Our Dark Matter, Stopping in Earth, etc.

Our Dark Matter Stopping in Earth

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"Bled" , July , 2023

[2]Speaker at the Work Shop "What comes beyond the Standard Models" in Bled.

Our Type of Dark Matter Model

The most crucial properties of a model, on which we worked long:

- **Our dark matter is not so dark as WIMPs, interact so much that they get stopped in the Earth.** We actually speculate that they might get essentially stopped from their 300km/s velocity in the depth around that of DAMA. Say "inverse darkness"

$$\frac{\sigma}{M} \approx 150cm^2/g = 15m^2/kg(\text{low velocity}) \quad (1)$$
$$\frac{\sigma}{M} \approx 1.5cm^2/g = 0.15m^2/kg(200\text{km/s}) \quad (2)$$

- **The dark matter particles can be excited to radiate 3.5 keV X-ray or presumably also electrons.**

Velocity fits by Camilla Correa from dwarf Galaxies

Self-interacting d

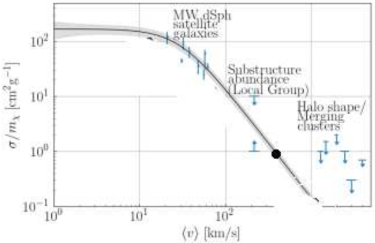


Figure 7. Same as Fig. 6, but extended to cover the range of MW- (~200 km/s) and cluster-size (~1000 – 5000 km/s) haloes' velocities. The figure shows upper and lower limits for σ/m_χ taken for substructure abundance studies (e.g. Volgelsberger et al. 2012 and Zavala et al. 2013), as well as based on halo shape/ellipticity studies and cluster lensing surveys (see text).

A hard Probelm: How can Anais Disagree with DAMA ?

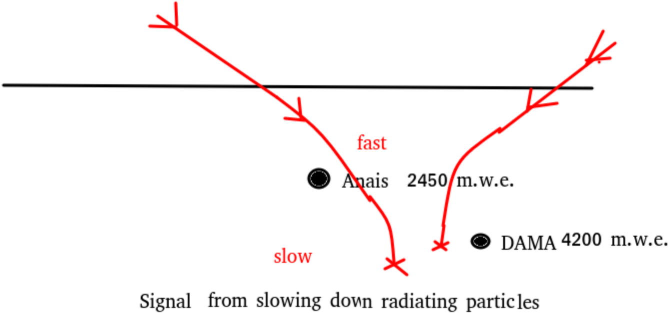
These tow underground experiments looking for dark matter are **very similar**:

- Both use NaI(TI= Thallium),
- Both look for seasonal variation,
- Depth is 1400 m $\sim 4200 m.w.e.$ for DAMA-LIBRA, while Anais is at 2450m.w.e.

But Anais "sees" **no dark matter** yet and claim to deviate by 3 σ from **DAMA** which **sees** 0.0103 cpd/kg/keV.

Dark matter Pass Anais Fast, but Slow down or stop at Dama

(if, what is seen, is radiating pearls, then this explains)

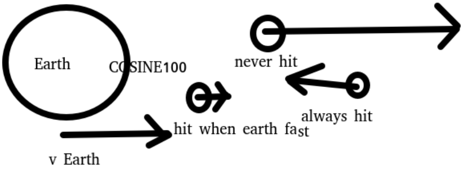


(m. w. e. = meter water equivalent)

Even more strange ?: COSINE-100 (opposite phase!)

Even more mysterious at first might be COSINE-100[1], which finds the opposite phase (the wrong season has over abundance)! In our model an experiment in some given depth, would have just those dark matter particles stop in the instrument, which have just the right velocity.

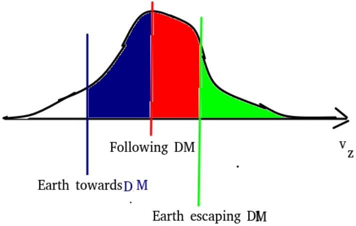
On a site of Earth Only particles running down towards this site can hit, except Earth can take over some slow ones.



Exagerating think: Each experiment sees Only Dark Matter with One Velocity

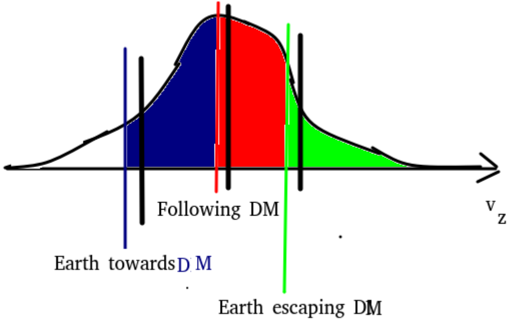
If the dark matter is seen by some radiation from it being excited, say on the way down through atmosphere and shielding, it will be seen most easily when being stopped to low speed.
Exagerating for simple estimation: take that each experiment only sees just those dark matter particles, which are stopped just in the depth of that experiment.

Earth is hit by different velocity spectrum depending on relative motion to the Dark Matter



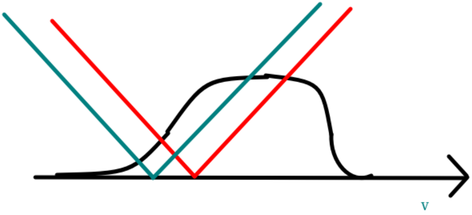
The distriution of the velocities of pearls in the dark matter cloud in direction towards the Earth, i.e. downward. If Earth folows the dark matter, then just the half of the dark matters with the downward velocity hit the earth. But if Earth moves towards the center of mass of the dark matter it can catch even some dark matter running slowly upwards.

If only a (narrow) range of relative to earth velocities are observed, then seasonal rate variation could be complicated



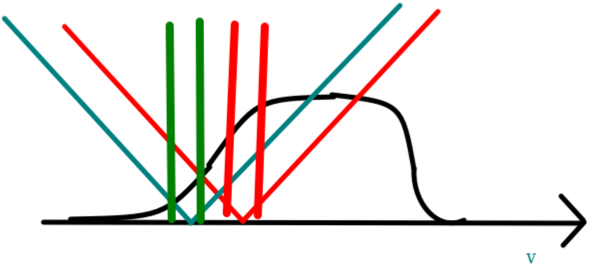
The black thick lines symbolize favourite velocity relative to Earth causing observation possibility.

For WIMPs say Multiply Velocity Distrbution with $|v_z|$ to get Rate



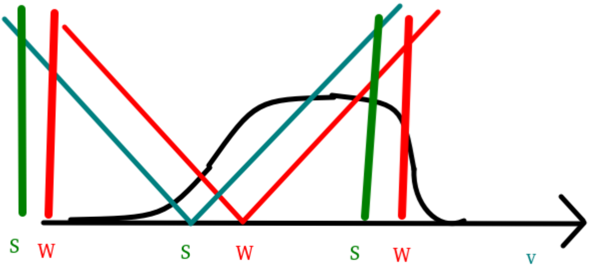
The hitting rate goes as the density of particles with a given velocity multiplied by the numerical value of the velocity relative to the earth (and the cross section). The tips of the v-shaped curves are the Earth velocity say summer and winter.

If only very low velocity relative to Earth observable,...



...it is possible as seen here that the season with high relative velocity of Earth versus Dark Matter has the lower rate (contrary to the WIMP say.)

In DAMA it might be a bigger velocity relative to Earth, that is observable



But if the observable velocity is a large value it could be also the "normal" that high relative velocity gives high rate of observations.

At the Slowing Down Either Stop or Falling Slowly

- If total stop, we should find a lot of stopped Dark matter to be dog out as heavy pearls (much like if it were gold dust. One should wash it out).
- If it sinks slowly, it of course goes deeper inside the Earth.

Short Review of Our Dark Matter Model:

- Only "new physics": There are several different phases of vacuum, but all with same energy density. (**Multipel Point Criticallity Principle = MPP**).
- Our dark matter particles are macroscopic objects consisting of bubbles of a second vacuum filled with some ordinary matter e.g. carbon.
- There is a skin/wall seperating the two vacuum phases with a tension of the order of

$$S \approx (30MeV)^3 \quad (3)$$

$$S^{1/3} \approx 30MeV \quad (4)$$

- The nucleons have a lower potential inside the pearl vacuum than in the outside vacuum, wherein we live, by a difference

$$\Delta V = 3MeV. \quad (5)$$

Properties of Our Dark Matter Pearls (continued)

The value $\Delta V = 3MeV$ for the potential for nucleons being lower in the phase that is the inside of the dark matter bubbles than in the outside vacuum, in which we live was fitted to the inside material having a gap - homolumo gap - between the empty and the filled electron-states arranged to let the dark matter preferably emit X-ray with the observed energy per photon 3.5 keV.

