Protein folding and crystallization applied to qubit interactions and fundamental physics yields a modified inflation model for cosmology

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Abstract (500 words)
Protein folding achieves a clear solution structure in a huge parameter space (the so-called protein folding problem). Proteins fold in water, and get by this a highly ordered structure. Finally, inside a protein crystal for structure resolution, you have everywhere the same symmetries as there is everywhere the same unit cell. We apply this to qubit interactions to do fundamental physics:

in a modified cosmology, we replace the big bang by a condensation event in an eternal all-encompassing ocean of free qubits. Interactions of qubits in the qubit ocean are quite rare but provide a nucleus or seed for a new universe (domain) as the qubits become decoherent and freeze-out into defined bit ensembles. Second, we replace inflation by a crystallization event triggered by the nucleus of interacting qubits to which rapidly more and more qubits attach (like in everyday crystal growth). The crystal unit cell guarantees same symmetries everywhere inside the crystal. The textbook inflation scenario to explain the same laws of nature in our domain is replaced by the unit cell of the crystal formed.

Interacting qubits solidify, quantum entropy decreases (but increases in the ocean around). In a modified inflation scenario, the interacting qubits form a rapidly growing domain where the n**m states become separated ensemble states, rising long-range forces stop ultimately further growth. Then standard cosmology with the hot fireball model takes over. Our theory agrees well with lack of inflation traces in cosmic background measurements. We explain by cosmological crystallization instead of inflation: early creation of large-scale structure of voids and filaments, supercluster formation, galaxy formation, and the dominance of matter: the unit cell of our crystal universe has a matter handedness avoiding anti-matter.

We prove initiation of qubit interactions can only be 1,2,4 or 8-dimensional (agrees with E_8 symmetry of our universe). Repulsive forces at ultrashort distances result from quantization, long-range forces limit crystal growth. Crystals come and go in the qubit ocean. This selects for the ability to lay seeds for new crystals, for self-organization and life-friendliness.

The phase space of the crystal agrees with the standard model of the basic four forces for n quanta. It includes all possible ensemble combinations of their quantum states m, a total of n**m states. Neighbor states reach according to transition possibilities (S-matrix) with emergent time from entropic ensemble gradients. However, in our four dimensions there is only one bit overlap to neighbor states left (almost solid, only below Planck quantum there is liquidity left). The E_8 symmetry of heterotic string theory has six curled-up, small dimensions which help to keep the qubit crystal together and will never expand.

Mathematics focusses on the Hurwitz proof applied to qubit interaction, a toy model of qubit interaction and repulsive forces of qubits. Vacuum energy gets appropriate low inside the crystal. We give first energy estimates for free qubits vs bound qubits, misplacements in the qubit crystal and entropy increase during qubit decoherence / crystal formation. Scalar fields for color interaction/confinement and gravity are derived from the qubit-interaction field.

Key words: protein folding; crystallization; qubit; qubit interaction; decoherence; modified inflation; early cosmology;

Running head: qubit interactions and fundamental physics

Introduction

In protein folding we see how a clear solution is achieved in a huge parameter space (the so-called "protein folding problem"; Dandekar & Argos, 1994,1996). Moreover, since that time we investigate how proteins fold in water, and how proteins get by this a highly ordered structure (e.g. Sarukhanyan *et al*., 2022, 2023). Finally, in a crystal, for instance a protein crystal for structure resolution, you have everywhere the same symmetries as the crystal has everywhere the same unit cell. We take such considerations from protein folding and apply it to qubit interactions. This helps to answer questions from fundamental physics, such as:

How can proteins form by amino acid interactions at all and gain a highly ordered structure? Is that not anti-entropic? No: (i) outside entropy increases (the water solvent) and (ii) we have the peptide bond formation supporting more the energy for the whole process. Note that we see in protein folding how a huge parameter space is reduced.

Now if we apply this to qubits, a first question is, how and why should they interact, with any dimension and any type of particle. In this modified inflation cosmology, we do not start from nothing but we rather start with an eternal ocean of qubits (our "bulk" as string theory calls it or "water, solvent" in more mundane protein folding).

Next, we first of all want a trigger for folding. A first result for this question is that surprisingly, qubits of any arbitrary number of dimensions cannot interact with other qubits of any dimension. The Hurwitz theorem (Hurwitz, 1898) was originally applied to show that there are only real numbers, complex numbers, quaternions, and octonions. Applied to our question, how can qubits of any dimension interact, it shows, this is only possible in 1D,2D,4D and 8D.

The parameter space for crystals or universes resulting from such a trigger event is still huge, but string theory points out further consistency demands. Thus, the 8D solution is respected by E_8xE_8 heterotic string theory, reducing the parameter space for interaction still a lot, e.g. to accommodate the basic four forces. However, as the ratios of these basic forces to each other, of field and particles properties may vary for the E_8xE_8 heterotic string theory, this leaves a huge number of parameters still open (10**600 solutions).

Where comes the energy to allow qubit crystallization and what would hold such a crystal together? In protein folding, the rich peptide bonds and chaperons with ATP power this process in the cell. For qubit crystallization to happen, we suggest that in string theory the curled-up dimensions in all of the five flavors of it provide here the required energy and glue, as their interaction is not diluted by disentanglement (they have only one qubit extension). We will see also that there is a maximum size of expansion and quanta state for the macroscopic dimensions.

Moreover, the remaining free parameters have to be strongly reduced in their freedom of choice to allow a universe to be live-friendly (fine-tuning problem: why is this so?). Our explanation starts by looking at everyday crystals and proteins with usually finite life-time. Considering that the universe also at present exists only since 14 Gyrs, we think that our universe is not lasting forever (max 70 Gyrs in the future, big rip scenario). As we see in our modified cosmology also our universe as one of many qubit-frozen crystals in the large eternal ocean of free qubits, we suggest a scenario where a type of crystals generating seeds for the next generation will be favored over crystals lacking this ability. This is sufficient to trigger a process where after over several generations of crystal life-cycles only those which have the best and most seeds are accumulating. Such a life-like process, selecting for self-organisation and best off-spring and hence favoring inside a crystal small-scale self-organizing processes such as galaxy formation and life. It seems even to select for intelligent life, at least if we believe in an evolutionary scenario in the first place, as then also this feature should bear an advantage for survival of crystals.

We provide hence an explanation for the fine-tuning of life-like conditions in our domain instead of ignoring this fact or assuming a freak accident as in textbook cosmologies while explaining at the same time the bewildering openness of string theory regarding parameter settings: this is necessary so that an evolution-like process can select suitable qubit crystals with best offspring. We hence apply again a concept of biology to cosmology, but please bear in mind: selection and evolution apply to any entity, including *in silico* computer simulations, particles and other dead objects.

Thus, applying protein folding considerations to cosmology and fundamental physics leads to a modified inflation model with high explanatory power: We see, why there is the fundamental E_8xE_8 symmetry around, it is a similar process as protein folding, but triggered by qubits interacting in an ocean of free qubits. The crystal symmetry units ensures everywhere the same "laws of nature" inside the crystal, even if this grows slowly, super-rapid inflation by a hypothetical inflaton is not necessary. Fine-tuning or live-friendliness may be explained by selection processes over several generations as in normal proteins and crystals. Antimatter simply will reside in qubit crystals with different handedness of their unit cell and so on, e.g. dark matter may be prearranged by crystallization to allow even earlier galaxy formation etc.

In conclusion, we show using protein folding and crystallization as every day examples, how fundamental questions in cosmology are solved. We want to provide a real explanation, no big bang without any explanation why it happened, but just a normal evolution of crystallization from seeds in an ocean of chaos (n-dimensional qubits, undefined) sometimes triggering of formation of a crystal, but then the crystal again decays.

In the results we derive (i) the formulae to describe the qubit crystallization (overview with Figures 1-4, formulas summarized in Table 1, validation options in Table 2), (ii) show their further development, (iii) explain a toy model of qubit interaction, (iv) use the Hurwitz theorem to show that qubits of any dimension can only interact in 1D,2D,4D and 8D dimensions**,** (v) quantization derives a repulsive force for smallest qubit distances and (vi) give first qualitative estimates from our theory

There is still a lot to do, but the protein folding and qubit crystallization approach allows a fresh look at cosmology. Though only replacing the very first two steps of cosmology by something normal, already observed, qubit interactions, and then continuing "after the first three minutes" with the hot fireball expanding universe of the standard model allows to answer tough philosophically questions for the first time: why we are here, why the universe is so life-friendly and why string theory is there.

Physics-minded explanations include early galaxy formation by having dark matter optimally arranged in the crystal and the antimatter solution found only in another mirror crystal in the qubit ocean. Quite remarkable is that qubit crystallization may explain *why* there are 10**600 open string theory parameters (evolution can operate to select optimal crystal seeds) and *why* there is E_8xE_8 symmetric string theory in the first place, *why* there is a scalar field for gravity (from the qubit crystal field) and *why* for color confinement (scalar field, again from qubit crystal field after cooling down / decay into the four basic forces). Our hope is that we can stimulate the physics community to take our suggestions and models seriously and develop the implied new physics correctly further than is possible here in this first sketch.

Results

Overview on the results

Our motivation: The standard cosmology agrees well with observations, particular as soon as the expanding hot fireball scenario is reached (Weinberg, 1977). however, the very early steps of big bang and inflation are unclear. In particular, experiments like BICEP/2 (Ade et al., 2015) suggest that these early steps may involve no inflation favouring such non-inflation models (Ijjas and Steinhardt, 2016). To identify realistic, alternative scenarios, we were considering everyday phenomena of structure creation, in particular protein folding, where order in the protein may be created as entropy rises in the solvent around and crystallization, where first a condensation nucleus is generated and then crystal growth starts until long range forces limit further growth. Crystallization (and no inflation) ensures in this modified cosmology that everywhere the same symmetries exist according to the unit cell of the crystal. This hence ensures the same laws and symmetries everywhere inside the crystal without requiring the extraordinary process of inflation.

Taking both natural processes into account, we were motivated to investigate structure generation in an ocean of qubits having all sorts of wave function, dimension and space and how the universe could be triggered by qubits interacting (with rare probability) and the qubits crystallizing out to defined bit ensemble states. Further growth of the seed by attaching further qubits leads to a larger crystal until long range forces inside the crystal prevent further growth. Hence, this is no “creation from nothing” but our cosmology only investigates how crystals could form in a large, eternal ocean of qubits. Apart from the very early two events big bang and inflation replaced by rare qubit interactions triggering crystal growth, the cosmology is not modified, leading next directly to the early hot fireball and further developments according to textbook. A further motivation for our modified cosmology is that the reality of our universe is explained. Typically, cosmological models consider only the start of the universe as an awesome mystery. However, the fact that we have macroscopic fully defined states and no qubit multi-state indeterminism is the really stunning fact of our universe. In our model, this is explained as all quantum states freeze out and nearly completely solidify, only tiny liquidity is left according to Planck´s quantum h. Below this Planck´s quantum, all remains multistate, undefined wave functions as well-known from quantum physics. We have a number of further consequences such as emergent time and an explanation what holds the crystal together. We critically re-examine earlier efforts and results figures already given previously (Dandekar, 2023a,b; 2022). New are here connections to string theory including rolled-up dimensions, a refined protein-folding-minded treatment of qubit crystallization, accurate mathematics on several aspects and inclusion of latest work by others.

Our model: Our model is best understood and can then also be developed step-by-step further as a modified inflation scenario: We replace the “big bang” by a condensation event in an eternal all-compassing big ocean of qubits in our modified cosmology (Fig. 1). Interaction potential of qubits in the qubit ocean is rare (we give an estimate) but these provide a nucleus for a new universe and the qubits become decoherent, necessary for the universe. Second, we replace inflation by a crystallization event triggered by the nucleus of interacting qubits to which rapidly more and more qubits attach (like in everyday crystal growth) – the crystal unit cell guarantees same symmetries everywhere. Hence, the textbook inflation scenario to explain the same laws of nature in our domain is replaced by the crystal unit cell of the crystal formed. We give here only the perspective or outline of this modified inflation theory, as the detailed mathematical physics behind this has still to be formulated and described accurately.

Interacting qubits solidify, quantum entropy decreases (but increases in the ocean around). The interacting qubits form a rapidly growing domain where the n**m states become separated ensemble states (Fig. 2; toy model illustrates this with 6 qubits becoming defined 6 bit ensembles). Rising long-range forces stop ultimately further growth. After that very early events, standard cosmology with the hot fireball model takes over. Our theory agrees well with lack of inflation traces in cosmic background measurements, but more importantly can explain well by such a type of cosmological crystallization instead of inflation the early creation of large-scale structure of voids and filaments, supercluster formation, galaxy formation, and the dominance of matter (no annihilation of antimatter necessary, rather the unit cell of our crystal universe has a matter handedness avoiding anti-matter).

We prove (see detailed results below) that a triggering qubit interaction to start the process of forming a seed for later crystallization of qubits can, if it occurs, only have to 1,2,4 or 8 dimensional interactions (agrees with E8 symmetry of our universe). Repulsive forces at ultrashort distances result from quantization, long-range forces limit crystal growth. Crystals come and go in the qubit ocean. This selects for the ability to lay seeds for new crystals, for self-organization and life-friendliness.

The phase space for the standard model of the basic four forces for n quanta includes all possible ensemble combinations of their quantum states m, a total of n**m states (Fig. 2). Neighbor states reach according to transition possibilities (S-matrix) with emergent time from entropic ensemble gradients (Fig. 3). However, this means that in our four dimensions there is only one bit overlap to neighbor states left (almost solid, only below h dash liquidity left). However, the E_8 x E_8 symmetry of heterotic string theory has six rolled-up, small dimensions which help to keep the qubit crystal together and will never expand. This provides the basis for energy estimates for free qubits vs bound qubits, misplacements in the qubit crystal and entropy increase during qubit decoherence / crystal formation. Scalar fields for color interaction and gravity derive from the permeating qubit-interaction field. Hence, vacuum energy gets low only inside the qubit crystal. Condensed mathematics may advantageously help to model free (many states denote the same qubit) and bound qubits in phase space. Similarly, dark matter can be optimally distributed in a crystal to trigger galaxy formation (Fig. 4) and all the antimatter is not found in this domain (our universe) but simply in another - where a crystal with another basic symmetry unit was built.

We propose a model that rarely interacting qubits in an ocean of free qubits trigger decoherence leading to an ensemble of qubits that now becomes decoherent and splits up to its n**m states and provide the phase space of this universe (Fig. 1). In some sense, this is a phase transition from a more liquid, floating state to a solid, frozen out and defined state (6 bit toy model: Fig. 2; remaining qubit liquidity, Fig. 3; dark matter distribution, Fig. 4).

This model is then used to replace in a cosmological model the big bang by a condensation event (interacting qubits trigger this) and inflation (Albrecht et al., 2015) by a crystallization event (interacting qubits solidify and the n**m states become separated ensemble states). After that very early events, standard cosmology with the hot fireball model takes over. Extending own earlier efforts (Dandekar, 2022, 2023a,b), we show that a number of astronomical observations should fit better to our new cosmological model such as lack of inflation traces in cosmic background measurements (Ade et al., 2018; Chen et al., 2019), large-scale structure of the universe with voids and filaments (El-Ad et al., 1997), supercluster formation (Long et al., 2020), galaxy formation (Boylan-Kolchin, 2017), dominance of matter (BESIII collaboration, 2022) and the life-friendliness of the universe (Barrow and Tipler, 1988). On the other hand, apart from these very early events we do not touch the course of events or propose to change anything else here, so regarding the impacts of the later events our model follows the textbook (Weinberg, 1977), following the hot fireball and its expansion developing over billions of years into our present-day universe.

