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Some Remarks on Hyperstructures their Connections with Fuzzy Sets and Extensions to Weak Structures

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Abstract

A brief excursus on the last results on Hyperstructures and their connections with Fuzzy Sets. At the end a calculation of the Fuzzy Grade of Hv-structures of order two.

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1 Introduction

One knows that to every fuzzy set (H, μ_0) one hypergroup can be associated (which I proved [9], is a join space) in the following way:

$\forall (x, y) \in H^2$, one sets

$$x \circ_0 y = \{z \mid min\{\mu_0(x), \mu_0(y)\} \leq \mu_0(z) \leq max\{\mu_0(x), \mu_0(y)\}.$$

I proved also [18] that to every hypergroupoid $(H, \circ)$ a fuzzy set corresponds, defined as you can see below:

Set $\forall u \in H,\ Q(z) = \{(x, y) \mid u \in x \circ y\},\ q(u) = |Q(u)|$.

$$A(u) = \sum_{(x,y) \in Q(u)} 1/|x \circ y|, \quad \mu_1(u) = A(u)/q(u).$$

I proved that $H_0 = (H, \circ)$ is a join space.

So, to every hypergroupoid, a sequence of hypergroupoids and fuzzy sets is associated: $(H, \mu_0),\ (H, \mu_1), ...$

If $|H| < \aleph_0$, then the sequence is clearly finite.

We call *fuzzy grade* [20] of $(H, \circ)$ the minimum natural number of k, such that two consecutive join spaces are isomorphic.

For the H_v-structures, notion introduced by T. Vougiouklis, one can proceed in a similar way.

So, one defines the fuzzy grade of a H_v-hypergroupoid as

$$min\{k \mid H_k \simeq H_{k+1}\}.$$

Thomas Vougiouklis is author of many papers on Hyperstructures.

Just at the beginnng of his activity he invented and studied a structure, defining the following hyperoperation: given a hypergroupoid $(H; *)$ and a non empty subset P of H, he set $x \circ y = x * P * y$ and found several interesting results on this hyperoperation.

But the most important theory that he introduced is that one of the H_v-hyperstructures. He replaced the notion of associativity with that one of "weak associativity". That is instead of supposing

for every $x, y, z \in H,\ (x * y) * z = x * (y * z)$, one supposes

$$(x * y) * z \cap x * (y * z) \neq \emptyset.$$

One has considered also weak rings. It is enough to set

for every a, b, c in R, $a \circ (b + c) \cap (a \circ b + a \circ c) \neq \emptyset$.

The idea by Vougiouklis of considering weak Hyperstructures opened a new branch of Mathematics. Many significant results have been obtained in this field and probably many others will be found in the future.

A theme which deserves to be considered in this context is that one of HX structures. HX-groups were born in China, invented by Li Hongxing [81], and studied by him, Wang and others, see [79], [80], [87], [117], [118], [119]. In Italy, Corsini extended this notion to Hyperstructures. He and Cristea in Italy, Fotea in Romania, Kellil and Bouaziz in Saudi Arabia worked in this direction.

Given a group G and the set $\mathcal{P}^*(G)$ of all nonempty subsets of G, endowed with the operation

$$\forall(A, B) \in \mathcal{P}^*(G) \times \mathcal{P}^*(G),\ A \circ B = \{xy \mid x \in A, y \in B\}$$

a subgroup of $\mathcal{P}^*(G)$ is called an HX*-group.* One has calculated the fuzzy grade for $\mathbf{Z}/n\mathbf{Z}$ for $n \leq 16$ and also for other structures, for instance for the multiplicative group $\mathbf{Z}_2^{2,2}$ and the direct product of some $\mathbf{Z}/n\mathbf{Z}$, see [22], [23], [24].

It would very interesting to consider the same problems in the such general context of weak structures, that is to calculate the fuzzy grade of HX-hypergroup $\mathbf{Z}_n$.

Given an HX-group F, one considers the set F' of all nonempty subsets of F. Let us suppose that K is a subgroup of F.

We define the following hyperoperation

$$x \otimes y = \bigcup_{x\in A,\ y\in B,\ \{A,B\}\subseteq K} AB$$

in the set $\cup_{A\in K} A$.

The structure $(H, \otimes)$ is called an HX*-hypergroupoid.*

One can extend the notion of HX-hypergroup to weak hyperstructures.

Some open problems on weak structures:

- find conditions for an HX-hypergroupoid to be a hypergroup;
- the fuzzy grade of HX- weak hypergroups already considered in the classic case.

2 H_v-hypergroupoids of order 2

The H_v-hypergroupoids of order 2, which are not associative, are 10.

