Analysing the phase space of the standard model and its basic four forces from a qubit phase transition perspective: implications for large-scale structure generation and early cosmological events

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Running head: decoherence of the phase space

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Abstract (250 words)

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.

We replace the “big bang” by a condensation event (interacting qubits become decoherent) and inflation by a crystallization event – the crystal unit cell guarantees same symmetries everywhere. Interacting qubits solidify and 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, large-scale structure of voids and filaments, supercluster formation, galaxy formation, dominance of matter and life-friendliness.

We prove qubit interactions 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.

We give 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 model free / bound qubits in phase space.

Synopsis / long abstract (620 words)

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. This allows to sort the states according to the arrow of entropy. Each ensemble state is connected to its reachable direct neighbor states by its transition possibilities, concisely summarized by the S-matrix or using later refinements. The connections allow emergent time for entropic ensemble gradients and different world lines for the evolution of the n quanta ensemble with rising entropy during time.

Using this well-established description, the process of qubit decoherence is discussed. We argue that decoherence does not happen by observation, the quantum descriptions of observation model only our incomplete knowledge as we are part of the entropic ensemble gradient and cannot know the future, but only the possibilities. We argue for having decoherence and our universe as real and defined, the process of decoherence in reality happened as foundation of our universe from the start. 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 very similar to the phase space description mentioned above. Hence, an uneconomical gigantic Everett-type multiverse splitting with every decision is avoided. Moreover, we recommend a full treatment of the phase space of the standard model by the new branch of condensed mathematics. In the light of our approach, this should open deep insights on general relativity and quantum physics as this helps to distinguish a condensed space with frozen-out bits where general relativity holds from a “liquid” type of space with free qubits and corresponding wave functions. Condensed mathematics may advantageously model several states freely accessible to qubits as condensed space.

This model is then used to replace in a cosmological model the “big bang” at start by a condensation event (interacting qubits trigger this) and inflation by a crystallization event (interacting qubits solidify and form a rapidly growing domain where the n**m states become separated ensemble states). After that very early events, standard cosmology with the hot fireball model takes over. We show that astronomical observations fit better to our new cosmological model such as lack of inflation traces in cosmic background measurements, large-scale structure of the universe with voids and filaments, supercluster formation, galaxy formation, dominance of matter and life-friendliness.

As free and decoherent qubits are observed in quantum computation, we know both exist, but in an ocean of free qubits the interaction potential is clearly low. If they interact, the Hurwitz theorem proves interaction can only be 1,2,4 or 8 dimensional. The latter is the observed E8 symmetry of our universe. Repulsive force at ultrashort distances results from quantization, shown for LQG, long-range forces limit crystal growth as in magnetic growth. Qubit ensemble state connections and probabilities follow S-matrix theory

Moreover, we give first estimates for resulting energies from free qubits vs bound qubits, misplacements in the qubit crystal and for the entropy increase during qubit decoherence to individual bit state ensembles. Scalar fields for color interaction and gravity can and should be derived from the permeating qubit-interaction field. Vacuum energy gets low by this inside the qubit crystal and is 10^{20} higher outside in the qubit ocean.

Finally, bit-separated crystals come and go in the qubit ocean. This selects for the ability to lay seeds for new crystals. This self-organizing reproduction selects over generations crystal properties for seed generation, self-organization and hence their life-friendliness.

Connections to loop quantum gravity, string theory and emergent gravity are discussed. Standard physics (quantum computing; crystallization, solid state physics) allow further validation tests of this theory and will extend current results.

Introduction

We look at the phase space for the standard model of the basic four forces (Oerter, 2006). The phase space for n quanta includes all possible ensemble combinations of their quantum states m, hence there are only n**m states. This allows to sort the states according to the arrow of entropy. Each ensemble state is connected to its reachable direct neighbor states by its transition possibilities, concisely summarized by the S-matrix (Barut, 1971) or using later refinements. Hence, the connections allow emergent time for entropic ensemble gradients. These can also be considered as different world lines for the evolution of the ensemble of n quanta with rising entropy during time.

Using this well-established description, the process of quantum decoherence (Zeh, 1970; Schlosshauer, 2005) is discussed. We argue that decoherence does not happen by observation, the quantum description of observation typically models only correctly our incomplete knowledge as we are part of the entropic ensemble gradient and cannot know the future, and hence can estimate only the possibilities. However, we argue for having decoherence and our universe as a real and defined entity from the start of its existence, the process of decoherence in reality happened with the start and forming of our universe.

Hence, by looking at decoherence in a fundamental way, this becomes a cosmological theory:
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 very similar to the phase space description mentioned above. In some sense, this is a phase transition from a more liquid, floating state to a solid, frozen out and defined state.

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), we show that a number of astronomical observations 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 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, 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 allows validation tests (e.g. Imhof et al., 2018).

Results

1. The standard model: The standard model of the fundamental four forces in physics with involved particles, forces and interactions is well established:
In particular, we have a gauge quantum field theory containing the internal symmetries of the unitary product group SU(3) × SU(2) × U(1). The theory is commonly viewed as describing the fundamental set of particles – the leptons, quarks, gauge bosons and the Higgs boson.

The standard model is a quantum field theory, meaning its fundamental objects are *quantum fields* which are defined at all points in spacetime. These fields are
the fermion fields, ψ, which account for "matter particles";
the electroweak boson fields, and B;
the gluon field, Ga; and
the Higgs field, φ.
That these are *quantum* rather than *classical* fields has the mathematical consequence that they are operator-valued. In particular, values of the fields generally do not commute. As operators, they act upon a quantum state (ket vector).

2. Modelling the phase space of the standard model considering qubit and bit states
We consider now how we would describe or encode all different states of this model for an area of interest and desired resolution: we could encode space with three dimensions using a couple of bits. Next, we encode the involved particles, fields and so on, using a defined number of bits for each feature. Moreover, this is a quantum theory, so for each field you have the different quantum states to consider. Thus, for an ensemble of n fields with m states each you would have n**m possibilities for the states accessible for the ensemble. In our world, as long as you are at normal dimensions, you have the states nicely separated

(decoherence), but if you reach microscopic dimensions, there is overlap and superposition (below Planck´s quantum). Hence, you have for the system of interest you want to describe with the standard model the n quanta building up the system (e.g. a molecule or even the whole observable universe) and their fields to consider, and each quantum field can attain m specific states. In practice, the different fields can differ in the number of states they can have, but for the argument here we can assume always the same number of states m. In other words, we describe the phase space of our system.
In full superposition, you would have an overlap of all these states, then all quantum fields represent qubits. If you look at the states separated you have the fields in their separated bit state. This corresponds to the result of a collapsed wave function after observation, of a defined real state, and hence the state of affairs of measurements yielding defined states. Considering this transition, we would have for n qubits describing our phase space in full superposition ("free", "liquid") and they freely have all their m states accessible. After the measurement or "becoming real and defined" there are no longer qubits, the system has all states defined, the phase space consists of n**m different ensemble states, each formed of n quantum fields.

