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A NEW CLASS OF BH-ALGEBRA

صنف جديد من جبر إل- BH

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Abstract

In this paper, we introduce the notion of a U-BG-BH-algebra as a new class of a BH-algebra. Also we introduce the notion of a U-BG-ideal of U-BG-BH-algebra we state and prove some theorems and examples which determine the relationships between these notions and some types of ideals of a BH-algebra.

الخلاصة

عرفنا في هذا البحث مفهوم ***U-BG-BH-algebra*** كصنف جديد من جبر إل-BH, وكذلك قدمنا مفهوم U-BG-ideal في جبر U-BG-BH-algebra. وأعطينا وبرهنا بعض المبرهنات والأمثلة التي تحدد العلاقة بين هذه الأفكار مع بعض أنواع المثاليات في جبر إل-BH.

1. INTRODUCTION

The notion of BCK-algebra and BCI-algebra was formulated first in 1966 by Y.Imai and K.Iseki as a generalization of the concept of set-theoretic difference and propositional calculus [7]. In 1983, Q.P.Hu and X. Li introduced the notion of a BCH-algebra which was a generalization of BCK/BCI-algebras [9].In 1998 ,Y. B. Jun, E. H. Roh and H .S. Kim introduced the notion of BH-algebra, which is a generalization of BCH-algebra and the notion of ideal [12]. In 2002 , j.neggers and Hee Sik Kim introduced the notion of B-algebra[5]. In 2008 , Chang Bum Kim and Hee Sik Kim introduced the notion of BG-algebra which is a generalization of B-algebras [1]. In 2010 K.Megalai and A.Tamilarasi introduced the notion of TM-algebra [8]. In 2011 H. H. Abass and H. M. Saeed generalized the notion of BCA-part to BH-algebra[4]. In 2012 H.H. Abass and H. B. Dahham generalized the notion of BH-ideal to BH-algebra[3].

2. PRELIMINARIES

In this section, we give some basic concepts about a B-algebra , BG-algebra , BCK-algebra, BCI-algebra, BCH-algebra, TM-algebra, BH-algebra,(subalgebra, BCA-part, homomorphism, ideal**,** BH-ideal) of a BH-algebra with some theorems, propositions and examples.

Definition (2.1):[5]

A **B-algebra** is a non empty set X with a constant 0 and a binary operation "*" satisfying the following axioms:

i. $x*x=0$
ii. $x*0=x$
iii. $(x*y)*z = x*(z*(0*y))$, for all $x,y,z\in X$.

Definition (2.2) :[1]

A **BG-algebra** is a non-empty set X with a constant 0 and a binary operation " * " satisfying the following axioms:

i. $x*x=0$
ii. $x*0=x$
iii. $(x*y)*(0*y)=x$, for all $x,y\in X$.

Lemma (2.3) :[1]

Let $(X,*,0)$ be a BG-algebra. Then

i. The right cancellation law holds in X, i.e., $x*y = z*y$ implies $x=z$
ii. $0*(0*x)=x$, for all $x\in X$
iii. If $x*y=0$, then $x=y$ for all $x,y\in X$,
iv. If $0*x=0*y$, then $x=y$ for all $x,y\in X$,
v. $(x*(0*x))*x=x$, for all $x\in X$.

Definition (2.4) :[10]

A BCI-algebra is an algebra $(X,*,0)$ of type (2,0) , where X is a nonempty set, "*" is a binary operation and 0 is a constant , satisfying the following axioms:

i. $((x*y)*(x*z))*(z*y) = 0$, for all $x, y, z\in X$,
ii. $(x*(x*y))*y = 0$, for all $x, y\in X$,
iii. $x * x = 0$, for all $x\in X$,
iv. $x * y =0$ and $y * x = 0$ imply $x = y$, for all $x, y\in X$.

Definition (2.5) :[6]

A BCK-algebra is a BCI-algebra satisfying the axiom: $0 * x = 0$, for all $x \in X$.

Definition (2.6):[9]

A ***BCH-algebra*** is an algebra $(X,*,0)$, where X is a nonempty set ,"*" is a binary operation and 0 is a constant , satisfying the following axioms:

i. $x*x=0$, $\forall\ x\in X$.
ii. $x*y=0$ and $y*x=0$ imply $x=y$, $\forall\ x,y\in X$.
iii. $(x*y)*z=(x*z)*y$, $\forall\ x,y,z\in X$.

