A modified inflation cosmology relying on qubit-crystallization: rare qubit interactions trigger qubit ensemble growth and crystallization into "real" bit-ensembles and emergent time.

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Abstract

In a modified inflation scenario we replace the "big bang" by a condensation event in an eternal all-compassing big ocean of free qubits in our modified cosmology. Interactions of qubits in the qubit ocean are rare. If they happen, they provide a nucleus for a new universe 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. 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.

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, 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 a triggering 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, 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 symmetry of heterotic string theory has six rolled-up, small dimensions which help to keep the qubit crystal together and will never expand.

Finally, 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 and gravity derive from the permeating qubit-interaction field in the crystal. Hence, vacuum energy gets low inside the qubit crystal. Condensed mathematics may advantageously help to model free (many states denote the same qubit) and bound qubits in phase space. (491 words)

Introduction

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, 2023, 2022). New are here connections to string theory including rolled-up dimensions, a refined treatment of qubit crystallization, and inclusion of recent related 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. 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.

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, 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 universe triggering qubit interactions have to be 1,2,4 or 8 dimensional (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. Neighbor states reach according to transition possibilities (S-matrix) with emergent time from entropic ensemble gradients. 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.

The rest of the paper is divided as follows:
We first give a detailed sketch of the qubit interaction scenario with explanatory figures including a toy model of six interacting qubits (Results, part 1, p.3-4).
Next the path of physics formula necessary to develop for our scenario further is given (Results, part 2, p.4-8). Though the motivation and the high explanatory and phenomenological value of our approach is clear, the required physics is not yet fully spelled out (results, part 3, qualitative sketches on the mathematics, p. 9-13). On the other hand, a number of interesting connections are made clear (results, part 4, first mathematical details, p. 13-22) and the hope is to stimulate better experts in the field to straightened out and develop our scenario into a consistent physics theory. Rough estimates on simulations and their results are finally given (p. 23-26). Finally, we discuss our theory in the context of current thought and cosmological models, stressing nice new features (emergent time, explanations on fundamental physics) and weaknesses in mathematics and hence direct parameter estimates (p. 27-29) and conclude (p. 29/30).

Results I: A simple sketch of the qubit interaction scenario with figures

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, 2023), 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.

In an even larger perspective, such bit-separated qubit-derived frozen bit ensemble crystals come and go in the huge qubit ocean. Why? Well, if our universe exists only since 14 Gyrs, it is philosophically somewhat difficult to argue that it nevertheless should exist forever in the future. Moreover, normal crystals decay and dissolve after typical time scales. However, in the ocean of qubits with *a priori* very low interaction probability of qubits, this would lead to selection for seeds and the general ability to lay seeds for new crystals. This advantage for reproduction selects for such crystals and over generations also for self-organization and life-friendliness. Fine-tuning, perfect adaptation is only in physics explained as a rare or even extremely improbable event that sometimes happens, in biological sciences this is considered to be the result of a selection process, usually permitting evolution.

A first mathematical treatment (Dandekar, 2023) of the qubit interaction and qubit phase transition to form such bit ensemble crystals suggests to introduce a new type of quantum action theory as an even better framework for this phenomenon. Such type of a general lattice field theory (Byrnes and Yamamoto, 2006) would extend the toy bit ensemble model of 6 qubits mathematically treated here. As indicated and shown for the toy model presented here (Fig. 2), vacuum energy should get appropriately low by the binding properties of the qubit crystal. One has to consider free qubits vs bound qubits, misplacements in the qubit crystal and also study entropy during qubit decoherence giving rise to individual bit state ensembles. However, with such a detailed, powerful approach also more accurate quantification will become possible.
Moreover, and again extending the properties of our toy model, this should also permit to extend quantum chromo dynamics with scalar fields for color interaction and gravity directly derived from the permeating qubit-interaction field after the hot fireball universe cools down sufficiently.

The theory is hence 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.

As the inspiration of this theory on qubit decoherence came from quantum computing, the model advocated here can besides from astronomical observations also be probed and further developed by laboratory experiments. In fact, standard physics such as quantum computing; crystallization and solid-state physics allow validation tests (e.g. Imhof et al., 2018). With current status, only qualitative validation is possible. However, our hope is to motivate mathematically more gifted physicists to into detailed mathematical treatment, as with quantitative models far more extensive validation and/or modification according to experimental data is possible.

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

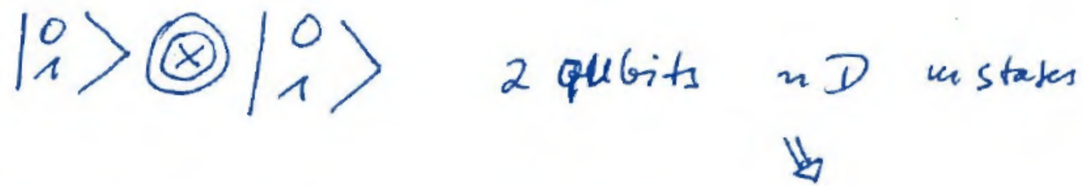
The different formulas required are summarized in Table 1. Moreover, validating observations motivating to follow up our theory are summarized in Table 2.
A key challenge for our qubit crystallization scenario is that two different areas need to be tackled and considered:

(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 overlap in our four “long” dimensions (time and space), which is a 1 by 1 interaction.

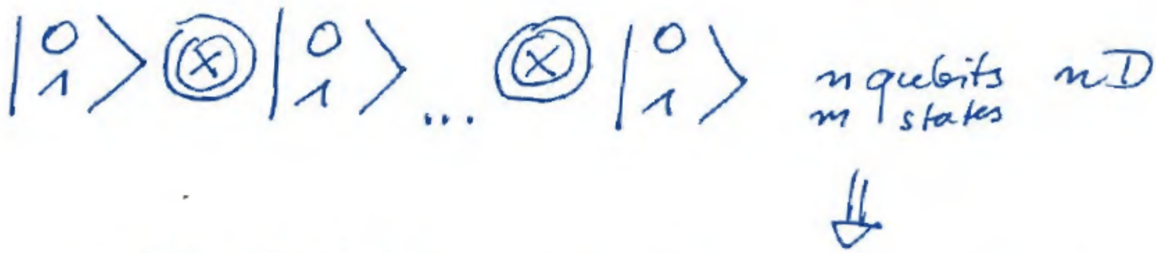
a) **Formula F1: strong interaction force between n qubits** → linear increase with number of qubits, scalar field at grand unification energy scale; only possible if correct dimensionality and direction, closeliness → really low *a priori* probability.

Proof: The Hurwitz theorem (Hurwitz, 1898; see Results, part III below) 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.

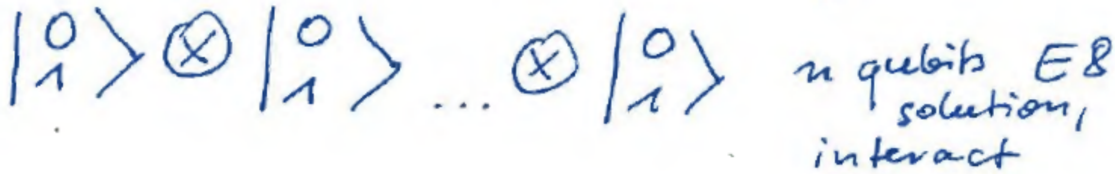
So, then we would write: First we have really free qubits, in full entanglement in the qubit ocean, and of any dimension; then with a really low probability (calculation estimate see below) we need two qubits to interact with any D, so double circle. This triggers then the seed for a new condensation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



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



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

$$\left\{\begin{array}{l}(000 \ldots 00)\\(000 \ldots 01)\\(000 \ldots 10)\\(000 \ldots 11)\\ \vdots \\(111 \ldots 11)\end{array}\right\}$$

⇓ frozen out n^m bit ensembles

2^6 in toy example 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

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

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)

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 the LQG treatment by Ashtekar et al. (2006).

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

Here we need the long-range surface loss term for estimates. A first estimate takes a quadratic growth of surface term as estimate (for 3 macroscopic dimenseions 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.

Step 2: 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).

Rolled-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. 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

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

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

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

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 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.