Crucial properties for the penetration into Earth:

- The pearls are so macroscopic and of such size compared to mass that get stopped in a distance of the order of the depth of DAMA (1400 m stone).
- The pearls are exitable so as to radiate X-ray of energy per photon, just to give the "mysterious line" 3.5 keV.

3.5 keV from Perseus Cluster

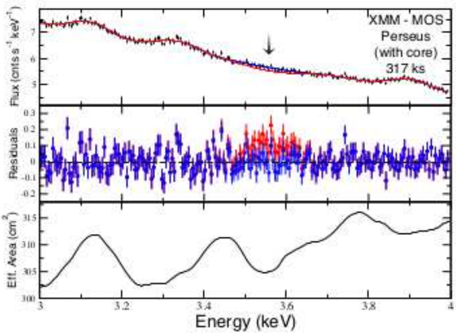


Fig. 1: The combined MOS spectrum of Perseus cluster scaled to 3-4 keV energy range. On top of their best-fit model, the series of the single-bin residuals corresponding to the extra emission line at 3.57 keV is shown in red. (Adapted from Figure 7 in [70]).

3.5 keV from Andromeda

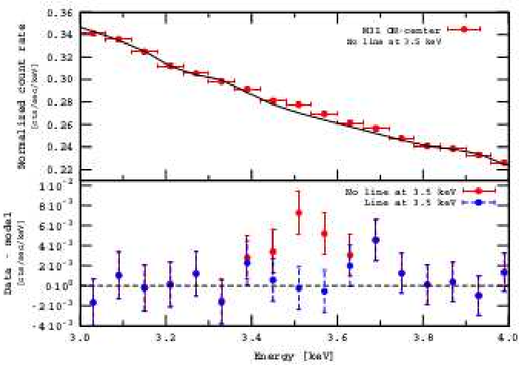
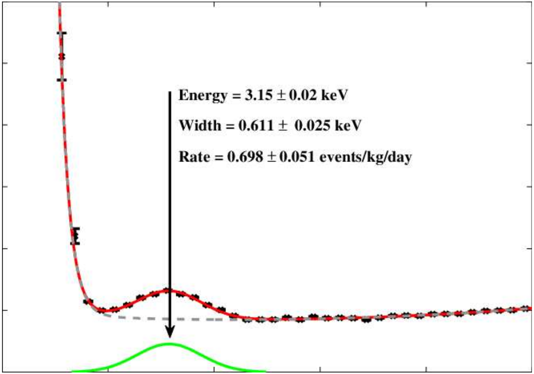


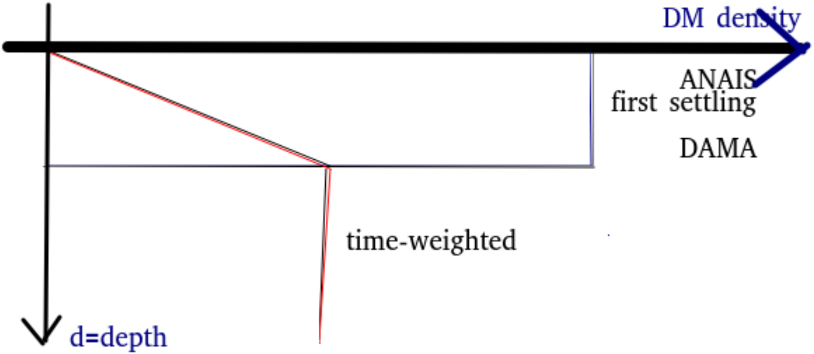
Fig. 2: The same as in the previous Figure 1 but for the combined spectrum of Andromeda galaxy. (Adapted from Figure 1 in [71]).

Distribution of Energy of Events in DAMA-LIBRA:

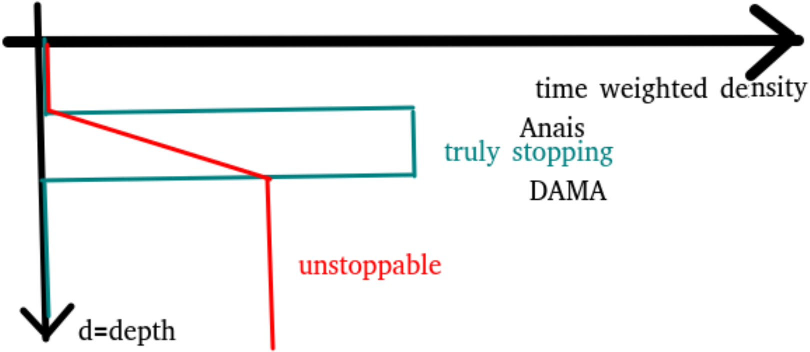


Fit (red) to the published DAMA/LIBRA low-energy spectrum [2], consisting of a background model (grey/dashed) and a Gaussian distribution function (green). The parameters of the Gaussian are given in the figure.

Timeweighted Presence of Dar Matter Pearls, Neglecting Gravity Untill Slowed Down to Only Sink.



Timeweighted Presence of Dark Matter being Slowed Down, Including Earth Gravity



Adhikari, G., Carlin, N., Choi, J. et al. An induced annual modulation signature in COSINE-100 data by DAMA/LIBRA's analysis method. Sci Rep 13, 4676 (2023). https://doi.org/10.1038/s41598-023-31688-4

The Dragging Force on a Pearl with Speed v

$$F_D = C_D \frac{A v^2 \rho_{material\ outside\ pearl}}{2} \quad (6)$$

where F_D is the drag force stopping the pearl, v its velocity, $\rho_{material\ outside\ pearl}$ the density of the fluid or materiaal through which the pearl flyes. C_D is the drag coefficient and is of order unity at high speed. $A \approx \sigma$ is the area shown to the motion.

$$M\dot{v} = -F_D = -\frac{C_D \sigma v^2 \rho_{material\ outside\ pearl}}{2} \quad (7)$$

Equation of Motion for Dark Matter Pearl being stopped in medium

Rewrite to

$$\frac{\dot{v}}{v^2} = -\frac{\sigma}{M} * \frac{C_D}{2}\rho_{material\ outside\ pearl} \quad (8)$$

$$-\frac{1}{v} = -t * \frac{\sigma}{M} * \frac{C_D}{2}\rho_{material\ outside\ pearl} + const. \quad (9)$$

$$v = \frac{1}{t * \frac{\sigma}{M} * \frac{C_D}{2}\rho_{material\ outside\ pearl} - const.} \quad (10)$$

$$l_{stopping} = \int v dt = \int_{v=300km/s}^{v\ small} \frac{dt}{t * \frac{\sigma}{M} * \frac{C_D}{2}\rho_{material\ outside\ pearl} - \cdots} \quad (11)$$

$$= -\left(\frac{\sigma}{M} * \frac{C_D}{2}\rho_{material\ outside\ pearl}\right)^{-1} \ln\left(\frac{\text{``small''}}{300km}\right)$$

Stopping length L and the pressed away material $L\sigma * \rho_{material\ outside\ pearl}$

Rewritting the estimate of the stopping length

$$L_{stopping} \approx \frac{1}{\frac{\sigma}{M} * \frac{C_D}{2}\rho_{material\ outside\ pearl} \ln(\frac{300km/s}{\text{``}small''})}$$

$$L_{stopping}\rho_{material\ outside\ pearl}\sigma \approx M\frac{2}{C_D}\ln(\frac{300km/s}{\text{``}small''}) \quad (12)$$

and noticing that $\frac{2}{C_D} * \ln\frac{300km/s}{\text{``}small''}$ is just of order unity, say 30, we see that mass in the region through which the pearl press its way is only an order of unity times bigger than the mass M of the pearl itself.

How big inverse darkness to just stop at DAMA?