Definition(2.7):[8]

A ***TM-algebra*** $(X,* , 0)$ is a non-empty set X with a constant 0 and a binary operation satisfying the following axioms :

i. $x *0 = x$, for all $x\in X$.
ii. $(x * y) (x * z) = z *y$, for all $x, y, z \in X$.

Definition (2.8) :[2]

A ***BH-algebra*** is a nonempty set X with a constant 0 and a binary operation"*" satisfying the following conditions:

i. $x*x=0$, $\forall\ x\in X$.
ii. $x*y=0$ and $y*x =0$ imply $x = y$, $\forall\ x, y\in X$.
iii. $x*0 =x$, $\forall\ x\in X$.

Remark (2.9):[12]

i. Every BCK-algebra is a BCH-algebra.
ii. Every BCK-algebra is a BH-algebra.
iii. Every BCI-algebra is a BH-algebra.

Definition (2.10) :[2]

Let X a BH-algebra and $S \subseteq X$. Then S is called a ***subalgebra*** of X if $x*y \in S$ for all $x,y \in S$.

Definition (2.11) :[4]

Let X be a BH-algebra. Then the set $X_+=\{x\in X:0*x=0\}$ is called the ***BCA-part*** of X.

Definition (2.12) [3] :

A non-empty subset N of a BH-algebra X is said to be ***normal*** of X if $(x * a) *(y * b) \in N$, for all $x * y, a * b \in N$.

Theorem (2.13) [3].

Every normal subset N of a BH-algebra X is a subalgebra of X.

Remark(2.14):[11]

Let X and Y be BH-algebras. A mapping $f:X\rightarrow Y$ is called a homomorphism if $f(x*y)=f(x)*f(y)$ for all $x,y\in X$. a homomorphism f is called a monomorphism (resp., epimorphism) if it is injective (resp., surjective). A bijective homomorphism is called an isomorphism. Two BH-algebras X and Y are said to be isomorphic, written $X \cong Y$, if there exists an isomorphism $f:X\rightarrow Y$. For all homomorphism $f:X \rightarrow Y$, the set $\{x\in X:f(x)=0\}$ is called the kernel of f, denoted by Ker(f), and the set $\{f(x):x\in X\}$ is called the image of f, denoted by Im(f). Notice that $f(0)= 0'$, for all homomorphism f.

Definition (2.15):[8]

Let $f : X \rightarrow Y$ be a ***homomorphism of a TM-algebras***. Then $f^{-1}(Y) =\{ x \in X : f (x) = y$, for some $y\in Y \}$ and $f (X) =\{ f(x) : x \in X \}$ is called the image of f.

We generalize the concept $f^{-1}(Y)$ to a ***BH-algebra***

Definition (2.16):

Let $f : X \rightarrow Y$ be a ***homomorphism of a BH-algebras***. Then $f^{-1}(Y) =\{ x \in X : f (x) = y$, for some $y\in Y \}$ and $f (X) =\{ f(x) : x \in X \}$ is called the image of f.

Definition (2.17) :[12]

Let I be a nonempty subset of a BH-algebra X. Then I is called an ***ideal*** of X if it satisfies:

i. $0\in I$.

ii. $x*y\in I$ and $y\in I$ imply $x\in I$.

Definition (2.18) :[3]

Let X be a BH-algebra and I be a subset of X. Then I is called a ***BH-ideal*** of X if it satisfies following conditions:

i. $0\in I$,

ii. $x*y\in I$ and $y\in I \Rightarrow x\in I$,

iii. $x\in I$ and $y\in X\Rightarrow x*y\in I$, $I*X\subseteq I$.

3. THE MAIN RESULTS

In this section, we introduce the concepts a U-BG-BH-algebra**,** a U-BG-ideal of U-BG-BH-algebra. Also we state and prove some theorems and examples about these concepts.

Definition (3.1):

A ***BH-algebra*** X is called is a ***U-BG-BH-algebra*** if there exists a proper subset **U** of X, such that:

i. $0\in \mathbf{U}$, $|\mathbf{U}| \geq 2$.

ii. **U** is a BG-algebra.

