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Generalized Intuitionistic Fuzzy Ideals Topological Spaces

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Abstract In this paper we introduce the notion of generalized intuitionistic fuzzy ideals which is considered as a generalization of fuzzy intuitionistic ideals studies in[6], the important generalized intuitionistic fuzzy ideals has been given. The concept of generalized intuitionistic fuzzy local function is also introduced for a generalized intuitionistic fuzzy topological space. These concepts are discussed with a view to find new generalized intuitionistic fuzzy topology from the original one in[5, 7]. The basic structure, especially a basis for such generated generalized intuitionistic fuzzy topologies and several relations between different generalized intuitionistic fuzzy ideals and generalized intuitionistic fuzzy topologies are also studied here.

Keywords Generalized Intuitionistic Fuzzy Ideals, Intuitionistic Fuzzy Ideals, Intuitionistic Fuzzy Local Function

1. Introduction

The concept of fuzzy sets and fuzzy set operations was first introduced by Zadeh[9]. Accordingly, fuzzy topological spaces were introduced by Chang[4]. Several researches were the generalizations of the notion of fuzzy set. The idea of intuitionistic fuzzy set (IFS, for short) was first published by Atanassov[1, 2, 3]. Subsequently, Tapas et al.[8] defined the notion of generalized intuitionistic fuzzy set and studied the basic concept of generalized intuitionistic fuzzy topology. Our aim in this paper is to extend those ideas of general topology in generalized intuitionistic fuzzy topological space (GIFTS, in short). In section 3, we define generalized intuitionistic fuzzy ideal for a set. Here we generalize the concept of intuitionistic fuzzy ideal topological concepts, first initiated by Salama et al.[6] in the case of generalized intuitionistic fuzzy sets. In section 4, we introduce the notion of the generalized intuitionistic fuzzy local function corresponding to GIFTS. Recently we have deduced some characterization theorems for such concepts exactly analogous to general topology and succeeded in finding out the generated new generalized intuitionistic fuzzy topologies for any GIFTS.

2. Preliminaries

Deifintion.2.1.[6] A nonempty collection of intuitionistic fuzzy sets L of a set X is called intuitionistic fuzzy ideal on X iff i) $A \in L$ and B $\subseteq$ A $\Rightarrow$ $B \in L$ (heredity), (ii) $A \in L$ and $B \in L$ $\Rightarrow$ A $\vee$ B$\in$L (finite additivity).

We shall present the fundamental definitions given by Tapas:

Definition 2.2.[8]. Let X is a nonempty fixed set. An generalized intuitionistic fuzzy set (IFS for short) A is an object having the form $A = \{\langle x, \mu_A(x), \nu_A(x) : x \in X\rangle\}$ where the function $\mu_A : X \to [0,1]$ and $\nu_A : X \to [0,1]$ denote the degree of membership(namely $\mu_A(x)$) and the degree of non membership(namely $\nu_A(x)$) of each element $x \in X$ to the set A, respectively, and $\mu_A(x) \wedge \nu(x) \le 0.5$ for all $x \in X$.

Remark. 2.1. For the sake of simplicity, we shall use the symbol $A = \langle x, \mu_A, \nu_A \rangle$ for the GIFS $A = \{\langle x, \mu_A(x), \nu_A(x) : x \in X\rangle\}$.

Definition2.3.[8]. $O_\sim = \{\langle < x,0,1 >: x \in X\rangle\}$ and $1_\sim = \{\langle x,1,0\rangle : x \in X\}$ are empty and universal generalized inuitionistic fuzzy sets

Definition 2.4.[8]. A generalized intuitionistic fuzzy topology (GIFT for short) on a nonempty set X is a family τ of GIFSs in X satisfying the axioms in[8].

3. Basic Properties of Generalized Intuitionistic Fuzzy Ideals

Definition 3.1. Let X is non-empty set and L a family of GIFSs. We will call L is a generalized intuitionistic fuzzy ideal (GIFL for short) on X if

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$i) A \in L$ and $B \subseteq A \Rightarrow B \in L$ [heredity],

$ii) A \in L$ and $B \in L \Rightarrow A \vee B \in L$ [Finite additivity].

A generalized intuitionistic Fuzzy Ideal L is called a σ - generalized intuitionistic fuzzy ideal if $\{A_j\}_{j \in N} \leq L$, implies $\vee_{j \in J} A_j \in L$ (countable additivity).

