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Pams Quantum Periodic Table, an improvement over the existing Mendeleev's Periodic Table

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Abstract : Atoms of chemical elements have three dimensional structures, and it is necessary that periodic table must have 3D shape. "Pams Quantum Periodic Table", which is an improvement over the Mendeleev's Periodic Table, without disturbing its basic theme is a three dimensional periodic table. All four quantum numbers can be visualized in this periodic table at a time, where as in Mendeleev's Periodic Table only principal and azimuthal quantum numbers can be displayed at a time. Folding the P, D and F blocks in three dimensional way and wrapping of those three blocks around S block is the effect of the magnetic quantum number. The spin quantum number plays a different role in the case of Pams Quantum periodic table and it divides the total periodic table in to two structures which have mirror image symmetry. This paper shows the perfect construction of Pams Quantum periodic table according to quantum principles. Pams Quantum periodic table will further help in viewing the data of periodic table trends in new perspective.

Keywords : Periodic Table of chemical elements, Pams Quantum Periodic Table, Mendeleev's Periodic Table, 3D Periodic Table, quantum numbers, symmetry, dimensions, Periodic trends.

Introduction

Language of chemistry has its own alphabets. Its letters are symbols of chemical elements[1]. Alphabets are developed by us where as the Elements are developed by nature. We arranged the Alphabets in to a chart. We also arranged the Elements in to a chart and called it periodic table. The Nature which is intelligent enough to make all the elements with atomic numbers in a serial order, must also have tried to arrange elements in its own pattern. This paper deals with the arrangement of whole chemical elements into a lattice type of symmetrical structure. This paper is divided in to two sections. First section reviews the previous works on periodic table till date and second section deals with the concept of "Pams Quantum Periodic Table".

Section 1 : Mendeleev's Periodic Table, it's concept and background

Linear increasing order of Chemical Elements, the natures perfection

By the end of the 18th century, chemists had discovered a host of new elements not recognized before. But it was John Dalton's atomic theory that provided an explanation of the structure operating behind the scenes. In 1808 he published his ideas and declared that 'the atom' was the basic unit of the chemical element[2]. From that time, various analytical methods like chemical analysis, electro chemical methods, X-ray spectra method and radiometric method were the key factor which led to the discovery of new chemical elements[3]. Hafnium and Rhenium were the last stable elements to be discovered in nature in the years 1923 and 1928 respectively[4]. After discovery of the last stable element Rhenium, only four elements (with atomic numbers 43, 61, 85 and 87) were missing in the table between Hydrogen with atomic number 1 and Uranium with atomic number 92. Scientists went further and the history of synthesized elements starts with the work of these missing four elements[5]. A more rigorous foundation came with the development of quantum theory of atomic structure. As a result of all these scientific works long linear list of elements with serial atomic numbers was developed. This arrangement of elements in a perfect linear form, with a single digit increase every time shows the natures perfection in synthesizing atomic structures.

Prediction of new elements based on periodicity of properties

A connection between the atomic weights of the elements and their physical properties was sought by Prout in 1815, and later by Newlands and de Chaucourtois[6]. As early as 1817 Johann Wolf Dobereiner had begun to notice some consistent relationships in the atomic weights of certain groups of similar elements. By 1861, a number of Chemists had been playing around for several years with the idea of triads based on similarities of their properties. In 1864, the London industrial chemist John Alexander Reina Newlands was the first to notice that a table of elements arranged by order of atomic weights showed a pattern in which "the eighth element, starting from a given one, is a kind of repetition of the first" and called it as law of octaves. But Dmitry Mendeleyev was the one who played with the idea of order among the elements the most creatively and pushed it to its most logical conclusions. Dmitri Mendeleev (1834-1907) arranged in the table the 63 known elements based on atomic weight, and published in 1869. He left space for new elements, and predicted three yet-to-be-discovered elements. And it was the identification of those elements in 1875 and 1886 that made him famous, and led to the general acceptance of the periodic table[7-9]. Scientists later realized the fact that atomic masses do not increase regularly with atomic number, and although many details of lay out have evolved since then, his basic idea has been retained, of ordering elements horizontally in periods so that they fall in vertical groups with similar chemical properties[10].

Mendeleev's Periodic Table, it's block Structure, groups, periods and associated Quantum numbers

The Mendeleev's periodic table is arranged by atomic number, so it is arranged by increasing electron count. The ground state electron configuration follows the Pauli Aufbau filling order, so the periodic table is arranged according to quantum mechanics[11] (see Fig. 1).

PERIODIC TABLE OF THE ELEMENTS

1 1A	2 2A	3 3B	4 4B	5 5B	6 6B	7 7B	8 8B	9 8B	10 8B	11 1B	12 2B	13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1 **H** 1.008																	2 **He** 4.003
3 **Li** 6.941	4 **Be** 9.012											5 **B** 10.81	6 **C** 12.01	7 **N** 14.01	8 **O** 16.00	9 **F** 19.00	10 **Ne** 20.18
11 **Na** 22.99	12 **Mg** 24.31											13 **Al** 26.98	14 **Si** 28.09	15 **P** 30.97	16 **S** 32.07	17 **Cl** 35.45	18 **Ar** 39.95
19 **K** 39.10	20 **Ca** 40.08	21 **Sc** 44.96	22 **Ti** 47.88	23 **V** 50.94	24 **Cr** 52.00	25 **Mn** 54.94	26 **Fe** 55.85	27 **Co** 58.93	28 **Ni** 58.69	29 **Cu** 63.55	30 **Zn** 65.39	31 **Ga** 69.72	32 **Ge** 72.61	33 **As** 74.92	34 **Se** 78.96	35 **Br** 79.90	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.91	40 **Zr** 91.22	41 **Nb** 92.91	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.1	45 **Rh** 102.9	46 **Pd** 106.4	47 **Ag** 107.9	48 **Cd** 112.4	49 **In** 114.8	50 **Sn** 118.7	51 **Sb** 121.8	52 **Te** 127.6	53 **I** 126.9	54 **Xe** 131.3
55 **Cs** 132.9	56 **Ba** 137.3	57 **La** 138.9	72 **Hf** 178.5	73 **Ta** 180.9	74 **W** 183.8	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.2	78 **Pt** 195.1	79 **Au** 197.0	80 **Hg** 200.6	81 **Tl** 204.4	82 **Pb** 207.2	83 **Bi** 209.0	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** (226)	89 **Ac** (227)	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (262)	108 **Hs** (265)	109 **Mt** (266)	110 **Ds** (269)	111 **Rg** (272)	112 **Uub** (277)		114 **Uuq** [illegible]		116 **Uuh** [illegible]		118 **Uuo** [illegible]