With 4200m w.e. the DAMA depth requires for just stopping there

$$4200m * 1000kg/m^3 = \frac{M}{\sigma}\frac{2}{C_D} * \ln\frac{300km/s}{\text{“small”}} \quad (13)$$

$$\text{giving } \frac{\sigma}{M} = \frac{1}{4.2 * 10^6 kg/m^2 * 30} \quad (14)$$

$$= 10^7 m^2/kg \quad (15)$$

$$\text{to compare Correa } \frac{\sigma}{M} = 1cm^2/g = 0.1m^2/kg \text{ for about } 300km/s \quad (16)$$

We need that the pearls comming into the earth has been washed off so much that their cross section has diminished by a factor 1 million. So in area, they should have lost a factor 10^6 and in linear scale a factor 10^3.

Physics of Phase Transition, hoped for

By fitting to our dark matter model we got to the order of magnitude of the tension S of the domaine wall between the two phases should be

$$S \quad = \quad (\text{few} MeVs)^3 \text{to say } (30 MeV)^3 \qquad (17)$$

This indicates that the physics involved in making this two-vacuum, if it is right, should be in an energy range which not at all *new*. The number $(30MeV)^3$ is what letting the domaine walls replace the cosmological constant (the dark energy) would require.

Relation between Mass M and Tension S for our Pearls

Mainly by adjusting the density of the strongly compressed material of ordinary matter inside the new type of vacuum to have a HOMOLUMO gap suitable for emitting a line of 3.5 keV X-ray and assuming the pearls not far from collapsing and spitting the nuclei inside out in spite of a potential keeping them of $\Delta V = 3 MeV$ we get a mass relation to the suface tension S, expressed here about the cubic root of this S.

$$S^{1/3} = 1\, GeV \quad \Rightarrow \quad M = 24\, ton \tag{18}$$

$$\text{while} \quad S^{1/3} = 100\, MeV \quad \Rightarrow \quad M = 24\, mg \tag{19}$$

$$\text{and} \quad S^{1/3} = 10\, MeV \quad \Rightarrow \quad M = 2.4 * 10^{-14}\, kg = 1.4 * 10^{13} u. \tag{20}$$

Take say the tension to $(10 MeV)^3$, then we shall look for physics

Reserve Slides, a Proceeding paper

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Concerning its gravitational force the existence of dark matter is incorporated in the standard cosmological model, but the non-gravitational properties of the dark matter is much less well-established and even connected with seeming contradictions or mysteries.

Many physicists still believe in some WIMPs being the dark matter, while we ourselves go for a model hopefully incorporable into the Standard Model, in which the dark matter is more like macroscopic structures of ordinary matter (only with one new vacuum story added). But let us start by looking at a few questions:

- Why do the Xenon experiments *not* "see" the dark matter ?

  The answer of our model: The dark matter particles get stopped down to too low speed by the atmosphere and the shielding. Then they do not have enough speed to bring the nuclei in the detector up to a speed that gives visible scintillation in the counters.

- But how can then DAMA "see" the dark matter?

  Our answer: Dark matter radiates electrons. DAMA only tests that it is dark matter by the seasonal variation [1, 2], while the Xenon-experiments exclude (or can separate) the electron induced signal. So DAMA would accept as possible dark matter a signal with sufficiently high energy electrons. However such high energy electrons would not be produced by simple collisions of a few hundred km/s dark matter particles; so special radiation would be needed.

- Could the Xenon experiments then not look for electrons also?

  Our answer: Yes, and indeed Xenon1T "saw" a little excess of "electron recoil events" of energy about 3.5 keV [3]. Unfortunately this little electron-recoil effect was retested and it turned out, as reported in a paper published shortly after this workshop [4], to probably have been due to the presence of radon gas. So now the situation is that the Xenon-experiments saw nothing in electron recoil events either.

- But recoil electrons from 300 km/s collisions only have about 1 eV energy, not keV's!

  Our model answer: Our dark matter particles can be excited so as to radiate 3.5 keV X-rays or electrons.

- How does the dark matter get excited so as to radiate electrons in DAMA?

  Our answer: The dark matter particles get heated up and excited by the interaction with the atmosphere while being stopped.

- But if they get so easily stopped and slowed down, does it not mean that the dark matter is not truly dark?

  Answer: It has an "inverse darkness"

$$\frac{\sigma}{M} = 15m^2/kg \text{ (for velocity } v \to 0. \text{)} \qquad (21)$$

enough for stopping, but only little noticed in astronomy.
In fact Correa made a fit of dwarf galaxy star velocities in a model with self interacting dark matter, SIDM, and obtained the value $15m^2/kg$ for the low velocity limit of the ratio of

the cross section relative to the mass of a dark matter particle [5]. At higher velocities the cross section falls off. Her results are displayed in Figure 1.

Self-interacting d

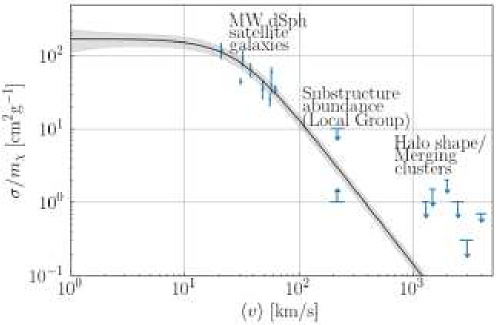

Figure 7. Same as Fig. 6, but extended to cover the range of MW- (~200 km/s) and cluster-size (~1000 – 5000 km/s) haloes' velocities. The figure shows upper and lower limits for σ/m_χ taken

Figure: By fitting to various dwarf galaxies Correa [5] has obtained the ratio of the cross section for one dark particle hitting another one divided by the mass of such a particle, $\frac{\sigma}{M}$, also called the inverse darkness, as a function of the velocity in the collision. Since varying the mass and the cross section by the same factor would not change any effect of the dark matter, one can of course never obtain but this ratio from the dark matter effects on the ordinary matter.

In our model the dark matter particles or pearls consist of a tiny bubble of a new speculated vacuum filled with highly compressed ordinary matter, say carbon, surrounded by an approximately 100 times larger dust grain. This dust grain can be washed off in the Earth's atmosphere, leaving behind a cleaned vacuum bubble with a cross section say 10000 times smaller than that of the dusty pearl. The cleaned dark matter pearl gets decelerated to a much slower speed in the atmosphere and can then penetrate slowly through the shielding of the earth down to say DAMA.

Thus we have for the dusty pearls (at low velocity and at 1000 km/s in big galaxy clusters) and cleaned pearls the following values for the "inverse darkness " $\frac{\sigma}{M}$ (where σ is the cross section of the pearl and M its mass):

$$\frac{\sigma}{M}|_{v\to 0} = 15m^2/kg \text{ (``observed'', dusty)} \quad (22)$$

$$\frac{\sigma}{M}|_{clean} = 10^{-3}m^2/kg \text{ (cleaned, vacuum-bubble)} \quad (23)$$

$$\frac{\sigma}{M}|_{v=1000km/s} = 10^{-2}m^2/kg \text{ (``observed'', dusty, big clusters)} \quad (24)$$

Note that even our dusty dark matter is dark compared to atoms, but conventional WIMP dark matter is much darker than ours:

$$\text{Carbon C: } \frac{\sigma}{M}|_C = \frac{\sigma_C}{12u * 1.66 * 10^{-27}kg/u} = 7.73 * 10^5 m^2/kg$$

$$\text{WIMP say: } \frac{m_W^{-2}}{m_W} \sim \frac{(0.2 * 10^{-17})^2 m^2}{2 * 10^{-27}kg} \sim 10^{-8}m^2/kg$$

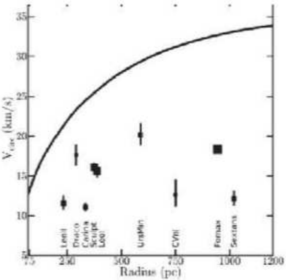

Figure: This figure should illustrate that when Correa simulated the dark matter distribution, under the assumption of a purely gravity interaction, and regained a prediction for the star velocities it was *not* successful. So there is a call for e.g. interaction of the dark matter with itself.