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,

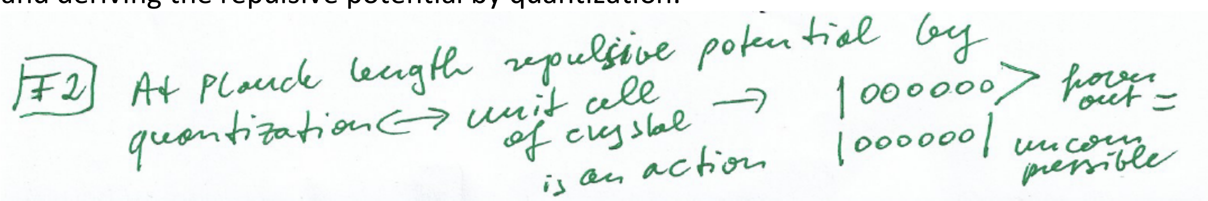
controlled, technological way. We know this for motors and energy generation. However, this allows us to create an artificial sun (nuclear fusion bomb, atomic power plant and fusion reactor). We can speculate that research and knowledge on dark matter may allow us generation of an artificial galaxy and 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).

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.

Results III: Some qualitative sketches of the required mathematical apparatus

F1 is sketched in its mathematics directly above (results II). The terms in **F1** do not vanish completely, but rather are still there in the quantum range (see results II). Hence a formula **F3.2.** is required to describe correctly the remaining entropy and liquidity, as h is BIG with few qubits and really small if qubits are a lot as in our universe. A mathematical further developed formula would allow by these considerations to describe a maximum range of the universe.

Next, **F2 is** the repulsive potential for ultra-short distances between qubits (see results II): by quantization, even resisting big crunch, as shown by Ashtekar et al. (2006), starting form **F1** and deriving the repulsive potential by quantization:



F3 formula above (see results II) should look at clustering of qubits and how a long-range force can build-up, but is also equal to a **grand unified energy potential** (high energy scalar field inside the crystal; we describe here only the very early universe up till the hot fireball; after that all formula of classical cosmology apply). Moreover, apart from the demanding quantum treatment only sketched in results II, the whole qualitative behavior is equal to
Magnetic domain growth as in Weiss zones and how they are limited from further growth in an everyday magnet. The classical treatment of this is given on page 18.

One can also try to calculate misplacements in the qubit crystal **F3.3**

a) According to normal crystals observed and misplacements observed

b) Using qubit formalism: basic fluctuations,
but from the very first start, and no inflation flattening and normal crystal assembly rate, so much higher
compared to inflation (show again **typical background fluctuation**
calculation from standard model, rapid expansion, no interaction creates
seeds)

And parametrization: nice case that observed much more seeds are necessary to meet observed distribution of superclusters, clusters, galaxies etc.
but also this argument will only be accepted if proper formula are used

F4 formula for seed formation (note: in the "free qubit ocean perspective" this happens all the timesand is destroyed again):
Gedankenexperiment on seed formation: Could seeds be generated by black holes? not really, as they are still connected to our universe, and not observed that they leave our universe, but rather the gravitation pull stays and even photos are possible.
As separate crumbles or drops: again, within the crystal or our observable universe never observed, would make big gravitational waves, and happens not.
Hence, very clear, only possibility three, the surface effect, is true. Only at the surface of the crystal there should be seed formation.

As in nucleus stability formulae or in neutron stars (more realistic, as gravity holds star together and now proton repulsive force), may be even quark-gluon plasma closer to the truly grand-unified potential within the crystal. This is then equal to the internal and surface forces in **observed every day crystals**, but needs transfer to a quantum treatment of the qubit crystallization process. On the other side, the "**tugging forces**" are simply the highly chaotic forces of the very high energy ("hot") chaotic boiling free qubit ocean around. Crystal growth is limited by these strong surface forces as long as the crystal cluster is sufficiently big.

Mathematics and how to derive concrete parameters from our scenario:

Modified inflation models are necessary as the BICEP/2 experiments (Ade et al., 2018) never measured the strong perturbations in cosmic background implied by normal inflation. This allows to derive parameters. Standard formalisms for normal crystallization processes including magnetization and Weiss domains as well as protein folding and treatment of solution entropy provide further details. We will sketch now how this allows to derive predictive parameters:

a) Applying the Hurwitz theorem (Hurwitz, 1898) to LQG proofs that any interaction between qubits can only be 1D,2D,4D,8D if they are represented (simplified) by quantum gravity loops. (hence: strong reduction of the solution space from any number of dimensions of qubits interacting to just four dimensionalities allowed as solution)
b) E8 String theory has also a clear form (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 $E_8 x E_8$ 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 an 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.

c) 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. However, 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. Again, this shows the powerful philosophical explanatory power of our theory: It is the first one to explain WHY there is such a bewildering openness in parameter space for string theories (so that evolution can operate on the crystal population) and nevertheless it has a satisfactory explanation why then in the end so optimal parameters for life are selected in our universe (so called fine-tuning problem; Barrow and Tipler, 1986): Simply as selection for seed generation from the crystals creating good quality seeds in the qubit ocean selects as a byproduct also for life-friendly processes and self-organization on smaller scales.

d) Next step: formulation HOW are these seeds formed, just “crumbles from the surface” or black holes or something more sophisticated? Interestingly, a whole surface can be “instructed” / imprinted and from this another surface can inherit patterns. Happens in biology all the time, but relevant also for the next generation of crystals. Some qualitative details are given on p.8/p.9 in results II.

e) Speculation: Entropic dissolution of the universe, tagging etc. the source of the dark energy? Here an entropic treatment has to start from protein folding and water entropy and crystal formation and dissolution (see also Eq. 2; p. 17/18-20).

Part B For very short distances, repulsive forces prevent the big crunch of the qubit condensate (by quantum forces)

This is given on p. 22 (results part 4, subsection “result 6”). The parameters one can derive (not shown on p.22, requires more extensive calculations as done in the paper Ashtekar et al. (2006)) compare favorable to other strong repulsive forces, for instance the Yukawa nuclear counter force: the elementary quantum repulsive force, or according to Ashtekar then a LQG qantization force (for sure also describable also as a string force) can even resist a big crunch of the whole universe, according to Ashtekar (2006). This is more like: field lines just in parallel, compressible to string dimensions one besides the other, but never ever tighter.

Note that the n qubits with m states each are first crystallizing out “background free” (no time, no space) to n**m bit ensembles. After crystallization they form a “frozen-out” state with little liquidity left. From each bit ensemble you go by the S-Matrix (or calculating the transition probabilities more sophisticated) to the next state.

In this way, the “crystal assembles”. The symmetry unit of this phase space has to satisfy for the mathematical reasons of string theory exactly the E8 symmetry (string theory was further development of the S-Matrix theory).

More parameters for now parametrizing the bewildering free E8 string theory come from

a) seed/crumble formation even for next universe(s) (see results II)
b) looking at self-organizing/life like processes in general or
c) astronomical observations like seed generation (misplacements!) for voids/filaments, superclusters, galaxies (e.g. including having cold dark matter in halo regions etc.). This is particularly fruitful if galaxy formation rates in the early universe (new data from James Webb telescope) can be compared with estimates from inflation scenarios (e.g. Rosa and Ventura, 2019) and the higher rate of galaxy formation (and also star formation) according to our crystal scenario (nicely in line with seeing too many early stars and galaxies with the new telescope).

Part C: n qubits with m states each crystallize out to nm ensembles with n bits each, long range forces start then to become so strong that further growth of the crystal is limited.**

Only then general relativity holds and our universe a little bit later transits into the hot fireball textbook universe rapidly expanding and cooling down, everything else agrees hence very well with observation on the earliest steps replace big bang by qubit interaction in ocean of qubits and inflation by qubit condensation. Only very little liquidity and free qubit superposition remains below Planck´s quantum. A fundamental calculation is given in results II, but this needs more detail for concrete parameter estimates.

To compare, too: Formula for qubit crystallization (results II) and our quantum entropy considerations: the entanglement terms are now wiped out, crystallization into non-overlapping bit ensembles. This anti-entropic, order creating process is compensated, according to our theory, by more chaos in the liquid ocean around our “little” crystal.

We can confirm this studying order creation in protein folding, also there the entropy in the water around increases. This helps also to get parameters right: Normal protein folding allows a lot of estimates regarding binding energy, time-scales, typical rate of misplacements. However, we need then to compare: estimated new fluctuations in the rapid inflation models and a full qubit and quantum physics treatment of our new cosmology.

The main implication of our new theory: There are far more misplacements from very early misplacements never flattened out in a normal crystallization process now happening in our qubit model are what is actually observed.

Part D The transition part to the hot fireball model – the interaction field holding the crystal together is also a grand unifying field holding all together, leading to decoherence

Formulas for qubit interaction giving rise to a Grand Unification Force field first, later cooling down to scalar fields for strong interaction.
Here our qubit interaction theory does explain WHY there is color confinement: By crystallizing out we have a permeating strong interaction field and this, after cooling down gives rise to the scalar field of color confinement and for gravity (or at least for the Higgs field)

Parameters: color confinement is observed, and also Higgs boson, so in principle the parameters from qubit interaction should fit to the observed Higgs field and colour field. It will be sufficient to stress this correctly and mathematically, but need not to derive exactly the parameters, rather use them for correct fitting (as a first step as in many other theories).