58 **Ce** 140.1	59 **Pr** 140.9	60 **Nd** 144.2	61 **Pm** (145)	62 **Sm** 150.4	63 **Eu** 152.0	64 **Gd** 157.3	65 **Tb** 158.9	66 **Dy** 162.5	67 **Ho** 164.9	68 **Er** 167.3	69 **Tm** 168.9	70 **Yb** 173.0	71 **Lu** 175.0
90 **Th** 232.0	91 **Pa** 231.0	92 **U** 238.0	93 **Np** (237)	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (262)

Fig. 1. Modern Mendeleev's periodic table, currently under use.

An element's location on the periodic table reflects the quantum numbers of the last orbital filled. The period indicates the value of principal quantum number for the valence shell, the lanthanides and actinides are in periods 6 and 7, respectively.

The block indicates value of azimuthal quantum number (l) for the last subshell that received electrons in building up the electron configuration, blocks are named for subshells (s, p, d, f). Each block contains a number of columns equal to the number of electrons that can occupy that subshell. The s-block has 2 columns, because a maximum of 2 electrons can occupy the single orbital in an s-subshell. The p-block has 6 columns, because a maximum of 6 electrons can occupy the three orbitals in a p-subshell. The d-block has 10 columns, because a maximum of 10 electrons can occupy the five orbitals in a d-subshell. The f-block has 14 columns, because a maximum of 14 electrons can occupy the seven orbitals in a f-subshell[12].

Groups are numbered 1 to 18 and Groups 1 and 2 of the periodic table are referred to as the s-block because these elements have outer electrons in an s-orbital. Groups 13 through 18 are referred to as the p-block because these elements have outer electrons in a p-subshell. Groups 3 through 12 are referred to as the d-block and the inner transition elements are f-block[11]. The f-block elements are known as the lanthanides and actinides. For ease of presentation they are generally shown as separate blocks below the main table. The lanthanides and actinides are in periods 6 and 7, respectively[13].

For the purposes of finding electron configuration from the periodic table and to remember the Aufbau filling order, Helium (He) could be placed in group 2 next to Hydrogen (H)[11].

Four quantum numbers to explain the state of the atom

The Bohr model was a one-dimensional model that used one quantum number to describe the distribution of electrons in the atom. The only information that was important was the size of the Orbit, which was described by the n quantum number.

Schrodinger's model allowed the electron to occupy three-dimensional space. It therefore required three coordinates, or three quantum numbers, to describe the orbitals in which electrons can be found. The three coordinates that come from Schrodinger's wave equations are the principal (n), angular (*l*), and magnetic (*m*) quantum numbers. These quantum numbers describe the size, shape, and orientation in space of the orbitals on an atom.

At first, the fourth quantum number was a mystery. It was Wolfgang Pauli, in 1924, who came up with the idea that this fourth quantum number described the electron's 'spin', which could only point up or down, giving the required doubled-valued quantum number. For the electron "$m_s = +1/2$ or $-1/2$". With these four quantum numbers we can describe the complete state of the atom[14].

It all comes together to show how these quantum numbers actually define the Periodic Table of the Elements (see Fig. 2). The first two columns on the left are when $l=0$, which are *s* orbitals. "*m*" is only zero, so there is

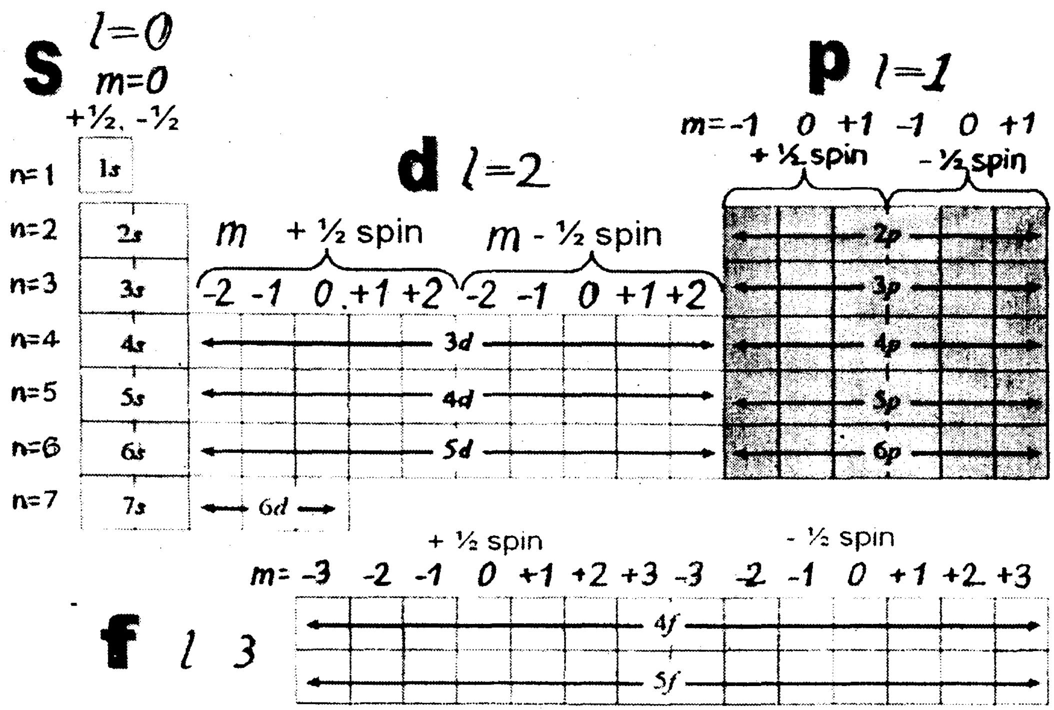

Fig. 2. The Scheme how the four types of quantum numbers actually defines the Periodic Table of the Elements. Explanation : "*n*" is principal quantum number, "*l*"is azimuthal quantum number, "*m*" is magnetic quantum number, "spin" is spin quantum number, "***s, p, d*** and ***f***" are blocks of periodic table named for "subshells *s, p, d* and *f*".