3. Decoherence – when does it happen?

In textbook physics decoherence, the defined outcome of an experiment, the collapse of the wave function is explained by acts of observation.
However, this runs into well-known and much discussed problems (see Zeh, 1970): in particular if you think that the act of observation is critical for the reality of the universe (Wheeler, 1990 and others) you can easily become somewhat esoteric believing e.g. that the world did not really exist before there were humans to observe it.

According to our model (see section 2) the decoherence has to happen on a much more fundamental way at the start of a universe which has the property to be real and defined. Hence, my argument would run such that you have defined bits and at all observable states in our universe or our domain only because it was derived from an ocean of qubits by a trigger of interacting qubits and subsequently these interacting qubits solidify, "freeze out" into their bit states and form then the basis of our universe, forming a type of a crystal. One of the consequences is that you have an arrow of time according to entropy, hence an emergent, "internal" time and as there is still some liquidity left on the quantum level, there is at all still a connection between the different states.

Different world line trajectories are slices of the crystal: a multiverse of all n**m ensemble states for an ensemble of n quanta with m states each. Each slice trajectory is separated from the next slice by h dash (**Fig. 3**). In fact, I would argue here that this liquidity is essential to have an interesting universe, a completely frozen out universe would have completely separated bit states where nothing happens. Only in the optimal state with some liquidity left you have an interesting universe with internal time and clear connection between the different states. If instead the assembly of qubits is completely liquid, the whole ensemble disintegrates and is just a part of the qubit ocean which is eternal, everywhere and only sometimes (if conditions are right) gives the chance of interaction occurring, a condensation seed for a new universe.

Interestingly enough, decoherence is considered here as the start and basis of our universe and not as the result of an individual observation. Everything happened at the start of the

universe, the bit states of the whole phase space of the universe are now almost separate, frozen out. On the connecting edges between the state spaces you can follow (governed by the S-Matrix theory or more refined by its successors) the arrow of time and have different and independent world lines. Hence, the unforeseeable results of the quantum experiment are unforeseeable only as we as observers do not know (reason: entropy, resulting arrow of time) which of the different possibilities according to S-Matrix theory is true. However, this is the case as we do not know in which world trajectory we are in. However, our world trajectory of bit ensemble states following the arrow of time is already predetermined from the start of the universe as with any other world trajectory (the others we can never observe). Hence, from this view point one would believe in a Bohm-like determinism and some results over the years show at the very least that observation results are compatible with Bohm´s determinism (Mahler et al., 2016).
Similarly, our phase state model is nevertheless quite economic compared to an Everett world model of splitting the universe in two alternative worlds with each decision. Our model, though it contains in each crystallized world all possible world trajectories for the whole phase space has from the start only n ** m ensemble states as it results from n qubits interacting sufficiently strong and each has only m quantum states to access.

The connection from each specific ensemble state of quanta to the next ones is given according to S-Matrix theory (Barut, 1971) as each ensemble state is connected to its directly connected ensemble states by such a matrix. We use here a general S-matrix, adapted depending on the population of the ensemble (which particles and fields are present). Hence, for each ensemble state you have the same symmetries of next states (general S-matrix theory). This is the basic symmetry of the qubit crystal and also everywhere in the crystal. Hence, the fact that the qubits interact is sufficient to generate everywhere the same laws of nature (no inflation necessary), provided that the qubits interact strong enough to form a crystal.
Similarly, the connections from one ensemble to the neighbor states ALL exist, but if the crystal solidifies (“becomes real”) then for each world-line one sequence of ensemble states is chosen and becomes decoherent and determined, while in another world line for the ensemble of n quanta this is another series. Little bit liquidity below Planck´s quantum of action is left.

4. Modelling decoherence as crystallization of qubits to bits: implications for cosmology

According to the considerations above, decoherence happens not with each new observation or measurement, but rather it had to happen on a fundamental way at the start of our universe (and will happen at the start of any universe): n qubits start to interact, hence, there is a force field **F1**, a repulsive field **F2** at ultrashort distances prevents a complete collapse of the system. Finally, the interacting qubits can like a magnet field attract further qubits and hence build up a big clade of interacting qubits, but as this implies that they form a connected solid state, on domain, now large-range force fields **F3** are possible that limit the further growth once they have become sufficiently strong. Only if **F3** is fully established (and hence the growth of the cluster of qubits is finished), you have also stable space-time, general relativity holds (and hence there is a reason for expansion, exactly as in the standard model given by laws of general relativity) and the defined states are nearly completely solid (there has some liquidity to be left to connect the parts (going from one state to the next) and,

particularly on the edges, make emergent time according to the arrow of entropy possible (**Fig. 1**).
As a result, you have then a hot fireball, which then expands completely like in the textbook scenario after the first three minutes of our young universe.

(ii) Hence, we replace here only the “big bang” by a qubit interaction, acting as a condensation seed and the extreme, never observed inflation phase, by a magnetization or crystallization-like process.

Why would qubits interact in the first place? Well, 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. 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- (1D, real numbers), two- (2D, complex numbers), four- (4D, quaternions) or eight-dimensional (8D, octonions). The richest type of interaction is the 8D case, which is the universe we observe and we live in.

We believe thus in a world model a bit like Bohm´s physics: everything is predetermined, but there is also no Everett-type like splitting of the world with every decision, but rather the full phase space of the quantum system (from a tiny molecule up to the whole observable universe) just freezes out to its n**m different states, each made up of n quanta and fully defined. Tiny liquidity is left if you look at small quantities (all below h dash, Planck´s quantum).

(iii) Moreover, we think that we have here a crystallization-like process: starting from a condensation nucleus of few (at least two) interacting qubits, a clade of interacting qubits starts to grow in the ocean of qubits, and, as mentioned above, the growing clade gets limited in its growth as long-range interactions start to become active which finally allow no further growth or integration of new qubits.

This is also a type of crystal, and as a crystal has a unit cell, also this qubit crystal has a unit cell, always repeated, and this ensures that you have in every part of the crystal the same laws of nature.

