|\beta| \right) \geq (1 - \varepsilon) \varepsilon > 1 - s \)

and

\[
v \left( ((\alpha T(\Delta x_m) + \beta L_1(\Delta y_m)) - (\alpha L_1 + \beta L_2), t < \varepsilon \right) \leq v \left( T(\Delta x_m) - L_1, t/2|\alpha| \right) v \left( T(\Delta y_m) - L_2, t/2|\beta| \right) < \varepsilon \varepsilon < s.
\]

This proves that

\[
A_3^c \subset \{ k \in \mathbb{N} : \mu \left( (\alpha T(\Delta x_k) + \beta L_1(\Delta y_k)) - (\alpha L_1 + \beta L_2), t \right) > 1 - s \mbox{ and } v \left( (\alpha T(\Delta x_k) + \beta L_1(\Delta y_k)) - (\alpha L_1 + \beta L_2), t \right) < \varepsilon \} . \mbox{ Hence } I^{(\mu,v)}(T,\Delta) \mbox{ is a linear space.} \quad \square
\]

**Theorem 3.2.** Every closed ball \( B_3^c(r,t)(T,\Delta) \) is an open set in \( I^{(\mu,v)}(T,\Delta) \).
Proof. Let \( B_x(r, t)(T, \Delta) \) be an open ball with centre \( x \in I^{(\mu, \nu)}(T, \Delta) \) and radius \( r \in (0, 1) \) with respect to \( t \), i.e.

\[
B_x(r, t)(T, \Delta) = \{ y \in I^{(\mu, \nu)}(T, \Delta) : \langle k \in \mathbb{N} : \mu(T(\Delta x_k) - T(\Delta y_k), t) \leq 1 - r \text{ or } \nu(T(\Delta x_k) - T(\Delta y_k), t) \geq r \rangle \in I \}.
\]

Let \( y \in B_x^c(r, t)(T, \Delta) \). Then \( \mu(T(\Delta x) - T(\Delta y), t) > 1 - r \) and \( \nu(T(\Delta x) - T(\Delta y), t) < r \). Since \( \mu(T(\Delta x) - T(\Delta y), t) > 1 - r \), there exists \( t_0 \in (0, t) \) such that \( \mu(T(\Delta x) - T(\Delta y), t_0) > 1 - r \) and \( \nu(T(\Delta x) - T(\Delta y), t_0) < r \).

Let \( r_0 = \mu(T(\Delta x) - T(\Delta y), t_0) \). Since \( r_0 > 1 - r \), there exists \( s \in (0, 1) \) such that \( r_0 > 1 - s > 1 - r \) and so there exists \( r_1, r_2 \in (0, 1) \) such that \( r_0 * r_1 > 1 - s \) and \( (1 - r_0) * (1 - r_2) < s \).

Let \( r_3 = \max\{r_1, r_2\} \). Then \( 1 - s < r_0 * r_1 \leq r_0 * r_3 \) and \( (1 - r_0) * (1 - r_3) \leq (1 - r_0) * (1 - r_2) < s \).

Consider the closed balls \( B_x^y(1 - r_3, t - t_0)(T, \Delta) \) and \( B_x^c(r, t)(T, \Delta) \). We prove that \( B_x^y(1 - r_3, t - t_0)(T, \Delta) \subseteq B_x^c(r, t)(T, \Delta) \). Let \( z \in B_x^y(1 - r_3, t - t_0)(T, \Delta) \). Then \( \mu(T(\Delta y) - T(\Delta z), t_0) > r_3 \) and \( \nu(T(\Delta y) - T(\Delta z), t - t_0) < 1 - r_3 \). Hence

\[
\mu(T(\Delta x) - T(\Delta z), t) \geq \mu(T(\Delta x) - T(\Delta y), t_0) * \mu(T(\Delta y) - T(\Delta z), t - t_0) > r_0 * r_3 \geq r_0 * r_1 > 1 - s > 1 - r
\]

and

\[
\nu(T(\Delta x) - T(\Delta z), t) \leq \nu(T(\Delta x) - T(\Delta y), t_0) \circ \nu(T(\Delta y) - T(\Delta z), t - t_0) < (1 - r_0) \circ (1 - r_3) < s < r.
\]

Thus \( z \in B_x^c(r, t)(T, \Delta) \) and hence \( B_x^y(1 - r_3, t - t_0)(T, \Delta) \subseteq B_x^c(r, t)(T, \Delta) \). Every closed ball \( B_x^c(r, t)(T, \Delta) \) is an open set in \( I^{(\mu, \nu)}(T, \Delta) \). It proves that \( B_x^c(r, t)(T, \Delta) \) is an open set in \( I^{(\mu, \nu)}(T, \Delta) \).