Figure 2 shows that dark matter with only gravitational interactions does not function so well in simulations on dwarf galaxies [5]. Provided we can invent some theoretical story like that QCD, instead of being simply confined and having the Gellman $SU(3)$ symmetry of rotating the light quarks into each other or better the chiral part of it being spontaneously broken, could have another phase where the diagonal subgroup of the two $SU(3)$s survives spontaneous breaking [6]. Then we could speculate on the existence of two phases of the QCD-part of the vacuum-structure. Really QCD and the usual Nambu-JonaLasinio spontaneous breaking is sufficiently complicated that a slightly *different QCD-part* of the vacuum structure can *not be excluded*. If such a possibility had just been overlooked so far then, due to the QCD-physics, there could be two phases of the vacuum, and our speculation about an extra vacuum inside of the dark matter bubbles could be realized completely inside the Standard Model. This could of course explain why LHC did not see any new physics in spite of it usually being strongly expected from considering dark matter.

- Why did LHC not see any dark matter?

  Our answer: In our model the dark matter is composed from ordinary stuff like nuclei and electrons being caught into a bubble of a second phase of the vacuum.
  There is no "new physics" in our model, except that we do not know how the two (or more) types of vacua come about. But we speculate that they can appear inside the Standard Model without genuine new physics; only with fine tunings of couplings.
  Presumably: *One vacuum with confinement; another one with QCD color Higgsed to be aligned with a Gellman* $SU(3)$.

Another idea is that Nambu-JonaLasinio Goldstone boson fields (the pseudoscalar meson fields) could be correlated a little differently in the different vacuum-phases. We shall show some "Columbia-plots" at the end that might give hope for this latter "different correlations in Nambu-Jonalasinio" idea.

There is another difficult question

- If DAMA can observe dark matter particles emitting fast electrons with energies of the order of 3.5 keV, then why can the Xenon-experiments not see them?

  Our model answer: *This is because the Xenon experiments have a fluid and when the dark matter particles come to the fluid they fall much faster than in the solid NaI in the DAMA experiment.* So the dark matter particles spend much less time in one kg of xenon than in one kg of NaI.
  This problem is very hard to solve with a WIMP-type model except if mysteriously the nuclear physics is very different for

xenon versus the other elements Na and I, which sounds almost like fine-tuning the xenon interaction with the WIMP to have a special cancellation! The fluid solid difference between the two scintillators is the almost only proper qualitative difference between them. (Remember that LUX and other xenon experiment have looked so accurately that had there even been the amount of WIMPs that would give the seasonal excess in DAMA, they should have been able to see it.)

A related question is:

- Is there a way to check our dark matter model?

We could propose to insert some solid stuff into the xenon bottles in the xenon experiments, so that the solid could stop the dark matter particles, if of our type, and if the inserted material is thin enough or itself scintilating, then one should see the 3.5 keV radiation from the slowed down bubbles, and they should be excited, if in the same depth as the excited by DAMA observed particle, that have survived down 1400 m. In any case making such an experiment, in which one gradually replace the xenon by say NaI - in stickes or strings inside the xenon bottle, would represent a gradual transition from the xenon type experiment to a DAMA-LIBRA-type. It is already very mystirious how DAMA can behave so different from the xenon experiments, almost whatever the dark matter might be. By making a gradual transition the mysterious difference would have to reveal itself at some point. So an investigation of such a transition would be very interesting. If the fluid non-fluid turns out the important point, a model of our type with stopped slowly falling dark matter particles would be called for.

In our model [7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18] the dark matter consists of macroscopic massive pearls, which in the interior has a little piece - very exactly a perfect sphere - of a vacuum in phase 2 so to speak filled with some ordinary material, such as say carbon, under high pressure. Then this little bubble of new vacuum is surrounded by a bigger but not so heavy grain of dust. The point is that, even though the ordinary material inside the bubble is in the new vacuum and highly compressed, it still interacts chemically and mechanically with the dust and thus presumably shall not stay clean in the universe for 13.6 milliards years even if it should have been created clean, in the sense that at first there was plasma around it rather than material that could contaminate it.

The dark matter particles or pearls are composed of:

- A nm-size bubble of a new speculated vacuum filled with atomic highly compressed stuff, say carbon. (We really have only very weak constraints on the size of the pearls.)
  Let us remark that there is not so much to observe that can give us a good estimate of the mass of the dark matter

particles. Therefore our estimates of the size of the dark matter pearls is very uncertain. If we use the idea to be found in our talk on "Tensions in Cosmology" [19] that the cosmological constant might be replaced by a network of domain walls, a surface tension of the dark matter bubbles of the order of $(30\ \mathrm{MeV})^3$ would be called for. Then dark matter bubbles would have sizes similar to the dust grain, say $10^{-7}m$, much larger than the here mentioned nanometre size. But, as stressed above, the mass is not well determined.

- A surrounding dust particle of "metallicity" material such as C, O, Si, Fe, ..., presumably of some non-integer Hausdorff dimension about 2. This atomic matter is influenced by the electrons being partly in superposition of being inside the bubble of the new vacuum, where there is a very high gap between filled and unfilled electron states.

The pearls interact:

- with other dark matter particles,

- with atomic matter

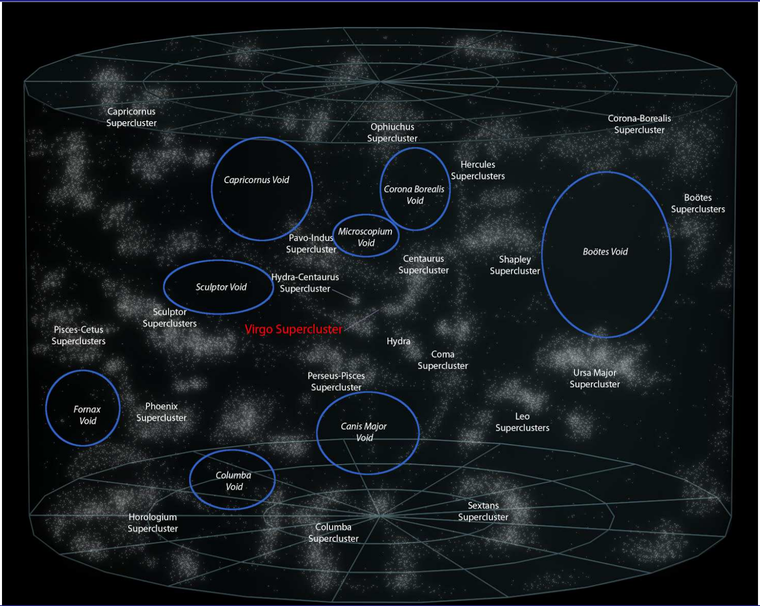
Capricornus Supercluster
Ophiuchus Supercluster
Corona-Borealis Supercluster
Capricornus Void
Hercules Superclusters
Corona Borealis Void
Boötes Superclusters
Microscopium Void
Pavo-Indus Supercluster
Centaurus Supercluster
Shapley Supercluster
Boötes Void
Sculptor Void
Hydra-Centaurus Supercluster
Sculptor Superclusters
Pisces-Cetus Superclusters
Virgo Supercluster
Hydra
Coma Supercluster
Perseus-Pisces Supercluster
Ursa Major Supercluster
Fornax Void
Phoenix Supercluster
Canis Major Void
Leo Superclusters
Columba Void
Sextans Supercluster
Horologium Supercluster
Columba Supercluster

Figure: This picture is an attempt to draw in perspective as 3-dimensional the distribution of galaxies. It shows several voids, regions with only a few galaxies, and by accident has rings around these voids. You could roughly take these rings to suggestively represent domain walls, in a speculation that the voids were of a different type (phase) of vacuum than the galaxy rich regions (clusters etc.)

If really the idea - our main new idea - that there are several phases of vacuum were true, as well as our assumption that the different phases have the same energy density, then a priori one could expect huge, astronomically large, regions with a different vacuum phase from that of another large region. If so, however, there would still be the surfaces - the domain walls - in between these different regions.
Now if these surfaces in between the regions would have energy per area densities as expected by dimensional arguments for new physics beyond the Standard Model, then these densities of energy

on the domain wall would be so huge that astronomical size domain walls would upset our usual cosmological picture very strongly. Only because the domain wall energy density needed to fit our dark matter turns out to be surprisingly small from the new physics expectation point of view, it becomes possible to speculate seriously that the domain walls could really exist out in space - and e.g. surround the voids (the big regions in space with rather few galaxies) - and only contribute tolerably to the cosmological parameters. This is illustrated in Figure 3.