Example (3.2):

Consider the BH-algebra X={0,1,2,3} with binary operation"*" defined as follows:

*	0	1	2	3
0	0	1	2	0
1	1	0	1	0
2	2	2	0	0
3	3	2	1	0

The subset U={0,1,2} of X is a BG-algebra in X, with the binary operation"*", Therefore X is a **U-**BG-BH algebra.

Lemma (3.3):

If X is an U-BG-BH algebra, then X is a BH-algebra.

Proof:

Is from definition (3.1). ∎

Remark (3.4):

The converse of lemma (3.3) is not correct in general as in the following example.

Example (3.5):

Let X={0,1,2} be a set with binary operation"*" defined by:

*	0	1	2
0	0	0	1
1	1	0	0
2	2	1	0

Then X is a BH- algebra but it is not U-BG-BH-algebra, because X is not contain a proper subset U, such that U is a BG-algebra.

Proposition (3.6):

Let X be a BH algebra and X= X_+ .Then X is not U-BG-BH algebra.

Proof:

Let U⊆X is a proper BG-algebra and let 0,x∈U such that x≠0

⇒ 0*x=0=0*0. [Since X= X_+. By definition (2.11)]

⇒ U is not BG-algebra because 0*x=0*0 ⇒ x=0. [By lemma(2.3)(iv)]

This contradiction!

⇒ X is not U-BG-BH algebra. ∎

Corollary (3.7):

Let X be an BCK-algebra. Then X is a not a U-BG-BH-algebra.

Proof:

Let X be a BCK-algebra, since every BCK-algebra is a BH-algebra [By. Remark(2.9)(ii)]

⇒ 0*x=0 [By. Definition (2.5)]

⇒ X=X_+.

Therefore, X is not a U-BG-BH algebra. ∎ [By. Proposition(3.6)]

Definition (3.8):

A nonempty subset I of a U-BG-BH algebra X is called a ***U-BG-ideal*** of X related to U if it satisfies:

i. 0∈I.

ii. x*y∈I ⇒ x∈I, for all x∈U and y∈I.

Example (3.9):

Consider a U-BG-BH-algebra $X=\{0,1,2,3\}$ with binary operation"$*$" defined as follows:

*	0	1	2	3
0	0	1	2	0
1	1	0	1	2
2	2	2	0	1
3	3	1	0	0

where $U=\{0,1,2\}$.The subset $I=\{0,3\}$ of X is U-BG-ideal of X.

Remark (3.10):

$\{0\}$,X are U-BG- ideals of X, they are called trivial U-BG-ideals. An ideal I is said to be a proper if $I\neq X$.

Proposition (3.11):

Let X be a U-BG-BH-algebra. Then every ideal of X is a U-BG-ideal of X.

Proof:

Let I be an ideal of X, $x\in U$ and $y\in I$ such that $x*y\in I$,

$\Rightarrow x\in I$, [Since $U\subseteq X$ and I is an ideal of X]

$\Rightarrow$ I is a U-BG-ideal of X. ∎

Remark (3.12):

The converse of Proposition (3.11) is not correct in general as in the following example.

Example (3.13):

Consider the U-BG-BH-algebra X in example (3.9), where $U=\{0,1,2\}$, the subset $I=\{0,2\}$ is a U-BG-ideal of X, but I is not an ideal of X. Since $3\in X$, $2\in I$ and $3*2=0\in I$ but $3\notin I$.

Proposition (3.14):

Let X be a U-BG-BH-algebra, U_1 and U_2 be a BG- algebra ,which are properly contained in X and $U_1 \subseteq U_2$,Then every U_2-BG-ideal is U_1-BG-ideal.

Proof:

Let I be U_2-BG-ideal and let $x\in U_1$ and $y\in I$ such that $x*y\in I$

$\Rightarrow x\in I$. [Since $U_1\subseteq U_2$ and U_2-BG-ideal of X]

$\Rightarrow$ I is U_1-BG-ideal. ∎

Remark (3.15):

The converse of Proposition (3.14) is not correct in general as in the following example.

Example (3.16):

Consider the U-BG-BH-algebra $X=\{0,1,2,3,4\}$ with binary operation"$*$" defined as follows.