The smallest and largest generalized intuitionistic fuzzy ideals on a non-empty set X are $\{0_{\sim}\}$ and GIFSs on X. Also, $GIF.L_f$, $GIF.L_c$ are denoting the generalized intuitionistic fuzzy ideals (GIFLS for short) of fuzzy subsets having finite and countable support of X respectively. Moreover, if A is a nonempty GIFS in X, then $\{B \in GIFS : B \subseteq A\}$ is an GIFL on X. This is called the principal GIFL of all IFSs of denoted by GIFL$\langle A \rangle$.

Remark 3.1.

i) If $1_{\sim} = \{\langle x,1,0 \rangle : x \in X\} \notin$ L, then L is called generalized intuitionistic fuzzy proper ideal.

ii) If $1_{\sim} \in$ L, then L is called generalized intuitionistic fuzzy improper ideal.

iii) $O_{\sim} = \{\langle x,0,1 \rangle : x \in X\} \in$ L.

Example.3.1. Let $A = \langle x,0.2,0.4 \rangle$, $B = \langle x,0.5,0.6 \rangle$, and $D = \langle x,0.5,0.3 \rangle$, then the family $L = \{O_{\sim}, A, B, D\}$ of GIFSs is an GIFL on X.

Example.3.3. Let $X = \{a,b,c,d,e\}$ and $A = \langle x, \mu_A, \nu_A \rangle$ given by :

X	$\mu_A(x)$	$\nu_A(x)$	$\mu_A(x) \wedge \nu_A(x)$
a	0.6	0.3	0.3
b	0.5	0.3	0.3
c	0.4	0.4	0.4
d	0.3	0.5	0.3
e	0.3	0.6	0.3

Then the family GIF $L = \{O_{\sim}, A\}$ is an GIFL on X.

Definition 3.2. Let L_1 and L_2 be two GIFLs on X. Then L_2 is said to be finer than L_1 or L_1 is coarser than L_2 if $L_1 \leq L_2$. If also $L_1 \neq L_2$. Then L_2 is said to be strictly finer than L_1 or L_1 is strictly coarser than L_2.

Two GIFLs said to be comparable, if one is finer than the other. The set of all GIFLs on X is ordered by the relation L_1 is coarser than L_2 this relation is induced the inclusion in IFSs.

The next Proposition is considered as one of the useful result in this sequel, whose proof is clear.

Proposition 3.1. Let $\{L_j : j \in J\}$ be any non - empty family of generalized intuitionistic fuzzy ideals on a set X. Then $\bigcap_{j \in J} L_j$ and $\bigcup_{j \in J} L_j$ are generalized intuitionistic fuzzy ideal on X, where $\bigcap_{j \in J} L_j = \langle \wedge \mu_{L_j}, \vee \mu_{L_j} \rangle$ and

$\wedge \mu_{L_j}(x) = \inf\{\mu_{A_i}(x) : i \in J, x \in X\}$

$\vee \nu_{L_j}(x) = \sup\{\nu_{A_i}(x) : i \in J, x \in X\}$.

In fact L is the smallest upper bound of the set of the L_j in the ordered set of all generalized intuitionistic fuzzy ideals on X.

Remark3.2. The generalized intuitionistic fuzzy ideal by the single generalized intuitionistic fuzzy set $O_{\sim} = \{\langle x,0,1 \rangle : x \in X\}$ is the smallest element of the ordered set of all generalized intuitionistic fuzzy ideals on X.

Proposition.3.3 A GIFS A in generalized intuitionistic fuzzy ideal L on X is a base of L iff every member of L contained in A.

Proof.(Necessity) Suppose A is a base of L. Then clearly every member of L contained in A.

(Sufficiency) Suppose the necessary condition holds. Then the set of generalized intuitionistic fuzzy subset in X contained in A coincides with L by the Definition 3.1.

Proposition.3.4. For a generalized intuitionistic fuzzy ideal L_1 with base A, is finer than a fuzzy ideal L_2 with base B iff every member of B contained in A.

Proof. Immediate consequence of Definitions

Corollary.3.1. Two generalized intuitionistic fuzzy ideals bases A, B, on X are equivalent iff every member of A, contained in B and via versa.

