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Intuitionistic (α,β)-Fuzzy H_v-Ideals

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Abstract- Atanassov introduced the notion of intuitionistic fuzzy sets as a generalization of the notion of fuzzy sets. In this paper we introduce the concept of an intuitionistic (α,β)-fuzzy H_v-ideal of an H_v-ring by using the notion of "belongingness $(\in)$" and "quasi-coincidence (q)" of fuzzy points with fuzzy sets, where $\alpha \in \{\in, q\}$, $\beta \in \{\in, q, \in \vee q, \in \wedge q\}$ and, then we investigate the basic properties of these notions.

Mathematics Subject Classification: 20N20

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1. Introduction

The concept of hyperstructure was introduced in 1934 by Marty [4]. Hyperstructures have many applications to several branches of pure and applied sciences. Vougiouklis [13] introduced the notion of H_v-structures, and Davvaz [1] surveyed the theory of H_v-structures. After the introduction of fuzzy sets by Zadeh [8], there have been a number of generalizations of this fundamental concept. The notion of intuitionistic fuzzy sets introduced by Atanassov [5] is one among them. For more details on intuitionistic fuzzy sets, we refer the reader to [6, 7].

The idea of quasi-coincidence of a fuzzy point with a fuzzy set, which is mentioned in [10], played a vital role to generate some different types of fuzzy subgroups. Bhakat and Das [11, 12] gave the concepts of (α,β)-fuzzy subgroups by using the notion of "belongingness ($\in$)" and "quasi-coincidence (q)" between a fuzzy point and a fuzzy subgroup, where α, β are any two of $\{\in, q, \in \vee q, \in \wedge q\}$ with $\alpha \neq \in \wedge q$, and introduced the concept of an $(\in, \in \vee q)$-fuzzy subgroup. In [15] Yuan, Li et al. redefined (α,β)-intuitionistic fuzzy subgroups. M. Asghari-Larimi [9] gave intuitionistic (α,β)-fuzzy H_v-submodules. This paper continues this line of research for fuzzy H_v-ideals of H_v-rings. The paper is organized as follows: in section 2 some fundamental definitions on H_v-structures and fuzzy sets are explored, in section 3 we define intuitionistic (α,β)-fuzzy H_v-ideals and establish some useful theorems.

2. Basic Definitions

We first give some basic definitions for proving the further results.

Definition 2.1 [3]
Let X be a non-empty set. A mapping $\mu : X \to [0,1]$ is called a fuzzy set in X. The complement of μ, denoted by μ^c, is the fuzzy set in X given by

$$\mu^c(x) = 1 - \mu(x) \quad \forall x \in X .$$

Definition 2.2 [3]

An intuitionistic fuzzy set A in a non-empty set X is an object having the form $A = \{(x, \mu_A(x), \lambda_A(x)) : x \in X\}$, where the functions $\mu_A : X \to [0,1]$ and $\lambda_A : X \to [0,1]$ denote the degree of membership and degree of non membership of each element $x \in X$ to the set A respectively and $0 \le \mu_A(x) + \lambda_A(x) \le 1$ for all $x \in X$. We shall use the symbol $A = \{\mu_A, \lambda_A\}$ for the intuitionistic fuzzy set $A = \{(x, \mu_A(x), \lambda_A(x)) : x \in X\}$.

Definition 2.3 [3]

Let $A = \{\mu_A, \lambda_A\}$ and $B = \{\mu_B, \lambda_B\}$ be intuitionistic fuzzy sets in X. Then

(1) $A \subseteq B \Leftrightarrow \mu_A(x) \le \mu_B(x)$ *and* $\lambda_A(x) \le \lambda_B(x)$,

(2) $A^c = \{(x, \lambda_A(x), \mu_A(x)) : x \in X\}$,

(3) $A \cap B = \left\{ \begin{matrix} (x, \min\{\mu_A(x), \mu_B(x)\}, \\ \max\{\lambda_A(x), \lambda_B(x)\}) : x \in X \end{matrix} \right\}$,

$$(4)\ A\cup B=\left\{\begin{matrix}(x,\max\{\mu_A(x),\mu_B(x)\},\\ \min\{\lambda_A(x),\lambda_B(x)\}):x\in X\end{matrix}\right\},$$

$$(5)\ \Box A=\{(x,\mu_A(x),\mu_A^c(x)):x\in X\},$$

$$(6)\ \Diamond A=\{(x,\lambda_A^c(x),\lambda_A(x)):x\in X\}.$$

Definition 2.4 [14]

Let G be a non–empty set and $*:G\times G\to\wp^*(G)$ be a hyperoperation, where $\wp^*(G)$ is the set of all the non-empty subsets of G. Where $A*B=\bigcup_{a\in A,\,b\in B}a*b$, $\forall A,B\subseteq G$.