The idea of having huge astronomical size vacuum bubbles will be taken up in our contribution to the Corfu workshop on "Tensions in Cosmology" just after this workshop [19].

As mentioned above our main new idea which we incorporate into the Standard Model is the Multiple Point Principle (MPP) [20, 21, 22, 23], according to which there should be several phases of the vacuum and that they should be degenerate in the sense of having the same energy density. This principle can be used to fine-tune and hence predict the value of coupling constants. It was applied some time ago at the Planck scale in a somewhat complicated model to correctly predict the number of families in the Standard Model [24, 25], prior to the LEP measurement of the number of light neutrino species.

Later we used MPP to PREdict the mass of the Higgs particle before this particle was found experimentally [26, 27]. In addition to the usual vacuum with a Higgs vacuum expectation value of 246 GeV, we obtained another vacuum degenerate with it but having a very large Higgs field expectation value of order the Planck scale $\sim 10^{18}$ GeV. In Figure 4 we reproduce a copy of a painting including one of us, in which the Higgs mass prediction $135\ GeV \pm 10\ GeV$ is on the black board (although the 1 in the 135 is hidden behind the member of the cabinet Mogens Lykketoft's head).


C D FROGGATT
VOR GAUGE GR
ANTI-G.U.T.''
EN 37 dimensional
DEN STØRSTE
UNDERGRUPPE AF G
HIGGS |φ|
FELT
STÆRKT
FØRSTE ORDENS OVERGANG.
10 GeV (ENDNU IKKE MÅLT)
174 GeV ± 5 GeV
LARS ANDERSEN: "SKAK" DET NATIONALHISTORISKE MUSEUM PÅ FREDERIKSBORG SLOT.

Figure: This painting of one of the authors and the Danish finance minister was painted long before the Higgs particle was observed at LHC. Nevertheless due to our "Multiple Point Criticality Principle", we predicted the mass value for the Higgs particle 135 $GeV \pm 10\ GeV$ as with the 1 hidden by Mogens Lykketoft's head is seen on the painting. The much later measured value is 125 GeV.

There may not exist any true derivation of our "Multiple Point Criticality Principle", because it is basically an assumption. A good argument for it is very similar to the argument for having the melting point temperature when you have both say ice and water together. It occurs often and even has a name "slush", and having slush one knows that the temperature is 0^0 Celsius (see Figure 5).

Figure: Slush

The most important support for our model may be that we find the energy number 3.5 keV in **two** different places as a possible favourite level transition energy difference for dark matter:

- The long from dark matter suspected otherwise not understood X-ray line from galaxy clusters, galaxies and strangely the Tycho supernova remnant.
- As average of the energy of the DAMA dark matter events.

In section 17 we report on some progress made since the workshop on our understanding of the intensity of the 3.5 keV X-ray radiation as observed. Our picture now is that most of the sources are well understood by the fit of Cline and Frey [28], in which the rate of this line emission goes as the square of the dark matter density. This corresponds to the dominating process being a collision or perhaps annihilation of two dark matter particles, which get some excitation emitting the 3.5 keV line. However, of course the emission in a visible amount from the Tycho supernova remnant cannot be dominantly due to this dark + dark collision, but must involve some ordinary matter colliding with the dark matter. Also the outskirts of the Perseus Cluster, where the dark matter density has fallen, and the centre of the Milky Way are two further sources of the 3.5 keV line, where we now think that it is collision of ordinary matter - expected to be hot atoms with energy of the order of X-rays - with the dark matter that excites the latter to emit the 3.5 keV line.

In our model we have long supposed that the dark matter bubbles of new vacuum contain matter in which the electron spectrum has a gap, a homolumo gap between the filled levels and the empty levels. It is this homolumo gap which, because of the very high pressure in the ordinary matter contained inside the bubble, has the unusually high value (compared to ordinary chemistry) of 3.5 keV for the energy difference between the highest(H) occupied(O) level (molecular orbit = MO) and the lowest(L) unoccupied(U) molecular orbit. This should then explain the tendency for the dark

matter bubble to emit an X-ray of just this frequency. The excited electrons should go to the lowest unoccupied states and from there jump, under 3.5 keV X-ray line emission, down to a hole in the band of normally occupied states.
Since our bubbles of new vacuum contain - are pumped up with - ordinary matter (under pressure) it is not surprising, but rather expected, that a chemical interaction could be formed between the ordinary matter inside the bubble and the ordinary matter outside. In fact we expect that, due to the high pressure, some electrons will already by the Fermi statistics flow a bit over and actually be present outside the proper skin (= domain wall). So the bubbles have a high chance of getting contaminated by dust or other matter in the outer space where they move along. So we should imagine that the true dark matter particles are probably much like dust grains with a bubble of new vacuum filled with say carbon sitting in it somewhere. Or, if the bubbles are very large, they may

literally be dirty bubbles.
Simulations of the growth of a dust grain, in which the atoms get attached to the dirt rather few at a time [29], show that the dust grain easily develops to have a lower Hausdorff dimension than a compact dust ball would have. The dust could easily be more like a little surface or some stringy network structure. The growth of a dust grain and the development of its fractal dimension in such a simulation is given in Figure 6 .

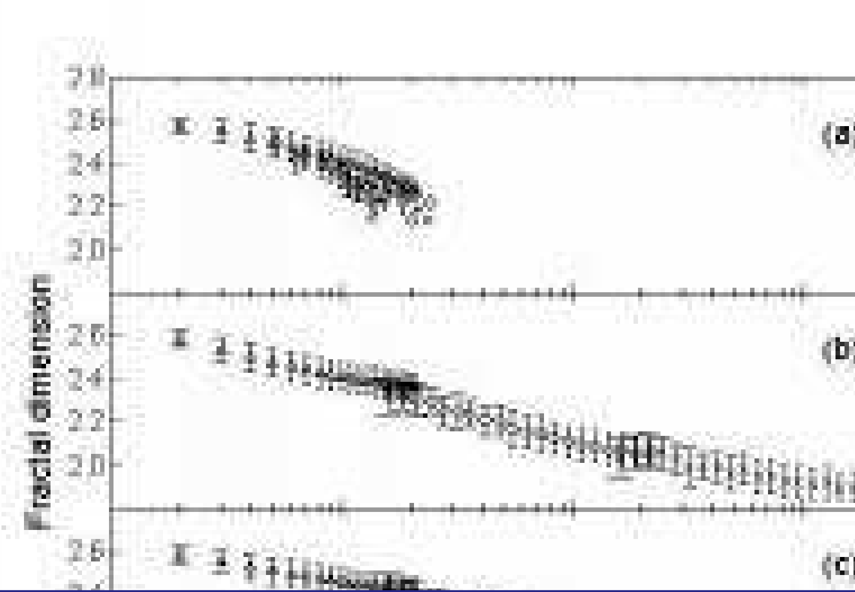

Figure: Results of simulations of dust grains growing by adding single atoms or molecules [29] suggest that the Hausdorff dimension can become low of the order 1 or 2.

An example of such a fractal cosmic dust grain built up from 1024 monomers [30] is given in Figure 7.

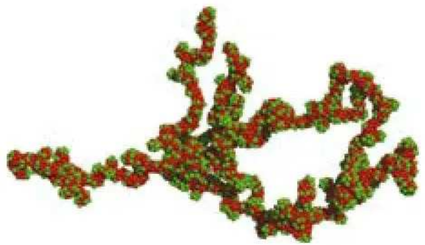

Рис. 3. Фрактальная модель космической пылинки [5]

Figure: Picture of fractal cosmic dust grain constructed from 1024 monomers [30]. The mentioned lower Hausdorff dimensionality of the dust grains - if say 1 - would mean that the dust grain is really more like some knot of strings of molecules than a pearl.

We expect that such a dust grain would collect on top of one of our dark matter pearls, which in itself is very much like a seed atom. We may illustrate that in Figure 8 by drawing our little pearl as a bubble of new vacuum inside the dust grain.

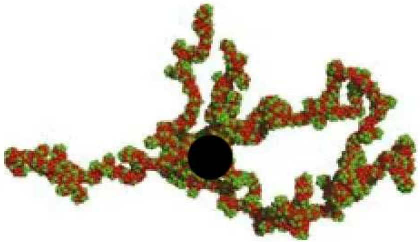

Рис. 3. Фрактальная модель космической пылинки [5]

Figure: Our dark matter particle is a bubble with a dust grain round it. The bubble is supposedly much heavier than the dust grain.