From what is this crystal made of? Well, we explained, we look here only at the phase space of the standard model, but we start from the assumption that we have a phase transition from the “free” state of all possibilities to the “frozen out”, defined bit states of all wave functions. Hence, a system made from n qubits with m states has then reached the complexity of n**m bit states, each made up of n bits.
This is an abstract crystal, representing our universe by all its accessible ensemble states; it is encoding in this way the phase space, and use here for simplicity of our explanation the approximation that the quantum fields involved have only m different states.
Finally, as real crystals do, the crystal does not last forever, the crystal will dissolve again by the entropic forces acting from the solvent on it (**Fig. 1**). We believe this tugging could be a reason for the observed dark energy and accelerated expansion of our universe.
Furthermore, if you have an ocean with few crystals in it, there will be a selection to promote those crystals which lay seeds for a new generation before they dissolve again in the ocean (**Fig. 1**). Crystal evolution allows fine-tuning, selection for life and maybe even civilizations, if

they in the end at least in one trajectory of events and overall help better reproduction of the crystal.

Figure 2 shows this in detail for the crystallized bit ensemble states for a toy-system of five qubits. Hence, there are 32 states made up of 5 bits each, and again for simplicity and illustration, we have only two quantum states for each bit "up" or "down". Looking at **Figure 2** shows also clearly that similar quantum states are closer by. Moreover, we have an emergent internal time (according to the arrow of entropy), emergent space (using e.g. at least 3 bits to encode two positions on x, y and z coordinate), interaction (yes or no, using 1 bit – or more), particle type (e.g. one type and either there or not/other particle) and quantum state ("up" or "down"). **Figure 3** illustrates that each series of events (following arrow of entropy from one ensemble state to the next) yields an independent world line, but they are forever separated in the crystallized qubit crystal. Hence, the sequence of events is forever unknown for an observer in the slice and he/she can only calculate probabilities and uses hence the S-matrix to predict experimental outcomes.

For a full treatment, we would need the set of 12 equations given in **Table 1**. We treat in any detail the equations describing the large-scale structure (**Eq. 1** till **Eq. 6**) and central are the three force field formulae **F1** to **F3**.

The crystallization process would start with few qubits (first only two) interacting (formula **F1**, see mathematical part below). In its early phase we have only a condensation nucleus, no space evolved yet and all qubits interact in a cluster governed by a constant scalar field. Moreover, there is for ultrashort distances a repulsive force preventing collapse to a black hole (formula **F2**, a derivation from quantization according to Ashtekar et al., 2006 see mathematical part below)

Expansion phase: then the qubit cluster involves more and more qubits, which all become defined ("nearly completely frozen out") and due to this phase transition, spread out in phase space. The different phase space states freeze out and get more bits as more qubits assemble. The qubit-to-bit crystal is sorted and connected according to ensemble state similarity. The symmetry units within the crystal form according to the basic symmetries of nature and as I can go from one phase space state to a related one only, if I follow the laws of nature, hence related states are sorted according to the permissible and non-reachable transitions. Hence, the abstract form of solidified qubit crystal is maybe easier to understand and we see nevertheless, why in each unit cell the same symmetries are there: according to similarity of the phase space, but as the qubits solidify, the closely related states are only those which are permitted by the laws of nature. You can also say you have the generalized S-Matrix in every unit cell, as this are the only transition possibilities open for each ensemble state of qubits turned to concrete bits. We advocate a growth of the frozen-out qubit domain inside the qubit ocean triggered by the condensation nucleus. This will be as rapid as other magnetization processes, or typical crystallization and ensures everywhere the same unit cell and hence symmetries or "laws of nature" according to the unit cell chosen by the crystal as basic crystallization unit. However, this is completely different from inflation (Albrecht et al., 2015) and requires not this hypothetical particle but has on the other hand a comparatively rapid expanding domain, similar to inflation.
As soon as long-range forces become strong and dominant, further growth of the crystal is stopped (formula **F3**, see mathematical part below).

Moreover, crystallization is not perfect, so you have tiny misplacements at start as seeds for superclusters of galaxies; similarly, dark matter can easily be distributed in halo regions (Boylan-Kolchin, 2017) while normal matter is in central regions of the galaxy, already pre-placed by our crystal (**Fig. 4**).

As bit-separated crystals come and go in the vast and eternal qubit ocean, there is selection for the ability to lay seeds for new crystals. This self-organizing reproduction selects over generations also for life-friendliness. Rates for crystal dissolution are well-known from normal everyday crystals (Lasage and Lüttge 2003, 2001) including population models of crystal growth and dissolution (McCoy, 2001).

5. Establishing the required mathematical framework

We present in the following some basic mathematical insights on the required framework (**Table 1**).

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.

S-matrix theory connects neighbor ensemble states in phase space: Instead, in the approach followed here, we start instead from S-Matrix theory (Barut, 1971) as this easily allows to connect different ensemble bit states to the directly connected ensemble states according to observed particle physics and probabilities. However, S-Matrix theory was only the pre-runner to string theory which provides a full global description of quanta and fields instead of just the matrix connection.

In general relativity, events are continuous and deterministic, meaning that every cause matches up to a specific, local effect. In quantum mechanics, events produced by the interaction of subatomic particles happen in jumps, with probabilistic rather than definite outcomes. Quantum rules allow connections forbidden by classical physics.

My theory clearly shows we have to consider two different types of phase space, one where general relativity holds and which is made up of frozen-out qubits, i.e. all bit ensembles accessible to the qubit ensemble are in a separated defined, frozen out state – and there is a second type of phase space, outside of our domain or crystal, where qubits are free or "liquid". In the latter, the mathematical space is condensed in that sense that many different ensemble states describe all the same ensemble of free qubits. For the

correct treatment of such a condition, the tools and mathematical framework of Scholze (2019) and coworkers has been developed. Hence, condensed mathematics allows to describe both types of phase space and even starts with the concept of condensed sets, very much as the free qubit ensembles with access to all ensemble states for their wave function form such condensed sets. Hence, using the formula language of condensed mathematics you can easily compare both types of phase space and establish a unifying language, starting from S-matrix theory again to have then the basic connections right between ensemble states but then *replacing string theory by the next better concept*, considering *condensed sets* where ever bit ensembles can freely be in many states being qubit-like (all coherent states of quanta) and separate, defined bit ensembles (decoherent states with clear results). Our world is a mixture of both, the coherent states banned to the physics below h dash, Planck´s quantum. Clearly, this is a task ahead and it will hopefully be undertaken soon by the theoretical physics community using condensed mathematics as framework.
In this way, a new flavor of a fundamental theory can be built-up, but as we did not nail down any concrete mathematical results, this is more to motivate theoreticians who want an alternative to string theory to have a new fascinating mathematical model to explore.

