The Simple Algorithm Of Abiyev's Balanced Cubes Of Odd Order

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Abstract: - For the first time, a simple algorithm for writing the balanced cubes of odd order has been found. With the help of this algorithm we can write color balanced (magic) cubes from any numbers (rational, irrational, complex, symbols etc.) of any orders. Examples have been shown for these cubes and compared with Marian Trenkler's cube. This algorithm can be easily applied to informatics, optimal problems and other computer programs. Abiyev's balanced cube of 1001 order has been formed with this algorithm.

Key-Words: - Balanced cube, information**,** algorithm, optimal programs, magic cubes.

I. Introduction

The fact that famous mathematicians like P. Fermat, B. Pascal, L. Euler, A. Cayley and others were involved in magic squares, shows them to be a serious mathematical problem [1,2]. Understanding this seriousness the German thinker P. Carus has expressed his impressions on the magic squares by the following words: "There is no science that teaches the harmonies of nature more clearly than mathematics, and the magic squares are like a mirror which reflects the symmetry of the divine norm immanent in all things, in the immeasurable immensity of the cosmos and in the construction of the atom not less than in the mysterious depth of the human mind" [1].

It should be noted that today the problem in magic squares is to reveal the compliance between their unique properties and the laws of nature, and to direct them towards the development of science and technology [3,4]. The correlation between Abiyev's balanced squares and periodic tables of elements can be an obvious example to confirm the above -said [5].

However, having more information than magic squares, magic cubes need a simple algorithm in order to expand their application spheres.

The algorithm proposed by M. Trenkler for writing magic cubes allows to write only the natural magic cubes [6,7]. By the algorithm described in this article, it is possible to write colored magic cubes of any order and from any numbers (rational, irrational, complex, symbols and etc.

II. Latin squares

Latin squares are used in the design of experiments, tournament scheduling and constructing magic squares and cubes. A Latin square is an arrangement of m variables $x_1, x_2, \ldots, x_m$ into m rows and m columns such that no row and no column contains any of the variables twice. Two Latin squares are called orthogonal if when one is superimposed upon the every ordered pair of variables occurs once in the resulting square.

In this site [8] the writing of magic squares from natural numbers according to its own order base was programmed. The perfection of this algorithm is that this square corresponds to a joint state of 2 orthogonal Latin squares. In Fig.1, the example of this square is shown. If we use coefficients of this square and formula $k_{ij}c+p_{ij}b+ a_0=m_{ij}$ as a result we will get a square from any numbers [9]; where k_{ij} and p_{ij} - are the elements of Latin square, $0 \le i,j \le n-1$. It should be mentioned that these Latin squares have mirror symmetry. The magic number of this square is calculated with the formula: $M_n=\frac{2a_0+(n-1)(c+b)}{2} n$, where c, b and a_0 are any numbers (rational, irrational, complex, symbols and etc).

If $a_0=1$, $b=1$, $c=n$, then this square is transformed to natural magic square and the magic number is calculated with the formula $M_n = \frac{n^2+1}{2} n$ This number is expressed with the formula $M_n = \frac{(n-1)n}{2} \times (1,1)_n$ according to order base of

the square. The magic number of Latin squares is equal to $M_n = \frac{(n-1)n}{2}$.

3'4	2'5	1'6	0'0	6'1	5'2	4'3
4'5	3'6	2'0	1'1	0'2	6'3	5'4
5'6	4'0	3'1	2'2	1'3	0'4	6'5
6'0	5'1	4'2	3'3	2'4	1'5	0'6
0'1	6'2	5'3	4'4	3'5	2'6	1'0
1'2	0'3	6'4	5'5	4'6	3'0	2'1
2'3	1'4	0'5	6'6	5'0	4'1	3'2

superimposed

3	2	1	0	6	5	4
4	3	2	2	0	6	5
5	4	3	2	2	0	6
6	5	4	3	2	2	0
0	6	5	4	3	2	1
1	0	6	5	4	3	2
2	1	0	6	5	4	3

C_7

4	5	6	0	1	2	3
5	6	0	1	2	3	4
6	0	1	2	3	4	5
0	1	2	3	4	5	6
1	2	3	4	5	6	0
2	3	4	5	6	0	1
3	4	5	6	0	1	2