only one orientation (spherical). The +1/2 and −1/2 spins gives us two elements in this block. The right block represents "$l=1$" which is the *p* orbitals. Since "*m*" has 3 orientations and there is a + and – spin for each orientation, there is a progression of 6 electrons that cover these combinations. That's why this block is six elements wide. The middle block is for "$l=2$", which is the *d* orbitals. As mentioned, *m* goes from –2 to +2 giving us 5 orientations. With the two spins, it takes 10 steps to fill up the *d* orbitals, which is why there's a run of 10 elements that go across this middle section. Finally, the Periodic Table always shows a separate block of elements. This is for "$l=3$", which is the *f* orbitals. Since *m* can go from –3 to +3, that's 7 steps. With both spins, that means there it takes 14 electrons to fill up the *f* orbital and why there are 14 elements in that row[15].

Though the standard scheme is given above and universally accepted, the individual element may or in some occasions may not fit in to the frame. The periodic table's rows and blocks roughly correspond to how an atom's electrons are arranged, in a series of "shells" around the proton-rich nucleus[16].

Different Periodic Tables for Different Purposes

Though modern form of the Mendeleev's Periodic Table with increasing order of the Z value has been accepted and retained by modern scientific community, a large number of other forms of Periodic tables have been developed, based on the requirement of scientific groups for last 150 years. Although, few of them are highly scientific and informative no one of them could reach the heights of Mendeleev's Periodic Table. The reason is simple, either because those could not carry the basic theme of Mendeleev's Periodic Table or could have developed for a specified purpose narrowing its limits. All Periodic Tables other than Mendeleev's Periodic Table are collectively called as 'Alternative Periodic Tables'. Most of them can be accessed by visiting "Internet Database of Periodic Tables" available at "The Chemogenesis Work book" (http://www.metasynthesis.com/webbook/35_pt/pt_database.php). There are hundreds of periodic tables across web space, but this is the one comprehensive database of periodic tables and periodic system formulations[17].

Section 2 : "Pams Quantum Periodic Table", it's concept and features

Missing dimension in Mendeleev's periodic table

With the arrangement of elements with increasing order of Z value, the arrangement became a linear and one-dimensional ribbon like structure. By cutting and arranging ribbon like structure in rows and columns the periodic table became two dimensional. Here, at this juncture, we cannot ignore the fact that elements are building blocks of the universe and each element and atom has a three dimensional structure. When we start arranging three dimensional elements in a systematic order it is not necessary that it may be in the same form as Mendeleev's Periodic Table. Mendeleev's Periodic Table is the comprehensive, well organized, historical and highly accepted by scientific community. Any modification or change in it, which would disturb the basic idea or theme of Mendeleev's Periodic Table, may get a total rejection from scientists. At the same time, we can't ignore the facts which have to be studied and evolved. Here comes the "Pams Quantum Periodic Table", which is an improvement over the Mendeleev's Periodic Table, without disturbing its basic theme. As the study of the Mendeleev's Periodic Table in detail will help to understand the core theme of the Pams Quantum Periodic Table, the Mendeleev's Periodic Table was well explained in the previous sections.

"Pams Quantum Periodic Table", an improvement over the Mendeleev's Periodic Table

"Pams Quantum Periodic Table" is a three dimensional periodic table of chemical elements developed by the author of this paper. It is an improvement over the Mendeleev's Periodic Table, without disturbing its basic theme. All four quantum numbers can be visualized in this periodic table at a time, where as in Mendeleev's Periodic Table only principal and azimuthal quantum numbers can be displayed at a time. It is highly symmetrical compact and informative. The name Pams Quantum is chosen for this periodic table suggests four quantum numbers principal, azimuthal, magnetic and spin. First letters of names of quantum numbers are picked to frame the name. The letter 'Q' suggests the word "quantum".

Detailed features of "Pams Quantum Periodic Table of Chemical elements"

In Pams Quantum periodic table pictures (see Fig. 3) each cube indicates an individual element. Number indicated on each cube indicates the Z value (atomic number) of that element. Cubes with chips texture at the centre of the periodic table (bearing Z values 1, 2, 3, 4 etc.) represent s-block of the Mendeleev's periodic table. Cubes next to s-block with vertical lines tex-