The path of physics formula necessary to develop for our scenario further

The different formulas required are summarized in Table 1. Moreover, validating observations motivating to follow up our theory are summarized in Table 2. In the following we refer in bold letters to the formulas **F1** (low probability interaction of qubits), F2 (entropy treatment of crystallization) to **F3** (long range interactions limiting further growth of the crystal) in Table 1 and give a bit more detail how to derive concrete equations **Eq.1** to **Eq. 6** describing the processes involved. However, this is currently only examining in which direction a full formalism could be established using often only the classical description while a full quantum treatment of qubits is required and currently missing (only a preprint, accurate treatment follows). The path is as follows:

A key challenge for our qubit crystallization scenario is that two different areas need to be tackled and considered:

(i) A scalar interaction field between all qubits, the stronger, the more qubits interact (based on the “small”, rolled-up dimensions of string theory, see below) and

(ii) Qubits have to overlap in our four “long” dimensions (time and space), otherwise the world is broken up into independent frozen-out defined ensemble states. Here we think that one qubit overlap allows to connect one ensemble state with its neighbor states (Fig. 2) with transition probabilities according to S-Matrix theory (Barut, 1971) and different layers of the crystal realizing defined, different world lines.

a) **Formula F1: strong interaction force between n qubits** → linear increase with number of qubits, scalar field at grand unification energy scale; only possible if correct dimensionality and direction, closeliness → really low *a priori* probability.

For this we use the Hurwitz theorem (Hurwitz, 1898) to proof that if qubits of any form and dimension should interact at all, they only can so in four ways: There is only a 1D,2D,4D and

8D solution is possible for strings or qubits of arbitrary dimension to really interact, nothing else → E_8 symmetry is part of the 8D solution. E8 is our symmetry unit in our world (Wolchover, 2019) and a representation of the 8-dimensional solution, hence explanation WHY there is string theory in our world: E_8 with 8 dimensions is the main possibility how qubits interact.

So, then we derive: First we have really free qubits, in full entanglement in the qubit ocean, and of any dimension; then with a really low probability (calculation estimate see below) we need two qubits to interact with any D, so double circle. Then this triggers the seed for a new condensation nucleus and world.

Ad Eq. 1 - Probability calculation to reach our "well-tuned" universe from chaos: As the latter is the qubit ocean and has full degrees of freedom, we have not only as low probability as to reach E_8 symmetry compared to any 8-dimensional (8D) solution, but we have to consider our very special parametrization and hence can estimate:

(i) 200 bits specify each "large" dimension → total of 600 bits for each direction x, y and z.
(ii) Further 600 bits to specify all particles, fields, their strengths (may be even more bits).

→ really low probability to reach our high order universe from our chaos ocean: 1 in 2**1200 or about 10**360 (estimate for our universe, all time points, bit states / possibilities / trajectories)

Ad Eq. 1b (energy difference between free and bound qubits): The next formula in **Table 1** describes this energy difference starting from the Hamiltonian corresponding to the kinetic and potential energies of a system:

$$\hat{H} = \hat{T} + \hat{V}$$

But now you have a huge difference for the potential energy operator V:
In the bound state it is 10**20 times higher and that explains why the vacuum energy inside our crystal is so much lower than you would expect with the typical calculation of virtual particles. To get here any further we have to start from the text book calculation for vacuum energy and derive the derivation of the qubit binding energy from this, knowing that the real vacuum energy in our world is 10**20 lower: probably the kinetic term of the qubit interaction goes down in the textbook calculation by 10**20 when we consider that all is now bound in the qubit crystal, so hence we could derive by this additional field from the qubit-crystal the correct potential energy in our everyday world, as all is decoherent, solidified and defined and no longer free undefined quantum state.

Formula F2: Repulsive force for ultrashort distances

This prevents to have just a singularity from the strong scalar unified field between the qubits. For this we can at least show how a LQG treatment of **Eq. 2** could look like, following closely the paper by Ashtekar et al. (2006).

Formula F3: Equilibrium between further growth and surface loss against "boiling bulk":

Here we need estimates for the long-range surface loss term to get the long range forces limiting further growth of the qubit-interaction initially rapid growing crystal (**Eq. 3**). I hope that the experts for inflation models will have hear better insight, because we are proposing as our modified cosmology a modified inflation model focusing on qubit interaction, but do not yet

show the actual quantum treatment, here an expert treatment has to await the next iteration of our model.
A first estimate takes a quadratic growth of surface term as estimate (for 3 macroscopic dimensions and time), also in this confrontation with the n-dimensional or nD bulk.
As an example: if this quadratic limiting long range force is in equilibrium with 2**1200 qubits (we are background-free in this generalized nD LQG approximation, so no distances, gravity fields etc., but just the number of qubits counts) then we would have for 2**1100 qubits (so 100 qubits less extension) only a long-range surface loss term from this smaller crystal that is 2**100 or 10**30 times smaller.

F 3.2 (remaining quantum liquidity of the crystal)**: As soon as equilibrium is reached, there is freezing-out of qubits with defined reality and emergent time**

Our theory assumes that as soon as an equilibrium is reached between further growth and direct surface loss (see above) the crystal of qubits can solidify further. Hence, the overlap between the qubit ensembles is getting less and less until only one qubit overlap is reached
It is necessary to have at least this "liquidity" left: (i) to move or get from one ensemble state to the next neighbor of the ensemble states. All neighbor states are directly connected as observed in quantum physics, simple description is by S-matrix theory, better description by string theory. This liquidity is exactly 1 Planck´s quantum big, as observed, here we still have the full quantum overlap (Formula **F 3.2**; here only qualitatively described).
Furthermore, this loss in quantum entropy is compensated by an increase in entropy in the chaotic qubit ocean around the crystal. Starting from a mother solvent, here an eternal qubit ocean, it is a new thought for cosmology, but everyday practice and observed in protein folding as well as mundane crystal formation.

Connected large dimensions: In my theory this is necessary so that the four "large" dimensions form a universe and become not completely separated bit ensembles which do not connect.

Emergent time: Moreover, in this way, the arrow of entropy connects all 1 bit neighbor states by an emergent time. Interestingly, if you are in any reasonable high energy state (as now and for the next billions of years), the past is well determined (only one solution to the next lower entropy state) whereas the future is unclear (several options for next 1 bit states with lower entropy). This is illustrated in our toy example with 6-bit ensemble states (Fig. 2).

Curled-up dimensions hold the crystal together as constant scalar field: However, at the same time, the remaining strong unified force field holds everything together and this is provided by the "rolled-up" six dimensions of our $E_8 \times E_8$ heterotic string theory: They are already microscopic, 1 bit in length. In compactification this is usually considered as small, "rolled-up" Kalabi-Yau manifold (Yau and Nadis, 2010), accommodating the 6 additional dimensions in this way in the macroscopic only four-dimensional space-time of our universe.
These dimensions do not change when the crystal freezes out. However, the "rolled-up" six dimensions provide a pretty strong field, unchanging, holding the crystal together and allowing our everyday macroscopic dimensions to freeze out and become a "real", defined universe for bit-ensembles (only one h dash quantum liquidity left) instead of a qubit-limbo the whole original universe is.
There are already first results supporting this: Kaya and Rador (2003) analyze a cosmological model in 1 + m + p dimensions, where in m-dimensional space there are uniformly distributed p-branes wrapping over the extra p dimensions. They find that during cosmological evolution m-dimensional space expands with the exact power-law corresponding to pressure-less matter while the extra p dimensions contract. These authors derive in formula 27 for the rolled-up dimensions r_p a really small dimension of

$$r_p \approx 10^{-5} \times 10^{-138/[p(p+4)]} \text{ m.}$$

While their formula (23) implies that the radius after the early phase stays fixed.

$$ds^2 = -dt^2 + (\alpha_1 t)^{4/m}\, dx^i\, dx^i + (\alpha_2 t)^{-4\omega/[p(1+\nu)]}\, dy^a\, dy^a, \qquad (23)$$

Adding matter, they also obtain solutions having the same property. This hence might explain in a natural way why the extra dimensions are small compared to the observed three spatial directions. However, these results are given here only for illustration how our new cosmological model fits with literature.

The Hot fireball universe is resulting from this, next text book cosmology continues: We modify here only big bang and inflation by qubit interaction as trigger, next qubit ensemble growth until equilibrium and finally subsequent freezing out of qubits to separated bit-ensemble states in the universe. After that, as vindicated by all observations until now, the hot fireball universe continues to expand as in the text-book scenario. We are hence confident, that this theory fits well to observation, is compatible but modifies current inflation theories by a more realistic and fundamental scenario of qubit interaction, growth and crystallization. We have different crystal universes coming and going in a large ocean of qubits.
Interestingly, as the hot unified scalar field cools down, the basic four forces separate at lower temperature. In our view, the basic strong scalar field from the E8 string theory and postulated strong interaction of the six rolled-up dimensions gives rise then to the scalar field of color interaction, implying a reason for the observed confinement, and, with cooling down but quite early, gives also rise to the scalar field for gravity, acting on the Higgs boson.

Formula F4 (seed formation)**, next generation of crystals:** Any normal, everyday observed crystal exists only a limited time and is ultimately dissolved. Also in our picture of the world, a large ocean in which at different places and times crystals form and dissipate again, seed generation for the next generation of crystals is advantageous and if it can happen at all, it will be preferred and selected over several generations of crystals generating their own seeds for further children (if you look closely again only a modification of the well-known cosmological scenario of “eternal inflation” to a more everyday-like picture of generations of crystals.

How and where could seed generation happen? For seed generation in a universe, a previous suggestion was made by Lee Smolin (1996), fecund universes generated from black holes. In my view this is not so plausible, as a black hole, at least by its gravity is still part of our universe. Moreover, in a second droplet-like scenario to separate from our big crystal universe as a crumble or a droplet, such a true separation would require a lot of energy and create major ripples in gravity up till now never observed.
Instead, black holes stay pretty connected with our universe and form for instance the detailed shape of many galactic nuclei and this applies up till now also to super-massive black holes, they never separate.

Hence, in our crystal theory, the seed generation happens only at the surface (or “the limit” of the universe) by the entropic or “tugging” forces of the boiling vacuum around it.
To model then the seed generation at the surface hence needs only further details and modifications of **formula F3.** Moreover, the long-range force considerations above show that seed generation “inside” the crystal is hopeless, requiring too much energy as the scalar field holds everything together and the long range surface forces become too weak.

How could this select for life-friendly or even intelligent life-friendly universes?

a) Selection for survival of surface / replication at the surface → selection for properties which also allow selection of survival at surfaces as is the case for early life
b) Selection of long survival and long evolution in a universe → selection for processes such as intelligent life → so could be that this particular “higher life friendliness” selection implies that higher life also useful for enhancing replication of the universe. In particular, intelligent life can technically use any natural process in a better, controlled, technological way. We know this for motors and energy generation. However, this allows us to create an artificial sun (nuclear fusion bomb, atomic power

plant and fusion reactor). We can speculate that research and knowledge on dark matter may allow us generation of an artificial galaxy and ultimately knowledge on dark energy will allow us creation of the next universe in a controlled way (including understanding the entropy tugging of the chaos ocean on the formed crystal and may be surface interactions imprinting some directions of development into the seed).

Formulas F1, F2, F3: Condensed mathematics could provide a frame work to describe free and bound qubits.

As an interesting point to be explored (not shown here), we recommend a full treatment of the phase space of the standard model by the new mathematical field of **condensed mathematics** („verdichtete Mathematik" coined by Peter Scholze, 2019). It describes topological algebraic structure based on condensed sets.

In the light of our approach, this should open deep insights on general relativity and quantum physics as this will help to distinguish a phase space with frozen-out bits where general relativity holds (our domain and crystal) from a "liquid" type of phase space with free qubits, only quantum physics holds and corresponding wave functions describing the qubit ocean around our domain and crystal. In the latter, a condensed set can be used to identify the many states accessible to a qubit to pertain in fact to the same qubit.

In particular, Peter Scholze, in joint work with Dustin Clausen, established condensed sets (Scholze, 2019; Lecture I) and locally compact Abelian groups (lecture IV). He explained also globalization (Lecture IX) and coherent duality (lecture XI) in the light of condensed mathematics. However, this is only a suggestion for further exploration.

In the following we give some more detailed results on specific points of our theory:

Formulae F1-F3: Formulating the toy model of qubit interaction / condensation using 6 qubits to bit transition

If two qubits really can interact, according to the Hurwitz theorem (see below) there are only four solutions possible, restricting hence the interaction possibilities and dimension possibilities for interaction drastically: Either only a 1D (one dimensional) interaction, a 2D,a 4D, or last solution 8D (8 dimensional) interaction is mathematically possible, so for an initial first start two qubits have to interact and they can have **any** dimension (**fat circle**) have to interact:

$$\left|\begin{smallmatrix}0\\1\end{smallmatrix}\right\rangle \circledcirc\!\!\!\!\otimes \left|\begin{smallmatrix}0\\1\end{smallmatrix}\right\rangle \quad \text{2 qubits} \quad nD \quad m \text{ states}$$

$$\Downarrow$$

Then more qubits align (like in magnetization), e.g. 4 qubits,

$$\left|\begin{smallmatrix}0\\1\end{smallmatrix}\right\rangle \circledcirc\!\!\!\!\otimes \left|\begin{smallmatrix}0\\1\end{smallmatrix}\right\rangle \ldots \circledcirc\!\!\!\!\otimes \left|\begin{smallmatrix}0\\1\end{smallmatrix}\right\rangle \quad n \text{ qubits}, \ m \text{ states} \quad nD$$

$$\Downarrow$$

However, the interaction can occur in 1D,2D,4D or 8D way, in our world this is the E_8 symmetry and unit cell, matching heterotic string theory

$$\left|\begin{smallmatrix}0\\1\end{smallmatrix}\right\rangle \otimes \left|\begin{smallmatrix}0\\1\end{smallmatrix}\right\rangle \ldots \otimes \left|\begin{smallmatrix}0\\1\end{smallmatrix}\right\rangle \quad n \text{ qubits } E8 \text{ solution, interact}$$

and lowering the quantum entropy these become separated ensembles, in the toy example 6 bit ensembles.

$$\begin{Bmatrix} (000 & \ldots & 00) \\ (000 & \ldots & 01) \\ (000 & \ldots & 10) \\ (000 & \ldots & 11) \\ & \vdots & \\ (111 & \ldots & 11) \end{Bmatrix}$$

⇓ frozen out n^m bit ensembles

2^6 in toy examples ensembles

but still to overlap

If we have the frozen-out state, quantum entropy is lost, i.e. exactly the entanglement terms get lost, in formulas for a simplified normal space interaction of two qubits (just for illustration), we would have the following clear states and removal of entropy as follows:

