A Space-Frame Periodic Table Representation
System Testing Relativity in Nucleosynthesis of the Elements

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Abstract. The geometric Lie algebra SU(3) isotropic vector matrix realization of the periodic table reported at PIRT 2017 has now been broken up to a disjoint-set modular $R^3 \times SO(3)$ building kit, exactly sufficing to stage the Big Bang and ensuing nucleosynthesis events: First the ultrashort radiation/plasma inflation of the Big Bang phase transition moment with release of photons, neutrinos and module precursors, which in next seconds recombine to the Protium proton/electron compound and its neutron conversion to continue separately or in fusion of the two get on to Deuterium and from there to Tritium, Helium in isotope and $\alpha$ form, and traces of Lithium and possibly Beryllium. That is, literally the whole primordial start-gas delivered within a few minutes to billion-year wait for sufficiently energetic perturbations with itself for astrophysical/cosmogenic/experimental nucleosynthesis of the full periodic table and likewise replicable by systematic space-filling assembly/disassembly of the here disclosed neutrino and photon lattice vector, $\beta$ particle, $\alpha$ wave-packet and neutron building bricks, providing clues also on isotope/neutron excess, shell/subshell, spectroscopy, and chemical bond structural make-up and disposition. Furthermore, the absolute trigonometric sharpness of the nucleosynthesis phase transition burst and expansion is reciprocal to the absolute speed of light and hence a specific test and verification of the relativity theory.

1. Introduction
In previous PIRT proceedings [1-4] and elsewhere [5-16], a direct SU(3) structural realization of the elementary particle spectroscopy has been reported (Figure 1), which can shortest be described as a faithful real space implementation of the original “nye (new) Classe Geometriske Transformationer” disclosed by Marius Sophus Lie in 1871 [17,18] according to their full differential equation scope of iterating their universal partial derivative “geodetic curves of length equalling zero” to “transform two spaces into each other”, and more specifically in the SU(3) case how the “Plücker line geometry can be transferred into a sphere geometry” by trigonometrically “transforming space $r$’s straight lines into space R’s…spheres’ rectilinear generatrices” ( = infinitesimal generators), where “$x, y, z$ are perceived as parameters and…$dx, dy, dz$ as direction cosines” [Ib.].

2. Methods and Results
Figures 2 and 3 summarize this trigonometric phase transition switch between the cubical $R^3$ and spherical $SO(3)$ infinitesimal symmetries as a necessarily space-filling crystallization of the
Figure 1. a-d) Duplicated $A_2$ diagram knits a hexagonal SO(3) infinitesimal generator lattice in and out of the unit sphere, e,f) globally distributed and linking in space-filling parallelepiped $R^3$ geometry-aligned chaperon enclosures. Note in Figure 1e the root vector projection of the major semiaxes of volume-preserving ellipsoidal $\Lambda^0$ and $\Delta^{0,++}$ transformations and that one charged SO(3) root vector, $p =$ proton, and two neutral $R^3$, $n =$ neutron space vectors are in central pivotal lattice position.

Figure 2. a) Linking of coherent charged $t$ isospin root vectors, forming between them an outwards connected lattice, which from a chosen outset, here at the octahedron equator, b) iterates to an one octahedron/two tetrahedrons truss isotropic vector matrix mesh dual to that of the cubical space.