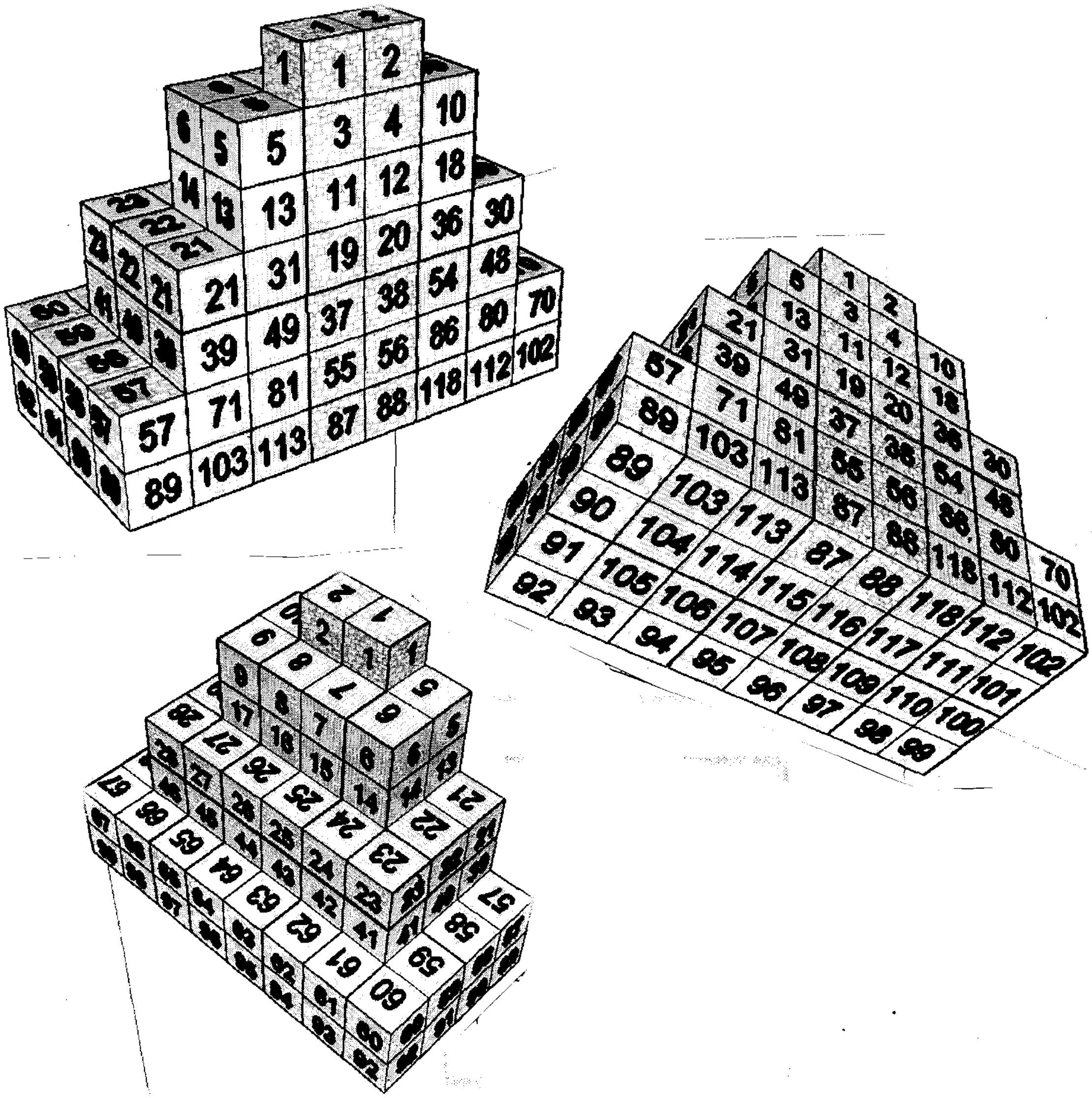

Fig. 3. Front-top view, Front-bottom view and Rear view of the Pams Quantum Periodic Table of Chemical elements in 3-dimensions. Each cube represents one chemical element and Z value of that element is written over the block on all sides. Central two rows with chips texture form "s" block. Rows with vertical lines form "p" block. Rows with horizontal lines form "d" block. Rows with brick pattern form "f" block.

ture (bearing Z values 5, 10, 13, 18 etc.) represent p-block of the Mendeleev's periodic table. Cubes next to p-block with horizontal lines texture (bearing Z values 21, 30, 39, 48 etc.) represent d-block of the Mendeleev's periodic table. Cubes next to d-block with brick texture (bearing Z values 57, 70, 89, 102 etc.) represent f-block of the Mendeleev's periodic table.

In Pams Quantum periodic table each element is considered as a cube with 3D space irrespective of the size and radius of the atom. It is an extension to the 2-dimensional space shown as square boxes in the Mendeleev's periodic table. The cube has an additional advantage of uniform symmetry on all the sides with translational property.

In Mendeleev's periodic table blocks are arranged in a side by side manner. s, p and d blocks are arranged one after another from left to right, and f-block is arranged below those three (see Fig. 4). In Pams Quantum periodic table blocks are arranged in a manner that s, p, and f blocks comes one behind another so that s block comes in the front and f-block comes behind all (see Fig. 5). This type of arrangement will not disturb the order of principal quantum number and all the periods follow the same 'n value' and rules as in the case of Mendeleev's periodic table (see Fig. 6).

The front and behind arrangement of blocks represents azimuthal quantum number. To brief (see Fig. 5), in this three dimensional periodic table height and depth of the space is represented by principal and azimuthal quantum number respectively. Groups are also maintains the same structure without any disturbance, where as arranged in a different pattern (see Fig. 7). This new pattern of arrangement of groups in three dimensional space

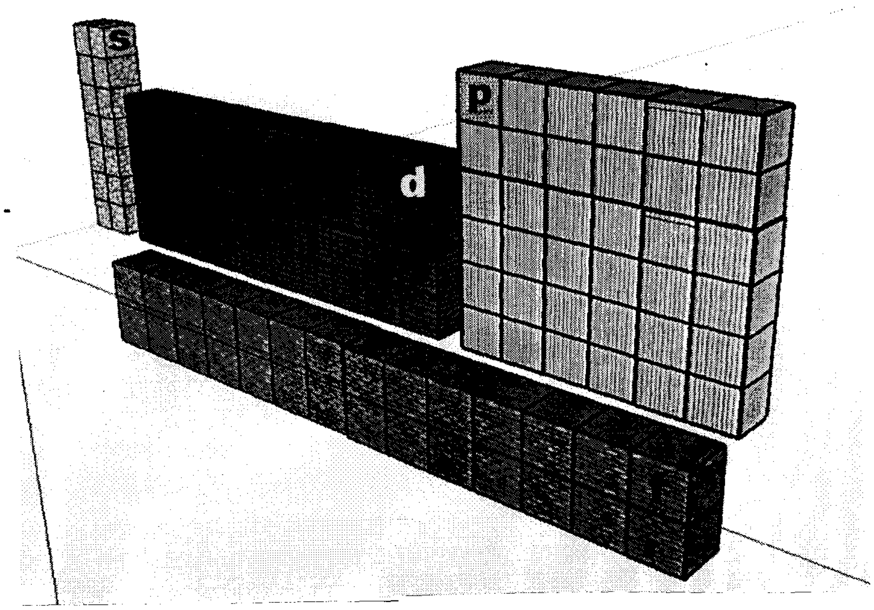

Fig. 4. Arrangement of "s, p, d and f blocks" in the side by side pattern as in the case of Mendeleev's Periodic Table of Chemical elements.