B_7

Fig.1. The Abiyev's balanced square of 7th order in own base, B_7 and C_7 are orthogonal Latin squares of 7th orders

III. The Algorithm Of Balanced Cube Of Odd Order

In order to write the magic cube of odd order, three Latin squares are used. Let's mark them with *A*, *B* and *C*. Accept the element (1,1) of Latin squares (Ls) *A(i,j)* and *B(i,j)* to be equal respectively to 0 and n-1, increase the first row elements of these two Ls from right to left and elements in columns top to down successively. And the Ls *C(i,j)* is the mirror reflection of Ls *B(i,j)*. For writing Ls A_{n-1}, B_{n-1} and C_{n-1} the following simple method is used: The Ls A_n and C_n are copied and slipped one column right, and B is slipped one column left (Fig.2.). The last columns of Ls A_n and C_n are cut and pasted in front of the first column, and Ls B_n -the first column is cut and pasted next to the last column. Thus, the obtained Ls will form the Ls A_{n-1}, B_{n-1} and C_{n-1}. Using this algorithm we get Latin squares (A_{n-2}, B_{n-2}, C_{n-2}); (A_{n-3}, B_{n-3}, C_{n-3}); …,(A_1, B_1, C_1). Here A_k=B_{n+1-k}. For example A_n=B_1 and $A_{(n+1)/2}$=$B_{(n+1)/2}$.

If we multiply the elements of Latin squares, A_k, B_k and C_k respectively by *d*, *c*, *b* and add a_0, that is $m_n = A_k(i,j)\, d + B_k\,(i,j)c + C_k(i,j)b + a_0$ then we will get horizontal cuts of the magic cube, where $A_k(i,j)$, $B_k\,(i,j)$ and $C_k(i,j)$ are the elements of k^{th} Latin squares *A*, *B* and C, respectively. The magic number of this magic cube is $M_n = \frac{2a_0+(n-1)(d+c+b)}{2} n$, where *d*, *c*, *b* and a_0 are any numbers (rational, irrational, complex, symbols and etc.). We call this magic cube Abiyev's General Balanced Cube.

M. Trenkler's natural magic cube is obtained with the formula $m_n = A_k(i,j)\, n^2 + B_k\,(i,j)n + C_k(i,j) + 1$ and magic number $M_n = \frac{n^3+1}{2} n$. Note that $A_k = C_{n+1-k}$ and A_k, B_k are symmetrical by mirror reflection.

In figure 3 the general balanced cube of 5th order is shown as an example.

In figure 4, Abiyev's balanced (1), Trenkler's magic (3) and natural cubes are displayed for comparison. The colours in these cubes have been obtained from natural cube in accordance with numbers. The white cells consist of two different colours. The algorithm of Abiyev's General Balanced Cube allows us to write a magic cube upon request.

Suppose that, *n*=5; m_5=(2,2,5)=π; m_5=(4,4,3)=e; m_5=(1,5,2)=i=$\sqrt{-1}$ and the magic number M_5=1. According to the data, system equations are written and solved; and as a result algorithm parameters: $d = 0{,}25e + 0{,}5i - 0{,}15$; $c = 0{,}5\,n + 0{,}25e + 0{,}5i - 0{,}25$; $b = 0{,}5e - 0{,}1$; $a_0 = -(\pi + 2e + 2i - 1{,}2)$; $M_5 = 5[a_0 + 2(d + c + b)] = 1$ are found. Using these constants the third (medium) cut of balanced cube of fifth order has been written (fig.5). We can write the other cuts in the same way as well.

$m_5(4,4,3) = a_0 + 2d + 2c + 4b = e$;
$m_5(1,5,2) = a_0 + 2d + 2c + 4b = i$;
$m_5(2,2,5) = a_0 + 4c + 2b = \pi$;
$M_5 = 5[a_0 + 2(d + c + b)]$=1.

The system equations .