charged $t$ isospin root vectors in the form of a continuous cloverleaf ‘singlet coil’ sequence of 12 unit steps – equally many as the edges of the cube – outlining the only other space-filling regular solid convolution, namely, a complex of one octahedron and two tetrahedrons (Figure 2 a) iterating into the dual organization of an isotropic vector matrix (IVM) space-frame [16,19]. As shown in Figures 2 and 3, the IVM like the parent cubical lattice of equally infinitely many “grains” [19], is spacefilling per se because every unit occupies only its own site throughout the universal field. However, unlike the Euclidean space mesh it is also continuous so that it is possible to find an “analytical”, that is, iterating non-overcrossing sequence of its parallelepiped $R^3$ lodgment (Figure 3 a), which both as the parent Lie algebra neighborhood of its phase transition [17,18] and as the chaperon of the consecutive further stashing of this will by two complementary halves (Figure 3 b,c) go into the shortest way of not only repeating the parallelepiped shape of the primary plasma modules (Figure 3d) into the next hierarchical generation of global realization but also taking the step out there (Figure 3 c,e) to bridge its worldline continuation. Quite concretely, it is about as simple as possible transforming a cubical $R^3$ mesh into an IVM SO(3) mesh of equally many infinitesimal elements - “straight lines of length equal to zero” [Ib.] - in the mutual Euclidean canvas of our physical interactions, measurements and representations, in a course that is continuous and coherent, that is, not
Figure 3. a) 12-step SO(3) singlet coils are mirror-distributed in coherent parallelepiped $R^3$ frames, and b) in the phase transition of these to the IVM distribution retain this spatial portioning so that the further continuous path is found by the consecutive close-packing of these virtual chaperon boxes into the most compact next parallelepiped node that can in turn self-assembly into further hierarchical cycles of dense Euclidean spacefilling. c) Shown in side view, the primary plasma element of this initial Big Bang expansion is the $2 + 8 + 18 + 32 + 32 + 32 + 18 + 8 + 2 = 152 \times 12$-step trapezoid stack forming a flat-bottomed base (with virtual grid lines sketched) which induces a flat-roofed cap (represented in sole SO(3) constitution without grid lines by colors alone referring to shell/subshell and noble gas organization), which by adding $152 \times 12$ steps modifies d) the top view contour of the compound module so that it can join others with (shown) or without unit central gap to fill space sideways, too. e,c). However, it also adds an extra step to the module so that the relative inertia becomes $(2 \times 153 \times 12 = 1836 = \text{the proton/electron mass ratio, but the extra step cannot find place in the already crammed space, obliterating this variety;}} except perhaps in deep-frozen Bose-Einstein condensation events.

obliterating into a Gordian knot already from the outset (Figure 3 e).

Figure 4 indicates the way out of the deadlock by an alternative interlinking of the initial phase transition plasma elements, i.e. the bottom plate as outlined in Figure 2 b and c. When pairwise squeezed obliquely rather than end-to-end (Figure 4 a) they may split and recombine in two orthogonally inclined mirror halves, together filling up 152 $R^3$ voids in a half-rectangle layout with empty corner which when filled out in the compound module reaches the $153 \times 12$ proton/electron mass ratio (Figure 4 b). Figures 4 c-e in a sequence of pictures summarize that together with the other contributions from the roof part, the compound modules can duplicate by a twist and so form $^1H$, Protium, which gathers to $H_2$, while Figures 4 f and g show the outcome when they are equally aligned in the interception and the electron mesh in one of them is then snapped off in reverse order as a positron and in that process materializing the till then latent $R^3$ chaperon lattice as a neutron which may continue as such or (Figure 4 g) hybridize with the other Protium in concrete fully accomplished $R^3 \times SO(3)$ wave-packet form [16] to the $^1H^2$ Deuterium atom, which, in turn, can wind into the Helium atom, or $\alpha$ particle. Figure 4 h finally shows that the remaining basic building/decay blocks of the initial Big Bang nucleosynthesis are parts of the system, too, namely, the different neutrinos and photons from the $R^3$ and SO(3) lattice isovectors and their straight and in SO(3) also sinuously zigzagging concatenations; all of infinite path length and consequential zero mass expression.

This has been a very brief recapitulation of the initial and early Big Bang spectroscopy [20], reproducing its elements and operations within one and the same system under the empirical aim
Figure 4. As in text. The straight-to-round phase transition means that the primary plasma modules are filled by the SO(3) IVM mesh alone (although the chaperon grid is shown in the beginning sketches). The IVM wiring is not outlined but instead its crystallization template and spectrum by a color charting referring both to noble gas period and shell/subshell organization. The figure aims to be self-explanatory but g) noteworthy is the reversible split of a proton/Protium to a neutron, i.e., an up to a down quark in the standard model, by a neutrino unlocking snap and peeling off a positron emission. Note also various $\nu$ and $\gamma$ sequences when lattice edges may break off in different fusion processes (h).