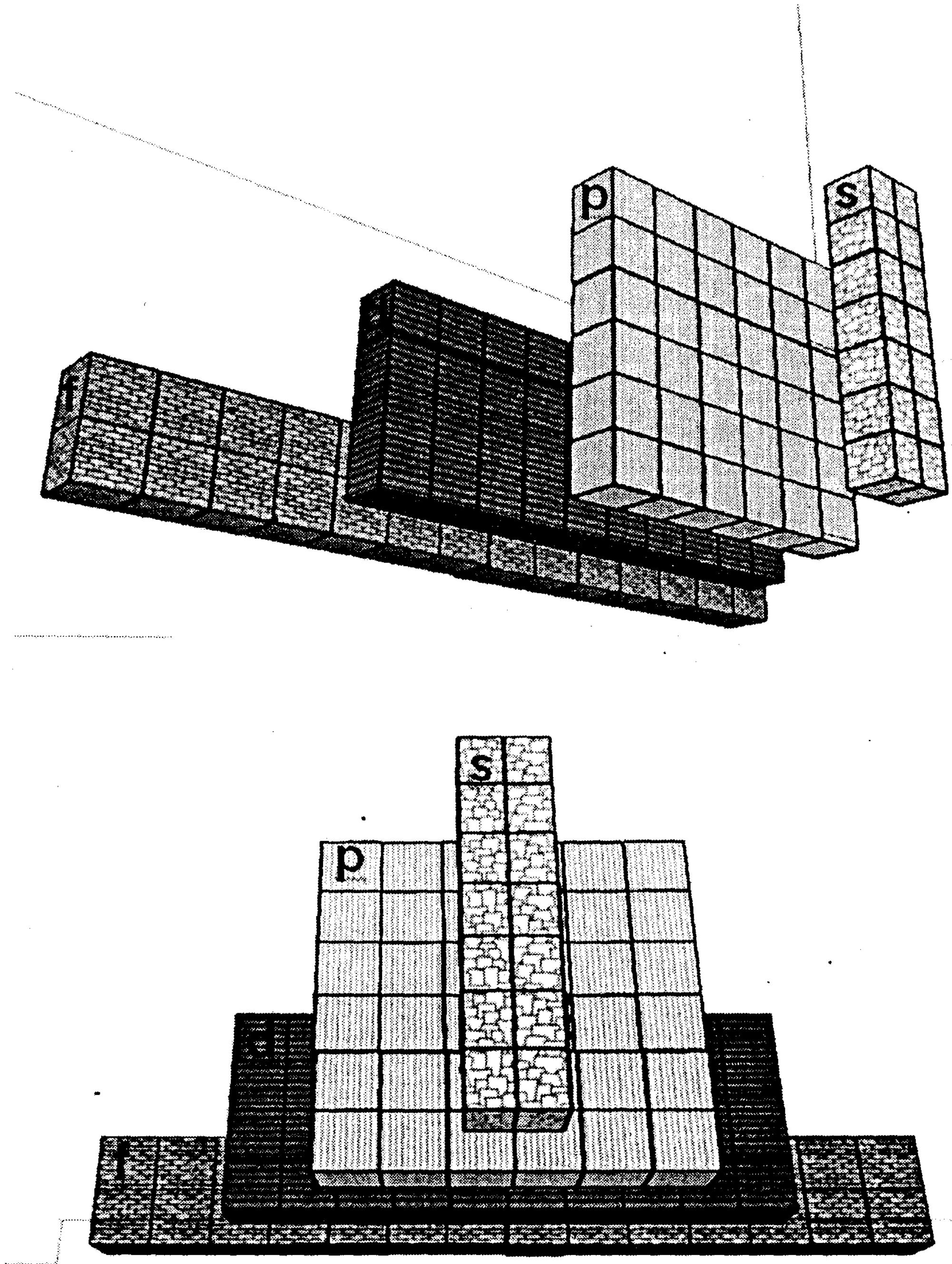

Fig. 5. Arrangement of "s, p, d and f blocks" in front to behind pattern as in the case of Pams Quantum Periodic Table of Chemical elements and this picture shows front view and side view.

will not alter principal or azimuthal quantum number of any element. Folding the p, d and f blocks in three dimensional way and wrapping of those

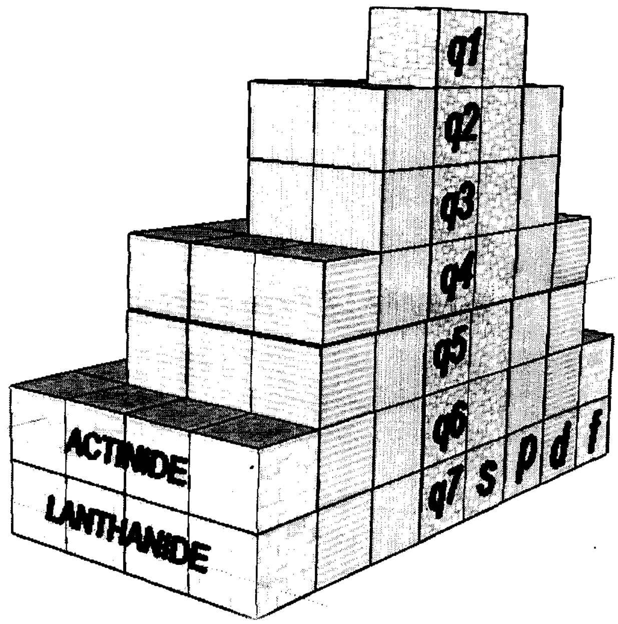

Fig. 6. Pams Quantum Periodic Table of Chemical elements, showing principal quantum number and s, p, d and d blocks. f-block includes Actinides and Lanthinides one below the other.