On the other hand, the basic formalisms introduced next may equally well be transferred to string theory or loop quantum gravity (LQG) for better modelling of the cosmological consequences. In fact, the central symmetry and unit cell of our crystal is proven to be 8-dimensional and so the formalisms and foundations of heterotic string theory could easily catch this central aspect of our theory. Such theories are based on a peculiar hybrid of a type I superstring and a bosonic string. There are two kinds of heterotic strings differing in their ten-dimensional gauge groups: the heterotic $E_8 \times E_8$ string which should work here best (representing in the crystal unit cell then all particles and basic symmetries for the force fields) and the heterotic SO(32) string. On the other hand, quantifications are difficult with the many free parameters of string theory, and hence, applying LQG not only for the repulsive field **F3** by appropriate quantization as shown here, but also to the other formulae should be advantageous to get more concrete quantification.

However, this is not shown or done here. Instead, I will now come more from basic physics, showing more direct approaches to derive the key formulas for **Table 1**. This is a more pragmatic approach, not yet a unifying mathematical treatment. On the other hand, this allows nevertheless first semiquantitative insights (**Fig. 5** - **Fig.7**).

First, we have to derive formula F1, when and how qubits can interact.

Why would qubits interact in the first place? Well, this is sure, the state of decoherence we observe for most macroscopic objects in our universe. However, the state of coherence is observable, too. A good example are calculations in quantum computers, where perfect superposition of all wave states is there during calculation (coherence), but needs a lot of effort to prevent interaction of the qubit with the rest of the world (Ball, 2021). The all-to-easy interaction with the rest of the world happens according to our theory due to the strong force field holding the qubit ensemble together. If we could be “outside” of our domain, we would easily notice the free qubit ocean in which there is nothing precipitating decoherence. We hence know from our world that interaction is possible and that there are also free qubits, but from this consideration we can also see that in the qubit ocean “outside” of our domain the qubits are very free and hence we suspect that the *a priori* interaction probability inside the qubit ocean is quite low, so that most of the ocean stays liquid and there are only few crystals formed. In fact, looking at typical crystal concentrations in liquids allows first estimates for the probability.

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:

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

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

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

(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.

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.

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 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 good hint is then to apply again LQG, as then the energy considerations are again far easier transported to interactions of any number of dimensions.

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 E8 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**).

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 $\mathbf{q}$.
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 E8 Lie group has applications in theoretical physics and especially in string theory and supergravity. E8×E8 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. E8 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 E8 to its maximal subalgebra SU(3)×E6.
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 Ashthekar 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 the paper shows how due to appropriate quantization the result is this may even resist the big crunch**.** Specifically, in section IV of their paper (Asthekar et al., 2006) the authors return to LQC (Loop quantum cosmology) and construct the physical sector of the

theory. The LQG (Loop quantum gravity) Hamiltonian constraint is given by eq. (2.34) in their paper:

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

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

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

$$\begin{aligned}e_\omega(v) &\overset{v\gg1}{\longrightarrow} A\underline{e}_{|k|}(v) + B\underline{e}_{-|k|}(v), \\ e_\omega(v) &\overset{v\ll-1}{\longrightarrow} C\underline{e}_{|k|}(v) + D\underline{e}_{-|k|}(v).\end{aligned} \qquad (5.2)$$

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. 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 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:

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

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

We present a framework for our qubit crystal formation: freezing out of the separated ensemble states as clear bit state ensembles in an ocean of free qubits (**Table 1**) and we suggest that the new mathematical field of “condensed space” (Scholz, 2019) can give rise to a formalism beyond string theory: one starts 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 qubits ensembles.

We suggest how the unified scalar field for qubit interaction can be derived, but this is not shown in detail, 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 super-heterotic E8 string theory illustrates well that there is a basic unit cell to our domain, having the E8 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 can and should be formulated in both approaches or, our preference, using condensed mathematics. Unfortunately, this is beyond the reach of this first paper.

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 this and 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, did also get impetus from earlier suggestions (Bohm; others; hidden variables and Einstein´s apodictic “*god plays no dice*”) – 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). Also 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 here 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.

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. Also 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. This is another feature of the model left open.

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).

Future extensions: With a quantum formalism we should be able to show more directly and better the limitations implied by applying the Hurwitz theorem to qubit interactions. There should even be a link to a string theory formulation, so that you more directly can see, yes, the E8xE8 super-heterotic string theory is the direct consequence of qubit crystallization and we live in the richest solution according to Hurwitz (1898) the 8-dimensional solution. However, the parameter chosen are such that the crystal and hence, our universe, is stable and well self-organized (“live-friendly”). According to our theory, the live-friendliness is a necessary condition that the crystal creates enough offspring.

Similarly, the quantization trick by Asthekar et al. (2006) for **F1** can be applied to a qubit interaction formalism directly, but one has to quantize and formulate then formula **F1** better according to more modern formalisms from quantum physics to be able to do this. In fact, the quantization trick to derive a very strong repulsive force **F2** can also be applied using not LQG but for instance string theory.

The same applies to **F3,** the magnetization like growth of the condensation nucleus as I used standard formulas for magnets. Applied to cosmology, the **F3** field would help to establish (i) that inside the crystal general relativity (GR) holds and (ii) a unified scalar field. In particular, showing the connection from the magnetization-like growth and the early hot fireball universe at grand unification energies cooling down to a Higgs boson scalar field or even derive the scalar field for quark confinement (so for the strong nuclear force) would strengthen the mathematical physics foundation of our theory.

We presented and achieved **a toy model of qubit crystallization** for 6 qubits. We show that the Hurwitz theorem clearly implies only four solutions, the richest being the observed 8-dimensional symmetry of the universe as observed (in my theory the unit cell of our condensed qubit crystal). This is shown for LQG and qubits in a first simplified way. One can of course derive more sophisticated descriptions of the qubit interaction field, starting from two wave functions in free state with two states accessible for them. When they are interacting, they would have frozen out four bit states (a simple system with two qubits in two states each → four frozen out bit states possible). Next one can consider six qubits in two states each (see our standard toy example) → 32 different frozen-out bit states possible from five qubits. In our toy model, the first three bytes encode space and time, next byte encodes 8 types of particles, next byte encodes different forces. Finally, we can show generalization for n qubits in m states, with n**m ensemble states. By this it is then better described, how the real world is encoded by the qubits, encoding particles, properties, interactions etc., as well as leptons, bosons, fermions and baryon number etc.