Figure 5. a) When Deuterium merges with a neutron, Tritium is formed, and with a Protium/proton the $^2$Helium$^3$ isotope. b) Iteration of the modules fills space in all directions; the transversal plane by the consecutive end-to-end build and linking of the modules, and the vertical (in this projection) with the proton/electron inertial ratio by the climb in the central pivot gap when a cycle has completed a layer and turns to the next in reverse order (not shown). c) In this way, $^3$Lithium$^6$ can be synthesized in the Big Bang by an $\alpha$ and a $\beta$, $^3$Lithium$^5$ by an $\alpha$ and a Protium/proton and $^2$Helium$^5$ by an $\alpha$ and a neutron. All of these have the same volume, spanning the same space, but different stability and charge. Also Beryllium can be formed at this stage, here $^4$Be$^8$ by an $\alpha$ and two $\beta$, offering two binding sites, one of these indicated for a BeH molecule.

to find a direct structural counterpart to the observed data. These also involve the intermediary Tritium and $^2$Helium$^3$ plus some trace generation of Lithium and possibly Beryllium, which Figure 5 demonstrates are covered, too. Thereby literally the whole primordial start-gas for
Figure 6. a) $\alpha$ and $\beta$ module and simplified block outline with space-filling tessellation of the Lithium to Neon period. Numbers refer to oxidation states. b) $\alpha$ and $\beta$ block representation/space-filling tessellation of the stable ground states in the Sodium to Argon period. Note symmetry by Neutron bricks (grey) in uneven states. As shown in Argon the mapping is bidirectional allowing retrieval of ground structure. Colors refer to those of the terminal noble gas of the period in the scintillation tube.

the ensuing actual astrophysical/cosmogenic/experimental nucleosynthesis of the entire periodic table billions of years later has been retrieved from one single prototype, and can continue to be deployed under the higher energy conditions then at hand. However, with increasing mass the detailed module graphs become blurred. With example from recent “computational astrophysics for the future” [21] a simpler, “duplo” representation by square $\alpha$ and $\beta$ blocks has therefore been applied as illustrated in Figure 6, together with the fine-grained original in the Lithium to Neon period and alone in the Sodium to Argon. Space-filling tessellation is possible without extra elements, enabling the full periodic table kaleidoscopy as further surveyed in Figure 7, where some of the basic assembly lines of the construction set and tools provided by the Big Bang are summarized. No other building elements or modes are available but the energies raised in the different self-pertutative stages reached plus the renewed supplies of materials like excess amounts of neutrons feed the isotope forging up till the transuranes, from which a high-precision tailored whole-atom splicing as presently crowned by Oganesson can take over in the designated laboratory [20].

Reciprocal to the often double-step synthesis processes, there are both single-step and larger decay channels serving to chisel out from the wide isotope spectrum the states which by themselves and in accommodability with the other atoms are (most) stable. The decisive factor due to their modular construction is the congruent space-filling form of their two-dimensional transversal cross-section plane. Figure 8 gives an example from a Gallium isotope sequence entering via $^{30}$Zinc into a $\beta$ decay chain which, like the whole isotope panorama over the entire periodic table range can be exhaustively and exactly reproduced by permutations of the building bits delivered by Big Bang in the origin. Without further examples, therefore, it should be ready to go on with the next, Potassium to Krypton row of the periodic table. It is an interesting series because almost in its middle lies Iron, which is the heaviest atom principally produced by fusion and beyond which with Iron-56 as main accumulated seed material the predominant astrophysical element formation is by the slow neutron capture process [20,22,23] in the lower subsequent mass range. Figure 9 aims to cover the brick-laying of Potassium to Iron, and the neutron source for the ensuing slow neutron capture process in the Iron to Krypton
Figure 7. Kaleidoscopic survey in fine- and coarse-grained brick representation of some basic assembly/decay modes of the building set once instantly provided by the Big Bang, when after billion-year wait entering into the self-perturbative astrophysical nucleosynthesis stages (which in practice are exhausted by iron although possible to proceed in the laboratory).

series, which in turn is surveyed in Figure 10 in two tentative varieties of preserving the quadratic cross-section form which would allow space-filling both of the individual stable isotopes and of their molecular combinations.

With Krypton the fourth round of the periodic table is completed, like the previous noble gas
Figure 8. a) Gallium to Zinc $\beta$ decay process entering into b) Zinc to Iron decay sequence.