If the grain size is $0.1\mu m$ and the bubble size is $1nm = 0.0001\mu m$, then the bubble is about 100 times smaller than the dust grain. But now if we should seek to implement the ideas of adjusting the tension in the domain walls to make it possible for the domain walls to take over the role of the cosmological constant, we should take somewhat larger bubbles in the middle and the dust grain would not be much larger than the bubble of the second vacuum.

Important achievements of our model:

- Explain that only DAMA "see" the dark matter by the particles interacting so strongly as to be quite slow and unable to knock nuclei so as to make observable signals. Instead the DAMA signal is explained as due to emission of electrons with the "remarkable energy 3.5 keV" from pearls in an excited state.
- The favourite frequency of electron or photon emission of the dark matter particles is due to a homolumo gap in the material inside the bubble of the new vacuum. This gap should be equal to the 3.5 keV.
- We have made a rather complicated calculation of what happens when the bubbles - making up the main part of the

dark matter particle - hit each other and the surface/skin/domain wall contracts and how one gets out a part of the energy as 3.5 keV X-rays [13]. We fit with one parameter both the very frequency 3.5 keV, and the overall intensity of the corresponding X-ray line observed from galaxy clusters etc. The production mechanism gives an intensity proportional to the dark matter density squared and we use the results of the analysis of Cline and Frey [28] whose model shares this property.

- We explain why - otherwise mysteriously - the 3.5 keV line was seen by Jeltema and Profumo [31] from the Tycho supernova remnant and probably also problems with the Perseus galaxy cluster 3.5 keV observations. This is by claiming the excitation of the bubbles come from cosmic radiation in the supernova remnant. After the workshop we now tend to think that it is not the cosmic rays, but rather hot atoms, that are most important. Cosmic rays would survive so long that they would make embarrassingly high intensities for the 3.5 keV line from say the supernovae in the Milky Way Center.

- According to expectations from ideal dark matter that only interacts essentially by gravity there should be e.g in a dwarf galaxy a concentrated peak or cusp of dark matter (the NFW distribution [32], but that seems not to be true. The inner density profile rather seems to be flat as expected for self-interacting dark matter [33], as illustrated in Figure 9. Correa [5] can fit the dwarf galaxy star velocities by the hypothesis that dark matter particles interact with each other with a cross section over mass ratio increasing for lower velocity, as shown in Figure 1. We fit the cross section over mass velocity dependence of hers. But we need a "hardening " of the dust around the bubbles.

We have already seen in Figure 1 how the inverse darkness $\frac{\sigma}{M}$

of the dark matter varies with velocity roughly in the way that it stands at about $15 m^2/kg$ up to velocities of the order of 220 km/s. For higher velocity it begins to fall and becomes so small that one mainly has upper bounds for $\frac{\sigma}{M}$ for velocities present in the interior of big galactic clusters.

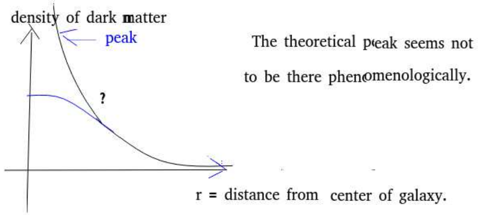

Figure: Illustration stressing that the pole peak in the ideal NFW-distribution at the centre of a galaxy, which is what truly only gravitationally interacting dark matter should form, is not quite as sharp as it should be. This could reveal self interaction of dark matter SIDM as in Correa's fits.

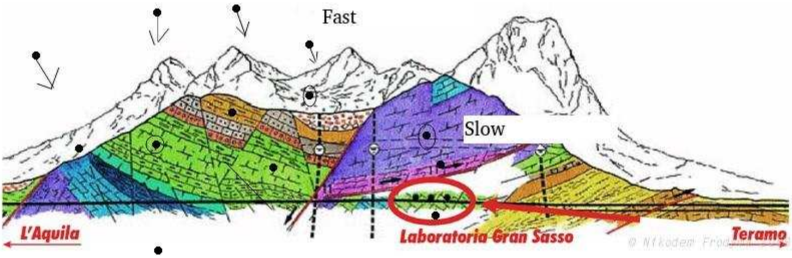

Figure: The mountains above the Gran Sasso laboratories.

We imagine that the dark matter pearls lose their dust grain in the atmosphere or at least, if not before, by the penetration into the earth shielding and that they at the same time get excited by means of the energy of the braking of the pearls. For a very small number of the pearls this excitation energy gets radiated first much later when the pearl has passed through the earth shielding to the underground detectors (see Figure 10), so as to deliver X-ray radiation with just the characteristic 3.5 keV energy per photon. The energy is delivered we guess by electrons or photons. Thus experiments like the xenon experiments do not "see" it when looking for nucleus-caused events. Only DAMA, which does not notice if it is from nuclei or from electrons does not throw electron-caused events away as something else.

The dark matter pearls come in with high speed (galactic velocity), but get stopped down to a much lower speed by interaction with the shielding mountains, whereby they also get excited to emit 3.5 keV X-rays or *electrons*.

The really most mysterious result is that the xenon-based experiments do not "see" the dark matter, while DAMA "sees" it[72]. We want to explain the seemingly severe contradiction on Figure 11 of 5 orders of magnitude say: the DAMA-LIBRA experiment see per kg roughly 10^5 times more than the upper limits for the best xenon experiments. Compared to LUX it may only be a factor 10^3 say, but even that is a severe contradiction.

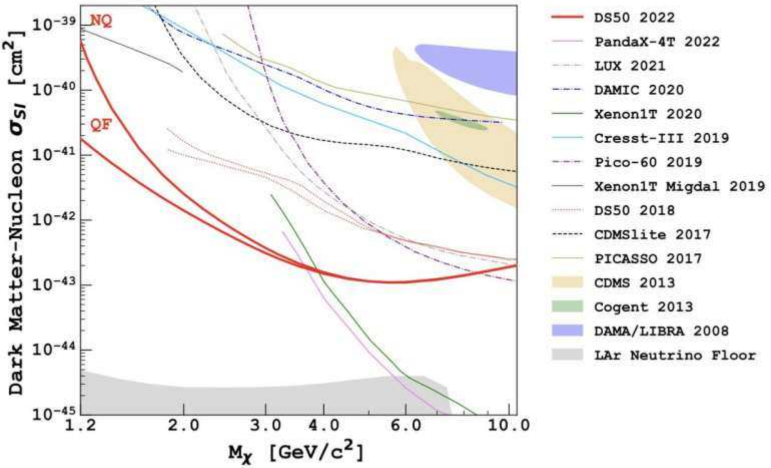

Figure: The top to the right in lilac is the DAMA region of combinations interpreted in the WIMP way of mass of the WIMP and cross section for it on nuclei. What we see on the figure has it roughly at $\sigma = 10^{-40} cm^2$ cross section, while in the same mass region of $10 GeV$ some of the experiments - with xenon - goes down to $10^{-44} cm^2$ or $10^{-45} cm^2$, i.e. about 5 orders of magnitude in contradiction with DAMA.