The $*$ is called weak commutative if $x*y\cap y*x\neq\phi,\quad\forall x,y\in G$.

The $*$ is called weak associative if $(x*y)*z\cap x*(y*z)\neq\phi,\quad\forall x,y,z\in G$.

A hyperstructure $(G,*)$ is called an H_v–group if

(i) $*$ is weak associative.

(ii) $a*G=G*a=G,\quad\forall a\in G$ (Reproduction axiom).

Definition 2.5 [14]

An H_v–ring is a system $(R,+,\cdot)$ with two hyperoperations satisfying the ring-like axioms:

(i) $(R,+,\cdot)$ is an H_v-group, that is,

$((x+y)+z)\cap(x+(y+z))\neq\phi\quad\forall x,y\in R,$

$a+R=R+a=R\quad\forall a\in R;$

(ii) $(R,\cdot)$ is an H_v-semigroup;

(iii) $(\cdot)$ is weak distributive with respect to $(+)$, that is, for all $x,y,z\in R$,

$(x\cdot(y+z))\cap(x\cdot y+x\cdot z)\neq\phi,$

$((x+y)\cdot z)\cap(x\cdot z+y\cdot z)\neq\phi.$

Definition 2.6 [2]

Let R be an H_v-ring. A nonempty subset I of R is called a left (resp., right) H_v-ideal if the following axioms hold:

(i) $(I,+)$ is an H_v-subgroup of $(R,+)$,

(ii) $R\cdot I\subseteq I$ (resp., $I\cdot R\subseteq I$).

Definition 2.7 [2]

Let $(R,+,\cdot)$ be an H_v–ring and μ a fuzzy subset of R. Then μ is said to be a left (resp., right) fuzzy H_v-ideal of R if the following axioms hold:

(1) $\min\{\mu(x),\mu(y)\}\le\inf\{\mu(z):z\in x+y\}$ $\forall x,y\in R,$

(2) For all $x,a\in R$ there exists $y\in R$ such that $x\in a+y$ and $\min\{\mu(a),\mu(x)\}\le\mu(y),$

(3) For all $x,a\in R$ there exists $z\in R$ such that $x\in z+a$ and $\min\{\mu(a),\mu(x)\}\le\mu(z),$

(4) $\mu(y)\le\inf\{\mu(z):z\in x\cdot y\}$ respectively $\mu(x)\le\inf\{\mu(z):z\in x\cdot y\}\quad\forall x,y\in R.$

Definition 2.8 [2]

An intuitionistic fuzzy set $A=\{\mu_A,\lambda_A\}$ in R is called a left (resp., right) intuitionistic fuzzy H_v-ideal of R if

(1) $\min\{\mu_A(x),\mu_A(y)\}\le\inf\{\mu_A(z):z\in x+y\}$ $\forall x,y\in R,$

(2) For all $x,a\in R$ there exists $y,z\in R$ such that $x\in(a+y)\cap(z+a)$ and $\min\{\mu_A(a),\mu_A(x)\}\le\min\{\mu_A(y),\mu_A(z)\},$

(3) $\mu_A(y)\le\inf\{\mu_A(z):z\in x\cdot y\}$ respectively $\mu_A(x)\le\inf\{\mu_A(z):z\in x\cdot y\}\quad\forall x,y\in R,$

(4) $\sup\{\lambda_A(z):z\in x+y\}\le\max\{\lambda_A(x),\mu_A(y)\}$ $\forall x,y\in R,$

(5) For all $x,a\in R$ there exists $y,z\in R$ such that $x\in(a+y)\cap(z+a)$ and $\max\{\lambda_A(y),\lambda_A(z)\}\le\max\{\lambda_A(a),\lambda_A(x)\},$

(6) $\sup\{\lambda_A(z):z\in x\cdot y\}\le\lambda_A(y)$ respectively $\sup\{\lambda_A(z):z\in x\cdot y\}\le\lambda_A(x)\quad\forall x,y\in R.$

Definition 2.9 [12]

Let μ be a fuzzy subset of R. If there exist a $t\in(0,1]$ and an $x\in R$ such that

$$\mu(y)=\begin{cases}t & if\ \ y=x\\ 0 & if\ \ y\neq x\end{cases}$$

Then μ is called a fuzzy point with support x and value t and is denoted by x_t.