$\theta \in [0, 2\pi]$

$$|\psi\rangle = |1\rangle + e^{i\theta}|0\rangle$$

clear states:

$$\sigma_x = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}, \sigma_y = \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}, \sigma_z = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$$

removal of entanglement entropy

$$\sigma_\alpha \sigma_\beta - \sigma_\beta \sigma_\alpha = i \sigma_\gamma \quad \varepsilon_{\alpha,\beta,\gamma}$$

We next show for comparison, following Menke et al. (2022) how a really observed toy model of tunable three-body interactions between superconducting qubits is described. This is a real system and measurable, validating partly some of our qubit interaction considerations. Hence, we can also fully parametrize it (see Menke et al., 2022). However, of course this happens in our everyday world, so here the actual cosmological qubit interaction and condensation is not considered, but the three qubit interaction, pairwise coupled both among themselves and to a coupler element are described as an effective 3-qubit system with the following eigenbasis Hamiltonian:

$$H/\hbar = -\sum_{i=1}^{3} \frac{\omega_i}{2} \hat{Z}_i + \sum_{\substack{i,j=1 \\ i<j}}^{3} J_{ij} \hat{Z}_i \hat{Z}_j + K_{123} \hat{Z}_1 \hat{Z}_2 \hat{Z}_3, \quad (1)$$

The system is implemented as a superconducting circuit that consists of three flux qubits. In their paper, the qubits are operated at the flux insensitive point, before diagonalizing the system to obtain the form (1), each flux qubit is described by the following Hamiltonian in the persistent-current basis (2):

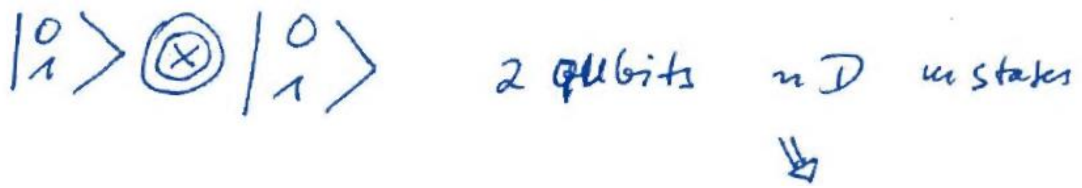
$$H_{\mathrm{QB}i} = \varepsilon\left(\Phi_{\mathrm{QB}i}\right) \hat{z}_i + \Delta_{\mathrm{QB}i}\, \hat{x}_i, \qquad (2)$$

F1, Qubit interaction: The Hurwitz theorem proofs that only a 1D,2D,4D and 8D solution is possible for strings of arbitrary dimension to really interact.

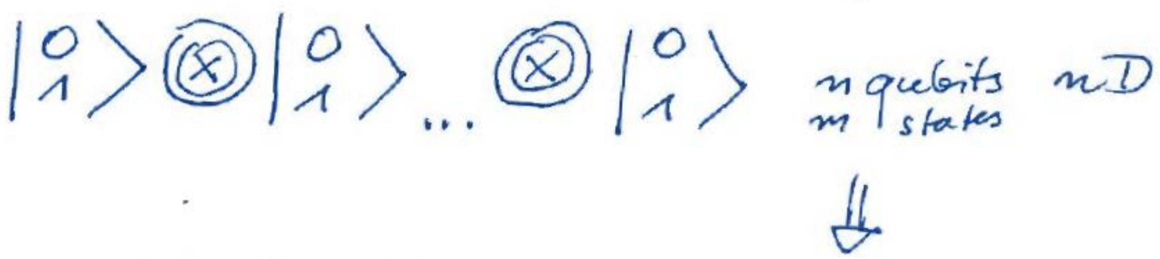
Proof: The Hurwitz theorem proofs that only a 1D,2D,4D and 8D solution is possible for strings of arbitrary dimension to really interact, nothing else → E_8 symmetry is part of the 8D solution.

E8 is our symmetry unit in our world and a representation of the 8-dimensional solution, hence explanation WHY there is string theory in our world: E_8 with 8 dimensions is the main possibility how qubits interact.

So, then we would write: First we have really free qubits, in full entanglement in the qubit ocean, and of any dimension; then with a really low probability (calculation estimate see below) we need two qubits to interact with any D, so double circle. This event triggers then the seed for a new condensation nucleus and world.
If two qubits really can interact, according to the Hurwitz theorem (see below) there are only four solutions possible, restricting hence the interaction possibilities and dimension possibilities for interaction drastically: Either only a 1D (one dimensional) interaction, a 2D, a 4D, or last solution 8D (8 dimensional) interaction is mathematically possible, so for an initial first start two qubits have to interact and they can have **any** dimension (**fat circle**) have to interact:



Then more qubits align (like in magnetization), e.g. 4 qubits,



Introducing qubits directly: However, the new concept introduced by me here are qubits and we allow qubit interactions over any number of dimensions (including even several time-like dimensions) and then we see immediately that the summation over energies as given above can only work if the mathematical operation of summation is possible despite the high or low number of dimensions chosen.

Strikingly, according to the Hurwitz theorem (1898) any type of mathematical operation for complex or hyper complex numbers is mathematically consistent only possible for 1,2,4 or 8 dimensions.

So, we first remind by accurate mathematics how Hurwitz came to this proof, following as accurate as possible his proof (blue font: directly following and citing Hurwitz, 1898):

In the domain of quadratic forms of n variables a composition theory will take place, if for any three quadratic forms ϕ, ψ, χ of non-vanishing determinant the equation

$$(1) \qquad \varphi(x_1, x_2, \ldots x_n)\psi(y_1, y_2, \ldots y_n) = \chi(z_1, z_2, \ldots z_n)$$

can be satisfied by replacing the variables z_1, z_2, … z_n by appropriately chosen bilinear functions of the variables x_1, x_2,… x_n and y_1, y_2,… y_n. Since a quadratic form can be transformed into a sum of squares by linear transformation of the variables, so one may, without affecting the generality, substitute the following equation (1):

$$(2) \qquad (x_1^2 + x_2^2 + \cdots + x_n^2)(y_1^2 + y_2^2 + \cdots + y_n^2) = z_1^2 + z_2^2 + \cdots + z_n^2$$

According to this, the question whether a composition theory exists for quadratic forms with n variables is essentially identical with the other one, whether one can satisfy equation (2) by appropriate bilinear functions $z_1, z_2, \ldots z_n$ of the 2n independent variables $x_1, x_2, \ldots x_n$ and $y_1, y_2, \ldots y_n$. In the following lines I will show that this is only possible in the cases n = 2; 4; 8.
so that only for binary forms, for quaternary forms and for forms with 8 variables
a composition theory exists. By this proof then in particular also the old controversy whether the known product formulas for sums of 2, 4 and 8 squares can be applied to sums of more than 8 squares is finally decided in the negative sense[2].
In order to simplify the presentation, I make use of the calculation with linear transformations, which can probably be traced back to Ca y l e y[3].
Calculus with linear transformations. Denotes (3)

$$(3) \qquad A = \begin{Bmatrix} a_{11}, & a_{12}, & \ldots & a_{1n} \\ a_{21}, & a_{22}, & \ldots & a_{2n} \\ . & . & . & . \\ . & . & . & . \\ a_{n1}, & a_{n2}, & \ldots & a_{nn} \end{Bmatrix}$$

or more briefly A = (a□□) such a transformation, then A_0 should be understood as that transformation which results from A by interchanging the horizontal and the vertical series.
The task to solve equation (2) by n bilinear functions

$$z_\alpha = a_{\alpha 1} y_1 + a_{\alpha 2} y_2 + \cdots + a_{\alpha n} y_n \qquad (\alpha = 1, 2, \ldots n)$$

can now obviously be formulated in this way:
Let the elements a□□ of the transformation A be linear homogeneous functions of the variables
$x_1, x_2, \ldots x_n$ such that the transformation A satisfies the equation

$$(4) \qquad AA' = (x_1^2 + x_2^2 + \cdots + x_n^2)$$

If A is ordered by the variables $x_1, x_2, \ldots x_n$, then you obtain

$$(5) \qquad A = x_1 A_1 + x_2 A_2 + \cdots + x_n A_n,$$

where $A_1, A_2, \ldots A_n$ denote transformations with constant coefficients, and the equation (4) gains the shape:

$$(6) \qquad (x_1 A_1 + x_2 A_2 + \cdots + x_n A_n)(x_1 A_1' + x_2 A_2' + \cdots + x_n A_n') = (x_1^2 + x_2^2 + \cdots + x_n^2).$$

The comparison of the terms with X_n^2 shows that $A_n A'_n$ must be 1. Hence, one next carries out the transformations

$$(7) \qquad B_1 = A_1 A_n', \; B_2 = A_2 A_n', \; \ldots \; B_{n-1} = A_{n-1} A_n'$$

and sets accordingly

$$A_i = B_i A_n, \qquad A_i' = A_n' B_i', \qquad (i = 1, 2, \ldots n-1)$$

then the equation (6) changes into the following equation:

$$(8) \qquad (x_1B_1 + x_2B_2 + \cdots + x_{n-1}B_{n-1} + x_n)(x_1B_1' + x_2B_2' + \cdots + x_{n-1}B_{n-1}' + x_n) = (x_1^2 + x_2^2 + \cdots + x_n^2).$$

If we develop the left side here, the coefficient comparison yields

$$B_iB_i' = 1, \qquad B_i' = -B_i, \qquad B_iB_k' = -B_kB_i', \qquad (i \lessgtr k)$$

and the latter equations can obviously also be replaced by the following ones:

$$(9) \qquad B_i^2 = -1, \qquad B_iB_k = -B_kB_i, \qquad B_i' = -B_i. \qquad (i \gtrless k)$$

In this way, every transformation A which satisfies the condition (4) yields,
n-1 transformations B_1, B_2, …B_{n-1} which satisfy the equations (9). Conversely, if B_1, B_2, …B_{n-1} satisfy the equations (9), if furthermore A_n denotes an arbitrarily chosen orthogonal transformation, then the transformation

$$A = x_1B_1A_n + x_2B_2A_n + \cdots + x_{n-1}B_{n-1}A_n + x_nA_n$$

satisfy the equation (4).

After this we only have to deal with the task of determining all systems of n-1 transformations B_1, B_2, …B_{n-1} which satisfy the equations (9). We now subject equations to a more detailed discussion, which will show that only in the cases n = 2; B_{n-1} the cases n = 2; 4; 8, systems of n-1 transformations B_1, B_2, …B_{n-1} can exist, for which the equations (9) are satisfied.

Let us first consider the equations $B'_i = -B_i$

The same states that the transformations B_i are skew symmetric. Therefore, the equations (9) are incompatible if n is odd. Because in this case the determinant of B_i would have to vanish, which contradicts the equation $B_i^2 = -1$.

In the further discussion we may assume that n is even. Because of the equations (9), any integer function of B_1, B_2, …B_{n-1} is linearly representable by the 2^{n-1} transformations

$$(10) \qquad 1, \quad B_{i_1}, \quad B_{i_1}B_{i_2}, \quad B_{i_1}B_{i_2}B_{i_3}, \ldots, \quad B_1B_2\ldots B_{n-1},$$

where the indices or all, satisfying the inequalities

$$0 < i_1 < n, \quad 0 < i_1 < i_2 < n, \quad 0 < i_1 < i_2 < i_3 < n, \ldots$$

value systems have to be preserved. Regarding these transformations (10) the following equation teaches

$$(B_{i_1}B_{i_2}\cdots B_{i_r})' = B_{i_r}'\cdots B_{i_2}'B_{i_1}' = (-1)^rB_{i_r}\cdots B_{i_2}B_{i_1} = (-1)^{r+(r-1)+(r-2)+\cdots+1}B_{i_1}B_{i_2}\cdots B_{i_r},$$

that the transformation

$$B_{i_1}B_{i_2}\cdots B_{i_r}$$

is symmetric or skew-symmetric, depending on whether r $\equiv$ 0, 3 (mod 4) or r $\equiv$1,2 (mod 4).
This fact allows us to decide whether there can be a linear dependence between the transformations (10).

Let us denote in general by R, R_1, R_2, … linear combinations of the transformations (10) with non-vanishing coefficients, then R = 0 will introduce the general shape of a linear relation between the transformations (10).

Each of the transformations (10), which in such a relation is afflicted with a nonvanishing

coefficient in such a relation, should be termed connected to the relation or "involved" in the relation. Furthermore, if $R_1 = 0$; $R_2 = 0$ are two relations, then I want to call them "alien to each other", if there is no transformation, which is involved in both relations at the same time.
Finally, a relation $R = 0$ is called "reducible", if its left side can be put into the form $R = R_1 + R_2$ such that $R_1 = 0$; $R_2 = 0$ represent two relations which are alien to each other. In the opposite case $R = 0$ is called "irreducible".
Obviously, it is sufficient to consider the irreducible relations. Such a relation remains irreducible, if one multiplies it by one of the transformations (10), and by such a multiplication one can achieve that transformation 1 goes with a non-vanishing coefficient into the relation. Furthermore, it is clear that transformations in an irregular relation are either all symmetric or all are skew symmetric. Now we have

$$(11) \qquad 1 = \sum c_{i_1 i_2 i_3} B_{i_1} B_{i_2} B_{i_3} + \sum c_{i_1 i_2 i_3 i_4} B_{i_1} B_{i_2} B_{i_3} B_{i_4} + \cdots$$

as an irreducible relation. By multiplication with B_i, where i denotes any of the indices 1, 2,… n -1 the same passes into:

$$B_i = \sum c_{i_1 i_2 i_3} B_{i_1} B_{i_2} B_{i_3} B_i + \sum c_{i_1 i_2 i_3 i_4} B_{i_1} B_{i_2} B_{i_3} B_{i_4} B_i + \cdots .$$

Here only skew-symmetric transformations are allowed to occur. Therefore, it must be $c_{i1}, c_{i2}, c_{i3} = 0$, if the index i is not among the indices i_1, i_2, i_3. But since the index i is arbitrarily selectable, all coefficients $c_{i1}, c_{i2}, c_{i3} = 0$. Likewise it follows that $c_{i1}, c_{i2}, c_{i3}, c_{i4} = 0$, if the index i occurs among the indices i_1, i_2, i_3, i_4, consequently, all the coefficients $c_{i1}, c_{i2}, c_{i3}, c_{i4} = 0$.

Concluding in this way, we see that the relation (11) can only have the form

$$(11') \qquad 1 = c \cdot B_1 B_2 \ldots B_{n-1}$$

where, moreover, $n \equiv 0$ (mod: 4) must hold, because otherwise $B_1, B_2, \ldots B_{n-1}$ would be a skew-symmetric transformation. If we square the two sides of the relation (11'), we see that c must be equal to +/-1. Apart from the relation (11') no other irreducible relations can exist.
Summarizing the above considerations, we can say:
If the n-1 transformations $B_1, B_2, \ldots B_{n-1}$ satisfy the equations (9), then necessarily n is an even number. The 2^{n-1} transformations (10) are furthermore linearly independent, if $n \equiv 2$ (mod: 4). In the case of $n \equiv 0$ (mod 4) they are either linearly independent, or there exist between them the relations which result from

$$(12) \qquad B_1 B_2 \cdots B_{n-1} = \pm 1$$

by multiplication with the transformations (10) and no other irreducible relations. Thus, the first 2^{n-2} of the transformations (10) are linearly independent under all circumstances.