As an alternative or next step, the action of quantum fields **F1, F2** and **F3** on the qubit ocean should mathematically directly establish first the toy model as an actual phase transition from liquid qubits (ideally of any dimension) to a solid bit crystal state. For this, one would do a generalization from the above toy model to derive a lattice field theory. Note that for this, only the generalization of the toy model is required, we need no “magical fit” of the parameters to the observed physics. Hence, we claim not here the “holy grail” of establishing the “correct” lattice model of the grand unified field theory (GUT). However, the scenario of many generations of crystals and new seeds, appropriately implemented, should automatically deliver parameters from crystal stability matching our life-friendly universe. By comparing our domain parameters with alternatives regarding new seed production this claim of our theory can be tested. Please keep in mind, that this claim is completely independent from the other statements of the theory, it was only derived due to its high explanatory power why our universe is so life-friendly.

It will be also interesting to see whether a lattice approach corresponds to something digital in our reality, for example, true movement being only possible either with c, velocity of light, or not at all and everyday movement only a mixture of both cases according to measured velocity, but the digital level will of course only apply at the smallest scale (string length).

Related theories: There are similarities of our theory to inflation which hopefully will motivate inflation-inspired cosmologists to take up our approach (Rosa and Ventura, 2019) as also the growth phase by inflation terminates by a phase transition. This is no accident, we simply think that our theory is a powerful refinement and replacement step of inflation cosmologies. We provide a better reason for quantum fluctuations as there are more present by misplacements during typical crystal growth and these will later stimulate the rise of its large-scale structures (Dandekar, 1991). We give here an alternative concept what could drive the very early growth of the universe and how emergence of space, general relativity and concomitant long-range forces limit further growth of the qubit cluster. Moreover, my approach should help to save central features of inflation-theories which are now in trouble (Chen et al, 2019) as strong gravitational disturbances were never observed in the BICEP/2 experiments. As we have a much more civilized, smoother growth process then textbook inflation, this agrees and fits better to the BICEP/2 experiments (Ade et al., 2018).

Qubit decoherence allows also to have emergent time in the direction of the arrow of entropy. Moreover, there is also emergent gravity, general relativity starts to hold only after the crystal of qubits solidifies. Hence, there are clear similarities to emergent gravity (Verlinde, 2017) and related concepts.

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. Entropy is not easy to consider in cosmology, a couple of papers considered entropy for cyclic universes and how it may increase over cycles (Ijjas and Steinhard, 2016).

Finally, bit-separated crystals come and go in the qubit ocean. This selects for the ability to lay seeds for new crystals. This self-organizing reproduction selects over generations crystal properties for their life-friendliness. However, this selection applies not only regarding fine-tuning conditions for life. As we have at least one example for conscious observation (mankind), there seems also to be a selection for conscious life and maybe even civilizations. There will only be a clear selection force if they in the end at least in one trajectory and world line contained in the crystal help in the end to better lead to the reproduction of the crystal and all contained world lines as the next crystal seed type will only become enriched if it is more successful than the mother seed. This follows a concept of fundamental external time (in the ocean of qubits) and has similarities to concepts by Smolin (1997, 2013a,b) and Kaku (2021).

The qubit ocean has only undefined qubits in all states, no clear, defined state versus the crystal with frozen out bit ensemble states making everything real;
However, our world is not completely collapsed, still some undefined states remain below Planck´s quantum h. We see that the uneconomic extravagant complex multiverse theories (Tegmark, 2019) from Everett-type are wrong: the perspective of a split in decisions into two new universes is replaced by one universe which just has n**m ensemble states. The different outcomes and hence trajectories for a decision option are still in our model, but these are simply the different world line trajectories connecting the ensemble states in our model (S-Matrix) and they do not change the number of n**m ensemble states accessible for n qubits.

Conclusion: We replace "big bang" at start by a condensation event (interacting qubits become decoherent) and inflation by a crystallization event – the unit cell in crystals guarantees the same symmetries in the whole crystal. Interacting qubits solidify and form a rapidly growing domain where the coherent n**m states of their wave function 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, large-scale structure of voids and filaments, supercluster formation, galaxy formation, dominance of matter and life-friendliness. We prove qubit interactions 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 finally life-friendliness.

Our theory is a stimulatory, fresh perspective on the fundamental questions of physics similar to Poe´s (1848) Eureka essay. In particular, we can explain better than standard cosmology the lack of inflation in the cosmic background, the early rise of galaxies and super clusters, why there is only matter and why the universe is so life-friendly. We filled our concept with data, appropriate formulae, give first energy estimates for free qubits vs bound qubits, misplacements in the qubit crystal and entropy increase during qubit decoherence / crystal formation (**Fig. 5-7**). Our first mathematical treatment suggests to introduce a new type of quantum action theory as a framework for a general lattice field theory (Byrnes and Yamamoto, 2006) to fully implement our approach such that more detailed quantitative predictions are possible.

Connections of our approach to loop quantum gravity (Rovelli, 2004), string theory (Green, 2000) were demonstrated deriving our formulae. Moreover, we have emergent space-time by the condensation event and qubit decoherence. Hence, there may also be inspiration for related concepts, such as emergent gravity (Verlinde, 2017). Standard physics (quantum computing; crystallization, solid state physics) allow validation tests (e.g. Imhof et al., 2018) of this perspective and will extend current results. Condensed mathematics (Scholze, 2019) may allow to treat bit states all referring to the same free coherent qubit (condensed space) and could support our framework by this.

We offer a new perspective on the relation of general relativity to quantum physics: we provide a first mathematical framework to distinguish a condensed phase space with frozen-out bits where general relativity holds: our domain and crystal where decoherence is the case for all macroscopic objects and little quantum liquidity left below Planck´s quantum. We distinguish this from the “liquid” type of phase space with free qubits, where only quantum physics holds and corresponding wave functions describing the qubit ocean around our domain and crystal including first semiquantitative results.

Conflict of Interest

The author declares to have no conflict of interesting

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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 can interact: is restricted to 1,2,4 and 8 dimensions)
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)
Eq. 4 (standard calculations for vacuum foam, free qubits 10**20 bigger then bound)
Eq. 5 (conservation laws expressed as symmetries of the crystal)
Eq. 6 or **F2** (repulsive force by quantization for ultrashort distances between qubits)

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 Tippler, 1986; Smolin, 2013b).

-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” senario, 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 E8 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 according to Brady and Sharp (1997) 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 similar results. The total system of our qubit ocean should have 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. Moreover, then the comparison should not be between two peptides but for instance between normal matter and dark matter.