Definition 2.10 [12]

Let μ be a fuzzy subset of R and x_t be a fuzzy point.

(1) If $\mu(x) \geq t$, then we say x_t belongs to μ, and write $x_t \in \mu$.

(2) If $\mu(x)+t>1$, then we say x_t is quasi-coincident with μ, and write $x_t q \mu$.

(3) $x_t \in \vee q\mu \Leftrightarrow x_t \in \mu \text{ or } x_t q \mu$..

(4) $x_t \in \wedge q\mu \Leftrightarrow x_t \in \mu \text{ and } x_t q \mu$.

In what follows, unless otherwise specified, α and β will denote any one of $\in, q, \in \vee q$ or $\in \wedge q$ with $\alpha \neq \in \wedge q$, which was introduced by Bhakat and Das [9].

3. Intuitionistic (α, β)-fuzzy H_v-ideals

In this section we give the definition of intuitionistic (α, β)-fuzzy H_v-ideal and prove some related results.

Definition 3.1

An intuitionistic fuzzy set $A=\{\mu_A, \lambda_A\}$ in R is called a left (resp., right) intuitionistic (α, β)-fuzzy H_v-ideal of R if for all $t, r \in (0,1]$,

(1) $\forall x, y \in R, \quad x_t \alpha \mu_A, y_r \alpha \mu_A \Rightarrow z_{t \wedge r} \beta \mu_A$ for all $z \in x+y$,

(2) $\forall x, a \in R, \quad x_t \alpha \mu_A, a_r \alpha \mu_A \Rightarrow (y \wedge z)_{t \wedge r} \beta \mu_A$ for some $y, z \in R$ with $x \in (a+y) \cap (z+a)$,

(3) $\forall x, y \in R, \quad y_t \alpha \mu_A \Rightarrow z_t \beta \mu_A$ for all $z \in x \cdot y$,

(4) $\forall x, y \in R, \quad x_t \bar{\alpha} \lambda_A, y_r \bar{\alpha} \lambda_A \Rightarrow z_{t \wedge r} \bar{\beta} \lambda_A$ for all $z \in x+y$,

(5) $\forall x, a \in R, \quad x_t \bar{\alpha} \lambda_A, a_r \bar{\alpha} \lambda_A \Rightarrow (y \wedge z)_{t \wedge r} \bar{\beta} \lambda_A$ for some $y, z \in R$ with $x \in (a+y) \cap (z+a)$,

(6) $\forall x, y \in R, \quad y_t \bar{\alpha} \lambda_A \Rightarrow z_{t \wedge r} \bar{\beta} \lambda_A$ for all $z \in x \cdot y$.

Lemma 3.2

Let $A=\{\mu_A, \lambda_A\}$ be an intuitionistic fuzzy set in R. Then for all $x \in R$ and $r \in (0,1]$, we have

$$(1)\ x_t q \mu_A \Leftrightarrow x_t \bar{\in} \mu_A^c.$$

$$(2)\ x_t \in \vee q \mu_A \Leftrightarrow x_t \overline{\in \wedge q}\ \mu_A^c.$$

Proof. (1) Let $x \in R$ and $r \in (0,1]$. Then, we have

$$\begin{aligned} x_t q \mu_A &\Leftrightarrow \mu_A(x)+t>1 \\ &\Leftrightarrow 1-\mu_A(x)<t \\ &\Leftrightarrow \mu_A^c(x)<t \\ &\Leftrightarrow x_t \bar{\in} \mu_A^c. \end{aligned}$$