However, even more interesting is the function of the rolled-up dimensions in string theory (results II, p. 7): We connect to another paper (Kaya and Rador, 2003) to give parameters on their size and that they shrink first and stay small in the later universe (from hot fireball start onwards). Interestingly enough, we show here a convincing reason WHY there are roled-up dimensions and why they "never do something or are observed": If our theory is correct, these rolled-up dimensions are critical to hold together the universe while at the same time allow the bit ensembles to almost completely separate, only connected by one quantum bit transition probabilities to all closest neighbors of bit ensemble states (as observed in everyday quantum physics and nicely summarized by S-matrix theory, Barut 1971). So, the claim is that qubit interaction can only crystal out and become real instead of either staying into a "qubit all possibility limbo" or disintegrating completely into separated bit ensemble states NOT connected to each other, as we have as direct result of qubit interaction only a 1,2,4 and 8-dimensional solution. The 8-dimensional solution is the richest solution and E_8 as mathematical consistent string theory solution of the heterotic string theory stands out as basis for our world: it´s rolled-up dimensions hold our world together while the macroscopic dimensions crystallize out as our real and everyday world. Probably one can show the same for the other four well-known and consistent string theories (Green, 2000; Gross et al., 1985), but this is beyond the scope of this manuscript.

This is an inherently more convincing and comforting scenario as the ever-splitting Everett multiverse (Tegmark, 2007). I 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**).

Part E Within our domain, all is crystallized, the universe is real, general relativity holds, but outside a qubit ocean exists, vacuum energy is much higher. Note also that 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; it is again much more convincing than any extreme annihilation scenarios of all matter/anti-matter in the very early universe postulated by others.

The typical formulas to calculate vacuum energy giving 10**20 too high energy, as there are lots of virtual particles created. We have to contrast this with the much lower, restricted vacuum energy inside the qubit crystal with the high interaction potential from the permeating scalar field of interaction making everything real and leading to rapid decoherence inside the crystal but also to the low vacuum energy. The parameters are as actually observed (our universe) but the art (not shown here) is to start with a pure qubit interaction treatment (results II), then derive the interaction potential and the grand unified field from this qubit interaction, considering also the "glue" by the roled up dimensions using a full $E_8 \times E_8$ heterotic string theory treatment and then end up with the much lower observed vacuum energy holding *inside* our qubit crystal.

Results, part 4: Mathematical details on all formulae for quantum action theory (see Table 1):

Ad F1: How do qubits interact? As we are doing here encoding of the phase space of the standard model, we could also say that interaction would be a mathematical operation.
Result 1: From this view point, the Hurwitz theorem shows that only 1D, 2D, 4D and 8D numbers are possible (the latter ones octonions). So, no matter which dimensions pure or "free" qubits can have, they can interact only in these four types, they can only interact if they are one- (real numbers), two- (complex numbers), four- (quaternions) or eight-dimensional (octonions). The richest type of interaction is the 8D case, which is the universe we observe and we live in.

Proof sketch: we want to show here that the interaction for qubits of any dimension and number of fields is nevertheless restricted to 1,2,4 and 8 dimensions, otherwise there is no interaction possible:

a) general treatment of qubits: The Hamiltonian is commonly expressed as the sum of operators corresponding to the kinetic and potential energies of a system in the form:

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

So kinetic energy operator T plus potential energy operator V, in classical writing like this:

$$\hat{V} = V = V(\mathbf{r}, t)$$

and

$$\hat{T} = \frac{\hat{\mathbf{p}} \cdot \hat{\mathbf{p}}}{2m} = \frac{\hat{p}^2}{2m} = -\frac{\hbar^2}{2m}\nabla^2$$

is the kinetic energy operator in which m is the mass of the particle, the dot denotes the dot product of vectors,
and

$$\hat{p} = -i\hbar\nabla$$

is the momentum operator where the upside down triangle is the del operator. The dot product of the del operator with itself is the Laplacian. In three dimensions using Cartesian coordinates the Laplace operator is

$$\nabla^2 = \frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}$$

Although this is not the technical definition of the Hamiltonian in classical mechanics, it is the form it most commonly takes. Combining these yields the familiar form used in the Schrödinger equation:

$$\begin{aligned}\hat{H} &= \hat{T} + \hat{V} \\ &= \frac{\hat{\mathbf{p}}\cdot\hat{\mathbf{p}}}{2m} + V(\mathbf{r},t) \\ &= -\frac{\hbar^2}{2m}\nabla^2 + V(\mathbf{r},t)\end{aligned}$$

which allows one to apply the Hamiltonian to systems described by a wave function

$$\Psi(\mathbf{r},t)$$

.

This is the approach commonly taken in introductory treatments of quantum mechanics, using the formalism of Schrödinger's wave mechanics. One can also make substitutions to certain variables to fit specific cases, such as some involving electromagnetic fields.

The formalism can also be extended to N particles:

$$\hat{H} = \sum_{n=1}^{N} \hat{T}_n + \hat{V}$$

Where potential energy is described as

$$\hat{V} = V(\mathbf{r}_1, \mathbf{r}_2, \ldots, \mathbf{r}_N, t),$$

now a function of the spatial configuration of the system and time (a particular set of spatial positions at some instant of time defines a configuration) and;

$$\hat{T}_n = \frac{\mathbf{p}_n \cdot \mathbf{p}_n}{2m_n}$$

is the kinetic energy operator of particle n, and del operator (upside down triangle) is the gradient for particle n, giving the Laplacian for each particle using the coordinates:

$$\nabla_n^2 = \frac{\partial^2}{\partial x_n^2} + \frac{\partial^2}{\partial y_n^2} + \frac{\partial^2}{\partial z_n^2},$$

Combining these yields the Schrödinger Hamiltonian for the -particle case:

$$\hat{H} = \sum_{n=1}^{N} \hat{T}_n + \hat{V}$$
$$= \sum_{n=1}^{N} \frac{\hat{\mathbf{p}}_n \cdot \hat{\mathbf{p}}_n}{2m_n} + V(\mathbf{r}_1, \mathbf{r}_2, \ldots, \mathbf{r}_N, t)$$
$$= -\frac{\hbar^2}{2} \sum_{n=1}^{N} \frac{1}{m_n} \nabla_n^2 + V(\mathbf{r}_1, \mathbf{r}_2, \ldots, \mathbf{r}_N, t)$$

Here we have to sum up terms to get Energy (kinetic and potential) correct:

a) 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.

Nevertheless, to be really sure about the applicability of the Hurwitz theorem to the general energy terms of qubit interaction one would have to transform the energy terms correctly into an addition of complex or hyper complex numbers. This remains to be accurately shown.

However, then, 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

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

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, showing 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 (see text part above), 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).

b) LQG treatment of qubit interaction potential:

As the qubit treatment is challenging, there is alternatively a LQG (loop quantum gravity) treatment possible following definitions and formulas introduced by Rovelli (2004):

A background free (BGF, without time) spin-network is introduced (see Rovelli, 2004).Dynamics (so things happening for a particle or a system of several particles in a space-time like our everyday world) are described in the spin network as follows (the amplitude, as shown by Feynman, encodes full quantum dynamics) and we write for the amplitude w (s) of spin network states (formula 1.12. in Rovelli, 2004):

$$W(x,t,x',t') = \langle x|e^{-\frac{i}{\hbar}H_0(t-t')}|x'\rangle = \langle x,t|x',t'\rangle.$$

In this notation, the particle is first observed at x´, t´ and then found at x, t.
The resulting space of events (x´,t´, x, t) is called G and includes (as long lists) all data-sets of the events. For another variable different from the position, the Amplitude becomes

$$A = \langle \psi_{\text{out}}|e^{-\frac{i}{\hbar}H_0(t-t')}|\psi_{\text{in}}\rangle.$$

(1.13; Rovelli, 2004)

(requiring then the tensor product of the Hilbert space of initial states and (the dual of) the Hilbert space of the final state). The physical transition amplitudes w (s,s´) are obtained by summing over spin foams bounded by the spin networks s and s´

$$W(s,s') \sim \sum_{\substack{\sigma \\ \partial\sigma = s \cup s'}} \mu(\sigma) \prod_v A_v(\sigma).$$

(1.17; Rovelli, 2004)

--Now all this treatment of the spin network according to the LQG formulas above *does not* specify here a specific dimension (the G, the dataset could be collected and applied to study events in a space-time of any number of dimensions). However, to calculate amplitudes we have to sum up between states in the spin network to follow a succession of events.