Figure 9. a) Stable(st) isotopes of first eight elements in the Potassium to Krypton period, forged in stellar astrophysical fusion processes and terminating with iron. Neutron placement is arbitrary, but serving to uniform space-filling packing. b) Two fusion sources for the neutron capture processes.

states packed by full $\alpha$ cells alone beside the neutrons. The wider isotope spectrum due to extra excess (or deficit) of these is not discussed here because the mechanisms are the same and they have their more vital roles towards the belt of stability where, especially with higher mass, the neutrons (and sometimes protons) serve to probe, adjust and pave the structural forms that fit and combine into the global adaptation. This is extra apparent with magic numbers of neutrons and notably around fifty, which is where Krypton and its successors lie. An interesting example with 48-49 neutrons involved is the $^{36}\text{Kr} - ^{37}\text{Rb} - ^{37}\text{Rb} - ^{38}\text{Sr}$ chain (Figure 11a) in which the three stable atoms may have the same shape and size of their lattice, yet $^{36}\text{Kr}$ is inert and the immediately following $^{37}\text{Rb}$ is a highly active alkali metal. In lower mass states, as showed for the Potassium/Chlorine alkali/halogen pair and two larger molecular cases in Figure 11 b [16], the atoms may interlock and spacefill directly from their complementary outline, but with larger size an evening out of the contour along the whole margin may happen, where the placement of the cells vary and the neutrons may have an electron extent mixed and may thus happen side to side steered by physical neighborhood impacts and pushes and gap
availability like with lego bricks and also with actual observed “spiral ... 2-D layer growth” crystallization processes at the atomic scale [24,25]. The stepwise, both chaotic and methodic accretion performed by nucleosynthesis and neutron capture points at this, and likewise the splicing together of whole atoms in the experimental production of the superheavy elements. It is a virtual spray-paint canvas where the rapid neutron capture offers yet another jet-stream with even more neutron excess so that the synthesis often goes backwards by decay. But the whole panorama, however intricate at sight, is still possible to perceive and discern and pursue as an identical and coherent ingredient of primary structural reality.

3. Discussion
However, it is a vast field so the present report stops here having reached at least one preliminary stage closer to fulfilment. There are many aspects only hinted at, for instance, the subshell organization, the structural basis for the spectroscopy features, the many different rates between even and uneven atomic weight elements, Bosons and Fermions etc. Clearly, a lot more large-scale research is warranted and should engage powerful scientific institutions.

**Figure 10.** a) Slow neutron capture nucleosynthesis of stable and unstable (*) isotopes of Iron$^{56}$ to Zinc$^{67}$. b) Same in Zinc$^{67}$ to Krypton$^{86}$. The placement of neutrons and outer shell bricks is quantitative and does not indicate specific patterns corresponding to e.g. subshell organization. Transitions are marked by arrows/lines.
Nonetheless, it is already fair to conclude that the definite Big Bang event has been faithfully replicated at the origin as a closed three-dimensional Lie/Grassmann/Clifford geometric algebra from its real state neighborhood [4,14-18], and that the coincidences are so large and objective that it would be irrational to judge them as fortuitous. For the entire nucleosynthesis there is in effect no other tool box available than that delivered by the Big Bang whether referred to by name alone or by a structure that is identical with the rest of concrete reality, and that builds it entirely bottom-up.

And that is itself built upon first principles such as the unity and hence complete filling of its own element and space and work of any specific physical realization. This is here that of extension in the Cartesian understanding that “the extension in length, width, and depth which constitutes the space occupied by a body, is exactly the same as that which constitutes the body…consequently, there cannot exist a space separate from body, since all spatial extension simply is body” [26]. Lie, who in the foreword of his thesis declared that it “stands in an intimate dependence on philosophical reflections upon the nature of Cartesian geometry” [Ib.], identified “not the point” but the infinitesimal “straight line whose length equals zero” [17,18] as its differential “space-element” both as a mechanistic matter of fact and in a deeper exegesis as the categorical contrast to nothing at all [11-18].

In its ground realization the periodic table comprises the realm of inorganic chemistry in an orthogonal symmetry which favors a cubic mode of crystallization. But the position of the module bricks may vary so that, albeit always in cylindric/prismatic form and therefore direct vertically stowable, other transversal configurations can result, too, for instance, hexagonal, rhomboid etc. Furthermore, in molecular combinations, nota bene with Carbon, other spacefilling/partly spacefilling solids than cubes/parallelepipeds and the octahedron-tetrahedron complex can be generated from the system such as dodecahedrons and icosahedrons and, as shown by Rowlands [27], open up and span organic chemistry including DNA and RNA by a coherent straight line microstructure alone.

Another interesting implication of the model is the absolute both trigonometric and temporal sharpness of the Big Bang phase transition which is reciprocal to the absolute speed of light and hence a test and confirmation of the relativity theory. Finally, since extension is a priori endless the process does not have a fixed centre but is isometrically distributed and decentralized from the outset.
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