(2) Let $x \in R$ and $r \in (0,1]$. Then, we have

$$\begin{aligned} x_t \in \vee q \mu_A &\Leftrightarrow x_t \in \mu_A \text{ or } x_t q \mu_A \\ &\Leftrightarrow \mu_A(x) \geq t \text{ or } \mu_A(x)+t>1 \\ &\Leftrightarrow 1-\mu_A^c(x) \geq t \text{ or } 1-\mu_A^c(x)+t>1 \\ &\Leftrightarrow x_t \bar{q} \mu_A^c \text{ or } x_t \bar{\in} \mu_A^c \\ &\Leftrightarrow x_t \overline{\in \wedge q} \mu_A^c. \end{aligned}$$

Theorem 3.3 If $A=\{\mu_A, \lambda_A\}$ is an intuitionistic $(\in, \in)$-fuzzy H_v-ideal of R, then $A=\{\mu_A, \lambda_A\}$ is an intuitionistic fuzzy H_v-ideal of R.

Proof Condition (1). Let $x, y \in R$ and $\mu_A(x) \wedge \mu_A(y)=t$. Then $x_t, y_t \in \mu_A$. By condition (1) of definition 3.1, we have $z_t \in \mu_A, \quad \forall z \in x+y$, and so $\mu_A(z) \geq t, \quad \forall z \in x+y$. Consequently $\mu_A(x) \wedge \mu_A(y)=t \leq \bigwedge_{z \in x+y} \mu_A(z)$ for all $x, y \in R$.

Condition (2). Now let $x, a \in R$ and $\mu_A(x) \wedge \mu_A(a)=t$. Then $x_t, a_t \in \mu_A$. It follows from condition (2) of definition 3.1 that $(y \wedge z)_t \in \mu_A$, for some $y, z \in R$ with $x \in (a+y) \cap (z+a)$. Thus $y_t, z_t \in \mu_A$, for some $y, z \in R$ with $x \in (a+y) \cap (z+a)$. So, for all $x, a \in R$, there exist $y, z \in R$ such that $x \in (a+y) \cap (z+a)$ and

$\mu_A(x) \wedge \mu_A(a) = t \leq \mu_A(y) \wedge \mu_A(z)$. Condition (3). Let $x, y \in R$ and $\mu_A(y) = t$. Thus $y_t \in \mu_A$. From condition (3) of definition 3.1, we have $z_t \in \mu_A$ for all $z \in x \cdot y$, and so $\mu_A(z) \geq t$ for all $z \in x \cdot y$. This proves that $\mu_A(y) = t \leq \bigwedge_{z \in x \cdot y} \mu_A(z)$ for all $x, y \in R$.

Condition (4). Let $x, y \in R$ and $\lambda_A(x) \vee \lambda_A(y) = s$. If $s = 1$, then $\lambda_A(z) \leq 1 = s$ for all $z \in x + y$. It is easy to see that $\bigvee_{z \in x \cdot y} \lambda_A(z) \leq \lambda_A(x) \vee \lambda_A(y)$ for all $x, y \in R$. If $s < 1$ there exists a $t \in (0,1]$ such that $\lambda_A(x) \vee \lambda_A(y) = s < t$. Then $x_t, y_t \overline{\in} \lambda_A$. By condition (4) of definition 3.1, we have $z_t \overline{\in} \lambda_A$, $\forall z \in x + y$ and so $\lambda_A(z) < t$.
Consequently $\bigvee_{z \in x \cdot y} \lambda_A(z) \leq \lambda_A(x) \vee \lambda_A(y)$ for all $x, y \in R$.

Condition (5). Now let $x, a \in R$ and $\lambda_A(x) \vee \lambda_A(a) = s$. If $s < 1$, there exists a $t \in (0,1]$ such that $\lambda_A(x) \vee \lambda_A(a) = s < t$ .Then $x_t, a_t \overline{\in} \lambda_A$. By condition (5) of definition 3.1, we have $(y \wedge z)_t \overline{\in} \lambda_A$ for some $y, z \in R$ with $x \in (a + y) \cap (z + a)$. Hence $\lambda_A(y) < t$ and $\lambda_A(z) < t$. Thus $\lambda_A(y) \vee \lambda_A(z) < t$. This implies that for all $x, a \in R$, there exist $y, z \in R$ such that $x \in (a + y) \cap (z + a)$ and $\lambda_A(y) \leq \lambda_A(x) \vee \lambda_A(a)$. If $s = 1$ the proof is obvious.
Condition (6). Let $x, y \in R$ and $\lambda_A(y) = s$. If $s < 1$, there exists a $t \in (0,1]$ such that $\lambda_A(y) = s < t$. Thus $y_t \overline{\in} \lambda_A$. From condition (6) of definition 3.1, we have $z_t \overline{\in} \lambda_A$ for all $z \in x \cdot y$, and so $\lambda_A(z) < t$ for all $z \in x \cdot y$. Then $\lambda_A(z) < \lambda_A(y)$. This proves that $\bigvee_{z \in x \cdot y} \lambda_A(z) \leq \lambda_A(y)$, for all $x, y \in R$. If $s = 1$ the proof is obvious.