We now only need to allow (x´, t´, x, t) over any number of dimensions (including time-like dimensions) and further we need a summation over amplitude squares (which should then be the actual quantum probabilities) then we see immediately that the summation over amplitude squares modifying formula 1.17 (Rovelli, 2004) accordingly can only work if the mathematical operation of summation of amplitude squares is possible despite the high or low number of dimensions chosen.

Strikingly, according to the Hurwitz theorem this is only possible for 1,2,4 or 8 dimensions. Specifically, 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

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

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.).

So, in summary, the LQG formalism allows any dimension in its formulation, such as for the interaction potential, the datasets of events and the amplitude for other properties then the position. Knowing this and then applying the Hurwitz theorem to it shows then that any summations or any more general mathematical operations are only possible for dimensions 1,2, 4 and 8. Hence LQG or any type of many-dimensional string interactions or many-dimensional spin networks are only possible for 1,2,4 and 8 dimensions or symmetries. The last one corresponds to the richest case and is our observed E8 symmetry of our domain.

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.
Result 1b: To get here 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 by 10**20, as all is now bound, so hence potential energy in our everyday world, as all is decoherent, solidified and defined and no longer free undefined quantum state.

Majorana qubits: An important example, how solid and strong interactions between qubits can become under the correct conditions are majorana qubits (Aguado and Kouwenhoven, 2020). Majorana qubits can be generated in topological materials at extreme low temperatures at the end of a connected chain of supra-conducting electrons. They are then half quasi-particles with zero excitation energy and so called zero modes. Several such zero mode paths can be braided with each other and then one has really stable majorana zero-modes and thus stable qubits for longer calculations (Ball, 2021). However, experimental verification of observed majorana qubits is very challenging, in particular alternative quantum states can look very similar and are also experimentally explored but not yet clearly nailed down either (bound Andreev state; other anyons, skyrmions in magnetic materials; Frolov, 2021).

However, our cosmological scenario is quite different, we have an ocean of usually free qubits but if they interact they become tightly bound and a seed for a new universe. We think that the binding energy for such a qubit seed is of the order of the calculated free vacuum versus the observed much lower energy. Braiding and separation allow in topological qubits longer conservation of states, however, in our perspective the topology of space and time is created (emergent time and space) by the tight interaction of the aggregate of qubits which rapidly grows by a magnetization-like process (Devizorova et al., 2019). The build-up of long-range forces limits growth, leads to the emergence of space and time and general relativity. This is only partly analogous to braiding of majorana qubits in a topological material but much more fundamental and leads to separated, frozen-out states of 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.

Result 2: 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., □□□□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 □□□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.

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

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).

Result 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).
Result 4: 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, in our everyday world, we have bound, interacting qubits, hence 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

Time invariance

$$H = \frac{\partial L}{\partial \dot{\mathbf{q}}} \cdot \dot{\mathbf{q}} - L.$$

Similarly, there may also be translational Invariance

$$p_k = \frac{\partial L}{\partial \dot{q}_k}.$$

Result 5: 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:

Result 6: 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:

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

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):

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

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.

5. First estimates on our simulation results

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.

Microscopic structure (see **Table 1**, second part): We show 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 basic mathematical properties of the S-matrix (**eq. 7**) are: (i) Relativity: The *S*-matrix is a representation of the Poincaré group; (ii) ; (iii) Analyticity: integral relations and singularity conditions which include: Crossing, i.e. the amplitudes for antiparticle scattering are the analytic continuation of particle scattering amplitudes. Dispersion relations, i.e. the values of the *S*-matrix can be calculated by integrals over internal energy variables of the imaginary part of the same values. Causality conditions, i.e. the singularities of the *S*-matrix can only occur in ways that don't allow the future to influence the past. Landau principle: Any singularity of the *S*-matrix corresponds to production thresholds of physical particles.

Term schemes (**eq. 8**) can again be used to consider all quantum states completely and are hence a toy example that shows how all quantum states "crystallized out" can be fully enumerated. These can start even simpler then S-Matrix theory, e.g. the transition probabilities or term schemes in spectroscopy. However, in full they consider quantum transitions, all paths and energy levels and are concisely summarized by Feynman diagrams.
Infinities in force field calculations (Yang Mills fields but also already electron force field; Jackiw, 1999) arise from the fact that you assume you can have infinitesimal small distances. In our perspective this is not the case: qubits which are free in the soup are completely free, but as soon as you form the solidified interaction state as basis for our universe and having real, defined bit states instead of qubits all condenses to a grid. Its granularity is the elementary quantum of action, Planck´s constant of 6.626 x 10-34 Js. Hence, this is a grid made from actions, not a space grid. However, this prevents infinities. Smaller than the size of the grid we have continuity and complete freedom, but anything larger occurs only in discrete quantum states (**Fig. 2**).

Eq. 9 (quantum computations for proton mass)
One can start simple: the proton composed of two up and one down quark and color charge. Still later one would consider larger systems, hydrogen atom, molecules etc. or further quantum parameters such as charges, spin, isospin etc.:

$$m_p = 2m_u + m_d + \Delta E$$

and next consider the colour charge e in more detail (Yang et al., 2018):

$$\Delta E = \frac{2\pi}{3}\frac{e_i e_j}{m_i m_i}|\psi(0)|^2 \boldsymbol{\sigma}_i \cdot \boldsymbol{\sigma}_j$$

And then it becomes step-wise more and more complex, e.g. considering the Baryon octet of spin parity ½ you then get for the proton the wave function:

$$\phi(P, J_z = +\tfrac{1}{2}) = \frac{1}{\sqrt{18}}[2u\uparrow u\uparrow d\downarrow + 2d\downarrow u\uparrow u\uparrow + 2u\uparrow d\downarrow u\uparrow - u\downarrow d\uparrow u\uparrow - u\uparrow u\downarrow d\uparrow - u\downarrow u\uparrow d\uparrow - d\uparrow u\downarrow u\uparrow - u\uparrow d\uparrow u\downarrow - d\uparrow u\uparrow u\downarrow].$$

Next, you derive from this the mass and do the more detailed calculation.

Eq. 10 (quantum action and qubit-to-bit transition for a proton)
In the next step you have then to apply our new perspective of a qubit to bit transition to this description of the proton mass, so applying **eq. 1, eq. 1b** and **eq. 3** to this but integrating them with the microscopic formulas (**eq. 7**- **eq.12**). This is a formidable mathematical task, not shown in this manuscript.

Eq. 11 (decoherence of quantum states in a multiple particle system): Next one has to consider multiple particle systems:.This is of course far more difficult and only sketched here. **Fig. 2** gives a toy example for a system with 6 qubits who only can have two quantum states. In full superposition they have their 64 different possible bit states mixed together as qubits, in decoherence each of them “freezes out”. There is emergent time according to the arrow of entropy and emergent space according to quantum state. However, to transfer the full enumeration of all quantum states to something more complex, for instance the proton, is far more difficult.

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).

Discussion

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. We claim that decoherence happened as the necessary condition for our universe to become real and not to stay longer in a quantum limbo of all alternatives. Logically, the universe cannot start in another way. It is high time to appreciate this argument. Instead, the standard "Big Bang" theory is no good philosophical explanation of a start of anything, let alone the universe: why? what happened? what was there before? – particular with this third question you realize how much more convincing my new explanation of qubit decoherence and qubit crystal formation is from a philosophical view point.
The "Big Bang" is rather the myth of the nuclear age in the 20th century, where everything starts or at least leads to an explosion, for no convincing reason.

Moreover, decoherence has long been a central mystery of quantum physics (Zeh, 1970; Schlosshauer, 2005). My 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) – my hope is that my line of argument is more convincing. In this paper, the heavy mathematics required for more certainty and more accurate quantification of our theory and its predictions is only briefly sketched. However, the better agreement with observations of the large-scale structure of the universe is high (Table 2). Moreover, the explanatory power is high and the why far better explained then in many alternative cosmological theories: Thus 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.

However, here we bring in the new concept of (i) qubit interaction and condensation nucleus and (ii) qubit cluster growth by a magnetization or crystallization-like process. The central hypothesis of our theory is that this creates our world, or in fact, any world with a physical reality, whereas without the phase transition you have free qubits and much higher vacuum energy. The much too high vacuum energy has long been known as disagreeing with observation, but we give a good explanation ***why*** this is the case. We explain here the creation of the universe from an ocean of free qubits having the high vacuum energy and how after qubits interact and provide a seed, a magnetization like growth agrees better with observation then inflation-like scenarios. Moreover, internal vacuum energy gets lower (10**20 times) as observed.