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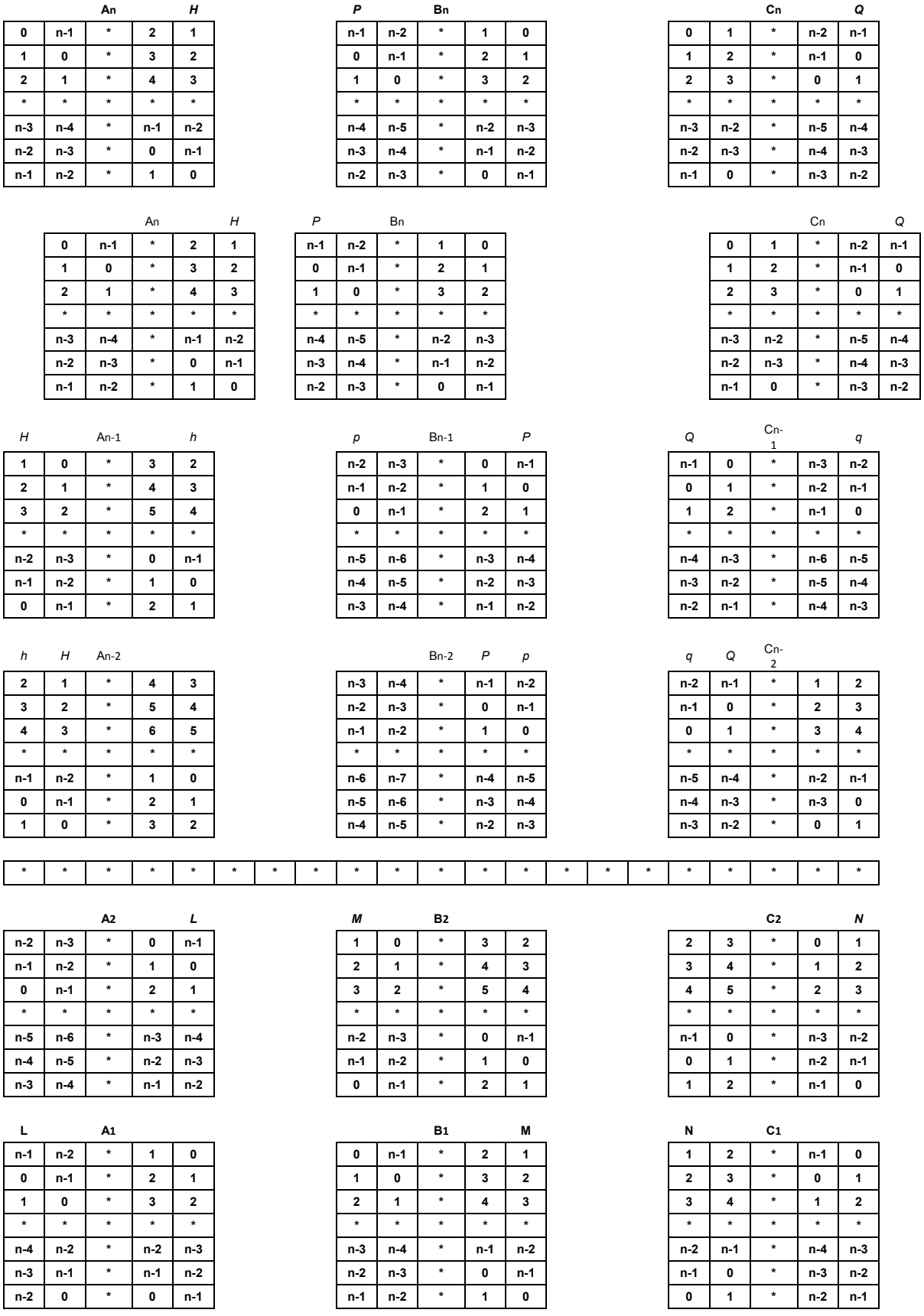