Our explanation should be that our dark matter bubble or pearl falls through the xenon experiment containers with liquid xenon essentially by free fall while they move much slower in the solid materials, especially the sodium iodide NaI. But in order not to get the seasonal variation smeared away, the pearls have to come the 1400 m down to the experiments in less than a year. So the velocity on the average down through the mountain has to be at least

$$\text{Sinking velocity } v_{sink} \geq \frac{1400m}{year} \tag{25}$$
$$= \frac{1400m}{31556926s} \tag{26}$$
$$= 4.4 * 10^{-5} m/s. \tag{27}$$

This is to be compared with the velocity, which a pearl of dark matter achieves in free fall inside the tank with the fluid xenon making up the typical xenon experiment. Since the earth acceleration at the surface is $9.8m/s^2$ the velocity reached in a tank of depth d is given as

$$v_{fall} \approx \sqrt{d * 9.8m/s^2} \tag{28}$$
$$= 3m/s \qquad (\text{for e.g } d = 1m \text{ big tank}) \tag{29}$$

This velocity in the essentially free fall in the fluid can reach up to be of order 10^5 times larger than the $4.4 * 10^{-5} m/s$ needed to avoid the pearls taking more than a year to come down.
It must though be seen here that if we want the pearl through somewhat faster than in a year then one should begin to see something soon in the xenon experiments. Now, however, what the xenon experiments looked for was a nuclear collision, and they at first sorted away the electron events. Their limits for electron events are much less strong and thus there is indeed no contradiction, provided that we believe the story of pearls being stopped and released again when coming to the fluid.
This means that indeed the slowed down particle idea could solve the otherwise extremely difficult to solve contradiction between the DAMA-LIBRA experiment and the xenon ones!
In the article [4] the XENON collaboration rechecked the "electron recoil excess" previously observed, and found that there was no

effect signalling anything strange anymore. Compared to the old finding we can say roughly that the number of events in one bin went down so that a previous excess of 30 $Events/(t * y * keV)$ becomes an upper limit of say 10 $Events/(t * y * keV)$ and another bin went even less down. With the original - now to be considered wrong - measurement we found [17] that there was a need for the faster passage through the liquid xenon than through the DAMA NaI to diminish the rate of electron observation per kg by a factor 250. In other words we needed that the pearl of dark matter spend per kg a factor 250 shorter time in the liquid xenon than in the NaI. Now we see that this factor 250 is not enough but should be increased by a factor corresponding to the decrease from the 30 $Events/(t * y * keV)$ to the 10 $Events/(t * y * keV)$ in one bin. Already the next most important bin is much less significant, and we shall crudely estimate that adding the two bins would mean the effect went down by a factor 4 just to be on what is now just the

upper limit. So the upper limit on the signal in the xenon is $4 * 250 = 1000$ times smaller than the signal in the DAMA-LIBRA experiment.
So if we say, for illustration, that the free fall velocity in the xenon experiments is 3m/s, then the speed through the NaI in DAMA-LIBRA needs to be 1000 times slower, so that the time spent in a region of a kg in DAMA-LIBRA becomes 1000 or more times longer than the corresponding time spent in a region of a kg in the liquid xenon experiments.
To achieve this the velocity through the NaI or similar solids should be $\frac{3m/s}{1000} = 3mm/s$. In this case the time taken to pass down

through the earth shielding will be

$$\text{“Passage time”}_{on\ limit} \approx \frac{1400m}{3mm/s} \quad (30)$$

$$= 4.2 * 10^6 s = \frac{4.2 * 10^6 s}{3.1 * 10^7 y/s} \quad (31)$$

$$= 1.3 * 10^{-1} y \quad (32)$$

$$= 1.5\ month \quad (33)$$

So our model is a bit in tension with the DAMA results. Namely it suggests that the time of year for the maximal signal from the dark matter observation in DAMA should be shifted to be a bit later - by 1.5 month - than the time of year estimated from the astronomical expectation of the motion of the rest system of the dark matter in the neighbourhood of our solar system.
We would like to get an estimate from the various types of matter available in the Universe as to how much dust can be afforded to

settle on the dark matter bubbles. This will provide a check of our ideas by comparing with the inverse darkness ratio $\frac{\sigma}{M}$ in the limit of low velocity, where one would expect the dust to play the dominant role in the case that the dust grain is larger than the proper bubble. Let us begin by reviewing the amount of matter of the different types available in the Universe:

- 27% dark matter (while 68% of a form of energy known as dark energy, and 5 % ordinary matter).
- The elements heavier than hydrogen and helium make up of order 2% of ordinary matter and are known as "metals". Oxygen is the most abundant "metal" making up about 1%, carbon about 0.5% and iron down to 0.1% The comoving density of these "metals" together [35] is

$$\text{"metal" density} \approx 5.0 * 10^6 M_\odot Mpc^{-3} \quad (34)$$

$$= 3.7 * 10^{-31} kg/m^3. \quad (35)$$

Using the atomic radii we can calculate the cross sections for the following atoms:

$$\text{Hydrogen H: } r_H = 25pm \Rightarrow \sigma_H = \pi r_H^2 = 1963pm^2 \quad (36)$$
$$\text{Helium He: } r_{He} = 30pm \Rightarrow \sigma_{He} = \pi * r_{He}^2 = 2827pm^2 \quad (37)$$
$$\text{Carbon C: } r_C = 70pm \Rightarrow \sigma_C = \pi * r_C^2 = 15394pm^2 \quad (38)$$
$$\text{Silicon Si: } r_{Si} = 110pm \Rightarrow \sigma_{Si} = \pi * r_{Si}^2 = 38013pm^2 \quad (39)$$

Using that one atomic unit $1u = 1.66 * 10^{-27}kg$ we get for the inverse darkness ratios $\frac{\sigma}{M}$ for the atoms mentioned:

$$\text{Hydrogen H:} \quad \frac{\sigma_H}{1u * 1.66 * 10^{-27} kg/u} = 1.183 * 10^6 m^2/kg \quad (40)$$

$$\text{Helium He:} \quad \frac{\sigma_{He}}{4u * 1.66 * 10^{-27} kg/u} = 4.26 * 10^5 m^2/kg \quad (41)$$

$$\text{Carbon C:} \quad \frac{\sigma_C}{12u * 1.66 * 10^{-27} kg/u} = 7.73 * 10^5 m^2/kg \quad (42)$$

$$\text{Silicon Si:} \quad \frac{\sigma_{Si}}{28u * 1.66 * 10^{-27} kg/u} = 8.18 * 10^5 m^2/kg \quad (43)$$

In a dust grain say the atoms will typically shadow each other and thus this ratio "the inverse darkness" will be smaller than if the atoms were all exposed to the collision considered. If we denote the average number of atoms lying in the shadow of one atom by "numberthickness" we will have for the ratio for the full grain say

$$\frac{\sigma}{M}\Big|_{grain} = \frac{\frac{\sigma}{M}\big|_{atom}}{\text{"numberthickness"}} \quad (44)$$

If the dust grain has a fractal dimension 2 or less there is no shadowing and the parameter "numberthickness" $= 1$.
If we insert in the grain a mass-wise dominating bubble, the whole object will of course get a smaller ratio due to the higher mass,

$$\frac{\sigma}{M}|_{composed} = \frac{\sigma}{M}|_{grain} * \frac{M_{grain}}{M}, \tag{45}$$

where M is the mass of the bubble or, if it dominates the whole composite object, the dark matter particle.
On the average of course the mass ratio $\frac{M_{grain}}{M}$ of the dust around the bubble and the bubble itself can never be bigger than the amount of dust-suitable mass to the dark matter in the universe.
So noting that the grain should largely be made by the elements heavier than helium, the so-called "metals", and that these make up only of the order of 1% of the ordinary matter which again is

only about 1/6 of the mass of the dark matter, we must have

$$\frac{M_{grain}}{M} \leq 1\%/6 = 1/600. \quad (46)$$

But really of course not all the "metal" has even reached out to the intergalactic medium, let alone been caught up by the dark matter. So we expect an appreciably smaller value for this ratio of dust caught by dark matter relative to the dark matter itself. Taking as the typical $\frac{\sigma}{M}$ for dust-suitable atoms $7 * 10^5 m^2/kg$ and using the so to speak simplest "equilibrium" $\frac{M_{grain}}{M}$ from combining equations (45, 46) using "numberthickness" $= 1$ we get

$$\text{First estimate:} \quad \frac{\sigma}{M} \approx \frac{7 * 10^5 m^2/kg}{600} \quad (47)$$

$$= 1.2 * 10^3 m^2/kg = 1200 m^2/kg \quad (48)$$

In earlier papers we have already used the dark matter self-interaction in the low velocity limit extracted from Correa's fit to the dwarf galaxy data shown in Figure 1 to give

$$\frac{\sigma}{M}|_{v-->0} = 15m^2/kg. \quad (49)$$

So our first estimate comes about a factor 100 over the observed value. However the dust on the dark matter was collected in a much earlier era than today, at least at first.
We now wish to use a crude estimate of the amount of dust that might pile up around a dark matter bubble with a given velocity during the evolution of the Universe. There are two important effects to be taken into account. First of all the metal density was higher in the past due to the reduction in the “radius” of the Universe by a factor $(1+z)^{-1}$ where z is the red shift. Secondly the metallicity was lower in the past and we use the linear fits of De Cia et al. [36] to its z dependence in our estimate of the rate of collection of metals by our pearls. We found that the most important time for the rate of collection of metals corresponds to