Theorem.3.1. Let $\eta = \{\mu_j : j \in J\}$ be a non empty collection of generalized intuitionistic fuzzy subsets of X. Then there exists a generalized intuitionistic fuzzy ideal $L(\eta) = \{A \in IFSs : A \subseteq \vee A_j\}$ on X for some finite collection $\{A_j : j = 1,2, \ldots\ldots, n \subseteq \eta\}$.

Proof : Clear.

Remark.3.3

ii) The generalized intuitionistic fuzzy ideal $L(\eta)$ defined above is said to be generated by η and η is called subbase of $L(\eta)$.

Corollary.3.2. Let L_1 be an generalized intuitionistic fuzzy ideal on X and A $\in$ IFSs, then there is a generalized intuitionistic fuzzy ideal L_2 which is finer than L_1 and such that $A \in L_2$ iff $A \vee B \in L_2$ for each $B \in L_1$.

Theorem.3.2. If an GIFS $L = \{O_{\sim}, \langle \mu_A, \nu_A \rangle\}$ is an generalized intuitionistic fuzzy ideal on X, then so is □ $L = \{O_{\sim}, \langle \mu_A, \bar{\mu}_A \rangle\}$ is an generalized intuitionistic fuzzy ideal on X.

Proof. Clear

Theorem.3.3. A GIFS $L = \{O_{\sim}, \langle \mu_A, \nu_A \rangle\}$ is a generalized intuitionistic fuzzy ideal on X iff the intuitionistic fuzzy sets μ_A, and $\bar{\nu}_A$ are generalized intuitionistic fuzzy ideals on X.

Proof. Let $L=\{O_{\sim},\langle\mu_A,\nu_A\rangle\}$ be an GIFL of X, $A=\langle x,\mu_A,\nu_A\rangle$, Ten clearly μ_A is a fuzzy ideal on X. Then $\underset{A}{\bar{\nu}}(x)=1-\nu_A(x)=\max\left\{\left(\underset{A}{\bar{\nu}}(x),0\right)\right\}=\min\left\{1,\bar{\nu_A}(x)\right\}$ if $\underset{A}{\bar{\nu}}(x)=O_x$. Then is the smallest generalized intuitionistic fuzzy ideal , Or $\underset{A}{\bar{\nu}}(x)=1_x$ then is the largest generalized intuitionistic fuzzy ideal on X.

Corollary.3.3. A GIFS $L=\{O_{\sim},\langle\mu_A,\nu_A\rangle\}$ is an generalized intuitionistic fuzzy ideal on X iff

□L= $\left\{O_{\sim},\left\langle\mu_A,\bar{\mu_A}\right\rangle\right\}$ and ◊ $L=\left\{O_{\sim},\left\langle\underset{A}{\bar{\nu}},\nu_A\right\rangle\right\}$ are generalized intuitionistic fuzzy ideals on X.

Proof. Clear from the definition 3.1.

Example.3.4. Let X a non empty set and GIFL on X given by: $L=\{O_{\sim},\langle 0.3,0.6\rangle,\langle 0.3,0.5\rangle\langle 0.2,0.5\rangle\}$.Then □L = $\{O_{\sim},\langle 0.3,0.7\rangle,\langle 0.2,0.8\rangle\}$ and◊ $L=\{O_{\sim},\langle 0.4,0.0.6\rangle,\langle 0.5,0.5\rangle\}$. and □L ⊆ ◊L.

Theorem.3.4. Let $A=\langle x,\mu_A,\nu_A\rangle\in L_1$ and $B=\langle x,\mu_B,\nu_B\rangle\in L_2$, where L_1 and L_2 are generalized intuitionistic fuzzy ideals on the set X. then the generalized intuitionistic fuzzy set $A*B=\langle\mu_{A*B}(x),\nu_{A*B}(x)\rangle\in L_1\vee L_2$ on X. and $\mu_{A*B}(x)=\vee\{\mu_A(x)\wedge\mu_B(x):x\in X\}$, and $\nu_{A*B}(x)=\wedge\{\nu_A(x)\vee\nu_B(x):x\in X\}$.