Fig.2. The Latin Squares of Abiyev's Balanced Cube of n order

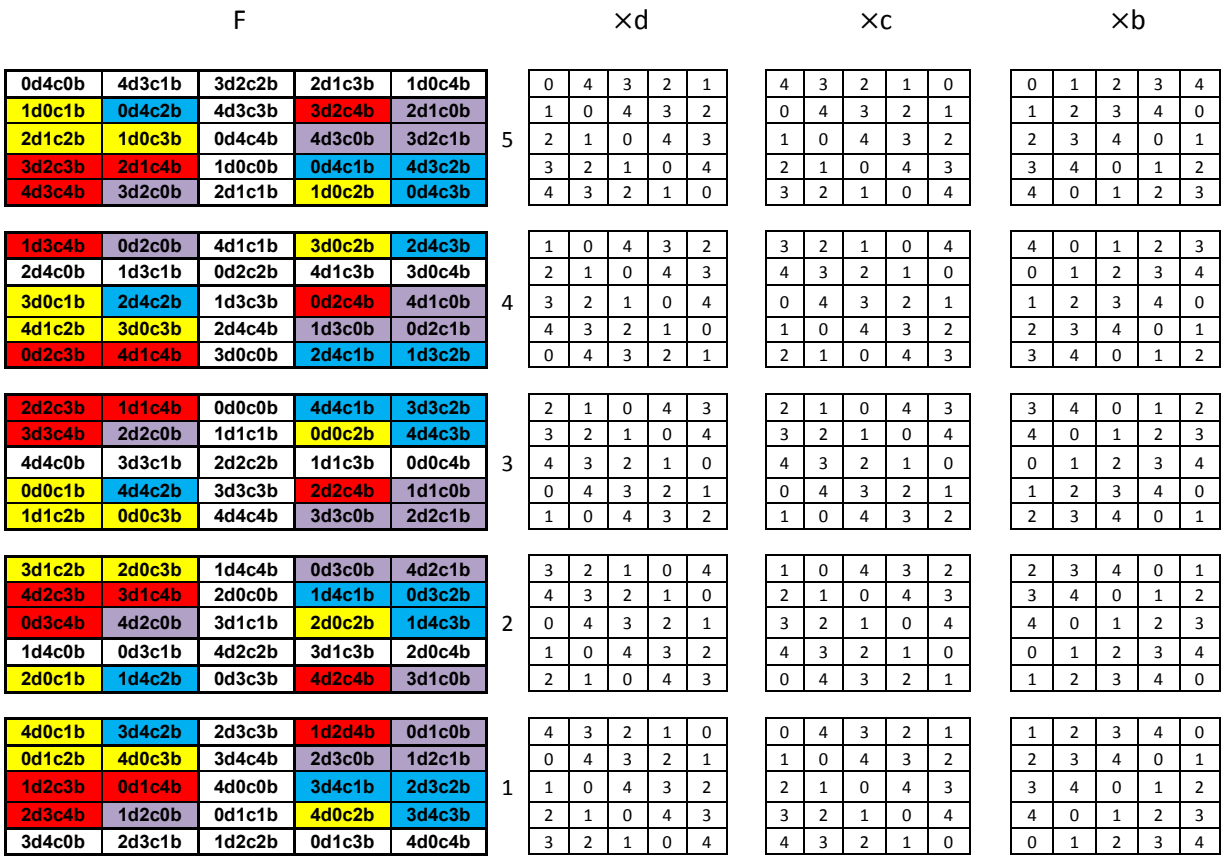

Fig.3. The general balanced cube of 5th order

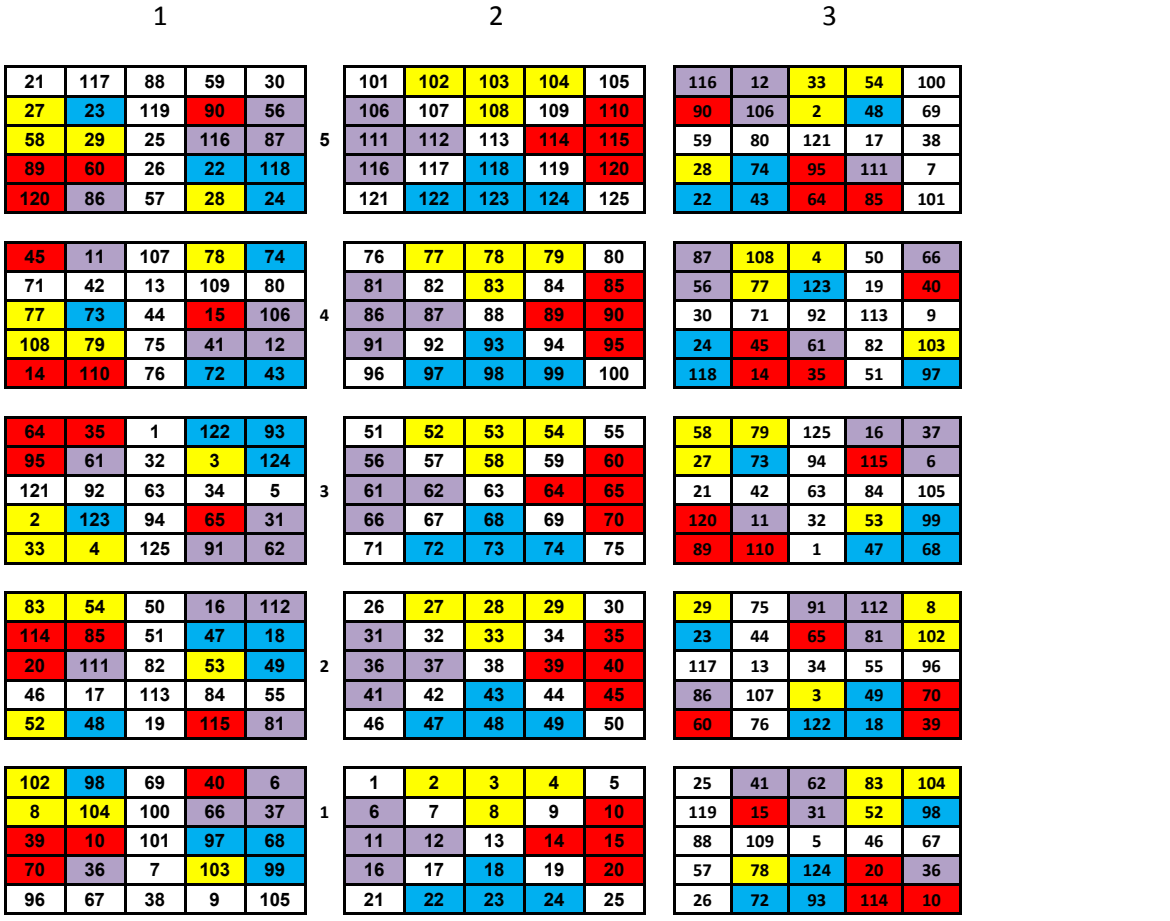

Fig.4. Comparison of Abiyev's balanced (1), natural (2) and Trenkler's magic cubes of 5th order.

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0,5e+0,1	**(-)0,5π+0,5e-i+0,4**	**(-)π-2e-2i+1,2**	**π+0,5e+2i-0,5**	**0,5π+0,5e+i-0,2**
0,5π+1,5e+i-0,4	**(-)e+0,4**	**(-)0,5π-e-i+0,7**	**(-)π-e-2i+1**	**π+1,5e+2i-0,7**
π+2i-0,4	**0,5π+i-0,1**	**0,2**	**(-)0,5π-i+0,5**	**(-)π-2i+0,8**
(-)π-1,5e-2i+1,1	**π+e+2i-0,6**	**0,5π+e+i-0,3**	**e**	**(-)0,5π-1,5e-i+0,8**
(-)0,5π-0,5e-i+0,6	**(-)π-0,5e-2i+0,9**	**π+2e+2i-0,8**	**0,5π-0,5e+i**	**(-)0,5e+0,3**

Fig.5. General balanced cube constructed upon request (third cut). Magic number equals to 1

IV. Conclusion

This algorithm, offered by us in order to write a magic cube of odd order, is very simple as it is seen and enables us to easily form a colored magic cube any order from any numbers. The algorithm can also be easily programmed. This programme can be used in many mathematical modellings. There is no doubt that colorful writing of magic cubes will enlarge the mathematical information spectrum. Abiyev's balanced cube of 1001 order has been formed with this algorithm.

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