Remark 3.1. It is clear that \( I^{(\mu, \nu)}(T, \Delta) \) is an IFNLS. Define

\[
\tau^{(\mu, \nu)}(T, \Delta) = \left\{ A \subseteq I^{(\mu, \nu)}(T, \Delta) : \text{for each } x \in A \text{ there exist } t > 0 \text{ and } r \in (0, 1) \right\}
\]

such that \( B_x^c(r, t)(T, \Delta) \subseteq A \).

Then \( \tau^{(\mu, \nu)}(T, \Delta) \) is a topology on \( I^{(\mu, \nu)}(T, \Delta) \).

Theorem 3.3. The topology \( \tau^{(\mu, \nu)}(T, \Delta) \) on \( I^{0(\mu, \nu)}(T, \Delta) \) is first countable.

Proof. It is clear that \( \{ B_x^c(1, 1)(T, \Delta) : n \in \mathbb{N} \} \) is a local base at \( x \in I^{(\mu, \nu)}(T, \Delta) \).

Then the topology \( \tau^{(\mu, \nu)}(T, \Delta) \) on \( I^{0(\mu, \nu)}(T, \Delta) \) is first countable.
Theorem 3.4. \( I^{(\mu,v)}(T, \Delta) \) and \( F^{(\mu,v)}(T, \Delta) \) are Hausdorff spaces.

Proof. Let \( x,y \in I^{(\mu,v)}(T, \Delta) \) such that \( x \neq y \). Then \( 0 < \mu(T(\Delta x) - T(\Delta y), t) < 1 \) and \( 0 < v(T(\Delta x) - T(\Delta y), t) < 1 \).

Let define \( r_1, r_2 \) and \( r \) such that \( r_1 = \mu(T(\Delta x) - T(\Delta y), t) \), \( r_2 = v(T(\Delta x) - T(\Delta y), t) \) and \( r = \max\{r_1, 1 - r_2\} \). Then for each \( r_0 \in (r, 1) \) there exist \( r_3 \) and \( r_4 \) such that \( r_3 \star r_4 \geq r_0 \) and \( (1-r_3) \circ (1-r_4) \leq (1-r_0) \).

Let \( r_5 = \max\{r_3, 1-r_4\} \) and consider the closed balls \( B_r^\mu(1-r_5, \frac{1}{2})(T, \Delta) \) and \( B_r^\nu(1-r_5, \frac{1}{2})(T, \Delta) \). Then clearly \( B_r^\mu(1-r_5, \frac{1}{2})(T, \Delta) \cap B_r^\nu(1-r_5, \frac{1}{2})(T, \Delta) = \emptyset \).

Suppose that \( x \in B_r^\mu(1-r_5, \frac{1}{2})(T, \Delta) \cap B_r^\nu(1-r_5, \frac{1}{2})(T, \Delta) \). Then
\[
\begin{align*}
r_1 &= \mu(T(\Delta x) - T(\Delta y), t) \\
\mu \left( T(\Delta x) - T(\Delta z), \frac{t}{2} \right) &\star \mu \left( T(\Delta y) - T(\Delta z), \frac{t}{2} \right) \\
r_5 \star r_5 &\geq r_4 \star r_4 \geq r_0 > r
\end{align*}
\]
and
\[
\begin{align*}
r_2 &= v(T(\Delta x) - T(\Delta y), t) \\
\nu \left( T(\Delta x) - T(\Delta z), \frac{t}{2} \right) &\circ \nu \left( T(\Delta y) - T(\Delta z), \frac{t}{2} \right) \\
(1-r_5) \circ (1-r_5) &\leq (1-r_3) \circ (1-r_4) \leq (1-r_0) < 1, r,
\end{align*}
\]
which is a contradiction. Hence \( I^{(\mu,v)}(T, \Delta) \) is a Hausdorff space. \( \Box \)