Theorem 3.4 If $A = \{\mu_A, \lambda_A\}$ is an intuitionistic $(\in, \in \vee q)$ and $(\in, \in \wedge q)$-fuzzy H_v-ideal of R, then $A = \{\mu_A, \lambda_A\}$ is an intuitionistic fuzzy H_v-ideal of R.
Proof The proof is similar to the proof of Theorem 3.3.

Theorem 3.5 If $\square A = \{\mu_A, \mu^c{}_A\}$ is an intuitionistic (α, β) -fuzzy H_v -ideal of R if and only if $\square A = \{\mu_A, \mu^c{}_A\}$ is an intuitionistic (α', β') -fuzzy H_v -ideal of R, where $\alpha \in \{\in, q\}$ and $\beta \in \{\in, q, \in \vee q, \in \wedge q\}$.

Proof We only prove the case of $(\alpha, \beta) = (\in, \in \vee q)$. The others are analogous. Let $\square A = \{\mu_A, \mu^c{}_A\}$ be an intuitionistic $(\in, \in \vee q)$-fuzzy H_v-ideal of R.

Condition (1). Let $x, y \in R$ and $t, r \in (0,1]$ be such that $x_t, y_r q \mu_A$. It follows from Lemma 3.2 that $x_t, y_r \overline{\in} \mu_A^c$. Since μ_A^c is an anti $(\in, \in \vee q)$-fuzzy H_v -ideal of R. Thus by condition (4) of definition 3.1, we have $z_{t \wedge r} \overline{\in \vee q} \mu_A^c$ for all $z \in x + y$. By Lemma 3.2, this is equivalence with $z_{t \wedge r} \in \wedge q \mu_A$ for all $z \in x + y$. Thus condition of (1) of definition 3.1 is valid.

Condition (2). Suppose that $x, a \in R$ and $t, r \in (0,1]$ be such that $x_t, a_r q \mu_A$. By Lemma 3.2, we have $x_t, a_r q \mu_A$ iff $x_t, a_r \overline{\in} \mu_A^c$. By hypotheses, μ_A^c is an anti $(\in, \in \vee q)$-fuzzy H_v-ideal of R . Thus by condition (5) of definition 3.1, we have $(y \wedge z)_{t \wedge r} \overline{\in \vee q} \mu_A^c$, for some $y, z \in R$ with $x \in (a + y) \cap (z + a)$. This is equivalence with $y_{t \wedge r} \overline{\in \vee q} \mu_A^c$ and $z_{t \wedge r} \overline{\in \vee q} \mu_A^c$, for some $y, z \in R$ with $x \in (a + y) \cap (z + a)$. By Lemma 3.2, it is easy to see that $y_{t \wedge r} \in \wedge q \mu_A$ and $z_{t \wedge r} \in \wedge q \mu_A$, for some $y, z \in R$ with $x \in (a + y) \cap (z + a)$ if and only if $(y \wedge z)_{t \wedge r} \in \wedge q \mu_A$, for some $y, z \in R$ with

$x \in (a+y) \cap (z+a)$. Thus condition of (2) of definition 3.1 is valid.

Condition (3). Let $x, y \in R$ and $t \in (0,1]$ be such that $y_t q \mu_A$. It follows from Lemma 3.2 that $y_t \overline{\in} \mu_A^c$. Since $\Box A = \{\mu_A, \mu^c{}_A\}$ is an intuitionistic $(\in, \in \vee q)$ -fuzzy H_v -ideal of R. Thus by condition (6) of definition 3.1, we have $z_t \overline{\in \vee q} \mu_A^c$ for all $z \in x \cdot y$. It is equivalence with $z_t \in \wedge q \mu_A$ for all $z \in x \cdot y$. Which verify conditions (3) of definition 3.1.