Definition.3.4 For a GIFTS (X, τ), A ∈ GIFSs. Then A is called

i) Generalized intuitionistic fuzzy dense if cl (A) = $1_{\sim}$.

ii) Generalized intuitionistic fuzzy nowhere dense subset if Int (cl(A))= $O_{\sim}$.

iii) Generalized intuitionistic fuzzy codense subset if Int (A) = $O_{\sim}$.

v) Generalized intuitionistic fuzzy countable subset if it is a finite or has the some cardinal number.

iv) Generalized intuitionistic fuzzy meager set if it is a generalized intuitionistic fuzzy countable union of generalized intuitionistic fuzzy nowhere dense sets.

The following important Examples of generalized intuitionistic fuzzy ideals on GIFTS (X.τ).

Example.3.5. For a GIFTS (X, τ) and L_n = {A ∈GIFSs : Int (cl(A)) = $O_{\sim}$ is the collection of generalized intuitionistic fuzzy nowhere dense subsets of X. It is a simple task to show that L_n is generalized intuitionistic fuzzy ideal on X.

Example.3.6 For a IFTS (X,τ) and L_m = {A ∈ IFSs: A is a countable union of generalized intuitionistic fuzzy nowhere dense sets} the collection of generalized intuitionistic fuzzy meager sets on X. one can deduce that L_m is generalized intuitionistic fuzzy σ - ideal on X.

Example.3.7. For a IFTS (X, τ) with generalized intuitionistic fuzzy ideal L. then

< L ∩ τ^c > = {A ∈ IFSs : there exists B ∈ L ∩ τ^c such that A ⊆ B} is a generalized intuitionistic fuzzy ideal on X.

Example.3.8. Let f: (X,τ_1) (Y, τ_2) be a function, and L, J are two generalized intuitionistic fuzzy ideals on X and Y respectively. Then

i) f (L) = {f (A): A ∈ L} is an generalized intuitionistic fuzzy ideal.

ii) If f is injection. Then f^{-1} (J) is generalized intuitionistic fuzzy ideal on X.

4. Generalized Intuitionistic Fuzzy local Functions and $*-$GIFTS

Definition.4.1. Let (X, τ) be an generalized intuitionistic fuzzy topological spaces (GIFTS for short) and L be generalized intuitionistic fuzzy ideal (GIFL, for short) on X. Let A be any GIFS of X. Then the generalized intuitionistic fuzzy local function $A^*(L,\tau)$ of A is the union of all generalized intuitionistic fuzzy points (IFP, for short) $C(\alpha,\beta)$ such that if $U\in N(C(\alpha,\beta))$ and $A^*(L,\tau)=\vee\{C(\alpha,\beta)\in X:A\wedge U\notin L$ for every U nbd of $C(\alpha,\beta)\}$ $A^*(L,\tau)$ is called an generalized intuitionistic fuzzy local function of A with respect to τ and L which it will be denoted by $A^*(L,\tau)$, or simply $A^*(L)$.

Example .4.1. One may easily verify that.

If L= {$0_{\sim}$}, then $A^*(L,\tau)=cl(A)$, for any generalized intuitionistic fuzzy set $A\in GIFSs$ on X.

If $L=\{\text{all GIFSs on X}\}$ then $A^*(L,\tau)=0_{\sim}$, for any $A\in GIFSs$ on X .

Theorem.4.1. Let (X,τ) be a GIFTS and L_1,L_2 be two generalized intuitionistic fuzzy ideals on X. Then for any generalized intuitionistic fuzzy sets A, B of X. then the following statements are verified

i) $A\subseteq B\Rightarrow A^*(L,\tau)\subseteq B^*(L,\tau)$,

ii) $L_1\subseteq L_2\Rightarrow A^*(L_2,\tau)\subseteq A^*(L_1,\tau)$.

iii) $A^*=cl(A^*)\subseteq cl(A)$.

iv) $A^{**}\subseteq A^*$.

v) $(A\vee B)^*=A^*\vee B^*$.,

vi) $(A\wedge B)^*(L)\leq A^*(L)\wedge B^*(L)$.

vii) $\ell\in L\Rightarrow(A\vee\ell)^*=A^*$.

$A^*(L,\tau)$ is generalized intuitionistic fuzzy closed set .