From this it follows that the solvability of the equations (9) satisfies the inequality

$$(13) \qquad 2^{n-2} \leqq n^2$$

since there is always a linear dependence between more than n^2 transformations. But the inequality (13) is no longer fulfilled from n = 10 on. Hence, there are only the cases n = 2; 4; 6; 8, in which possibly the equations (9) allow a solution.

The case n = 6 can be excluded without much work:
In this case the $2^5 = 32$ transformations (10) need to be linearly independent.

Among these transformations we find 5+10+1 = 16 skew symmetric ones.
In general, there are between n(n-1)/2 + 1 skew symmetric transformations with n variables and linear dependence, and for n = 6 the value of n(n-1)/2 + 1 equals 16.

In the cases n = 2; 4; 8 there is an easy, though somewhat complex discussion. This yields the real solvability of the equations (9) and thus the existence of transformations A which satisfy the condition (4). The result of this discussion is as follows: One understands by A_0 in these cases n = 2; 4; 8 respectively the transformation

$$A_0 = \left\{ \begin{array}{rr} x_1, & -x_2 \\ x_2, & x_1 \end{array} \right\},$$

$$A_0 = \left\{ \begin{array}{rrrr} x_1, & -x_2, & -x_3, & -x_4 \\ x_2, & x_1, & -x_4, & x_3 \\ x_3, & x_4, & x_1, & -x_2 \\ x_4, & -x_3, & x_2, & x_1 \end{array} \right\},$$

$$A_0 = \left\{ \begin{array}{rrrrrrrr} x_1, & -x_2, & -x_3, & -x_4, & -x_5, & -x_6, & -x_7, & -x_8 \\ x_2, & x_1, & -x_4, & x_3, & -x_6, & x_5, & -x_8, & x_7 \\ x_3, & x_4, & x_1, & -x_2, & -x_7, & x_8, & x_5, & -x_6 \\ x_4, & -x_3, & x_2, & x_1, & x_8, & x_7, & -x_6, & -x_5 \\ x_5, & x_6, & x_7, & -x_8, & x_1, & -x_2, & -x_3, & x_4 \\ x_6, & -x_5, & -x_8, & -x_7, & x_2, & x_1, & x_4, & x_3 \\ x_7, & x_8, & -x_5, & x_6, & x_3, & -x_4, & x_1, & -x_2 \\ x_8, & -x_7, & x_6, & x_5, & -x_4, & -x_3, & x_2, & x_1 \end{array} \right\}.$$

Then the most general transformation A satisfying condition (4) is the following:

$$A = PA_0Q,$$

where P and Q denote arbitrary orthogonal transformations with constant coefficients.
The above investigation raises some questions which are pointed out briefly:
If it is impossible, except for the cases n = 2; 4; 8, to calculate the product of two quadratic forms of n variables each $x_1, x_2, \ldots x_n$; $y_1, y_2, \ldots y_n$ as a quadratic form of n bilinear functions $z_1, z_2, \ldots z_n$ of those variables, then a representation of that point as a quadratic form of a sufficiently large number of bilinear functions of the variables $x_1, x_2, \ldots x_n$; $y_1, y_2, \ldots y_n$ is always possible. The question now is, which is the smallest admissible value of this number. Transforming the quadratic forms to sums of squares, the question takes the following form: What is the smallest value of m for which the equation

$$(x_1^2 + x_2^2 + \cdots + x_n^2)(y_1^2 + y_2^2 + \cdots + y_n^2) = z_1^2 + z_2^2 + \cdots + z_m^2 \tag{14}$$

can be satisfied by suitably chosen bilinear functions $z_1, z_2, \ldots z_m$ of the variables $x_1, x_2, \ldots x_n$ and $y_1, y_2, \ldots y_n$?
This question can be further generalized by substituting the equation (14) by the following:

$$(x_1^2 + x_2^2 + \cdots + x_p^2)(y_1^2 + y_2^2 + \cdots + y_n^2) = z_1^2 + z_2^2 + \cdots + z_m^2 \tag{15}$$

where p and n denote given numbers and again the minimum value of m is the question.
On the other hand, in the above equation one can also take n and m as given and ask for the largest admissible value of p. This question allows in the case n = m a different formulation: If

one considers in the space of n^2 dimensions, in which the n^2 coordinates of a point can be denoted by a_{ik} (i; k = 1, 2,… n), the entity, which is given by the equations

$$\sum_{i=1}^{n} a_{i1}^2 = \sum_{i=1}^{n} a_{i2}^2 = \cdots = \sum_{i=1}^{n} a_{in}^2, \ \sum_{i=1}^{n} a_{ih}a_{ik} = 0 \quad (h,\, k = 1,\, 2, \ldots n;\ h \gtrless k)$$

then the maximum value of p denotes nothing else than the highest dimension of linear spaces lying on this entity. By the way, an analysis which is quite similar to the one presented above shows that this maximum value of p is equal to 1 in the case of an odd n and in the case of an even n, it is constrained by the inequalities $2^{p-1} \leq n^2$ and $2^{p-2} \leq n^2$, respectively, depending on whether $n \equiv 2$ or $n \equiv 0$ (mod 4). Thus, if n is an even number, the maximum value of p cannot exceed (2 lg n / lg 2)+ 1 or (2 lg n /lg 2) + 2, respectively.

Now, to be really sure about the applicability of the Hurwitz theorem to the general energy terms of qubit interaction we have to transform the energy terms correctly into an addition of complex or hyper complex numbers.
Thus, following Hurwitz (1898) we consider transformations A such that they fulfil the equation

$$AA' = (x_1^2 + x_2^2 + \cdots + x_n^2)$$

(formula (4) of Hurwitz, 1898)

This implies that we have to satisfy the equation 9 of Hurwitz cited and given above

$$B_i^2 = -1, \qquad B_iB_k = -B_kB_i, \qquad B_i' = -B_i. \qquad (i \gtrless k)$$

which, as Hurwitz shows, is only possible, apart from real numbers (so dimension 1) for dimensions 2, 4 or 8 (for other values you get undefined division by zero etc.).

Using time t as just another dimension coordinate all can then be written as shown before, but introducing now qubits of any dimension instead of numbers of any dimension and any type of interaction field or particle instead of mathematical operations.
This shows that there are only 1D, 2D, 4D and 8D interaction of qubits possible.

Hence, then we can link up our theory of qubit interaction to our real world so the eight-dimensional symmetry of all particles and forces of the standard physics and of the world itself (Wolchover, 2017, 2019), and hence our real universe in fact implements the richest solution, the octonion result.

Moreover, this basic eight-dimensional symmetry of our world regarding basic forces and particles is also taken-up by the heterotic string theory (Gross et al., 1985). One gauge group or flavour is SO(32) (the HO string) while the other flavor is $E_8 \times E_8$ (the HE string) (Polchinski, 1998).

F2 or Eq. 6: Repulsive potential preventing qubit collapse after first interaction:
The formulas by Asthekar et al. (2006) describe how loop quanta interact and then the next point in this paper shows how due to appropriate quantization the result is this may even resist the big crunch**.** Specifically, in section IV of their paper (Asthekar et al., 2006) the authors return to LQC (Loop quantum cosmology) and construct the physical sector of the theory. The LQG (Loop quantum gravity) Hamiltonian constraint is given by eq. (2.34) in their paper:

$$\begin{aligned}\partial_\phi^2 \Psi(v, \phi) &= [B(v)]^{-1}(C^+(v)\Psi(v+4, \phi) \\ &\quad + C^o(v)\Psi(v, \phi) + C^-(v)\Psi(v-4, \phi)) \\ &=: -\Theta\Psi(v, \phi), \qquad (4.1)\end{aligned}$$

This is just a first glimpse how then the repulsive potential for qubits would have to be formulated using LQG as a first hint on how to get repulsion from appropriate quantization.

For LQG section V from (Asthekar et al., 2006) shows then how quantum states which are semiclassical at late times are then numerically evolved backwards, starting from eigenfunctions (and using these in simulations on a lattice):

$$e_\omega(v) \overset{v\gg 1}{\longrightarrow} A\underline{e}_{|k|}(v) + B\underline{e}_{-|k|}(v),$$
$$e_\omega(v) \overset{v\ll -1}{\longrightarrow} C\underline{e}_{|k|}(v) + D\underline{e}_{-|k|}(v). \quad (5.2)$$

The classical big bang is then replaced by a quantum bounce when the matter is extremely compressed to acquire a Planck scale density (Asthekar et al., 2006). However, this is only one way and one example how to derive the strong repulsive force for ultra-short distances by appropriate quantization, in this example achieved using LQG.

Part II: Further considerations on the Formulas describing qubit-crystallization

In the following we do not use detailed quantum descriptions as these are of course challenging. However, for general considerations these are also not really required. For instance, Ning et al. (2022) study a quantum circuit cosmology and the expansion of the universe since the first qubit. The authors consider cosmological evolution from the perspective of quantum information and present a quantum circuit model for the expansion of a comoving region of space, in which initially-unentangled ancilla qubits become entangled as expansion proceeds. They propose a toy model for the evolution of a fixed comoving region C, a simple quantum circuit (family resemblance to the proposal that the universe can be thought of as a quantum computer): *A quantum circuit consists of a network of quantum gates, each of which performs a unitary transformation on the basic factors of the Hilbert space of a quantum system, which we have taken to be qubits. This yields a convenient representation of the evolution of the system. At any time t, we can divide the n degrees of freedom in H into a number $n_E(t)$ that are entangled with each other (responsible for the spacetime structure), and a number $n_U(t)$ that are not entangled with anything* $n = n_E(t) + n_U(t)$.

The authors provide with their deep but non-fully quantized treatment a candidate description of the quantum state of our comoving region at very early times. If inflation lasted for just the minimal number of e-folds necessary to solve the horizon problem, then at the start of inflation our comoving region was approximately a Hubble volume and can thus argue that the total number of e-folds of inflationary and post-inflationary expansion since the time t1 is bounded, $N_{tot} \leq 140$. Though the study is studying cosmological expansion according to the standard model, their treatment shows nicely that also here a simple framework treatment is possible in spite of having to deal with qubits and avoiding a full quantum treatment of the quantum circuits. In the following we derive also only first simple formulas and estimates for our modified cosmological model of qubit interaction and crystallization in the same spirit.

F1, Qubit Interaction, probability calculation:

a) Very small, because in a qubit ocean now and then a crystal, as heuristic and image.
b) Very small, because the interaction between two qubits is actually only possible if the same quantum states, i.e. coherence, but for nD qubits very unlikely with infinite degrees of freedom just about zero, even with correction for "more populated" ground states.
c) Estimation (already in the old paper): degrees of freedom of the whole universe and how small then equal degrees of freedom are in the probability.
d) Even if it would be much higher (say ocean filled with crystals, only very small interstices), then evolution with finite lifetime and constraint would still hold.

Qubit interaction leads to decoherence, splitting of quantum superposition to single bit ensembles. This consumes energy, reduces quantum entropy.

However, the rolled-up dimensions interact firmly (otherwise nothing happens with them, they stay perfectly entangled, do not vary or yield in a defined states bit ensembles), they do not expand or change as the macroscopic dimensions do. For their interaction there is instead a linear increase of the interaction field and the released interaction energy with the number of qubits. The field is a type of gravitational field between the rolled-up dimensions (introduction: Randall, L., 2005)
At the same time there is a square increase (n * n-1)/2 of the qubit-qubit interaction terms (higher orders neglected for now), which then consumes more and more energy by "freezing out" the bit ensembles / the negentropy (quantum entropy disappearing).
As soon as equilibrium is reached, there is no more decoherence and further qubit accumulation possible, the “universe” (the qubit crystal in our theory) has reached its maximum size, it cannot consist of more qubits.

Eq. 2 (entropy treatment in crystallization): To derive this we consider everyday protein folding and crystallization and apply it to our qubit crystal. In particular, the creation of spontaneous order in the protein is paid for by increasing disorder (entropy) in the solvent around. Similar this explains how order can be created within the qubit crystal, as in the free qubit ocean around entropy increases. Entropy equations for protein folding are well established (Brady and Sharp, 1997). Thus, the Boltzmann expression for the entropy S reads for a system consisting of N atoms of protein, solvent ligand etc. is given by

$$S = -K_B \int P(r) \ln(P[r]) dr = -k_B \sum_i P_i \ln P_i \qquad (1)$$

Where K_B is the Boltzmann constant, T is the temperature and

$$P(r) \propto e^{-U(r)/kT}$$

is the probability of the system to being in a particular configuration with energy U(r), requiring 3n coordinates for n atoms to calculate the energy with r degrees of freedom. Subsequent treatment in the paper explains then conformational entropy considering backbone and sidechain and of course, solvent entropy has also to be considered.
The treatment for qubits needs to take this to a cosmological level, the solvent being the qubit ocean around, which experiences an entropy increase (even more chaos) while the condensation nucleus forms (like in everyday biophysics, Kawasaki and Tanaka, 2010). Fig. 7 compares different entropies between free and bound qubits (including also quantum entropy of entanglement or removing it).

Ad Eq. 2b: Dark energy, big rip tugging Here we start from the dissolution of normal crystals (phrased after Lasaga and Lüttge, 2003; 2001), in particular the simple case, treat for crystal dissolution the rate law as a simple linear relationship between rate and deviation from equilibrium (e.g., $\Delta \Delta G$), at least close to equilibrium. The most often invoked relationship has been based on the principle of detailed balancing or a transition-state theory (TST) approach and leads to the rate law

$$Rate = A \quad (1 - e^{\sigma \frac{\Delta G}{RT}})$$

where A is a general constant, which could vary with pH, T, inhibitor molecules, etc., and c should be 1 if ΔΔ G is based on 1 mol of the rate-limiting component. McCoy (2001) presents a population balance model for crystal size distributions: reversible, size-dependent growth and dissolution. The population balance equation, in combination with a mass balance for solute, can be solved for mass moments of the crystal size distribution. Furthermore, there are crystal dissolution kinetics since long time available (Uttormark et al., 1993).

Result 2b: These models have then to be transferred to our cosmological model, which requires a qubit quantum treatment, replacing the crystal fields by Yang-Mills fields or, may be still better, formalisms of LQG and string theory, not attempted here. However, we give here as a first estimate of the cosmological treatment result a typical "big rip" scenario. You can use a hypothetical example with $w = -1.5$, $H_0 = 70$ km/s/Mpc, and $\Omega_m = 0.3$ (Caldwell et al., 2003; w, the ratio between the dark energy pressure and its energy density; Hubble constant; and matter density, respectively). In this case the Big Rip (Fernandez-Jambrina and Lazkoz, 2022) is estimated to occur 22 billion years from the present.

$$t_{rip} - t_0 \approx \frac{2}{3\,|1+w|\,H_0\sqrt{1-\Omega_m}}$$

We think the time horizon is actually 70 Gyrs. This is better compatible with observations (e.g. Vikhlin et al., 2009) and takes also into account that according to our theory the "dark energy" is in fact resulting from tugging of the crystal by entropic forces of the solvent (which would be here the vast ocean of free qubits, sometimes interacting destructively with the more solid qubit-to-bit crystal).