*	0	1	2	3	4
0	0	1	2	3	0
1	1	0	3	2	0
2	2	3	0	1	0
3	3	2	1	0	0
4	4	3	1	2	0

The subset $U_1=\{0,1\}$ and $U_2=\{0,1,2,3\}$ are BG-algebra which are properly contained in X and $U_1 \subseteq U_2$, the subset $I=\{0,1,2\}$ is U_1-BG-ideal of X and it is not a U_2-BG-ideal of X. Since $3\in U_2, 1\in I$ such that $3*1=2\in I$ but $3\notin I$.

Proposition (3.17):

Let X be a U-BG-BH-algebra. Then every proper subset of X contain U is a U-BG-ideal of X .

Proof:

Let X be a U-BG-BH-algebra and I be subset of X contain U, to prove I is a U-BG-ideal of X.

Let $x \in U$ and $y \in I$ such that $x*y \in I$

$\Rightarrow x \in I$, [Since $U \subseteq I$]

$\Rightarrow$ I is a U-BG-ideal. ∎

Theorem (3.18):

Let X be a U-BG-BH-algebra . Then every normal subalgebra is a U-BG- ideal of X.

Proof:

Let X be a U-BG- BH-algebra and N be a normal subalgebra, to prove N is a U-BG-ideal of X.

Let $x , y \in N$. then $x * y \in N$. [Since N is a normal subalgebra. By theorem(2.13)]

i. $0=(x * y) *(x * y) \in N$

ii. Let $x \in U$, $x*y \in N$ and $y \in N$

Since $x*y , 0*y \in N$,

$\Rightarrow (x*y)*(0*y) \in N$ [Since N is a normal subalgebra. By theorem(2.13)]

$\Rightarrow (x*0)*(y*y) \in N$,

$\Rightarrow x*0 \in N$ [Since $x*0=x$]

$\Rightarrow x \in N$,

$\Rightarrow$ N is a U-BG- ideal of X. ∎

Proposition (3.19):

Let X be a U-BG-BH-algebra and$\{ I_i , i \in \lambda\}$ be a family of a U-BG-ideals of X. Then $\bigcap_{i\in\lambda} I_i$ is a U-BG-ideal of X.

Proof:

i. Since $0 \in I_i \quad \forall i \in \lambda$ [Since I_i is a U-BG-ideal ,$\forall i \in \lambda$. By definition(3.8)(i)]

$\Rightarrow 0 \in \bigcap_{i\in\lambda} I_i$

ii. Let $x \in U$ such that $x*y \in \bigcap_{i\in\lambda} I_i$, $y \in \bigcap_{i\in\lambda} I_i$

$\Rightarrow$ $x*y \in I_i$ and $y \in I_i$, $(\forall i \in \lambda)$,

$\Rightarrow$ $x \in I_i$, $(\forall i \in \lambda)$ [Since I_i U-BG-ideal of X, $\forall i \in \lambda$,by definition(3.8)(ii)]

$\Rightarrow$ $x \in \bigcap_{i\in\lambda} I_i$,

$\Rightarrow$ $\bigcap_{i\in\lambda} I_i$ is a U-BG-ideal of X. ∎

Remark (3.20):

Let X be a U-BG-BH-algebra and I, J be a U-BG ideal of X. Then $I \cup J$ is not necessary be a U-BG ideal of X as in the following example.

Example (3.21):

Consider the U-BG-BH-algebra X={0,1,2,3,4} with binary operation"*" defined as follows.

*	0	1	2	3	4
0	0	1	2	0	0
1	1	0	1	4	3
2	2	2	0	1	1
3	3	1	2	0	2
4	4	3	1	2	0

where U={0,1,2}, I={0,3} and J={0,4}are two U-BG-ideals of X, but $I \cup J$ ={0,3,4} is not a U-BG-ideal of X. Since $1 \in U, 3 \in I \cup J$ and $1*3=4 \in I \cup J$ but $1 \notin I \cup J$.

Proposition (3.22):

Let X be a U-BG-BH-algebra and $\{ I_i , i \in \lambda\}$ be a chain of a U-BG-ideals of X. Then $\bigcup_{i\in\lambda} I_i$ is a U-BG-ideal of X.