Proof.

i) Since $A \subseteq B$, let $p = C(\alpha,\beta) \in A^*(L_1)$ then $A \wedge U \notin L$ for every $U \in N(p)$. By hypothesis we get $B \wedge U \notin L$, then $p = C(\alpha,\beta) \in B^*(L_1)$.

ii) Clearly. $L_1 \subseteq L_2$ implies $A^*(L_2,\tau) \subseteq A^*(L_1,\tau)$ as there may be other IFSs which belong to L_2 so that for GIFP $p = C(\alpha,\beta) \in A^*$ but $C(\alpha,\beta)$ may not be contained in $A^*(L_2)$.

iii) Since $\{O_\sim\} \subseteq L$ for any GIFL on X, therefore by (ii) and Example 4.1, $A^*(L) \subseteq A^*(\{O_\sim\}) = cl(A)$ for any GIFS A on X. Suppose $p_1 = C_1(\alpha,\beta) \in cl(A^*(L_1))$. So for every $U \in N(p_1)$, $A^* \wedge U \neq O_\sim$, there exists $p_2 = C_2(\alpha,\beta) \in A^*(L_1) \wedge U)$ such that for every V nbd of $p_2 \in N(p_2), A \wedge U \notin L.$ Since $U \wedge V \in N(p_2)$ then $A \wedge (U \cap V) \notin L$ which leads to $A \wedge U \notin L$, for every $U \in N(C(\alpha,\beta))$ therefore $p_1 = C(\alpha,\beta) \in (A^*(L))$ and so $cl(A^*) \leq A^*$ While, the other inclusion follows directly. Hence $A^* = cl(A^*)$. But the inequality $A^* \leq cl(A^*)$.

iv) The inclusion $A^* \vee B^* \leq (A \vee B)^*$ follows directly by (i). To show the other implication, let $p = C(\alpha,\beta) \in (A \vee B)^*$ then for every $U \in N(p)$, $(A \vee B) \wedge U \notin L, i.e,$ $(A \wedge U) \vee (B \wedge U) \notin L.$ then, we have two cases $A \wedge U \notin L$ and $B \wedge U \in L$ or the converse, this means that exist $U_1, U_2 \in N(C(\alpha,\beta)$ such that $A \wedge U_1 \notin L$, $B \wedge U_1 \notin L,$ $A \wedge U_2 \notin L$ and $B \wedge U_2 \notin L$. Then $A \wedge (U_1 \wedge U_2) \in L$ and $B \wedge (U_1 \wedge U_2) \in L$ this gives $(A \vee B) \wedge (U_1 \wedge U_2) \in L,$ $U_1 \wedge U_2 \in N(C(\alpha,\beta)$ which contradicts the hypothesis. Hence the equality holds in various cases.

vi) By (iii), we have $A^{**} = cl(A^*)^* \leq cl(A^*) = A^*$

Let (X,τ) be a GIFTS and L be GIFL on X . Let us define the generalized intuitionistic fuzzy closure operator $cl^*(A) = A \cup A^*$ for any GIFS A of X. Clearly, let $cl^*(A)$ is a generalized intuitionistic fuzzy operator. Let $\tau^*(L)$ be GIFT generated by cl^* .i.e $\tau^*(L) = \{A : cl^*(A^c) = A^c\}$. Now $L = \{O_\sim\} \Rightarrow$ $cl^*(A) = A \cup A^* = A \cup cl(A)$ for every generalized intuitionistic fuzzy set A. So, $\tau^*(\{O_\sim\}) = \tau$. Again $L = \{all \text{ GIFSs on X}\} \Rightarrow cl^*(A) = A,$ because $A^* = O_\sim$, for every generalized intuitionistic fuzzy set A so $\tau^*(L)$ is the generalized intuitionistic fuzzy discrete topology on X. So we can conclude by Theorem 4.1.(ii). $\tau^*(\{O_\sim\}) = \tau^*(L)$ i.e. $\tau \subseteq \tau^*$, for any generalized intuitionistic fuzzy ideal L_1 on X. In particular, we have for two generalized intuitionistic fuzzy ideals L_1, and L_2 on X, $L_1 \subseteq L_2 \Rightarrow \tau^*(L_1) \subseteq \tau^*(L_2)$.

Theorem.4.2. Let τ_1, τ_2 be two generalized intuitionistic fuzzy topologies on X. Then for any generalized intuitionistic fuzzy ideal L on X, $\tau_1 \leq \tau_2$ implies

$A^*(L,\tau_2) \subseteq A^*(L,\tau_1)$ for every A $\in L$.