F3 (Long range interactions limiting growth of the cosmological crystal): To implement the build-up of the long-range interactions correctly, the classical treatment focusses on the energies. In the original Weiss theory the mean field H_e is proportional to the bulk magnetization **M**, where alpha is the mean field constant.

$$H_e = \alpha\, M$$

Then next, the size of the domain and the contributions of the different internal energy terms is described by the Landau-Lifshitz energy equation

$$E = E_{ex} + E_D + E_\lambda + E_k + E_H$$

The total energy is composed of E_{ex} (exchange energy; critical for the overall size, lowest when dipoles all pointed in the same direction. Additional exchange energy is proportional to the total area of the domain walls), E_D is magneto-static energy (self-energy, due to interaction of the field created by the magnetization in one part on other parts and reduced by minimizing overall energy, incorporating again large-range forces effects), E_λ is magneto-elastic anisotropy energy, E_k is magneto-crystalline anisotropy energy and E_H is Zeeman energy. Hence, detailed consideration of these energy terms allows to calculate the self-limiting growth of the Weiss domain by considering long-range versus short-range forces (Devizorova et al., 2019).

Eq 3: However, taken to cosmology, there are challenging n-dimensional string interactions and repulsive forces to calculate. It is a bit easier to transport the classical formulas to a first condensation nucleus and limitations by long range interactions.
Moreover, a first step for numerical estimates is then to apply again LQG, as then the energy considerations are again far easier transported to interactions of any number of dimensions. On this a more general treatment using string theory and qubit states in full can build.
Notes: We show here only a very general solution for the interaction field between loop quanta (or strings) and how they can form a crystal, where there is also again a size limit after crystallization. The mathematical formalism derived here allow many different parameters to fulfil it. Importantly, we need this open-ness so that evolution over several generations can operate on the parameters to select optimal crystals with best reproduction rate, stability and resulting high self-organization potential and overall fitness. The result is fine-tuning of conditions for best seeding the next generation of crystals including that the optimized crystals are particularly favorable to life.

This argument would similarly well apply to the openness of string theory, in particular we assume that 8-dimensional theories are allowed for the qubit interaction field (besides less interesting 1,2 and 4 dimensional solutions) and thus the E_8 heterotic string theory would also qualify not only as a solution to the qubit interaction potential but also to have the necessary openness in parameters (like all string theories) to allow evolution over several generations to select best life-like parameters.

Note also, that the basic unit cell of the crystal with its free parameters represents then one form of encoding the properties ("laws of nature") of the crystal. However, also surfaces of the crystal ("membranes") can influence the next generation of the crystal ("break away seeds"). This has the advantage that more detailed and specific information (and hence adaptation) can be transferred including a specific arrangement of world-lines reoccurring in the next generation of the crystal. Interestingly, this includes then also world-lines imprinting the success or failure of complex processes such as life and evolution or even an intelligent civilization in the next generation of the crystal. Phrased like this, this may sound quite esoteric, but it is just resulting from the surface properties of the crystal according to this theory, imprinting on the surface of the next generation of crystals. Different possibilities exist for this process of imprinting; normal crystals and the triggering of crystallization by condensation nuclei allow this to investigate. More mundane processes to validate the modelling include simple everyday processes such as rain and rain cloud formation.

Eq. 4 (standard calculations for vacuum foam, free qubits 1020 bigger then bound):** Vacuum energy effects are observed in experiments such as the Casimir effect and the Lamb shift. Considering the cosmological constant, the vacuum energy of free space has however been estimated to be 10^{-9} joules (10^{-2} ergs) ~5 GeV per cubic meter. Using instead quantum electrodynamics, consistency with the principle of Lorenz covariance and considering Planck´s constant derives a much larger value of 10^{113} joules per cubic meter due to a zoo of virtual particles. This discrepancy is huge and described as the cosmological problem (details in Jaffe, 2005). **Fig. 1** shows that the high energy calculation is correct but applies only outside our domain in the qubit ocean (see also simulation estimates below, **Fig. 5**). Inside the crystal, our everyday world, we have bound, interacting qubits, a drastically smaller zoo or possibility for virtual particles to play a role and hence the observed really low vacuum energy of our universe.

Eq. 5 (conservation laws expressed as symmetries of the crystal): In our perspective the conservation laws of nature in our horizon of observation (and may be beyond) are explained not by inflation of one quantum particle or field (we reject the idea of inflation) but rather reflect basic symmetries of our almost completely solidified qubit crystal we live in. These basic symmetries follow everywhere the symmetry unit of the cosmological qubit crystal (the typical "unit cell" of any normal crystal) and this makes sure that in every part of the crystal the same laws hold.

Examples include conservation of momentum and energy, and more advanced embodiments such as the Noether theorem:
For instance a Lagrangian that does not depend on time, i.e., that is invariant (symmetric)under changes of time $t \rightarrow t + \delta t$, without any change in the coordinates **q**.
In this case, $N = 1$, $T = 1$ and $\mathbf{Q} = 0$;
the corresponding conserved quantity is the total energy *H,* similarly, there may also be translational Invariance. Here, our claim is that the invariance or conservation law exists in our universe only as these are basic symmetries of the unit cell our condensed qubit crystal is made from. This applies even more so to our E8 symmetry underlying our domain.

In mathematics, E8 is any of several closely related exceptional simple Lie groups, linear algebraic groups or linear algebraic groups or Lie algebras of dimension 248; the same notation is used for the corresponding root lattice, which has rank 8. The designation E8 comes from classification of the complex simple Lie algebras by Wilhelm Killing and Elie Cartan. There are four infinite series A_n, B_n, C_n, D_n, and five exceptional labeled G2, F4, E6, E7 and E8. The E8 algebra is the largest and most complex of these exceptional cases.

Important for us here is that of course the E_8 Lie group has applications in theoretical physics and especially in string theory and supergravity. $E_8 \times E_8$ is the gauge group of one of the two types of heterotic strings and is one of two anomaly-free gauge groups that can be coupled to the N = 1 supergravity in ten dimensions. E_8 is the U-duality group of supergravity on an eight-torus (in its split form – again 8 dimensional).
Independent of such string-theoretical considerations, one way to incorporate the standard model of particle physics into heterotic string theory is the symmetry breaking of E_8 to its maximal subalgebra $SU(3) \times E_6$.
According to our theory, qubits can only interact, if they interact at all in an 1,2, 4 or 8-dimensional way and the richest case possible is the E8 symmetry. Our claim is furthermore that the richest solution is favored as particular favorable for self-organization, complex processes and life, and the formation of new seeds from the qubit-crystal.

Derivation of Eq. 6 or Formula F2 (repulsive force for ultrashort distances):
If Qubits interact (**Eq. 1**) there must be a counterforce to prevent that they (or ultimately even the whole qubit ocean) converge into a point or black hole etc. Here my suggestion would be to follow Ashtekar et al., 2006, who used LQG to show that quantization creates here a repulsive potential strong enough to resist even a "big crunch" of our whole universe. Evidently, this method can also be applied if you formulate the **Formula F2** using another approach, e.g. from string theory, you would have a repulsive force from the quantization and it will be quite strong (we want to have here repulsion for really small distances, for below the granularity of our action grid of Planck´s quantum). The repulsive force is derived as follows:

Microscopic structure (see **Table 1**, second part): We suggest here stepwise tackling larger structures, from the S-Matrix to term schemes, then tackling proton mass as example, multi particle systems, and finally the domain-wide scalar field holding the crystal together and giving next rise to scalar fields for color confinement and gravity. For a simple quantum field interaction, you can rely on standard formalisms such as the S-matrix (**eq. 7**) or a term scheme (**eq. 8**). The same applies to **Eq. 9** (quantum computations for proton mass), **Eq. 10** (quantum action and qubit-to-bit transition for a proton), **Eq. 11** (decoherence of quantum states in a multiple particle system), here textbooks give an introductory treatment, but the increasing complexity make then the last two challenging and something for the specialist.

Eq. 12 (**confinement of quarks by a scalar field**)
Unfortunately, there is not yet an analytic proof of color confinement in any non-abelian gauge theory. There is only asymptotic freedom of quarks in QCD (Gross and Wilczek, 1973; Politzer 1973). Qualitatively one can state that the force-carrying gluons of QCD have color charge, unlike the photons quantum electrodynamics (QED). However, our theory opens a perspective to find an analytical solution: As color charge is a *scalar field* it is impossible to have free quarks, they can only leave if being color neutral or white by one or two balancing quarks. According to our qubit crystallization theory, the resulting seed and crystal is a very strong interaction field over the whole crystal (our whole domain; see **eq. 1, eq. 1b** and **eq. 3;** additional treatment **eq. 9** - **eq. 11**). This treatment provides first a general scalar field at level of grand unification (holding the crystal together, and resulting in qubit decoherence) which then in our present-day cooler universe broke down (symmetry breaking) into the four basic forces, including gravity (deriving the scalar Higgs field) and a scalar field for color confinement (both then derived from the general scalar field).

First qualitative estimates

Comparison with quantum computation results: In the first figure, we give our first estimates comparing free qubits in a quantum computer (Gilbert et al., 2007) to the decoherent result state from quantum computation in our domain, our physical world (**Fig. 5**, bottom). There is some energy difference, but not so large: The quantum computer is part of our real world and as such, the “free” qubits used in the quantum computer calculation are not really free and the energy difference is not large. However, we show also in this plot our calculation for really free qubits, following the textbook calculation of free vacuum energy (Jaffe, 2005): then you have a 10**20 higher energy value (indicated here using logarithmic scaling; **Fig. 5**, top).

This well-accepted yet astonishing difference of the observed versus calculated vacuum energy is a nice support for our idea that in fact our universe started from qubit decoherence. Moreover, a full mathematical treatment of the qubit interaction and qubit phase transition beyond the toy model to form such bit ensemble crystals should start from a general lattice field theory (Byrnes and Yamamoto, 2006) and would allow to derive a more detailed general interaction potential within the crystal from **F1**, **F2** and **F3** (**Table 1**) responsible for holding the crystal together and causing thus also this really high tendency of quantum computer qubits in our domain to become decoherent after interacting within the crystal. This general field breaks down as the hot fireball cools down into the four basic forces. Hence, with such a lattice field theory approach also the scalar fields for color interaction and gravity can and should be derived from the permeating qubit-interaction field. Thus, the qubit interaction field is responsible for color charge and actually causing it. And this is in the same way true for gravity and the Higgs scalar field causing gravity. For both we have here an explanation by a more fundamental principle, the qubit interaction field.

Misplacements in the qubit crystal: We compare (**Fig. 6**) the typical observed amount of misplacements in a normal, everyday crystal (sodium salt, glutathione reductase etc.) with misplacements observed in cosmology and calculated for our qubit crystal. For cosmology, there are well known calculations for the quantum fluctuations in the early universe assuming that inflation by an inflaton happened (so different but related process to our crystal growth). According to Kawasaki and Tanaka (2010) we see that we in fact get by quantum fluctuations a reasonable number of seeds for later growth into large-scale structures, however, these estimates of seeds fall short of the amount really required according to observations.

We stress again: our scenario needs no inflation. Inflation was developed by Andre Linde starting in 1981 (reviewed in Linde, 2017) to explain *WHY* in our universe all laws of nature are similar in every place. The idea is that one quantum particle, the *inflaton*, doubled about 120 times to give birth to our universe (Rosa and Ventura, 2019). Then its properties are present everywhere in our domain. However, this is a hypothetical particle, never seen before and just postulated to explain the same laws of nature.

Please note that instead crystals are natural phenomena, so many times observed, and within the crystal you have everywhere the same unit cell and hence the same basic symmetries (or laws of nature). Again, in our model this is explained by qubits solidification. This crystallization process makes sure that we have not only everywhere the S-Matrix connections but also the same parameter settings for the ratios between basic forces, particle sizes, Planck´s quantum and so on.

Interestingly, as we do not even out very early our quantum fluctuations in our model as in an inflaton-driven growth of the primordial universe but rather propose a magnetization or crystallization-like growth process, this creates bigger and more seeds for subsequent large-scale structures such as filaments and voids, superclusters of galaxies, clusters of galaxies and galaxies (**Fig. 6**). This higher amount of seeds for starting and selecting larger structures in the universe and its large-scale structure (see also Dandekar, 1991) agrees also better with observation. **Table 2** assembles some more key points agreeing better to observation following our theory.

Entropy considerations. Qubit decoherence allows also to have emergent time in the direction of the arrow of entropy. As explained above, the decoherence of the whole phase space for all ensemble bit states of the involved n qubits allows to consider the entropy in the system and how this then creates time direction accordingly. Moreover, we can compare the entropy created by forming a universe in an ocean of qubits with data and estimates for entropy formation from everyday crystallization and protein folding (**Fig. 7**). We give here estimates for both and by a dashed line our approximated course of events for the total system of our qubit ocean. The latter has here as boundary condition not the full ocean of free qubits but deliberately terminated by 100 shells of free qubits around the toy “universe” (see **Fig. 2**) of 6 qubits forming a physical real universe and freezing out their individual bit states. As in the everyday examples, the entropy of course has to increase in the solvent if within we form order by having the ensemble bit states nicely separated and frozen out. Hence, the “internal time” in the crystal is only a simplification, replaced here by a perspective starting to consider the outside ocean. The time estimate for the big rip of about 70 Gyrs (Fernández-Jambrina and Lazkoz, 2022) is caused in our theory by entropic tugging on the crystal from the ocean. We consider the 70 Gyrs a good estimate both from the internal time perspective and from the outside ocean perspective.

Discussion

Overview: Motivated and studying normal everyday phenomena such as protein folding (Dandekar and Argos, 1994, Sarukhanyan and Dandekar, 2023) and crystallization (Kawasaki and Tanaka, 2010), we suggest a new type of modified inflation cosmology (Rosa and Ventura, 2019) where we modify very early cosmology, everything later follows the textbook cosmology (Dodelson and Schmidt, 2020) so from the expanding hot fireball scenario everything evolves according to textbook until our present day universe is reached. We have two modifications:

(i) rare qubit interactions replace big bang - we replace the "big bang" by a condensation event in an eternal all-encompassing ocean of free qubits. Interactions of qubits in the qubit ocean are quite rare but provide a nucleus or seed for a new universe ("domain") as the qubits become decoherent and freeze-out into defined bit ensembles.

(ii) Crystal Unit cell removes need for inflation - we then modify inflation by magnetic domain-like growth, triggered by the nucleus of interacting qubits to which smoothly more and more qubits attach (like in everyday crystal growth) – the crystal unit cell guarantees same symmetries everywhere inside the crystal. The textbook inflation scenario to explain the same laws of nature in our domain is replaced by our suggestion by the unit cell of the crystal formed. Crystals may grow rapidly or slow, the unit cell guarantees in both cases the same symmetries in the crystal everywhere and hence, in such a cosmological scenario there is no need for inflation.

Using more mathematical rigor then in previous steps (Dandekar 2022,2023a,b) we make in this preprint the motivation and connection to protein folding clear, using normal observed and measurable phenomena such as crystallization and protein folding and qubit interaction and not unobserved hypothetical strange events (big bang) or quantum particles (inflaton).