Proof:

i. Since $0 \in I_i , \forall i \in \lambda$ [Since I_i is a U-BG-ideal of X, $\forall i \in \lambda$,by definition(3.8)(i)]

$\Rightarrow 0 \in \bigcup_{i\in\lambda} I_i$

ii. Let $x \in U$ such that $x*y \in \bigcup_{i\in\lambda} I_i$, $y \in \bigcup_{i\in\lambda} I_i$

$\Rightarrow \exists\, I_i , I_k \in \{ I_i \}_{i\in\lambda}$, such that $x*y \in I_i$ and $y \in I_k$,

$\Rightarrow$either $I_i \subseteq I_k$ or $I_k \subseteq I_i$,

If $I_i \subseteq I_k$

$\Rightarrow x*y \in I_k$ and $y \in I_k$,

$\Rightarrow x \in I_i$ [Since I_i is a U-BG-ideal of X, $\forall i \in \lambda$,by definition(3.8)(i)]

$\Rightarrow x \in \bigcup_{i\in\lambda} I_i$,

Similarly, If $I_k \subseteq I_i$,

therefore $\bigcup_{i\in\lambda} I_i$ is a U-BG-ideal of X. ∎

Theorem (3.23):

Let X be U-BG-BH-algebra and I be a U-BG- ideal such that $x*y \notin I$, for all $x \notin I$ and $y \in I$.Then I is an ideal of X.

Proof:

Let I be a U-BG-ideal of X , $x \in X$ and $y \in I$.

i.$0 \in I$ [Since I is a U-BG-ideal of X. By definition(3.8)(i)]

ii. Let $x* y \in I$ and $y \in I$

$\Rightarrow$ There are two cases.

Case(I): If $x \in U \Rightarrow x \in I$ [Since I is a U-BG-ideal of X. By definition(3.8)(ii)]

Case(II): If $x \notin U$, either $x \in I$ or $x \notin I$,

If $x \in I$ $\Rightarrow$I is an ideal,

If $x \notin I$ $\Rightarrow x*y \notin I$, [By hypothesis]

and this contradiction! since $x*y \in I$,

Therefore, I is an ideal of X.∎

Proposition (3.24):
Let $f:(X,*,0)\rightarrow(Y,*^{\prime},0^{\prime})$ be a U-BG-BH-epimorphism, such that f(U) is a BG-algebra of X, if I is a U-BG-ideal of X. Then $f(I)$ is a f(U)-BG-ideal of Y.

Proof:
Let I be a U-BG-ideal of X.

i. Since $0\in I\Rightarrow f(0)=0^{\prime}\in f(I)$ [Since I is a U-BG-ideal of X . By definition(3.8)(i)]

ii. Let $x\in f(U)$ such that $x*^{\prime}y\in f(I)$ and $y\in f(I)$

$\Rightarrow$ $\exists\ a\in U, b\in I$ such that $f(a)=x$, $f(b)=y$,

$\Rightarrow$ $f(a)*^{\prime}f(b)\in f(I)$ and $f(b)\in f(I)$,

$\Rightarrow$ $f(a*b)\in f(I)$ and $f(b)\in f(I)$,

$\Rightarrow$ $a*b\in I$ and $b\in I$,

$\Rightarrow$ $a\in I$ [Since I is a U-BG-ideal of X. By definition(3.8)(ii)]

$\Rightarrow$ $f(a)\in f(I)$

$\Rightarrow$ $x\in f(I)$.

$\Rightarrow$ f(I) is a U-BG-ideal of X.■

Proposition (3.25):
Let $f:(X,*,0)\rightarrow(Y,*^{\prime},0^{\prime})$ be a U-BG-BH-epimorphism, such that $f^{-1}(U)$ is a BG-algebra of X, if I is a U-BG-ideal of Y. Then $f^{-1}(I)$ is a $f^{-1}(U)$-BG-ideal in X.