In addition, qubit interaction, according to the Hurwitz theorem explains ***why*** there can only be a 1D,2D,4D or 8D solution, we get as logical and physically consistent eight-dimensional solution the E_8x E_8 heterotic string theory. We explain, ***why*** there are rolled-up dimensions: Necessary glue for holding our world together which otherwise cannot crystallize out and become real. We develop an alternative to standard inflation cosmology with high explanatory, phenomenological power, fitting better observations as there is no inflationary flattening out of misplacements and concrete misplacements typical for any type of crystal (Table 2). The evolutionary postulate of our theory, many generations of crystals selecting for self-organization and more efficient seeds for the next generation imply even an explanation ***why*** our universe is so fine-tuned for life and self-organization-friendly including even intelligent life. However, the mathematics needs still much more detailed development as indicated in the sketches on required mathematics and the results.

We present a framework for our qubit crystal formation: freezing out of the separated ensemble states so that a universe becomes real and defined as clear bit state ensembles starts from an ocean of free qubits and then requires a number of formulas as summarized in **Table 1**. However, we give here mainly only qualitative results (Figures, Tables). There is a rather simplified mathematical treatment of the qubit interaction using quantum formalisms. This allows to describe seed generation from interacting qubits growing rapidly similar to everyday magnetization. We see from this that in our model instead of Big bang and inflation phase we have only a phase transition of the free qubits from the eternal and may be infinite qubit ocean. They interact with low probability from "liquid" (full entanglement and all quantum states possible) to "solid" state (real world, defined bit ensemble; only minimal liquidity left allowing still to move from one state by permuting one quantum state to all next neighbor state according to transition probabilities given by S-matrix theory and more modern treatments. This is then also shown simple and clear in a toy model of six qubits transiting to 64 bit ensembles each made of six bits with two states. This model also clearly show that we have here emergent internal time in the crystal and space and general relativity as well as low vacuum energy emerge when the "solid" state of the qubits forms fully and does not recruit new qubits anymore from the ocean (so as in an established magnetic zone). Though we then do our best to derive concrete parameters from the theory, this is clearly the weakest part regarding the mathematics and has to be improved in later versions. This manuscript is in this respect only an inspiring thought, as Edgar Alan Poe´s (1848) famous piece "Eureka" (which foresaw the expansion of the universe many decades before it was actually discovered using his own poetic notion of physics). Nevertheless, subsequent results in my manuscript illustrate several mathematical ideas applied to qubit interaction (Hurwitz theorem; entropy considerations from protein folding and comparison of cosmological qubit condensation and crystal growth to everyday crystal seeds and crystal growth. We sketch also how concrete parameters can be derived by later work and discuss extensively the qualitative results reachable for us at present.

A very intriguing lead is that rolled-up dimensions from string theory are considered here as critical to hold our bit ensembles together crystallized out in their macroscopic dimensions. Similarly, we can justify the E_8 x E_8 heterotic string theory as natural deriving as a physically consistent solution to the 8-dimensional possibility (one of only four possibilities) how qubits of arbitrary dimension can interact at all. This is a major break-through in string theory if mathematically properly treated. However, at present this is not achieved nor our ambition. Our hope is instead that this inspires string theoreticians to examine our model and straighten it out to achieve this.

Another again only qualitative result is that we suggest how the unified scalar field for qubit interaction can be derived, including the break-up of color scalar field and gravity scalar field. Inflation is not necessary to invoke, as in a crystal the unit cell guarantees the same symmetries everywhere (and hence "laws of nature"). We see also that typical misplacements in a crystal agree far better with observed with voids and filaments, superclusters and galaxy formation then the textbook big bang scenario which would wipe out irregularities.

For the repulsive force on ultrashort distances we apply a quantization from LQG to show how this is derived, and heterotic E_8 string theory illustrates well that there is a basic unit cell to our domain, having the E_8 symmetry, with the eight-dimensional symmetry being also the richest solution according to the Hurwitz theorem, and hence for qubits to interact and form a crystal. Nevertheless, we do not give preference to LQG or string theory or bring any of our basic formula to a more advanced treatment to these frameworks (string theory, LQG), but rather stress that the crystallization of qubits should be examined from all possible angles. Thus, a qubit of space has recently been simulated (Czelusta and Mielczarek, 2021) and it was investigated how the entanglement between a qubit clock and the geometry of a universe derives emergence of a time parameter (Nambu, 2022). 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.

How does the phase space decoherence approach help reconciling general relativity with quantum physics? Well, first of all, the bit ensemble states of the qubits forming the universe in question are nicely discrete, accurate and finite. There are no infinities from the start. Even the whole problem, approaching infinities as space becomes smaller and smaller is removed in our theory as in the first place we have no space but rather just the ensemble bit states. Space emerges as soon as the phase transition is complete and the qubit ensemble states fully separate and become discrete and defined. Then bit states specifying space are also there, and flat space means that the ensemble states have nicely evenly separated spatial neighbors in ensemble bit space. Gravitational fields result from bit states describing space coordinates no longer linear separated but having a stronger or weaker curvature.

This can be described according to general relativity (not modified here in this approach) and as soon as there is space, all can be calculated. We give here not yet a treatment of entropy and black holes as well as Hawking radiation, but we highly suspect here the well-known treatments by Bekenstein and others will simply hold also in our model. More complex is the quantum description: We model everything only implicit according to phase space and give no specific quanta description for gravitons or field quanta of gravity including the Higgs Boson and remains for later work.

Solid bound qubits crystals in an ocean of free qubits: Independent from this line of arguments around decoherence, quite important is the concept that in a crystal you have everywhere the same symmetries, the unit cell is propagated and does not require inflation. If you investigate the creation of the universe from an ocean of qubits (Kaku, 2021 considers such an ocean or chaos soup, too) and not a freak jump into existence as in big bang and inflation you thus get more realistic in your cosmological model.

Independent from this scenario, we postulate many generations of crystals (as normal crystals also exist only a finite time) and hence selection for optimal surviving crystals and generation of new crystal seeds. This explains then one of the toughest problems of all, why is our universe so life-friendly. Evolutionary 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).

Conclusion: 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 by 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. The phenomenological explanatory power of this new perspective is extremely high, justifying intensive follow-up. On the other hand, the current mathematical and physics treatment of details of the theory is only qualitative and preliminary, requiring a lot of more work critical for consistency checks and further development. Nevertheless, already now important and deep connections become apparent: (i) rolled-up dimensions as glue for our qubit-crystal-world; (ii) the E_8 heterotic string theory as natural consequence of qubit interaction extremely 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. Hence, we very much hope that these qualitative results encourage more fundamental physicists to follow this attractive perspective further up with higher accuracy and mathematical insight. It is imperative to tackle the deep question “how did our world become real?” on a fundamental, background-free level. Here this yields a new, fresh look on cosmology: Can free 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.