Evaluation: This is a modified inflation cosmology (e.g. Chen X, Loeb A, Xianyu ZZ, 2019; Ijjas A, Steinhardt, 2016). The trigger event are no cosmological bounces as in Ijjas and Steinhardt, 2016, but qubit interactions: After interacting at all, in our model the qubits interact stably and tighter, the qubits solidify, quantum entropy decreases (but increases in the ocean around). The interacting qubits form a rapidly growing domain where the n**m states become separated ensemble states, rising long-range forces stop ultimately further growth. This is modelled similar to magnetization processes (Devizorova et al., 2019) which also stop further growth by building-up of long-range forces. Then standard cosmology with the hot fireball and standard expansion takes over.

Looking at crystals to do cosmology has pre-runners, for instance Chuang et al. (1991) look at defect dynamics in liquid crystals, however, these authors had the aim to study the standard model of cosmology better.

In our modified cosmology, like with everyday crystals (Lasaga and Lüttge, 2001, 2003) the qubit-crystals are not eternal but have a finite life-span (see results). Crystals come and go in the eternal and all-encompassing qubit ocean. This selects for the ability to lay seeds for new crystals, for self-organization and life-friendliness. This advantage for reproduction selects for such crystals and over generations also for self-organization and life-friendliness. Fine-tuning, perfect adaptation for life (Barrow and Tipler, 1986) is instead in physics explained as a rare or even extremely improbable event that sometimes happens (e.g. Koonin, 2007). At least this insight and motivation from biological sciences that something otherwise really improbably should be considered to be the result of a selection process, should be more followed up.

Evolutionary cosmological scenarios have been proposed before: e.g. early black holes have been proposed by Smolin (1997). However, this was only regarding fecundity of a universe and black hole production, not regarding fine-tuning for life-friendly conditions. Similarly, application of observable phenomena to cosmology have been advocated before, but only to investigate aspects of standard cosmology (Chuang et al., 1991) and there is for example an old paper "Gravity as Theory of Defects in a Crystal with Only Second-Gradient Elasticity" (Kleinert, 1987).

For seed generation in a universe, a previous suggestion was made by Lee Smolin (1996) regarding fecund universes generated from black holes. In my view this is not so plausible, as a black hole, at least by its gravity is still part of our universe. Moreover, a scenario to separate from our big crystal universe as a crumble or a droplet, such a true separation would require a lot of energy and create major ripples in gravity up till now never observed.

The phase space of the crystal agrees with the standard model (Oerter, 2006) of the basic four forces for n quanta. It includes all possible ensemble combinations of their quantum states m, a total of n**m states. Neighbor states reach according to transition possibilities (S-matrix; Barut, 1971) with emergent time from entropic ensemble gradients. However, in our four dimensions there is only one bit overlap to neighbor states left (almost solid, only below Planck´s quantum there is liquidity left). This can be compared to other emergent cosmologies, e.g. emergent gravity and the dark universe (Verlinde, 2017).

The E_8 symmetry of heterotic string theory has six curled-up, small dimensions which help to keep the qubit crystal together and will never expand. That the crystal does not disintegrate in completely frozen-out bit ensembles requires the curled-up dimensions as glue, as these stay curled-up they always stay entangled and do not expand over time (Kaya and Rador, 2003).

The theory is illuminating fundamental physics and cosmology by a fresh perspective, but needs more detailed mathematical development. It combines and uses a number of concepts of current cosmology, particular connections to loop quantum gravity (Rovelli, 2004), string theory (Green, 2000) and emergent gravity (Verlinde, 2017) are shown. Standard physics such as quantum computing; crystallization and solid-state physics allow validation tests (e.g. Imhof et al., 2018).

The explanatory power of our theory is high: How should the universe start? Our argument runs as follows: Philosophically the start or choice of a specific world implies the rejection of all other alternatives. However, decoherence is exactly the rejection of all alternatives and that one, the observed macroscopic state becomes real. Decoherence has long been a central mystery of quantum physics (Zeh, 1970; Schlosshauer, 2005). Our notion, to have the decoherence from the start of the universe and not just from observation (or, more esoteric, *by* conscious observation; Wheeler, 1990), did also get impetus from earlier suggestions (Bohm and others; hidden variables and Einstein´s apodictic "*god plays no dice*") and new observations (Mahler et al., 2016)

We provide also an inherently more convincing and comforting scenario as the ever-splitting Everett multiverse (Tegmark, 2007). We believe there is only one world and that it is real, there is no limbo state which only becomes real by observation as some physicists think. However, every slice of our crystal is another world trajectory becoming real (**Fig. 3**). Our notion, to have the decoherence from the start of the universe and not just from observation (or, more esoteric, *by* conscious observation; Wheeler, 1990), did also get impetus from earlier suggestions (Bohm and others; hidden variables and Einstein´s apodictic "*god plays no dice*") and new observations (Mahler et al., 2016). We explain also *why* there is large-scale structure of the universe formed so early (Table 2). In addition, we explain *why* there is color confinement and *why* there is a Higgs field. The scenarios invoked were chosen that way. Thus, the big rip scenario (e.g. Caldwell et al., 2003) became far more probable when the acceleration of the universe was observed (Pain and Astier, 2012). Particularly insightful is the perspective to have the start of the universe not "early", "at the beginning", but rather beyond our internal time and hence "always" in our universe, by having everywhere in our universe qubit decoherence and macroscopic defined states. There is a paper which considers emergence of spacetime geometry from quantum entanglement (Cao and Carrol, 2018). This at least can motivate why we think that qubit interaction can be fundamental, and time emerges only after bit ensembles result, separated but still connected to their direct neighbor states. From this emerges then space-time following the entropic gradient according to our theory.

Mathematics: Using Hurwitz´s theorem (Hurwitz, 1898) we prove that if qubits of any dimension interact at all, the initiation of qubit interactions can only be 1,2,4 or 8-dimensional. This agrees with the E_8 symmetry of our universe (Wolchover, 2019). Repulsive qubit forces at ultrashort distances result from their quantization. To show this, we follow Ashtekar et al. (2006). Finally, long-range forces limit crystal growth, modelled similar to growth and growth limitations of magnetic domains and assuming a quadratic surface area term for the growth of long-range forces. Our qubit treatment is inspired by similar mathematical treatment of qubits in recent papers: A qubit of space has recently been simulated (Czelusta and Mielczarek, 2021) and our notation at start is inspired by this treatment. A similar simple yet full qubit treatment was used in the investigation how the entanglement between a qubit clock and the geometry of a universe derives emergence of a time parameter (Nambu, 2022) and hence we think that our notion of emergent time looking at our toy model should be sufficiently clear.

Later formulae in our manuscript do not include a detailed qubit treatment, however, we follow here a more general, implicit treatment as given by Ning et al. (2022) describing quantum circuit cosmology. A general lattice field theory (Byrnes and Yamamoto, 2006) could extend the toy bit ensemble model of 6 qubits mathematically treated here. Crystals of other basic symmetry may exist, for instance with antimatter instead of matter. Again, this has high explanatory power: This is a good explanation *why* there is only matter in our crystal, and no antimatter; this is much more convincing than any extreme annihilation scenarios of all matter/anti-matter in the very early universe postulated by others.

Interesting is the function of the rolled-up six dimensions in string theory as glue for the qubit crystal. A paper by Kaya and Rador (2003) gives parameters on their size and that they shrink first and stay small in the later universe (from hot fireball start onwards), exactly as required in our qubit crystal condensation scenario to properly act as glue to hold the crystal together while the four macroscopic dimensions unfolds.

Finally, the new mathematical field of “condensed space” (Scholz, 2019) could give rise to a formalism for our theory beyond string theory, starting again from S-matrix theory but not to derive string theory but now to describe decoherent and coherent qubits and the phase space for such qubit ensembles.

Reducing the state space of possibilities to derive our parametrization of the universe

Starting from the complete freedom of qubits we examine how these can evolve into defined bit ensembles as otherwise there will not be a really existing or defined universe. However, we also can sketch how this converges to our universe we live in. If the interaction of qubits is interpreted as a calculation, a now fashionable paradigm of the universe as a computer, then we can apply the Hurwitz theorem (Hurwitz, 1898) to qubit interactions (or algebraic operators). This straight away suggests that if n-dimensional qubits start to interact at all, this interaction can only be 1D(dimensional), 2D, 4D or 8D.

After this strong reduction of the solution space from any number of dimensions of qubits interacting to just four dimensionalities allowed as solution, there comes a second step. Due to its mathematical physics consistency requirements, the E8 String theory has also a clear form. It can be written down in suitable matching formula language, so that everybody can see *how* the general qubit interaction develops into basic interactions described by the E_8xE_8 heterotic string theory.

Interestingly, the E_8 string theory rules out many alternative formulations. It is far more concrete then just being 8-dimensional as apparent from the basic qubit interaction field. Hence, we have by this second step, the internal consistency of fields and interactions according to E_8 String theory a further strong reduction of the free parameters.

Moreover, our theory explains *why* there is E_8 String theory: It is a consistent, concrete formulation of one of four solutions how qubits can at all interact to form a universe. Such a fundamental reason *why* there is heterotic string theory and no other formula describing our basic four forces is a nice result of our qubit interaction theory.

However, also the E_8 string theory has many open parameters. This is necessary according to our theory on crystals of qubits forming and then, after some time (around 80 Gyrs for our universe) to dissipate in the chaotic qubit ocean: Hence, there is selection for better and better seed generation from any crystal giving rise to a universe and hence also for self-organizing processes such as life (so called fine-tuning problem; Barrow and Tipler, 1986). If string theory would *not* have so many open parameters, then otherwise there is no free parameters on which selection can operate to select optimal later condensation nuclei or seeds from the universe.

Experimental validation: Table 2 shows that the large-scale structure of the universe and particular large-scale structural elements (voids and filaments, superclusters, clusters and galaxies) should fit in their early generation far better to our new theory: There are far more misplacements from very early misplacements in a qubit crystal that is never flattened out in a normal crystallization process, removing the *inflaton* and modifying inflation to qubit crystal growth. A more detailed mathematical treatment of these qubit crystal misplacement should allow even quantitative comparisons with observations stressing early structure formation in the universe (e.g. Long et al., 2020) and rejection of inflation (e.g. Ade et al., 2018). Similarly, laboratory experiments on protein folding (Louros et al., 2023), on crystallization (Kato et al., 2023; Lasaga and Lüttge, 2001, 2003; McCoy, 2001) and on qubit interactions (Kato et al., 2023; Imhof et al., 2018; Menke et al., 2022) allow direct testing of our theory and to derive more accurate parameters, a clear advantage.

Conclusion: **(i) an attractive and realistic alternative qubit interaction cosmology:** Standard cosmology agrees well with observations, particular as soon as the expanding hot fireball scenario is reached. However, the very early steps of big bang and inflation are unclear. Recent experiments suggest that these early steps may involve no inflation. To identify an attractive and realistic alternative cosmology, we advocate to study and inspired by everyday phenomena of structure creation, in particular protein folding, where order in the protein may be created as entropy rises in the solvent around and crystallization, where first a condensation nucleus is generated and then crystal growth starts until long range forces limit further growth. Crystallization (and no inflation) ensures in this modified cosmology that everywhere the same symmetries exist according to the unit cell of the crystal. This hence ensures the same laws and symmetries everywhere inside the crystal without requiring the extraordinary process of inflation.

(ii) The phenomenological explanatory power of this new perspective is high: This justifies intensive follow-up. Mathematical and physics treatment of details of the theory is only qualitative and preliminary, but follows recent literature on qubit interactions and qubit circuits. Already now we suggest important and deep connections for the modified inflation scenario of qubit crystallization: (i) rolled-up dimensions as glue for our qubit-crystal-world; (ii) the E_8

heterotic string theory as natural consequence of qubit interaction rarely triggered in an eternal ocean of qubits; (iii) the correct vacuum energy. (iv) Emergent internal time following the arrow of entropy is explained and (v) dominance of matter, as well as (vi) early galaxy creation by natural crystal misplacement. Crystal life cycles and evolution explain fine-tuning and life-friendliness of our universe. These first results should encourage more fundamental physicists to follow this attractive perspective further up with higher accuracy and mathematical insight.

(iii) It is imperative to tackle the deep question "**how did our world become real?**" This Has to be done on a fundamental, background-free level, not fully mastered here in this preprint. However, already in its present state, this yields a new, fresh look on cosmology: Can free qubits from an eternal all-permeating ocean of qubits become decoherent, freeze-out und create by this our universe?

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Table 1. Quantum action theory: Mathematical overview

Large-scale structure (validation: astronomical observations, see results)
Eq. 1 or **F1** (when and how qubits interact: restricted to 1,2,4 and 8 dimensions); closely connected to this is the seed formation formula **F4**;
Eq. 1b (energy difference between free and bound qubits)
Eq. 2 (entropy treatment in crystallization)
Eq. 2b (Dark energy is in fact entropic tugging of the crystal)
Eq. 3 or **F3** (Long range interactions limiting growth of the cosmological crystal)
F3.2 remaining quantum entropy or "liquidity" in the crystal
Eq. 4 (standard calculations for vacuum foam, free qubits 10**20 higher energy)
Eq. 5 (conservation laws expressed as symmetries of the crystal)
Eq. 6 or **F2** (repulsive force by quantization for ultrashort qubit distances)

Microscopic structure (validation: particle physics, quantum experiments)
Eq. 7 (S-matrix theory)
Eq. 8 (Term scheme)
Eq. 9 (quantum computations for proton mass)
Eq. 10 (quantum action and qubit-to-bit transition for a proton)
Eq. 11 (decoherence of quantum states in a multiple particle system)
Eq. 12 (confinement of quarks by a scalar field)

Table 2. Observables supporting qubit decoherence as new concept

-There is the same symmetry by S-Matrix connections between neighbor states if you have a crystal of qubits. As in normal crystals due to the symmetry of the unit cell you have hence everywhere the same symmetries and hence laws of nature and do not have nor require inflation to guarantee this.
Observations: There is no inflation after BICEP/2 experiments (Ade et al., 2018)

- large voids and filaments (as they come in fact from a normal crystallization process, for big bang scenario instead rather difficult to explain)
Observations: El-Ad et al., 1997 and later works

-supercluster formation; (misplacements in the crystal happen naturally and provide seeds). **Observations**: e.g. Long et al., 2020

-galaxy formation, see **Fig. 4**; optimal distribution of dark matter in halo regions and normal matter in center: Crystal arrangement makes this easy to happen.
Observations: e.g. Boylan-Kolchin, 2017.

-Fine tuning and live-friendly conditions
our explanation: many generations of crystals seeded by rarely interacting qubits in the ocean of free qubits select for better seeds for next generation which then selects for self-organization and life-friendly conditions. Interesting corollaries: (i) there seems to be a similar selection for intelligent life, so should in this sense help in some way for generation of next generation seeds; (ii) however, as all bit-possibilities are realized in the crystal, it would even be sufficient for efficient selection if the success of the next generation of crystals can rely on fitness gain in at least one world-line and for one type of life.
Observations: observed by all conscious observers (e.g. Barrow and Tipler, 1986; Smolin, 2013).