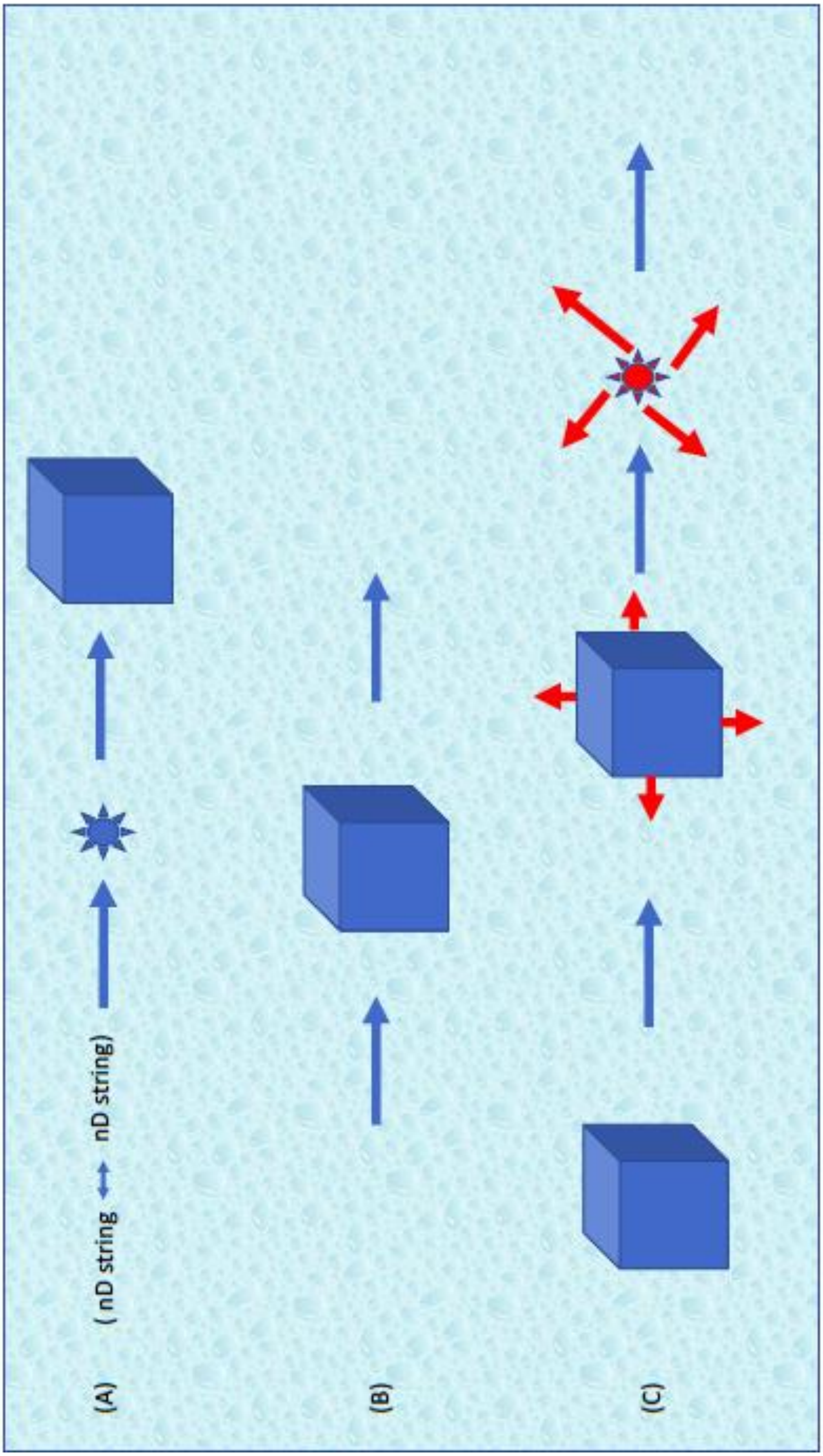

Fig. 1


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

Fig. 2

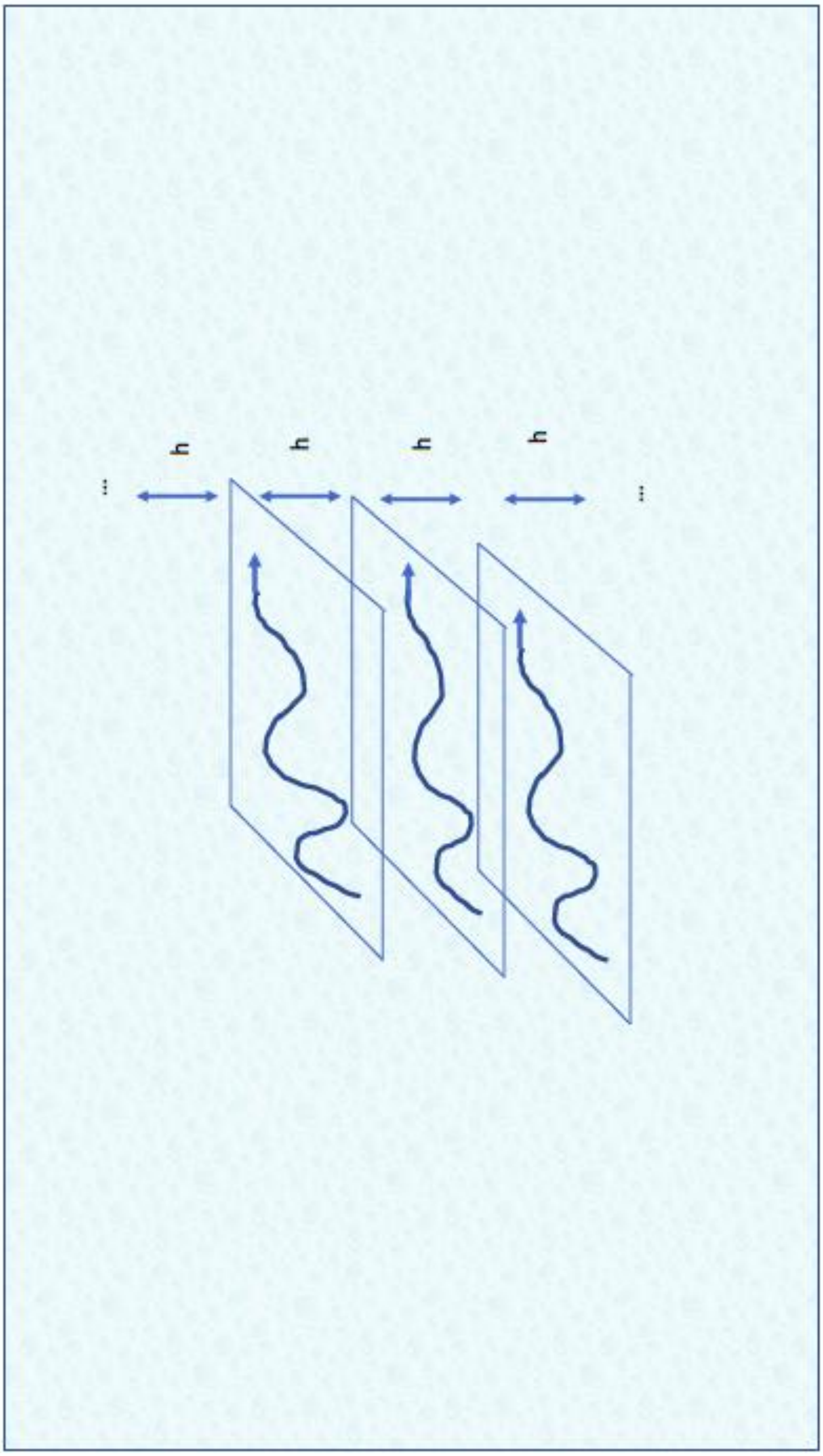

Fig. 3

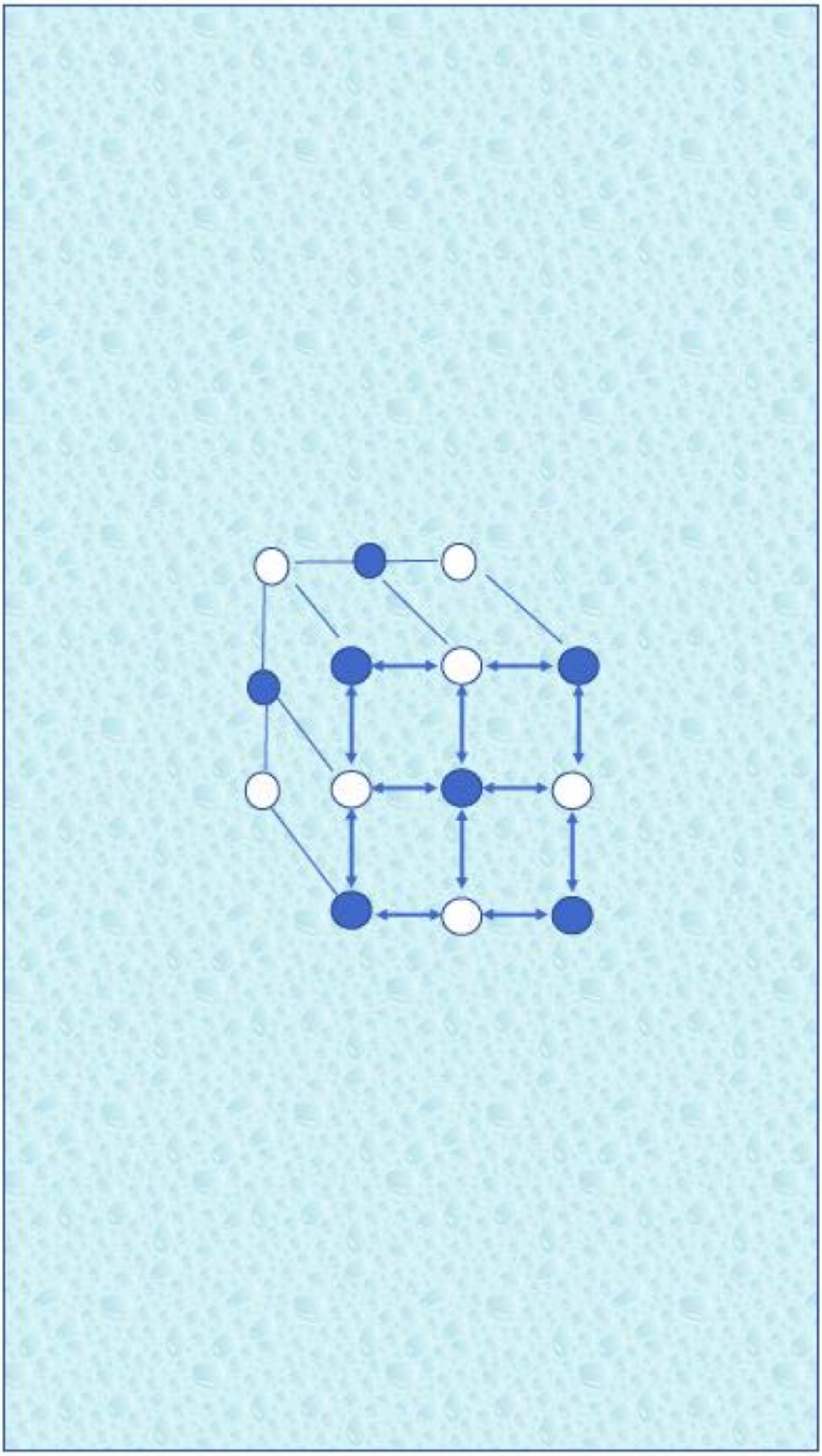