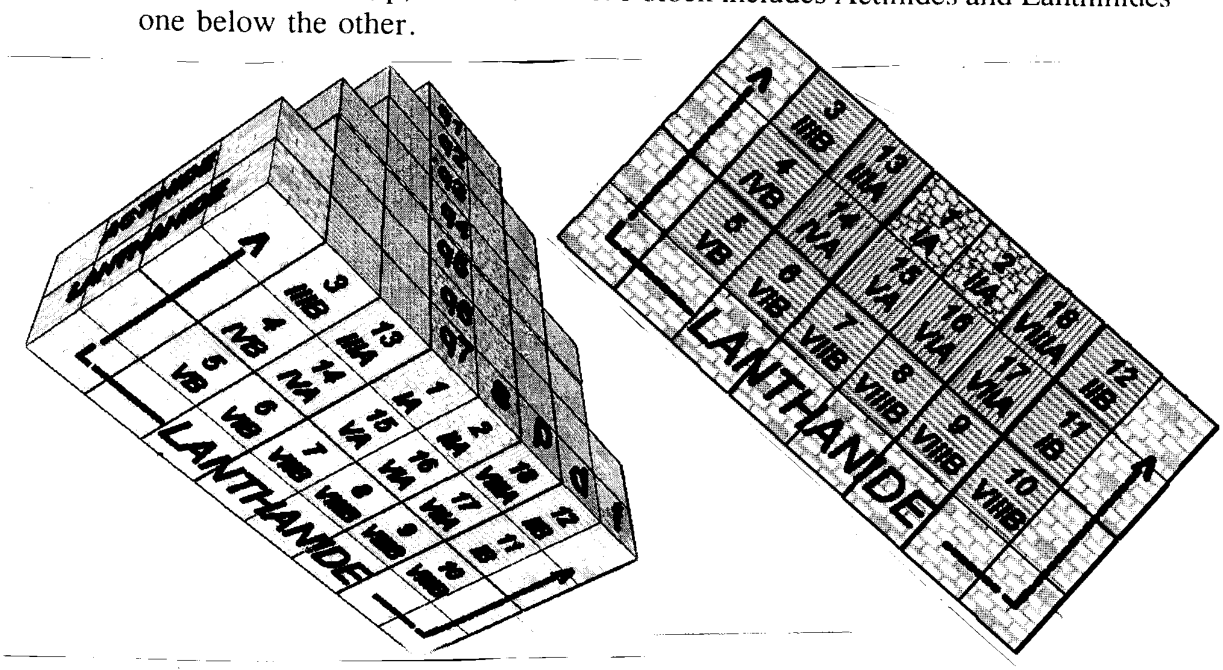

Fig. 7. Pams Quantum Periodic Table, showing groups of Chemical elements. This picture shows bottom-front view and direct view. All the 18 groups are exactly similar to the 18 groups of Mendeleev's periodic table, where as horizontal alignment is changed.

three blocks around s-block is the effect of the magnetic quantum number and will be explained in coming section (see Figs. 9 and 11). The spin

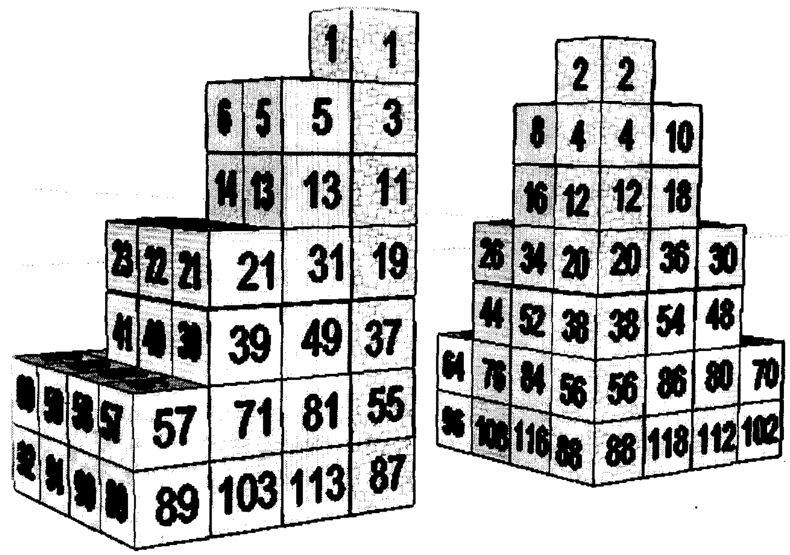

Fig. 8. Pams Quantum Periodic Table, showing two sections separated by spin quantum number with spin up and spin down activity, front view and bottom view. Section of the Periodic table which shows atomic number 1 at the top represents the electron's 'spin', which could only point up i.e. "$m_s = +1/2$", and the right half of the Periodic table which shows atomic number 2 at the top represents the electron's 'spin', which could only point down i.e. "$m_s = -1/2$" and it divides the total periodic table in to two structures vertically which have mirror image symmetry.

quantum number plays a different role in the case of Pams Quantum periodic table and it divides the total periodic table in to two structures which have mirror image symmetry (see Fig. 8). In the case of Mendeleev's periodic table, it can't be visualized in its structure. The left half of the Periodic Table which shows atomic number 1 at the top represents the electron's 'spin', which could only point up i.e. "$m_s = +1/2$", and the right half of the Periodic table which shows atomic number 2 at the top represents the electron's 'spin', which could only point down i.e. "$m_s = -1/2$". Spin quantum number divides the total periodic table in to two structures vertically which have mirror image symmetry. Though the spin quantum number divides the periodic table vertically in real sense it represents the spread of elements horizontally by its double-value of the quantum number, spin up and spin down. Now it is clear that in this three dimensional periodic table height and depth of the space is represented by princi-