$\tau^*{}_1 \subseteq \tau^*{}_2$

Proof. Clear.

A basis $\beta(L,\tau)$ for $\tau^*(L)$ can be described as follows:

$\beta(L,\tau) = \{A - B : A \in \tau, B \in L\}$ Then we have the following theorem

Theorem 4.3. $\beta(L,\tau) = \{A - B : A \in \tau, B \in L\}$ Forms a basis for the generated GIFT of the GIFT (X,τ) with generalized intuitionistic fuzzy ideal L on X.

Proof. Straight forward.

The relationship between τ and τ^* (L) established throughout the following result which have an immediately proof.

Theorem 4.4. Let τ_1, τ_2 be two generalized intuitionistic fuzzy topologies on X. Then for any generalized intuitionistic fuzzy ideal L on X, $\tau_1 \subseteq \tau_2$ implies $\tau^*{}_1 \subseteq \tau^*{}_2$.

Theorem 4.5 : Let (X,τ) be a GIFTS and L_1, L_2 be two generalized intuitionistic fuzzy ideals on X . Then for any generalized intuitionistic fuzzy set A in X, we have

i) $A^*(L_1 \vee L_2, \tau) = A^*(L_1, \tau^*(L_1)) \wedge A^*(L_2, \tau^*(L_2))$

ii) $\tau^*(L_1 \vee L_2) = (\tau^*(L_1))^*(L_2) \wedge (\tau^*(L_2))^*(L_1)$

Proof Let $p = C(\alpha,\beta) \notin (L_1 \vee L_2, \tau),$ this means that there exists $U_p \in N(P)$ such that $A \wedge U_p \in (L_1 \vee L_2)$ i.e. There exists $\ell_1 \in L_1$ and $\ell_2 \in L_2$ such that $A \wedge U_p \in (\ell_1 \vee \ell_2)$ because of the heredity of L $_1$, and assuming $\ell_1 \wedge \ell_2 = O_\sim$ .Thus we have $(A \wedge U_p) - \ell_1 = \ell_2$ and $(A \wedge U_p) - \ell_2 = \ell_1$ therefore $(U_p - \ell_1) \wedge A = \ell_2 \in L_2$ and $(U_p - \ell_2) \wedge A = \ell_1 \in L_1$. Hence

$p = C(\alpha,\beta) \notin A^*\left(L_2, \tau^*(L_1)\right)$, or $p = C(\alpha,\beta) \notin A^*\left(L_1, \tau^*(L_2)\right)$, because p must belong to either ℓ_1 or ℓ_2 but not to both. This gives $A^*(L_1 \vee L_2, \tau) \geq A^*\left(L_1, \tau^*(L_1)\right) \wedge A^*\left(L_2, \tau^*(L_2)\right)$ .To show the second inclusion, let us assume $p = C(\alpha,\beta) \notin A^*\left(L_1, \tau^*(L_2)\right)$, . This implies that there exist $U_p \in N(P)$ and $\ell_2 \in L_2$ such that $\left(U_p - \ell_2\right) \wedge A \in L_1$. By the heredity of L_2, if we assume that $\ell_2 \leq A$ and define $\ell_1 = \left(U_p - \ell_2\right) \wedge A$. Then we have $A \wedge U_p \in (\ell_1 \vee \ell_2) \in L_1 \vee L_2$. Thus, $A^*(L_1 \vee L_2, \tau) \leq A^*\left(L_1, \tau^*(L_1)\right) \wedge A^*\left(L_2, \tau^*(L_2)\right)$ and similarly, we can get $A^*(L_1 \vee L_2, \tau) \leq A^*\left(L_2, \tau^*(L_1)\right)$. This gives the other inclusion, which complete the proof.

Corollary 4.1. Let (X, τ) be a GIFTS with generalized intuitionistic fuzzy ideal L on X. Then

i)

$A^*(L,\tau) = A^*(L,\tau^*)$ and $\tau^*(L) = (\tau^*(L))^*(L)$.

ii) $\tau^*(L_1 \vee L_2) = \left(\tau^*(L_1)\right) \vee \left(\tau^*(L_2)\right)$

Proof. Follows by applying the previous statement.

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