Fig. 4


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

Fig. 5

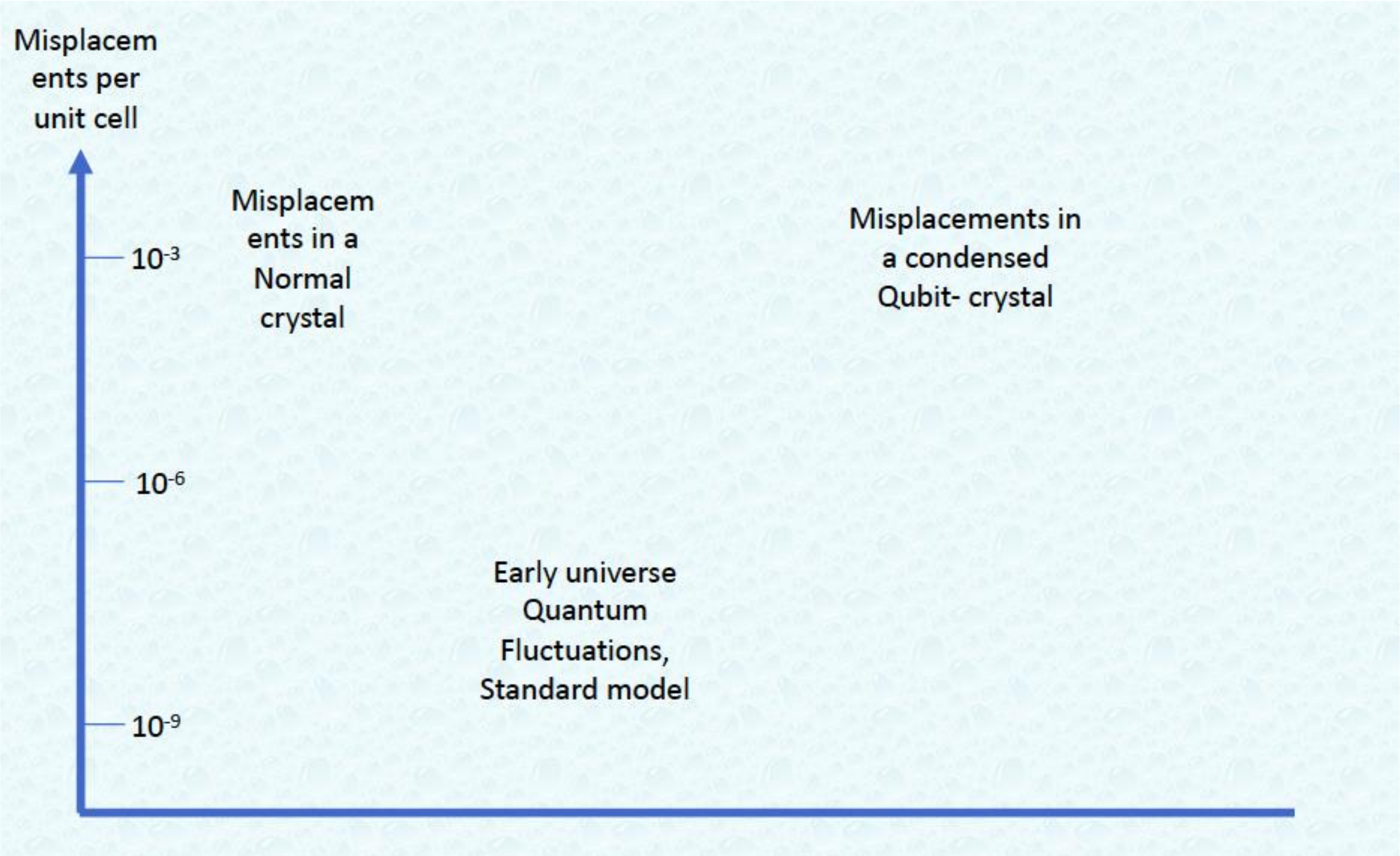
Misplacements per unit cell
10^{-3}
10^{-6}
10^{-9}