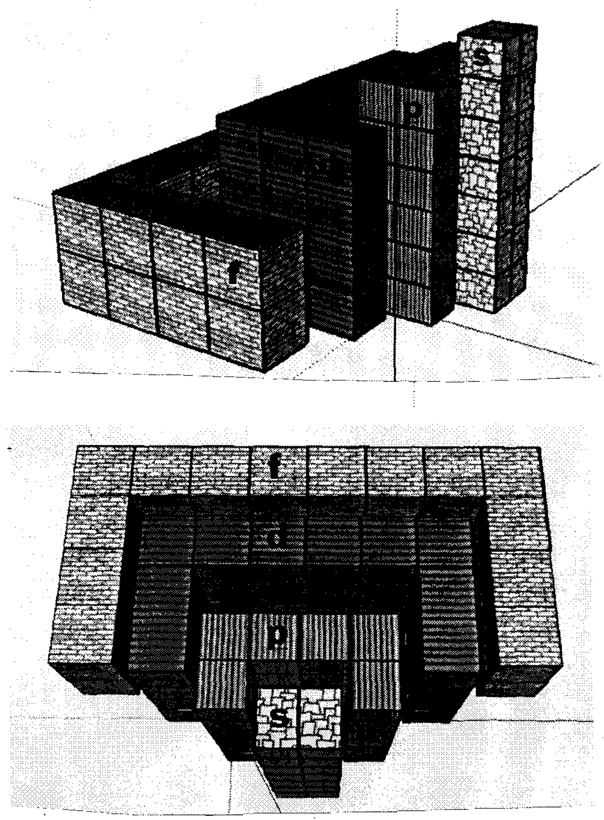

Fig. 9. Pams Quantum Periodic Table, showing s, p, d and f blocks each separately in side view and top view. Folding the p, d and f blocks in three dimensional way and wrapping of those three blocks around s block is the effect of the magnetic quantum number and is shown in the picture.

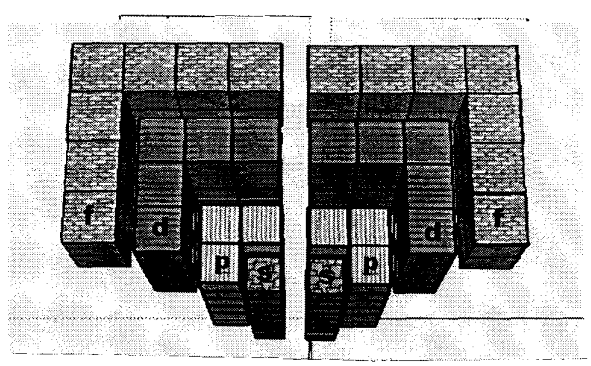

Fig. 10. Pams Quantum Periodic Table, showing s, p, d and f blocks each separately and each block divided in to two sections by the activity of the spin quantum number.

pal and azimuthal quantum number respectively, where as the spin quantum number and the magnetic quantum number represent the width of the periodic table.

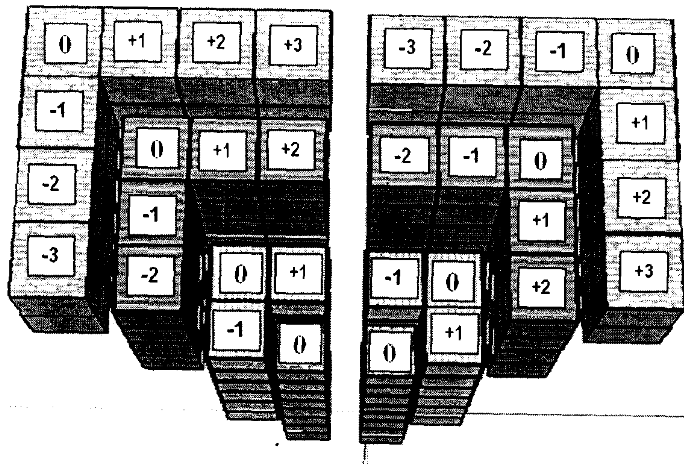

Fig. 11. After the visual division of the periodic table vertically by spin quantum number in to two sections, the effect of magnetic quantum number in imparting central fold to each section in a symmetrical pattern can be visualized. The centre element of each block of each section is represented by magnetic quantum number "0" and elements next to it are represented by plus signs in increasing order. In left section of the periodic table plus signs are on right side and in right section, plus signs are on front side of '0'. Similarly elements of each block of each section prior to '0' are represented by negative signs in decreasing order. In left section of the periodic table negative signs are on front side and in right section negative signs are left side of '0'.

Coming to the function and visualization of the magnetic quantum number, it plays role in folding the p, d and f blocks in three dimensional way and wrap those three blocks around s-block (see Figs. 10 and 11). After the visual division of the periodic table vertically by spin quantum number in to two sections, the effect of magnetic quantum number in imparting central fold to each section in a symmetrical pattern can be visualized. The centre element of each block of each section is represented by magnetic quantum number "0" and elements next to it are represented by plus signs in increasing order. In left section of the periodic table plus signs are on right side and in right section, plus signs are on front side of '0'. Similarly elements of each block of each section prior to '0' are represented by negative signs in decreasing order. In left section of the periodic table negative signs are on front side and in right section negative signs are left side of '0'.

Detailed view of "s, p, d and f-blocks" of Pams Quantum periodic table showing all the elements with their names, symbols and Z values

Though the 3-D figures of the Pams Quantum periodic table are presented, it is necessary to present all the blocks with details of name symbol and Z value of elements (see Figs. 12–15) give details of all essential details of elements of respective blocks. These pictures also give details of magnetic quantum number and spin quantum number of respective blocks.

1 H Hydrogen	2 He Helium
3 Li Lithium	4 Be berillium
11 Na Sodium	12 Mg Magnesium
19 K Potassium	20 Ca Calsium
37 Rb Rubidium	38 Sr Strontium
55 Cs Cesium	56 Ba Barium
87 Fr Francium	88 Ra Radium

Fig. 12. "s block" of the Pams Quantum periodic table with details of name, symbol and atomic number of each element. It is divided in to two equal sections by a black vertical strip in the centre. Left section shows the spin up activity of the spin quantum number and right section shows the spin down.