Condition (4). Let $x, y \in R$ and $t, r \in (0,1]$ be such that $x_t, y_r \overline{q} \mu_A^c$. It follows from Lemma 3.2 that $x_t, y_r \overline{q} \mu_A^c$ iff $x_t, y_r \in \mu_A$. Since $\Box A = \{\mu_A, \mu^c{}_A\}$ is an intuitionistic $(\in, \in \vee q)$-fuzzy H_v -ideal of R. Thus by condition (1) of definition 3.1, we have $z_{t \wedge r} \in \vee q \mu_A$ for all $z \in x + y$. By Lemma 3.2, this is equivalence with $z_{t \wedge r} \overline{\in \wedge q} \mu_A^c$ for all $z \in x + y$. Thus condition of (4) of definition 3.1 is valid.

Condition (5). Suppose that $x, a \in R$ and $t, r \in (0,1]$ be such that $x_t, a_r \overline{q} \mu_A^c$. This is equivalence with $x_t, a_r \in \mu_A$. By hypotheses, μ_A is an $(\in, \in \vee q)$-fuzzy H_v -ideal of R. Thus by condition (2) of definition 3.1, we have $(y \wedge z)_{t \wedge r} \in \vee q \mu_A$, for some $y, z \in R$ with $x \in (a+y) \cap (z+a)$, and so $y_{t \wedge r} \in \vee q \mu_A$ and $z_{t \wedge r} \in \vee q \mu_A$, for some $y, z \in R$ with $x \in (a+y) \cap (z+a)$. It follows from Lemma 3.2 that $y_{t \wedge r} \overline{\in \wedge q} \mu_A^c$ and $z_{t \wedge r} \overline{\in \wedge q} \mu_A^c$ for some $y, z \in R$ with $x \in (a+y) \cap (z+a)$ if and only if $(y \wedge z)_{t \wedge r} \overline{\in \wedge q} \mu_A^c$, for some $y, z \in R$ with $x \in (a+y) \cap (z+a)$. Thus condition of (5) of definition 3.2 is valid.

Condition (6). Let $x, y \in R$ and $t \in (0,1]$ be such that $y_t \overline{q} \mu_A^c$. Then, we have $y_t \in \mu_A$. Since $\Box A = \{\mu_A, \mu^c{}_A\}$ is an intuitionistic $(\in, \in \vee q)$ -fuzzy H_v -ideal of R. Thus by condition (3) of definition 3.1, we have $z_t \in \vee q \mu_A$ for all $z \in x \cdot y$. It is equivalence with $z_t \overline{\in \wedge q} \mu_A^c$ for all $z \in x \cdot y$. Which verify conditions (6) of definition 3.1.

Theorem 3.6 If $\Diamond A = \{\lambda_A^c, \lambda_A\}$ is an intuitionistic (α, β) -fuzzy H_v -ideal of R if and only if $\Diamond A = \{\lambda_A^c, \lambda_A\}$ is an intuitionistic (α', β')-fuzzy H_v -ideal of R , where $\alpha \in \{\in, q\}$ and $\beta \in \{\in, q, \in \vee q, \in \wedge q\}$.

Proof The proof is similar to the proof of Theorem 3.5.

Theorem 3.7 If $A = \{\mu_A, \lambda_A\}$ is an intuitionistic (α, β)-fuzzy H_v -ideal of R if and only if μ_A is an (α, β)-fuzzy H_v -ideal of R and λ_A^c is an (α', β')-fuzzy H_v -ideal of R , where $\alpha \in \{\in, q\}$ and $\beta \in \{\in, q, \in \vee q, \in \wedge q\}$.

Proof We only prove the case of $(\alpha, \beta) = (\in, \in \vee q)$. The others are analogous. It is sufficient to show that, λ_A^c is an $(q, \in \wedge q)$ -fuzzy H_v -ideal of R if and only if λ_A is an anti $(\in, \in \vee q)$-fuzzy H_v -ideal of R . This is true, because $x_t q \lambda_A \Leftrightarrow x_t \overline{\in} \lambda_A^c$ and $x_t \in \wedge q \lambda_A \Leftrightarrow x_t \overline{\in \vee q} \lambda_A^c$, $\forall x \in R$ and $t \in (0,1]$.

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