-Decoherence mystery explained: this has nothing to do with the act of observation but is actually the basis for the formation of our world, happened at “start”, to allow emergent time within the crystal.
Observations: see Schlosshauer (2005); Zeh (1970);

-dominance of matter - **Observations**: see e.g. BESIII Collaboration (2022)
A big mystery for standard theories, how matter could dominate. In my theory this symmetry of the crystal is chosen (only matter), another crystal (and domain) has the antimatter variant, unreachable and unobservable for us from here (our domain), separated by the free qubit ocean.

-there can be more added, remember, all features stemming from the hot fireball model, e.g. primordial synthesis of helium and lithium, agree anyway also with this theory as we only change the earliest steps, directly after that we arrive again at the hot fireball model.

Figure Legends

Figure 1. (a, top**): qubit interaction creates a condensation nucleus.** Further grows (star symbol) forms a crystal. Size limiting for the growth are long range interactions, a solid “crystal” of all interacting qubits “frozen-out” into their bit states is the end result. This is a very abstract type of crystal and it is made of interacting qubits (or strings of any dimension, abbreviated as nD-strings). Their interaction is only possible for the types of interaction allowed by the Hurwitz theorem (see results). We symbolize this crystallized world by a cube to remind the reader that the unit cell with its symmetries (e.g. a cube) will be repeated again and again over the whole crystal ensuring that everywhere are the same basic symmetries and laws of nature. Within the crystal all states are well separated, no longer liquid as in the background quantum foam “soup” shown as transparent bubbles in the background (superposition of all possibilities). **(b,** middle**): Crystal in ocean of string soup.** Only within h, Planck´s quantum, there is flexibility. outside: all is quantum fuzzy and the boiling soup of superposition with no decoherence, all states at the same time. GR holds only within the crystal; only here there is a clear reality, a strong decoherence field as stable as the qubit crystal. **(c,** bottom**): Dark energy allows to dissolve the crystal over time.** Entropic forces from the soup tug and grow (red arrows, middle). Beyond a threshold the crystal dissolves (“big rip” scenario, right), only the quantum bubble soup remains. Crystals which create new condensation seeds before they dissolved should be selected over time (external time, not the entropy-driven internal time bound to the crystal stability).

Figure 2. Emergent time and space in the solid, frozen-out qubit ensemble. The crystal formed by the solidifying qubit ensemble (box with black rims) is just resulting from the freezing out of the quantum states of m quanta which can be each in n states. For illustration, this is shown for 6 quanta (“world” made of 6 quanta) which each can have 2 states (blue up or down arrow). Direction of higher entropy (thick blue arrow on the right) provides an arrow of time for each trajectory connecting system states as edges. Just as these quanta have in the free state all 6**2 states superposed, they have due to the string interaction potential in the solid state, i.e. the “frozen-out” state, simply all these accessible quantum states separated from each other („decoherent“). There is no splitting after each decision or other strange things happening as in Everett-type models of our universe: there are just a clearly defined number of quanta in solid state instead of the liquid coherent state. Left: System states with the same entropy are „close by“ in the crystal, and the entropy gradient forms an internal arrow of time (within the crystal). A specific world line or world trajectory is shown by the three black arrows on the left.

Similarly, emergent space is easily resulting from assigning 3 of the 6 bits to encode the three space coordinates x,y,z. In this case, there is the high energy / low entropy state (e.g. all bits “up” → all resides in the upper starting corner) and then with increasing entropy the other areas of the mini-universe of 2x2x2 space units are populated.

The remaining three bits of our toy example could encode quantum / particle type (1 bit) and quantum properties (2 bits, e.g. charge, spin).

It is clear that easily more bits and hence larger emergent space, more particle types and quantum states can be considered and created by the qubit decoherence and forming a solid-state qubit ensemble with frozen out bit states.

Figure 3. World-lines. The layers of the crystal separated by h dash (indicated on the right) are the alternative worlds, within one quantum all is still “fuzzy”, the elasticity of the crystal. Only here is a defined time-trajectory for each layer, each “fate” of the world in one layer of the crystal (indicated by the slightly different trajectories in blue), only small decisions are different. Figure 2 with its more detailed view still applies: There is no Everett multiverse which myriads of splits but there are still only a total of m**n states (all combinations of m qubits with n different states).

Figure 4. **Dark matter and normal matter.** Qubit crystals contain in their frozen-out state two important entities of matter (like in a NaCl salt crystal): Dark matter and normal matter; for visualization of their specific interactions only these key ingredients are shown (however, in this abstract crystal and its E_8 symmetry group far more ingredients, particles, basic symmetries and hence emergent "laws of nature" are built in just by propagation of the basic symmetry unit – there is no inflation necessary). The figure visualizes that both types of matter easily interact in the crystal (in particular via gravity). The proper distribution of dark matter is important for galaxy formation inside the crystal. This applies to our universe: in halo regions is the dark matter, this is necessary to have nuclei of dwarf galaxies as well as for normal galaxies (Boylan-Kolchin, 2017).

Figure 5. Comparing energy levels of defined bits from quantum computation to free qubits in our domain and really free qubits. we give our first estimates comparing free qubits in a quantum computer to the decoherent result state from quantum computation in our domain, our physical world (Gilbert et al., 2007, **Fig. 5**, bottom). There is some energy difference, but not so large: The quantum computer is part of our real world and as such, the "free" qubits used in the quantum computer calculation are not really free and the energy difference is not large. However, we show also in this plot our calculation for really free qubits, following the textbook calculation of free vacuum energy (Jaffe, 2005): then you have a 10**20 higher energy value (indicated here using logarithmic scaling; **Fig. 5**, top).

Figure 6. Misplacements in the qubit crystal: We compare the typical observed amount of misplacements in a normal, everyday crystal (sodium salt, glutathione reductase etc.) with misplacements observed in cosmology and calculated for our qubit crystal. For cosmology, there are well known calculations for the quantum fluctuations in the early universe assuming that inflation by an inflaton happened (so different but related process to our crystal growth). According to the situation in normal crystals (Mc Coy, 2001) we see that we in fact get by quantum fluctuations a reasonable number of seeds for later growth into large-scale structures, however, these fall short of the amount really required.

Figure 7. Qubit decoherence cosmology allows also to have entropy estimates
The curves shown are citing the results by Brady and Sharp (1997) for illustration. These authors compare entropies looking at the two dipeptides cGG and cAA regarding vibrational frequencies in the gas phase (open squares and triangles) and crystal phase (black squares and triangles) for cGG (triangles) and cAA (squares).

We predict estimates comparing for the complete system of qubit ocean and a smaller crystal inside it will give qualitative similar results regarding entropy but will of course require a full quantum treatment and qubit interaction calculations to come up with correct quantities. The total system of our qubit ocean should have as boundary condition not the full ocean of free qubits but for a first estimate be deliberately terminated by several shells of free qubits around the toy "universe" (see **Fig. 2**) of 6 qubits forming a physical real universe and freezing out their individual bit states. As in the everyday example cited and given for illustration, the entropy of course has to increase in the solvent if within we form order by having the ensemble bit states nicely separated and frozen out. Moreover, then the comparison should not be between two peptides but for instance between normal matter and dark matter.

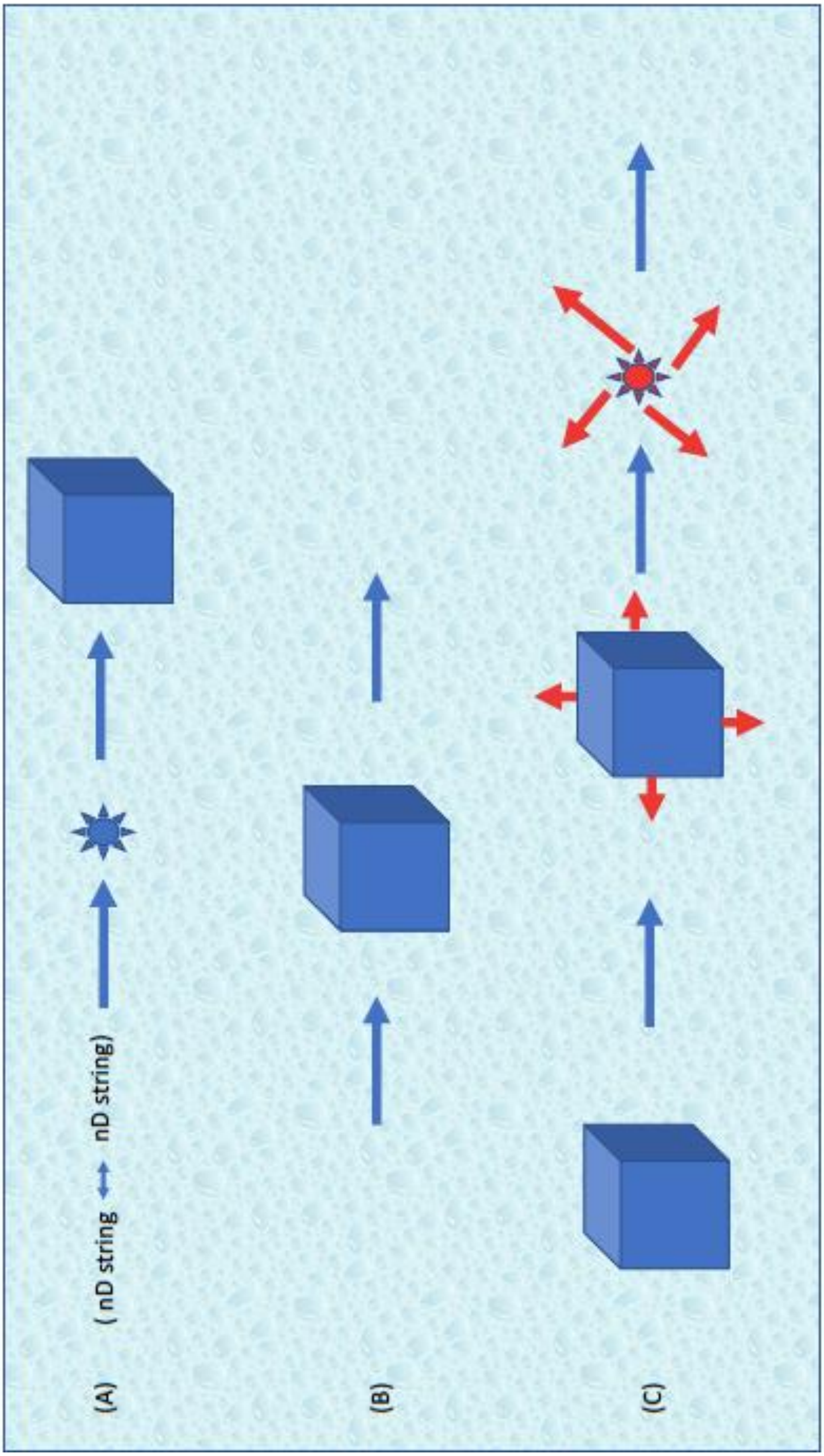

Fig. 1

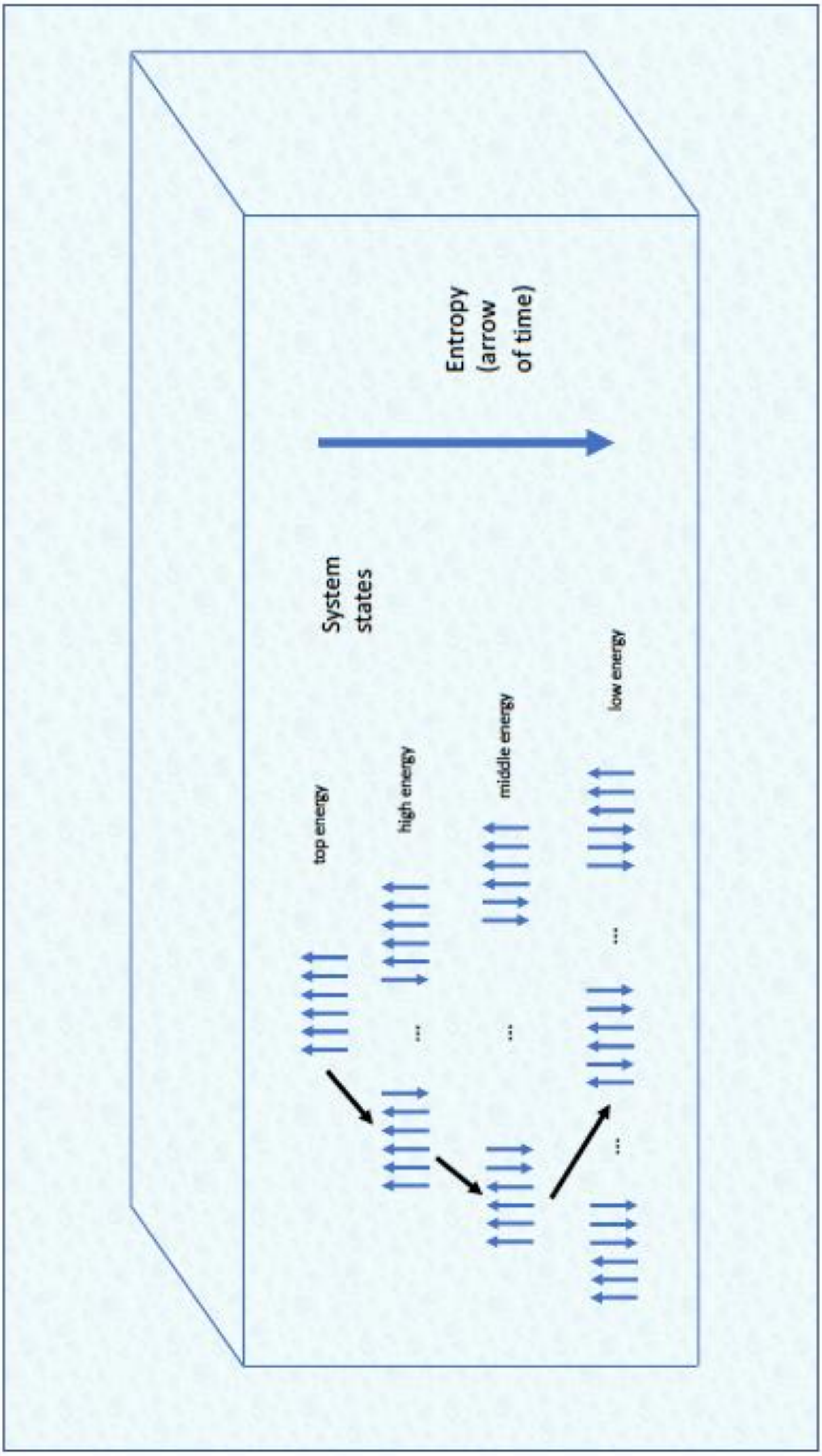
Entropy (arrow of time)
System states
top energy
high energy
middle energy
low energy

