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Research Article

AN UNUSUAL METHOD OF REPRODUCTION

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ABSTRACT

This article shows an unusual method for multiplying on the set of all positive real numbers.

KEYWORDS

Commutativity, associativity, distributivity.

INTRODUCTION

In the set of all composite numbers, a new multiplication can be specified by the relations

$$[a,b]=a^b.$$

Find all positive rational numbers for which the multiplication is as follows:

1) commutatively: $[a,b]=[b,a]$;
2) associatively: $[a,[b,c]]=[[a,b],c]$;
3) distribution right and left:
$[(a+b),c]=[a,c]+[b,c], [c,(a+b)]=[c,$
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I. If $b=a$, then the solution is obvious. Otherwise, we agree to consider b the greater of the numbers $(b>a)$. Then $b=ra$, where $r>1$ and $a^{r-1}=r$, or, what is the same, $a=r^{1/(r-1)}$. Let $1/(r-1)u/v$, where u and v are mutually prime numbers. Since a and r are rational, the number $r=(v+u)/u$ must be the v th power of a rational number. But then the numbers u and $v+u$, as mutually prime, are also equal to the v rd powers of integers. But the difference of two v powers with different bases is greater than v, unless it is equal to 1. Therefore, $v=1$ and $1/(r-1)=u$ are integers. Thus, $a=[(u+1)/u]^u$ and $b=[(u+1)/u]^{u+1}$.

II. Note that otrelation $a^{(bc)}=(a^b)^c$ holds if $a=1$, b and c are arbitrary numbers or $c=1$, a and b are arbitrary numbers. If $a\neq 1$, $c\neq 1$, then the relation $b^c=bc$ or $b^{c-1}=c$ must be satisfied. As arguments similar to those above show, $c=(u+1)/u$, $c=[(u+1)/u]^u$ where u is any integer, and the number a remains arbitrary.

III. Without limiting loss of generality, assume that $a\geq b$. Then $a=rb$, where $r\geq 1$, and the ratio $(a+b)^c=a^c+b^c$ reduces to the relations $(1+r)^c=1+r^c$. Suppose for the time that the parameter r changes continuously. Let $f_1(r)=(1+r)^c$, $f_2(r)=1+r^c$. Then at any $r>0$, derivatives $f_1'(r)$ and $f_2'(r)$ are related by one of three relations: $f_1'(r)>f_2'(r)$ at $c>1$, $f_1'(r)=f_2'(r)$ for $c=1$, and $f_1'(r)<f_2'(r)$ for $c<1$. But $f_1(0)=f_2(0)$. Therefore, $f_1(r)>f_2(r)$ for $c>1$, $f_1(r)=f_2(r)$ for $c=1$ and $f_1(r)<f_2(r)$ for $c<1$. Thus, the complete solution corresponds to $c=1$ and arbitrary a and b.

Let us now consider the relation $c^{a+b}=c^a+c^b$. Without loss of generality, assume that $a\geq b$.Then $a=br\ (r\geq 1)$. Let $c^b=v/u$, $r=p/q$, where p, q, u, v are positive integers, and each of the fractions v/u and p/q is irreducible and (because the $r\geq 1$) $p\geq q$. Relation $c^{a+b}=c^a+c^b$ in the accepted notation is reduced to the form $v^{p-q}(v-u)=u^p$. If $v=1$, then $(1-u)^q=u^p$. Since $p\geq 1$, $q\geq 1$, then every prime divisor of u must be a divisor of $1-u$ and therefore a divisor of unity. From this we conclude that $u=1$ but $u=1$ does not satisfy relation $(1-u)^q=u^p$. The resulting contradiction means that $v\neq 1$. Since v, is not a divisor of u^p, then $p-q=0$. But then, $b=a$ and $v-u=u$, or $u=1$, $v=2$. Thus, in the case under consideration, the complete solution is determined by the relations $a=b=1/n$, $c=2^n$, where n is any integer.

Let us now consider how the sets of elements are arranged, on which one of the properties of the new multiplication I-III is satisfied for any choice of its elements.

Let us first consider the set of elements on which the new multiplication is commutative. Such a set contains either one element, which is arbitrary, or two of the above elements.

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We move on to the set of elements, on which the new multiplication is associative. First of all, let us turn to the case when the set contains the identity element and element $a \neq 1$. From relation $[[a,1],a=[a,[a,1]]$, it follows that $a^a = a$, where $a = 1$. Thus, if a set bunch of contains unit, then it does not contain other elements. Let us assume that no element of the set is equal to unit. Then from relation $[a,[a,a]]=[[a,a],a]$ it follows that $a^a = a^2$, where $a = 2$. Thus, the set of elements on which the new multiplication is associative contains only one element equal to either 1 or 2.

Finally, consider the set of elements on which the new multiplication is distributive. In the case of distributivity, the right is $(a+a)^a = 2a^a$ or $2^a = 2$. Therefore, $a = 1$ and unit-single element belonging to the set. In the case of distributivity on the left $a^{(a+a)} = 2a^a$, or $a^a = 2$. Since this relation does not hold for rational a, the set under consideration is empty.

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