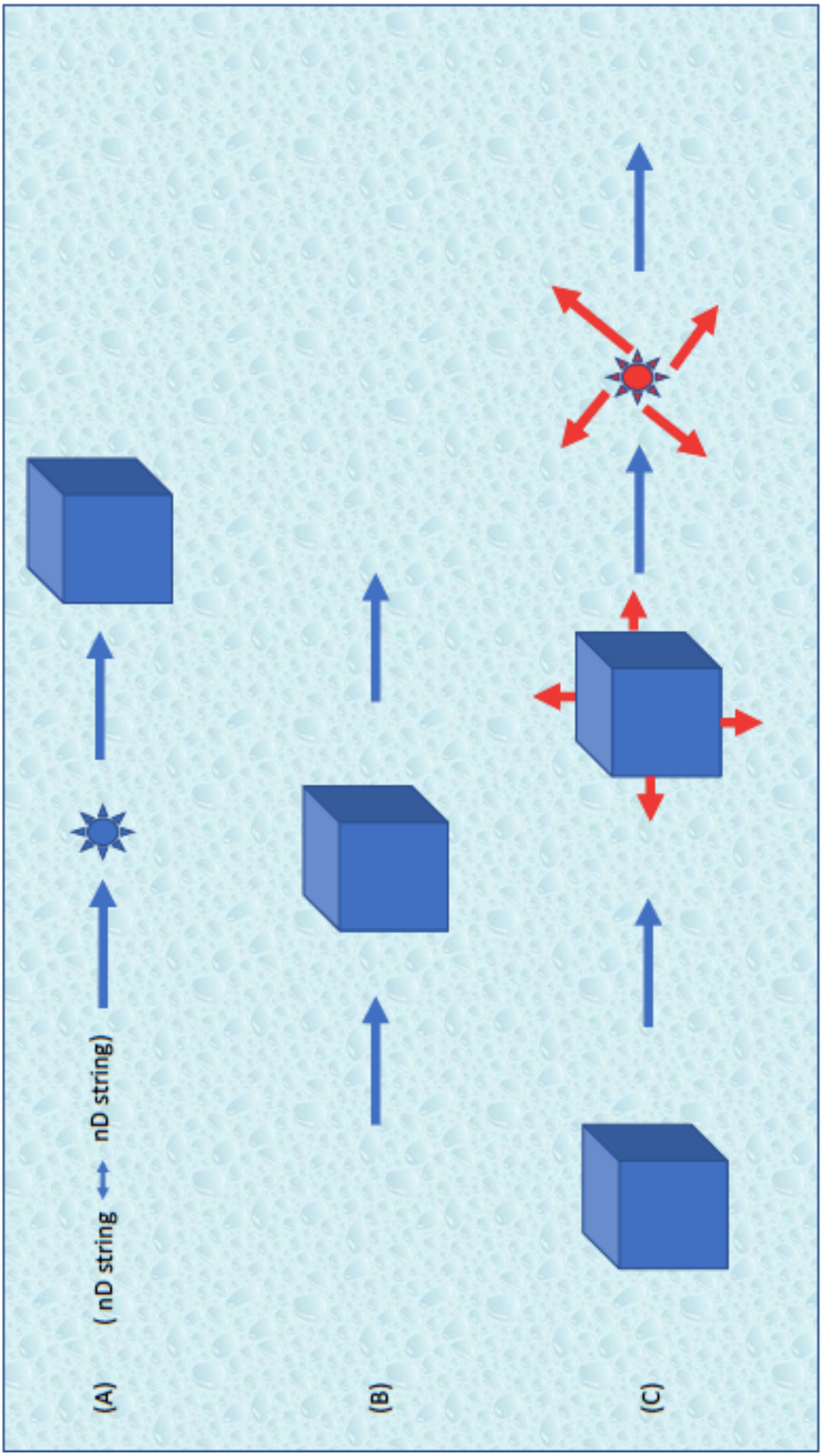

Fig. 1

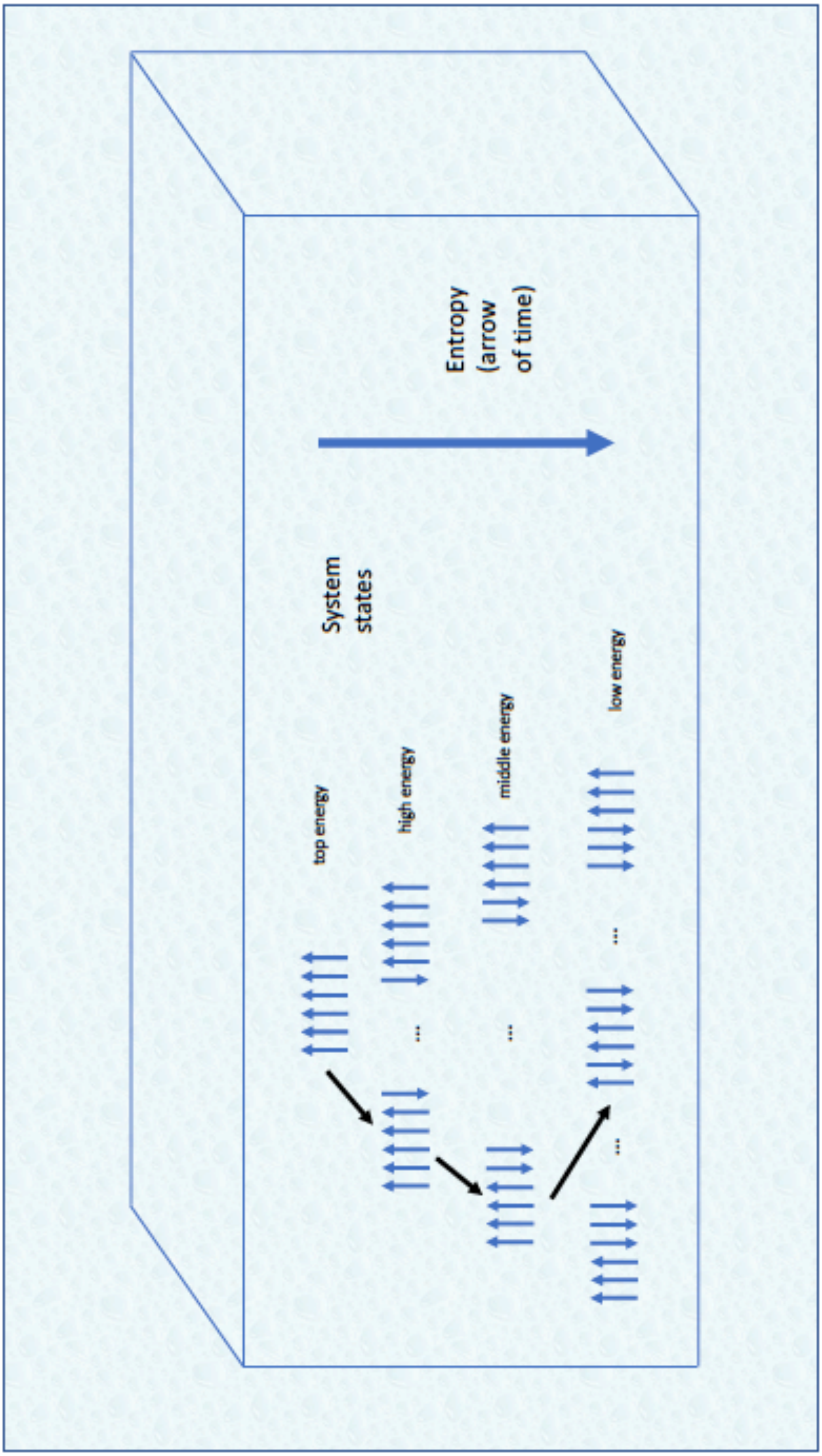
System
states
top energy
high energy
middle energy
low energy
...
Entropy
(arrow
of time)