Fig. 2

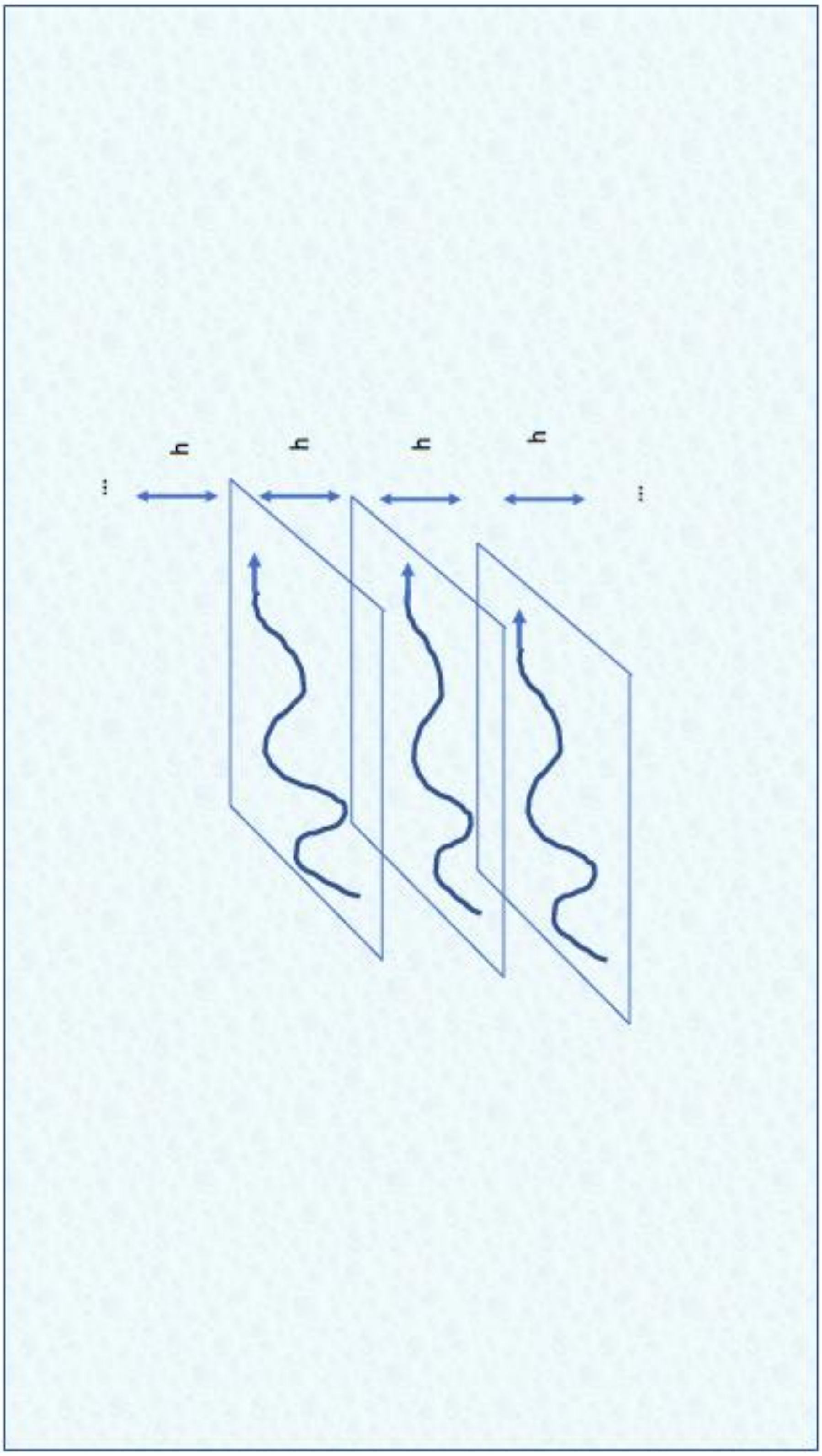

Fig. 3

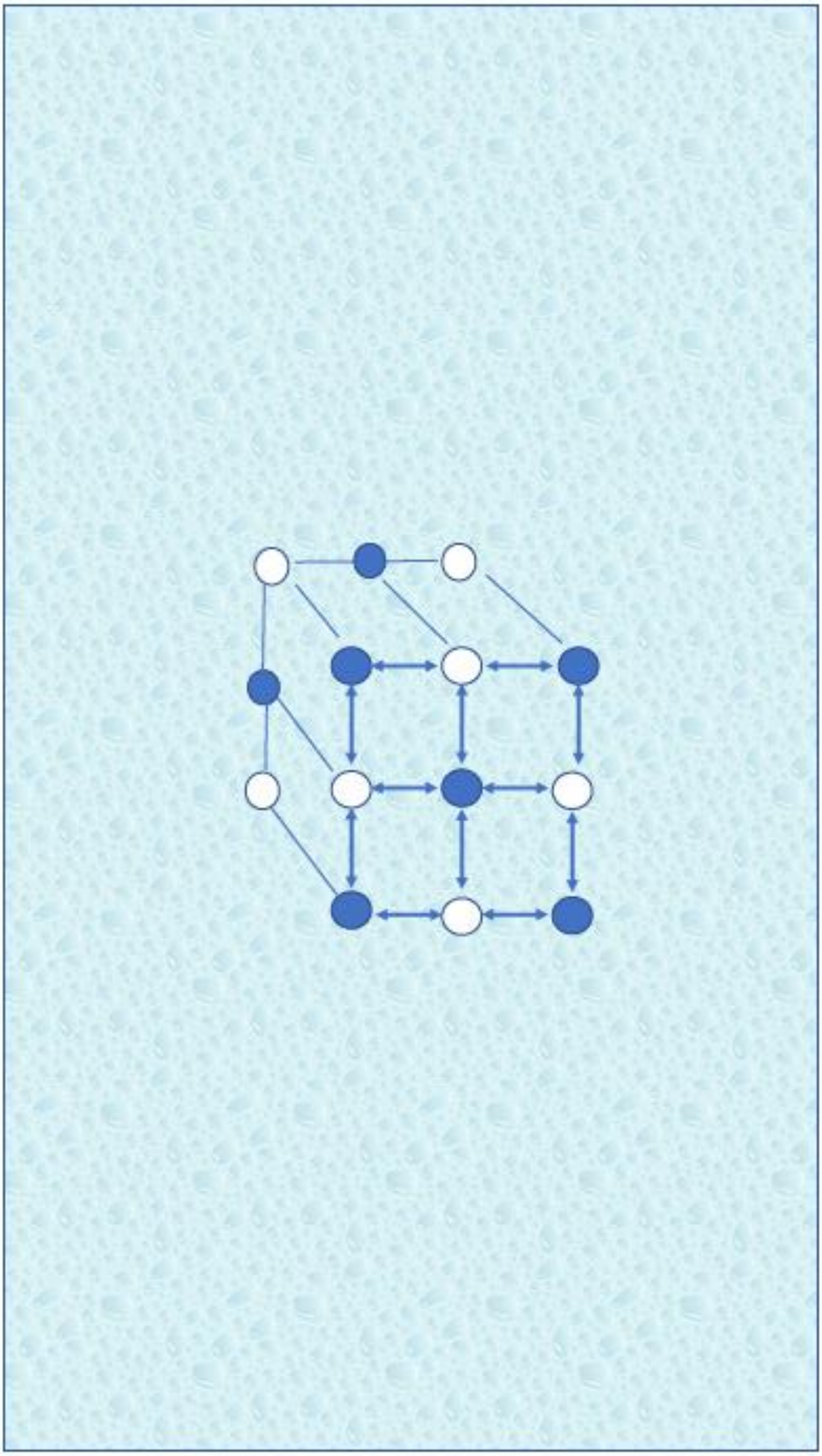

Fig. 4

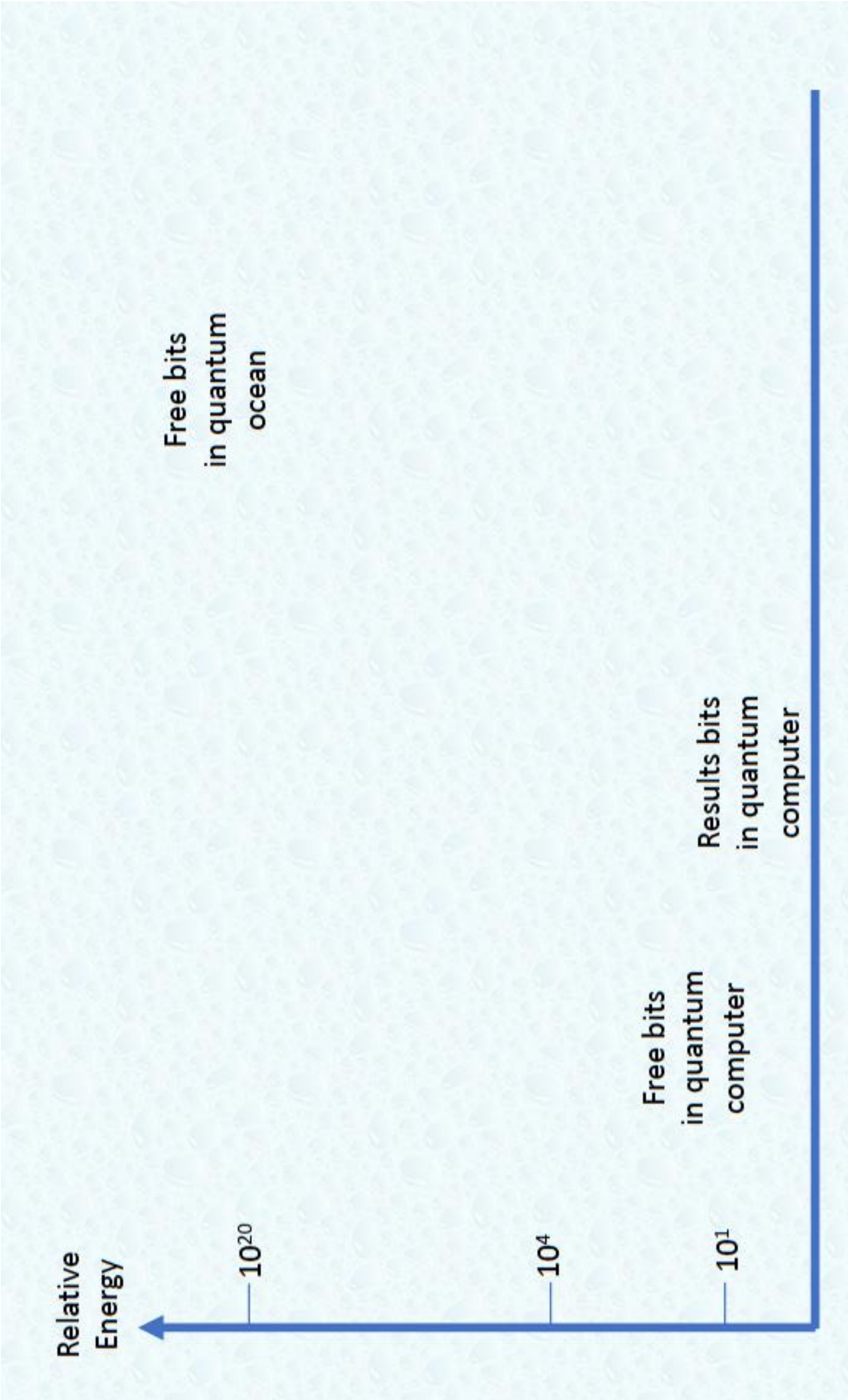
Relative Energy
10^20
10^4
10^1
Free bits in quantum ocean
Free bits in quantum computer
Results bits in quantum computer

Fig. 5


Misplacem
ents per
unit cell
10^{-3}
10^{-6}
10^{-9}
Misplacem
ents in a
Normal
crystal
Early universe
Quantum
Fluctuations,
Standard model
Misplacements in
a condensed
Qubit- crystal

Fig. 6

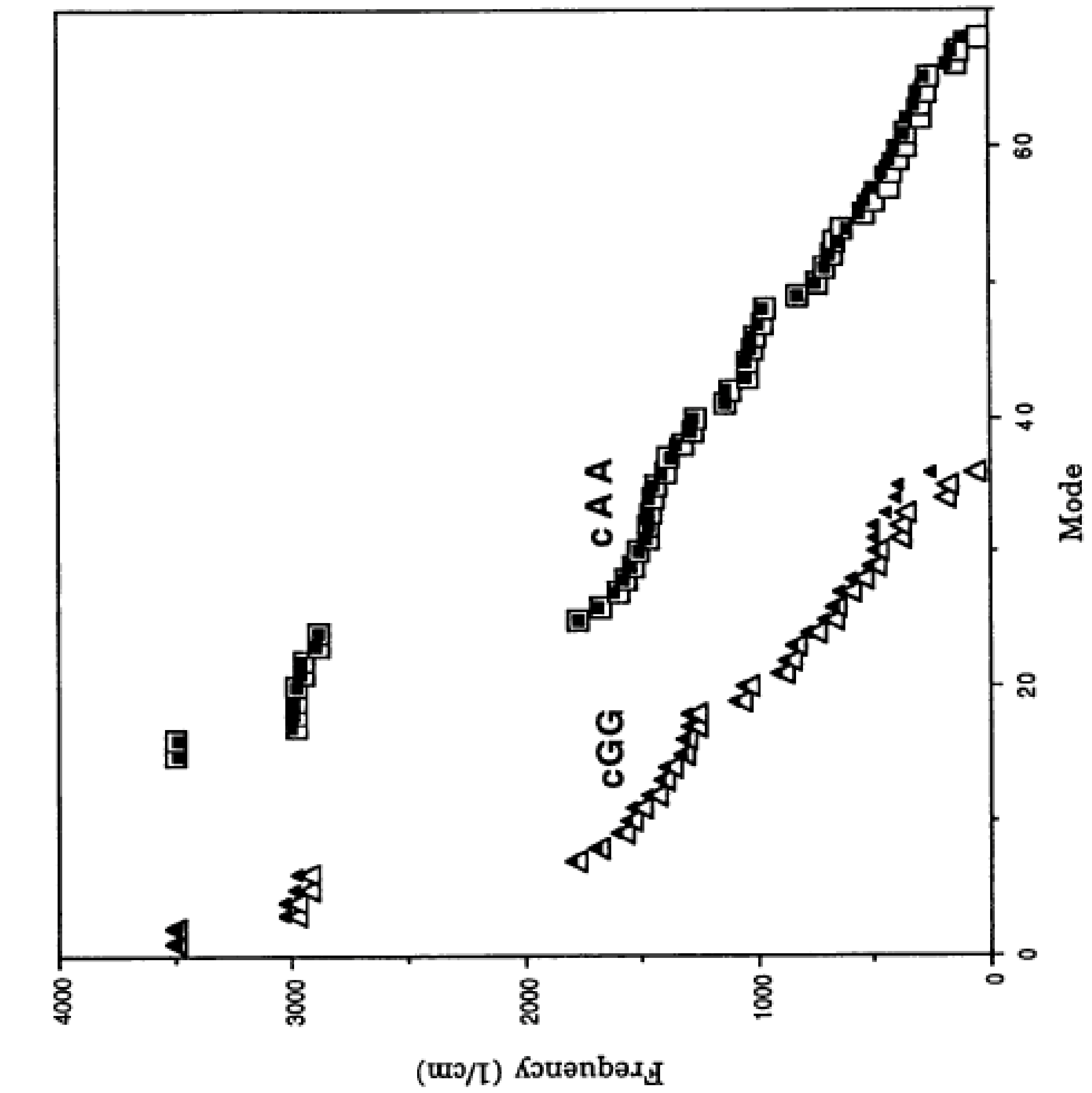

Fig. 7