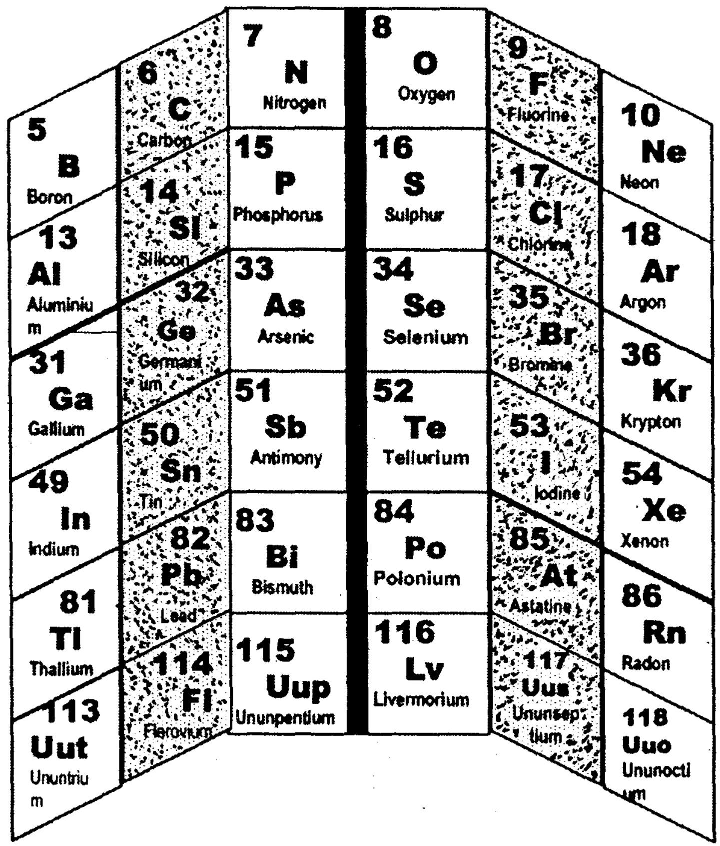

Fig. 13. "p block" of the Pams Quantum periodic table with details of name, symbol and atomic number of each element. It is divided in to two equal sections by a black vertical strip in the centre. Left section shows the spin up activity of the spin quantum number and right section shows the spin down. Central row of the each section is filled with fine dots and represents elements with the magnetic quantum number value "0". This row also represents corner row of each section.

Conclusions

Above data clearly shows that all four quantum numbers took share in construction and can be visualized in Pams Quantum periodic table. But, in the case Mendeleev's periodic table, only principal and azimuthal quantum numbers can be visualized. This shows the perfect construction of Pams Quantum periodic table according to quantum principles. Pams Quantum periodic table, will further help in viewing the data of periodic table trends in new perspective.

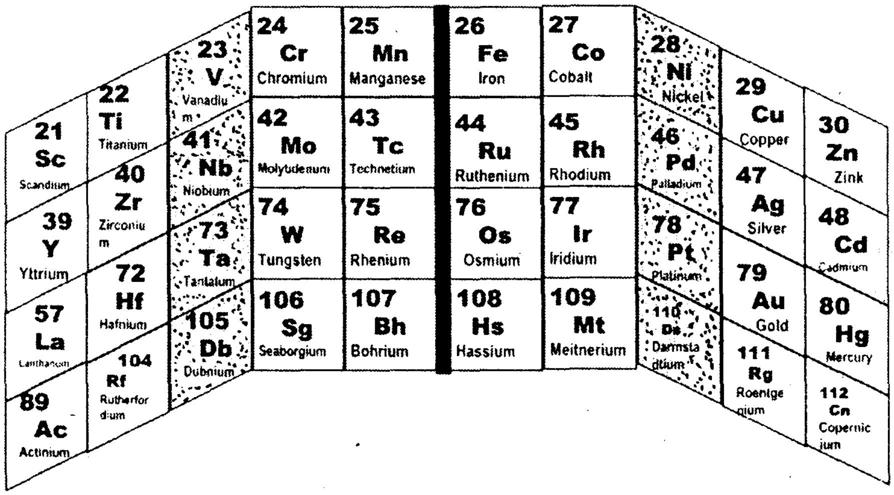

Fig. 14. "d block" of the Pams Quantum periodic table with details of name, symbol and atomic number of each element. It is divided in to two equal sections by a black vertical strip in the centre. Left section shows the spin up activity of the spin quantum number and right section shows the spin down. Central row of the each section is filled with fine dots and represents elements with the magnetic quantum number value "0". This row also represents corner row of each section.

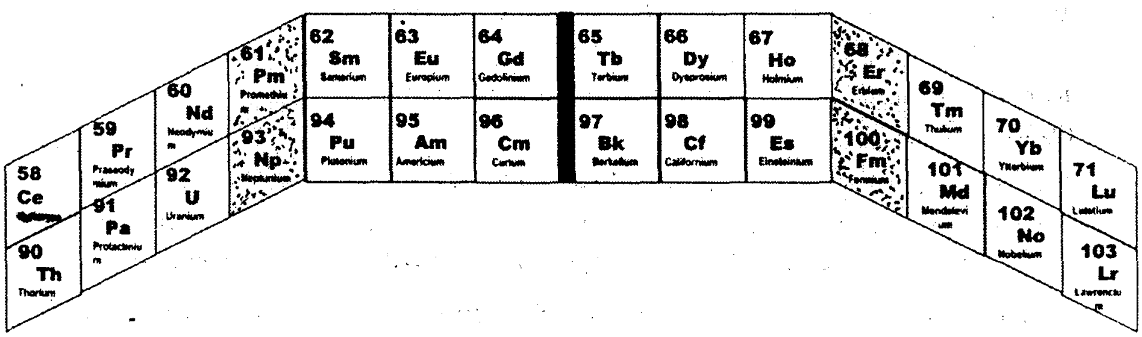

Fig. 15. "f block" of the Pams Quantum periodic table with details of name, symbol and atomic number of each element. It is divided in to two equal sections by a black vertical strip in the centre. Left section shows the spin up activity of the spin quantum number and right section shows the spin down. Central row of the each section is filled with fine dots and represents elements with the magnetic quantum number value "0". This row also represents corner row of each section.

Note : Figs. 3 to 11 are 3-D drawings of Pams Quantum periodic table, drawn with the help of "Google SketchUp 8 software". Elements are shown as three dimensional cubes. Rows with chips texture form "s" block. Rows with vertical lines form "p" block. Rows with horizontal lines form "d" block. Rows with brick pattern form "f" block.

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