Theorem 3.5. Let \( I^{(\mu,v)}(T, \Delta) \) be an IFNLS, \( \tau^{(\mu,v)}(T, \Delta) \) be a topology on \( I^{(\mu,v)}(T, \Delta) \) and \( (x_k) \) be a sequence in \( I^{(\mu,v)}(T, \Delta) \). Then a sequence \( (x_k) \) is \( \Delta \)-convergent to \( \Delta x_0 \) with respect to the intuitionistic fuzzy linear norm \((\mu, v)\) if and only if \( \mu(T(\Delta x_k) - T(\Delta x_0), t) \to 1 \) and \( v(T(\Delta x_k) - T(\Delta x_0), t) \to 0 \) as \( k \to \infty \).

Proof. Let \( B_{r_0}(r,t)(T, \Delta) \) be an open ball with centre \( x_0 \in I^{(\mu,v)}(T, \Delta) \) and radius \( r, (0, 1) \) with respect to \( t \), i.e.
\[
B_{r_0}(r,t)(T, \Delta) = \{(x_k) \in I^{(\mu,v)}(T, \Delta) : \\
\{k \in \mathbb{N} : \mu(T(\Delta x_k) - T(\Delta x_0), t) \leq 1-r \text{ or } v(T(\Delta x_k) - T(\Delta x_0), t) \geq r\} \in I\}.
\]
Suppose that a sequence \( (x_k) \) in \( I^{(\mu,v)}(T, \Delta) \) is \( \Delta \)-convergent to \( \Delta x_0 \) with respect to the intuitionistic fuzzy linear norm \((\mu, v)\). Then for \( r \in (0, 1) \) and \( t > 0 \), there exists \( k_0 \in \mathbb{N} \) such that \( (x_k) \in B_{r_0}(r,t)(T, \Delta) \) for all \( k \geq k_0 \). Thus
\[
\{k \in \mathbb{N} : \mu(T(\Delta x_k) - T(\Delta x_0), t) > 1-r \text{ and } v(T(\Delta x_k) - T(\Delta x_0), t) < r\} \in F(I).
\]
So \( 1 - \mu(T(\Delta x_k) - T(\Delta x_0), t) < r \) and \( v(T(\Delta x_k) - T(\Delta x_0), t) < r \), for all \( k \geq k_0 \). Then \( \mu(T(\Delta x_k) - T(\Delta x_0), t) \to 1 \) and \( v(T(\Delta x_k) - T(\Delta x_0), t) \to 0 \) as \( k \to \infty \).
Conversely, for each \( t > 0 \) and \( k \in \mathbb{N} \), suppose that \( \mu(T(\Delta x_k) - T(\Delta x_0), t) \to 1 \) and \( v(T(\Delta x_k) - T(\Delta x_0), t) \to 0 \) as \( k \to \infty \). Then for \( r \in (0, 1) \), there exists \( k_0 \in \mathbb{N} \) such that \( 1 - \mu(T(\Delta x_k) - T(\Delta x_0), t) < r \) and \( v(T(\Delta x_k) - T(\Delta x_0), t) < r \) for all \( k \geq k_0 \). So, \( \mu(T(\Delta x_k) - T(\Delta x_0), t) > 1 - r \) and \( v(T(\Delta x_k) - T(\Delta x_0), t) < r \) for all \( k \geq k_0 \). Hence \( (x_k) \in B^r_{\mu}(r,t) \) for all \( k \geq k_0 \). This proves that a sequence \( (x_k) \) is \( \Delta \)-convergent to \( \Delta x_0 \) with respect to the intuitionistic fuzzy linear norm \((\mu, v)\).

REFERENCES

12. V.A. Khan, Yasmeen, H. Fatima and A. Ahmed, Intuitionistic Fuzzy Zweier \( I \)-convergent Double Sequence Spaces defined by Orlicz function, EJPAM, 10(3) (2017) 574-585.