The following [12], [13], [15] have fuzzy grade 1.
The others [9], [10], [11], [14], [16], [17], [18] have fuzzy grade 2.

H_{12}	a	b
a	H	H
b	b	a

  We have $q_1(a) = 3,\ A_1(a) = 2$, so $\mu_1(a) = 2/3$.

  $q_1(b) = 3,\ A_1(b) = 2$, so $\mu_1(b) = 2/3$.

  Then $\partial H_{12} = 1$.

H_{13}	a	b
a	H	b
b	H	a

  We have $q_1(a) = 3,\ A_1(a) = 2$, so $\mu_1(a) = 2/3$.

  $q_1(b) = 3,\ A_1(b) = 2$, so $\mu_1(b) = 2/3$.

  Then $\partial H_{13} = 1$.

H_{15}	a	b
a	H	a
b	b	H

  Indeed we find $q_1(a) = 3,\ A_1(a) = 2$, so $\mu_1(a) = 2/3$.

  $q_1(b) = 3,\ A_1(b) = 2$, so $\mu_1(b) = 2/3$.

  Hence $H_1 = T$, the total hypergroup. Therefore $\partial H_{15} = 1$.

H_9	a	b
a	H	b
b	b	a

  We have $q_1(a) = 2,\ A_1(a) = 3/2$, so $\mu_1(a) = 3/4 = 0.75$.

  $q_1(b) = 3,\ A_1(b) = 5/2$, so $\mu_1(b) = 5/6 = 0.8333$.

  So we obtain

H_9^1	a	b
a	a	H
b	H	b

  Therefore $\mu_2(a) = \mu_2(b)$, whence H_9^2 is the total hypergroup, whence $\partial H_9 = 2$.

H_{10}	a	b
a	a	H
b	b	a

  We find $q_1(a) = 2,\ A_1(a) = 5/2$, so $\mu_1(a) = 0.833$.

  $q_1(b) = 2,\ A_1(b) = 3/2$, so $\mu_1(b) = 3/4 = 0.75$.

  We obtain

H_{10}^1	a	b
a	a	H
b	H	b

  so $\mu_2(a) = \mu_2(b)$, whence H_{10}^2 is the total hypergroup, whence $\partial H_{10} = 2$.

H_{11}	a	b
a	b	H
b	a	b

  We find $q_1(a) = 2,\ A_1(a) = 3/2$, so $\mu_1(a) = 0.75$.

  $q_1(b) = 3,\ A_1(b) = 5/2$, so $\mu_1(b) = 0.833$.

It follows

H_{11}^1	a	b
a	a	H
b	H	b

so $\mu_2(a) = \mu_2(b)$, so $\partial H_{11} = 2$.

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H_{14}	a	b
a	H	a
b	a	H

We find $q_1(a) = 4,\ A_1(a) = 3$, so $\mu_1(a) = 0.75$.
$q_1(b) = 2,\ A_1(b) = 1$, so $\mu_1(b) = 0.50$.
whence we hve

H_{14}^1	a	b
a	a	H
b	H	b

By consequence H_{14}^2 is the total hypergroup, whence $\partial H_{14} = 2$.

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H_{16}	a	b
a	a	H
b	H	a

We find $q_1(a) = 4,\ A_1(a) = 3$, so $\mu_1(a) = 3/4 = 0.75$.
$q_1(b) = 2, A_1(b) = 1, \mu_1(b) = 0.50$.
It follows

H_{16}^1	a	b
a	a	H
b	H	b

so $\mu_2(a) = \mu_2(b)$, whence H_{16}^2 is the total hypergroup, whence $\partial H_{16} = 2$.

H_{17}	a	b
a	H	H
b	a	H

  We find $q_1(a) = 4,\ A_1(a) = 5/2$, so $\mu_1(a) = 0.625$.

  $q_1(b) = 3,\ A_1(b) = 3/2$, so $\mu_1(b) = 0.50$.

  By cnsequence

H^1_{17}	a	b
a	a	H
b	H	b

  whence H^2_{17} is the total hypergroup, therefore $\partial H_{17} = 2$.

H_{18}	a	b
a	H	H
b	b	H

  We find $q_1(a) = 3,\ A_1(a) = 3/2$, so $\mu_1(a) = 0.50$.

  $q_1(b) = 4,\ A_1(b) = 5/2$, so $\mu_1(b) = 0.625$.

  We obtain

H^1_{18}	a	b
a	a	H
b	H	b

  By consequence, H^2_{18} is the total hypergroup, whence $\partial H_{18} = 2$.

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