Fig. 2

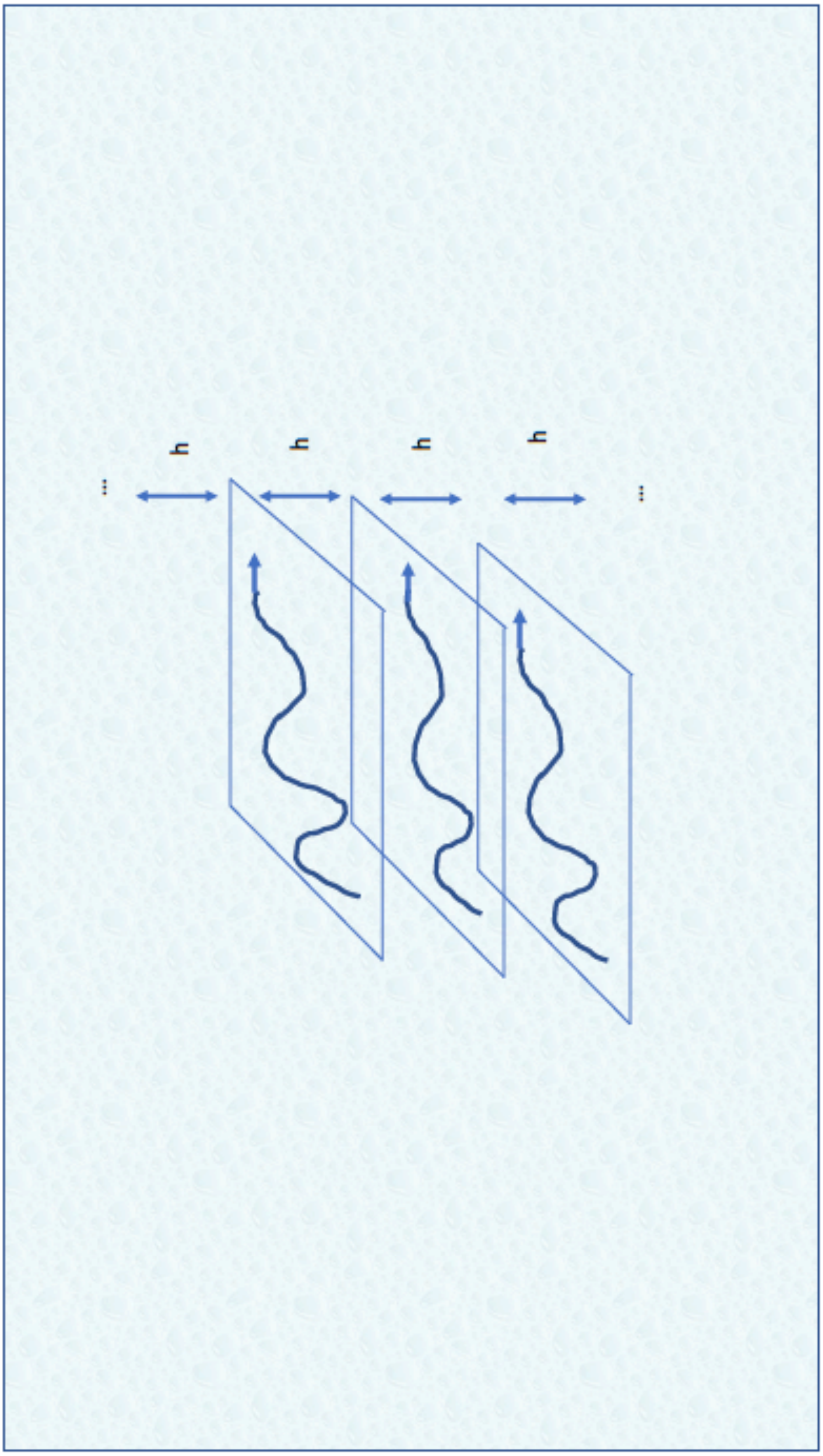

Fig. 3

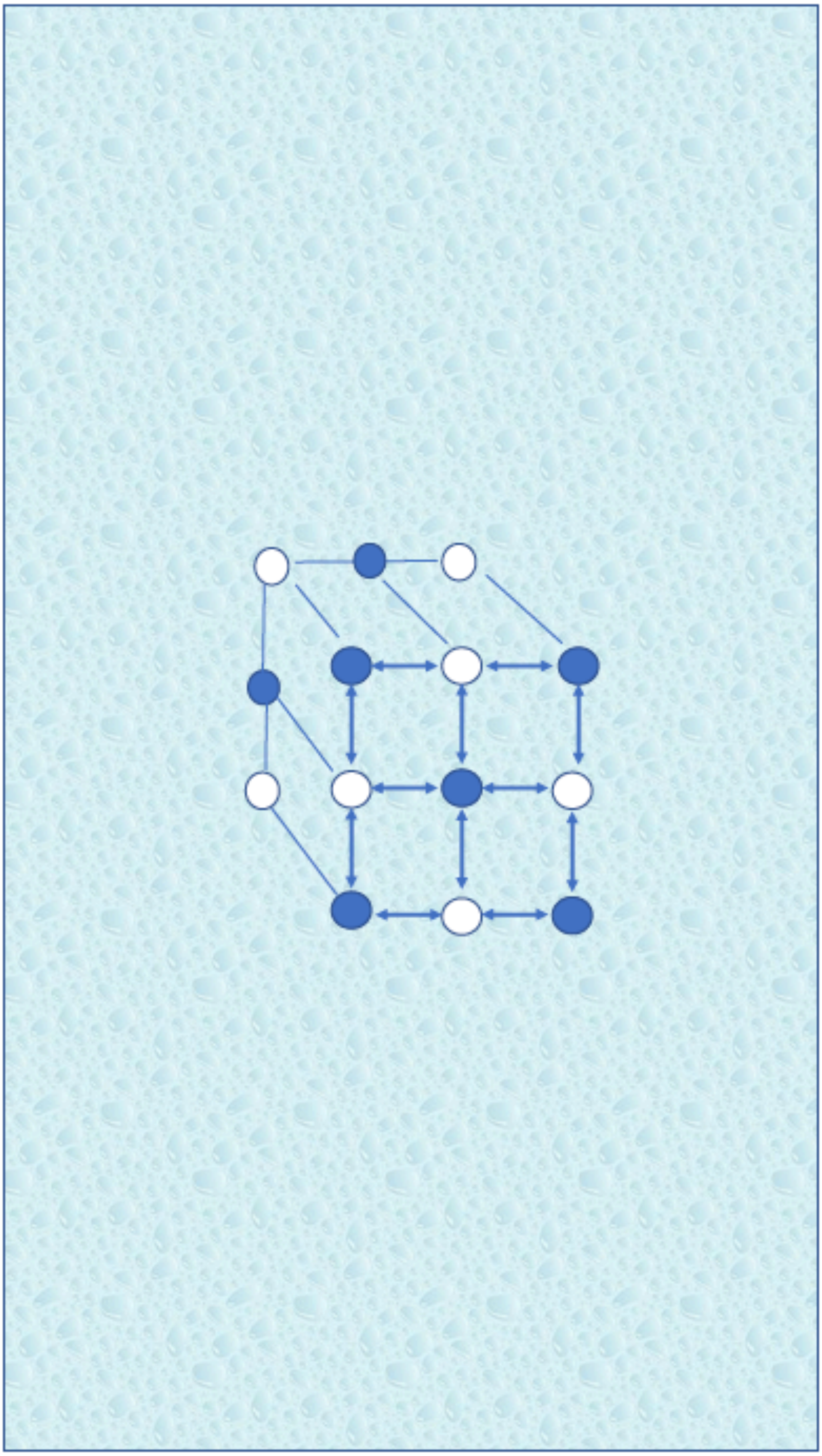

Fig. 4

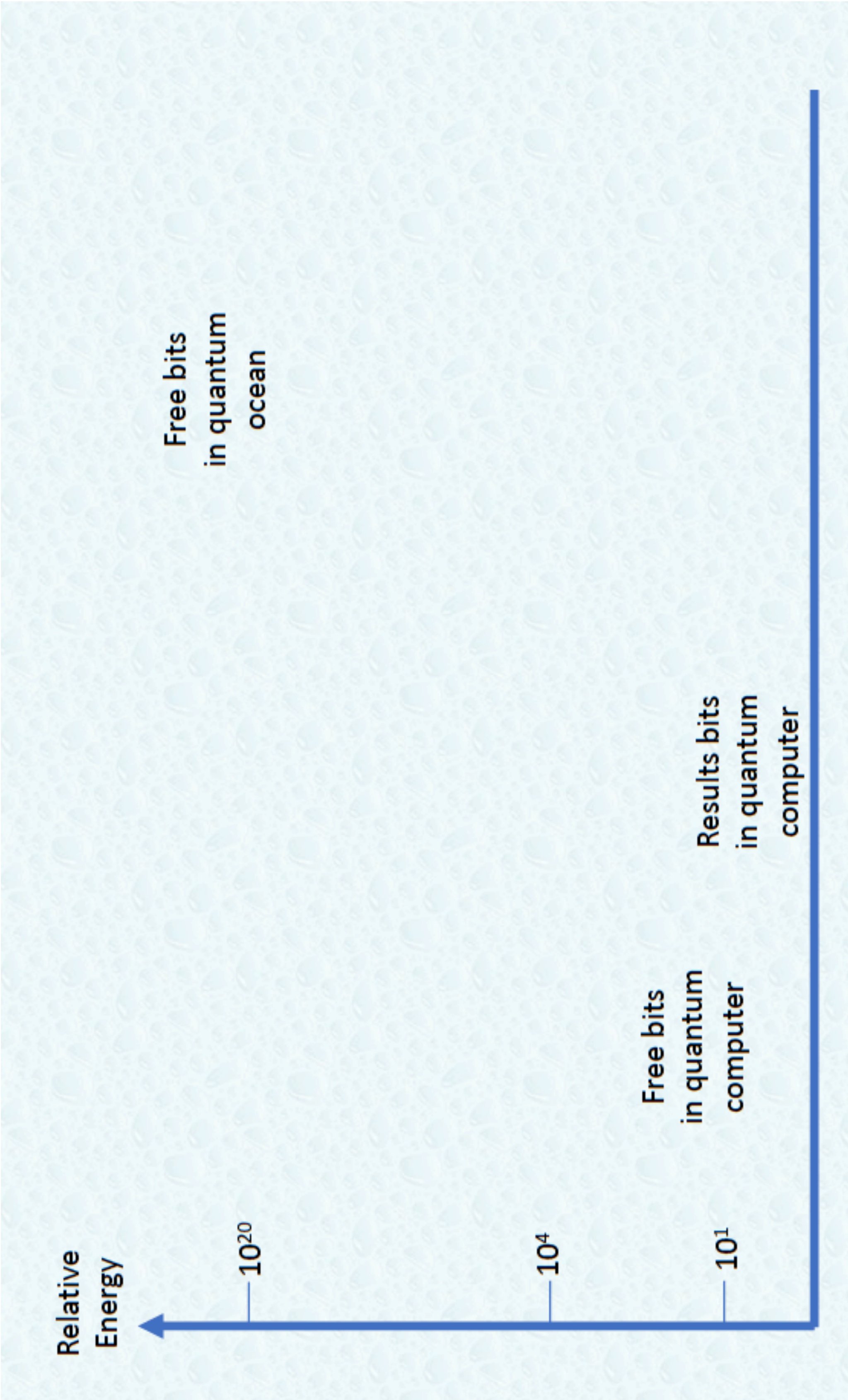
Relative
Energy
10^20
10^4
10^1
Free bits
in quantum
ocean
Free bits
in quantum
computer
Results bits
in quantum
computer