Misplacements in a Normal crystal
Early universe Quantum Fluctuations, Standard model
Misplacements in a condensed Qubit- crystal

Fig. 6

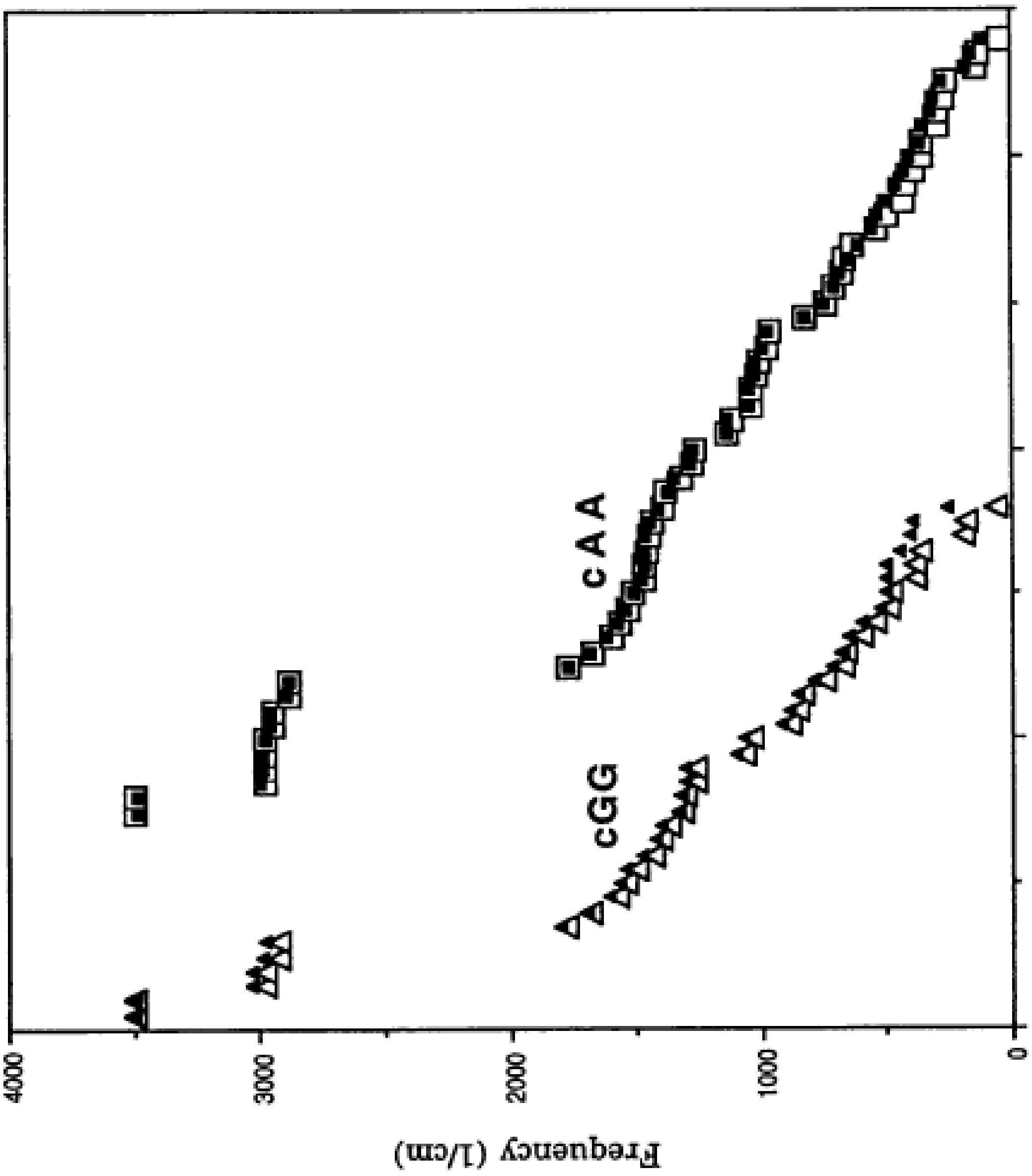

Fig. 7