Proof:
Let I be an U-BG-ideal in Y

i. Since $f(0)=0^{\prime}$ $\Rightarrow 0\in f^{-1}(I)$ [Since I is a U-BG-ideal of X. By definition(3.8)(i)]

ii. Let $x\in f^{-1}(U)$ such that $x*y\in f^{-1}(I)$ and $y\in f^{-1}(I)$

$\Rightarrow f(x*^{\prime}y)\in I$ and $f(y)\in I$

$\Rightarrow f(x)*^{\prime}f(y)\in I$ and $f(y)\in I$

$\Rightarrow f(x)\in I$ [Since I is a U-BG-ideal of X .By definition(3.8)(ii)]

$\Rightarrow x\in f^{-1}(I)$

$\Rightarrow f^{-1}(I)$ is a U-BG-ideal of X.■

Theorem (3.26):
Let X be a U-BG-BH-algebra. Then every U-BG-ideal in U is a BG-algebra with the same binary operation on X and the constant 0.

Proof:
Let X be a U-BG-BH-algebra, and I be a U-BG-ideal of X.

i. Let $x\in I\Rightarrow x\in U$ $\Rightarrow x*x=0$ [Since U is a BG-algebra. By definition(2.2)(i)]

ii. Let $x\in I$ $\Rightarrow x\in U$ $\Rightarrow x*0=x$ [Since U is a BG-algebra. By definition(2.2)(ii)]

iii. Let $x,y\in I$, $\Rightarrow x,y\in U\Rightarrow(x*y)*(0*y)=x$ [Since U is a BG-algebra. By definition(2.2)(iii)]

$\Rightarrow$ I is a BG-algebra of X.■

Remark (3.27):
Let X be a U-BG-BH-algebra and I be a U-BG ideal of X. Then I is not necessary a BH-algebra as in the following example.

Example (3.28):

Consider the U-BG-BH algebra $X=\{0,1,2,3\}$ with binary operation "*" defined as follows.

*	0	1	2	3
0	0	1	2	2
1	1	0	1	2
2	2	2	0	1
3	3	2	1	0

where $U=\{0,1,2\}$, the subset $I=\{0,3\}$ of X is U-BG-ideal but not BH-algebra, since I is not closed under "*".

Proposition (3.29):

Let X be a U-BG-BH algebra. Then every BH-ideal is a U-BG- ideal of X .

Proof:

Let X be a U-BG- BH algebra ,and I be a BH-ideal of X,

Since every BH-ideal is an ideal of X and every ideal is U-BG-ideal of X. [By proposition(3.11)]

$\Rightarrow$ I is a U-BG-ideal of X.■

Remark (3.30):

The converse of proposition(3.29) is not correct in general as in the following example.

Example (3.31):

Consider the U-BG-BH-algebra X in example(3.9), where $U=\{0,1,2\}$, the subset $I=\{0,1\}$ of X is U-BG-ideal of X which is not a BH-ideal of X, Since $0\in I$, $2\in X$ but $0*2=2\notin I$.

Proposition (3.32):

Let X be a U-BG-BH algebra. Then every U-BG- ideal of X satisfies the condition $(z * y)* x= 0$ then $z\in I$, for all $x,y\in I$, $z\in U$.

Proof:

Let $x,y\in I$, $z\in U$ and $(z*y)*x=0\in I$,

$\Rightarrow (z*y)*x\in I,\ x\in I,$

$\Rightarrow (z*y)\in I$ [Since I is a U-BG-ideal]

$\Rightarrow (z*y)\in I,\ y\in I$

$\Rightarrow z\in I$. ■ [Since I is a U-BG-ideal]

Proposition (3.33):

Let X and Y be two U-BG-BH-algebra and $f:X\rightarrow Y$ be a BH-homomorphism. Then ker(f) is a U-BG- ideal.

Proof:

i. Since $f(0)= 0' \Rightarrow 0\in \ker(f)$

ii. Let $x\in U$ such that $x*y\in \ker(f)$ and $y\in \ker(f)$

$\Rightarrow 0=f(x*y) =f(x)*f(y) =f(x)*0 =f(x)$

$\Rightarrow x\in \ker(f)$

$\Rightarrow$ ker(f) is an U-BG-ideal of X . ■

Proposition (3.34):

Let X be a U-BG-BH algebra and I be a U-BG-ideal of X such that if $x*y=0\in I$. Then $x\in I$, for all $x\in U$ and $y\in I$.

Proof:

Let $x\in U$ and $y\in I \Rightarrow x*y=0\in I$

$\Rightarrow x*y\in I,\ y\in I \Rightarrow x\in I$. ■ [Since I is U-BG- ideal]

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