Fig. 5

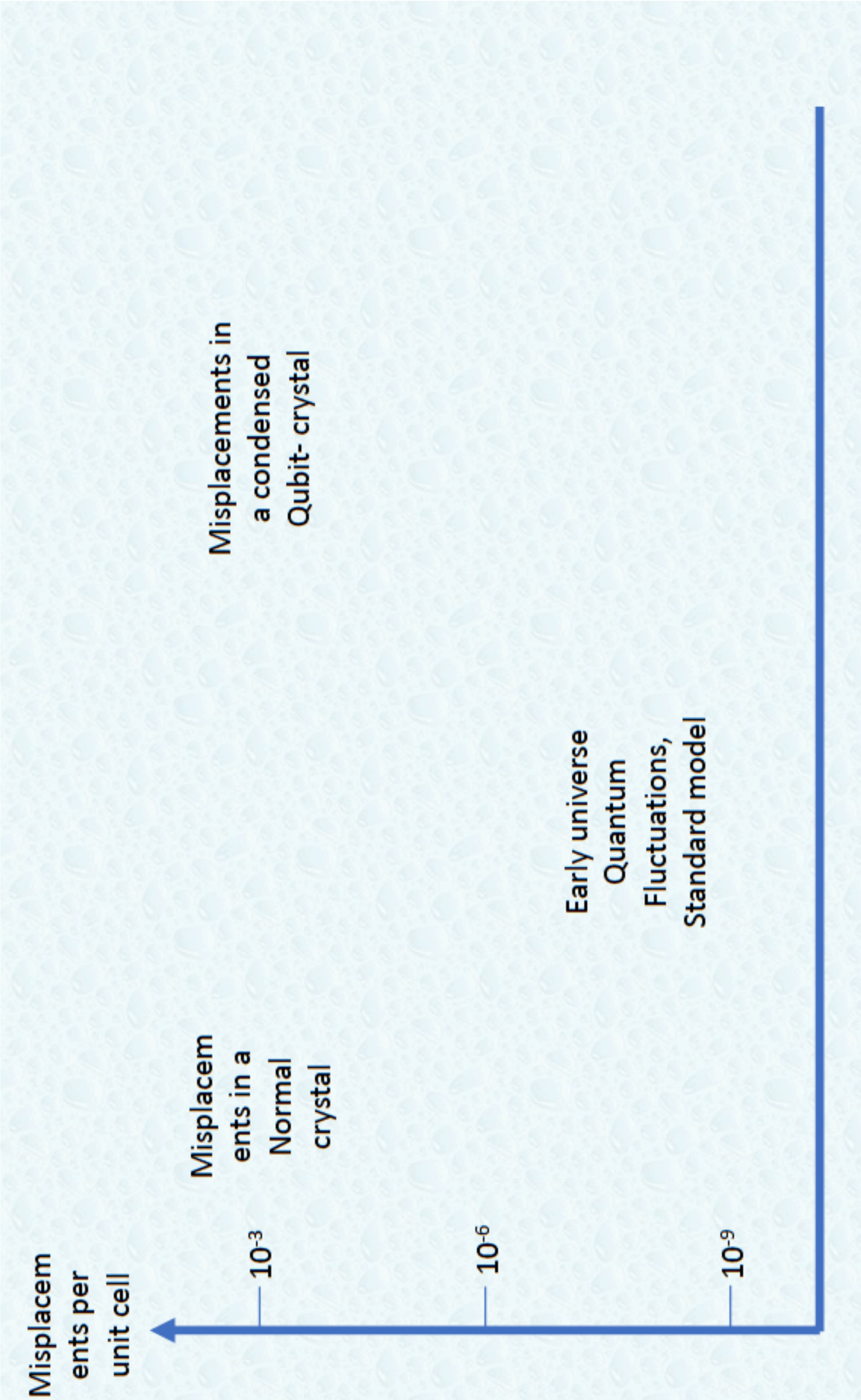
Misplacem ents per unit cell
10^{-3}
10^{-6}
10^{-9}
Misplacem ents in a Normal crystal
Early universe Quantum Fluctuations, Standard model
Misplacements in a condensed Qubit- crystal

Fig. 6

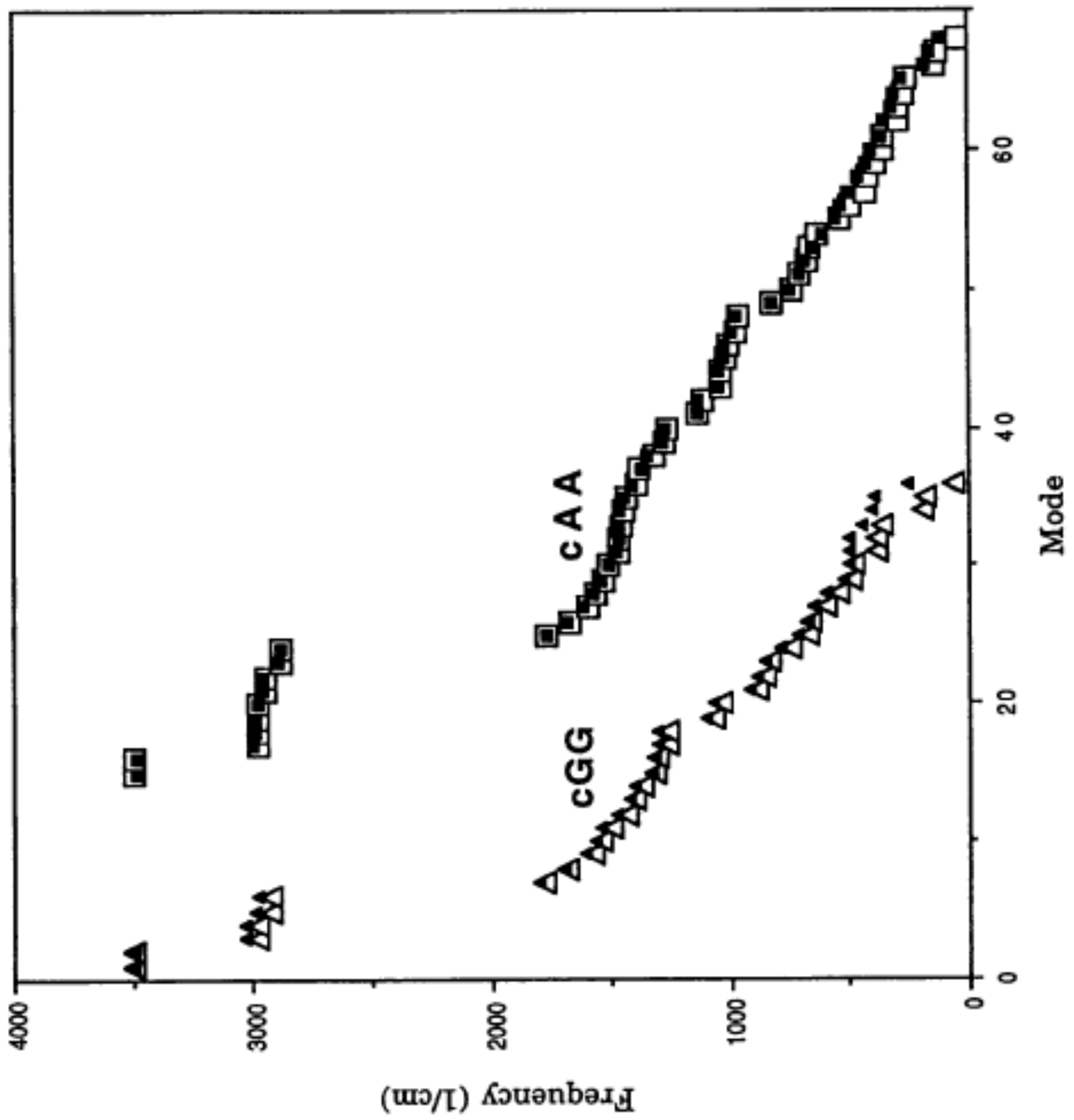

Fig. 7