$z = 3.3$, when the age of the Universe was 1.52 milliard years. At this time the rate of collecting metals for a given velocity was about 8.4 times bigger than if using the present metallicity and density. The metallicity at that time [36] was a factor 10^{-1} times the one today. So the factor 1/600 in equation (46) for the "metals" accessible to be caught by the dark matter composite particle becomes

$$\frac{M_{grain}}{M} = 1\%/6/10 = \frac{1}{6000}. \quad (50)$$

So taking $\frac{\sigma}{M}|_{atom} = 7 * 10^5 m^2/kg$ for the atoms of dust and assuming all the accessible "metals" are caught by our dark matter pearls, we obtain our estimate for the inverse darkness of the dark matter particle composed with a dust grain of dimension 2 or less:

$$\frac{\sigma}{M}|_{composed} = \frac{\sigma}{M}|_{grain} * \frac{M_{grain}}{M} \quad (51)$$

$$= 7 * 10^5 m^2/kg/6000 \quad (52)$$

$$= 1.2 * 10^2 m^2/kg. \quad (53)$$

This is of course really an upper limit for the inverse darkness, as not all of the "metal" will have been caught up by the dark matter. Our estimated ratio

$$\frac{\sigma}{M}|_{composed} = 120 m^2/kg, \quad (54)$$

is actually one order of magnitude larger the value extracted from the dwarf galaxy data

$$\frac{\sigma}{M}|_{Correa, v\to 0} = 15 m^2/kg. \quad (55)$$

This can be considered as a success for our model.
We now consider whether there is enough time to collect up so much dust. For orientation we could first ask how much metal-matter at all could be collected by a dust grain while already of the order of $10^{-7}m$ in size, meaning a cross section of $10^{-14}m^2$, and with a velocity of say 300 km/s $= 3 * 10^5 m/s$ during an effective age of the universe of 1.52 *milliard* years $= 4.8 * 10^{16}s$.
We obtain

$$\text{“available “metals” ”}_{for 10^{-14}m^2, 300km/s} = 3 * 10^5 m/s * 4.8 * 10^{16} s * 10$$
$$= 4.4 * 10^{-22} kg$$
$$= 2.4 * 10^5 GeV,$$

which is to be compared to what the mass of a $(10^7)m^3$ large dust particle with say specific weight $1000kg/m^3$ would be, namely $10^{-18}kg$.

So such a "normal" dust size $0.1\mu m$ grain could not collect itself in the average conditions in the Universe.
However, if the grain to be constructed had lower dimension than 3, it would help because then the cross section could be larger for the same hoped for volume and thus mass. Decreasing say the thickness in one of the dimensions from the $10^{-7}m$ to atomic size $10^{-10}m$ would for the same collection of matter give need a 1000 times smaller mass. This would bring such a "normal size" grain close to being just collectable in the average conditions in the Universe.
Our speculated stronger forces than usual due to the big homolumo gap would not help much, because the grain cannot catch the atoms in intergalactic space which it does not come near enough to touch.
In the approximation of only gravitational interaction of dark matter it is well-known that only the *mass density* matters, whereas

the number density or the *mass per particle is not observable.* With other than gravitational interactions one could hope that it would be possible to extract from the fits in say our model, what the particle size should be. But the possibility for that in our model is remarkably bad! The Correa measurement yields just the "inverse darkness" ratio

$$\frac{\sigma}{M} = \frac{\text{"cross section"}}{\text{mass}} \tag{58}$$

Our earlier estimate [17] for the rate of 3.5 keV radiation from dark matter seen by DAMA - very crudely - was based on:

- The total kinetic energy of the dark matter hitting the Earth per m^2 per s (but not on how many particles).
- The main part of that energy goes into 3.5 keV radiation of electrons.

- Estimate of a “suppression” factor for how small a part of this electron radiation comes from sufficiently long living excitations to survive down to 1400 m into the Earth.

None of this depends in our estimate on the size of the dark matter particles (provided it lies inside a very broad range)!
If the dark matter particles were so heavy that the number density is so low that the observation over an area of about $1m^2$ would not get an event through every year, then it would contradict the DAMA data. The rate of dark matter mass hitting a square meter of the Earth is

$$\begin{aligned} \text{Rate} &= 300km/s * 0.3GeV/cm^3 && (59)\\ &= 3*10^5 m/s * 5.34*10^{-22} kg/m^3 && (60)\\ &= 1.6*10^{-16} kg/m^2/s && (61)\\ &= 5*10^{-9} kg/m^2/y && (62) \end{aligned}$$

Taking the DAMA area of observation $\sim 1m^2$ we need to get more than one passage per year and thus

$$M \leq 5 * 10^{-9} kg \quad (63)$$
$$= 3 * 10^{18} GeV. \quad (64)$$

Using the bubble internal mass density as estimated from the 3.5 keV homolumo gap [17], this upper bound implies that the bubble radius $R \leq 10^{-7} m$.

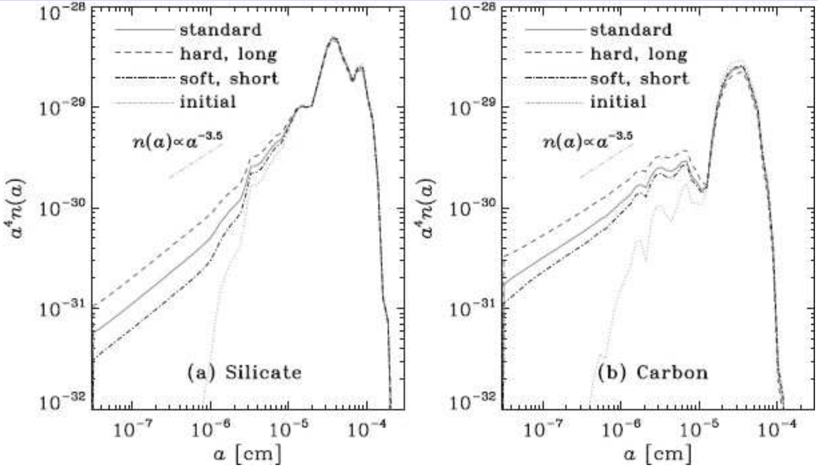

Figure: Simulated size distribution for dust grains.

If the bubble is small compared to the surrounding dust grain, then we would not expect the development of the dust grain around the dark matter bubble to be so different from the dust grains out in space not having any dark matter bubble in them. In Figure 12 we present the size distribution for dust grains from a simulation for ordinary dust particles of small dust grain production in galaxies [37]. We take a typical grain size of $10^{-7}m$ say. Then using the low velocity limit $\frac{\sigma}{M} = 15m^2/kg$ gives

$$M = (10^{-7}m)^2/(15m^2/kg) \quad (65)$$

$$= 7 * 10^{-16}kg. \quad (66)$$

Such a 3 dimensional compact grain of dust has "numberthickness" $\simeq$ 1000 atoms behind each other. But if now the dust grain is 2 or lower dimensional, but keeping the mass of the compact grain combined with $\frac{\sigma}{M} = 15m^2/kg$, there is no shadowing and we obtain a 1000 times bigger estimate for the total or say bubble mass:

$$M = 1000 * 7 * 10^{-16} kg = 7 * 10^{-13} kg \qquad (67)$$

(for low dimensional dust with mass as $10^{-7} m$ size).
In Table 1 we summarize the successes of our model and give a brief explanation of each item below.

Table: Successes

# & exp/th	Quantity	value	related Q.	value
1. exp th	Dwarf Galaxies inv. darkness = $= \frac{\sigma}{M}\vert_{v\to 0}$	 $15m^2/kg$ $120m^2/kg$	$\frac{M_{grain}}{M}$	 $2*10^{-5}$ $1.6*10^{-4}$
2. exp th. th.	Dwarf Galaxies Velocity par. v_0 with hardening without hard.	 $220km/s$ $77km/s$ $0.7cm/s$	 $4r_{dust}E$ $4r_{dust}E$ $4r_{dust}E$	 $8.1*10^{13}kg/s^2$ $1*10^{13}kg/s^2$ $400kg/s^2$
3. exp th th	DAMA-LIBRA air stone	 $0.041cpd/kg$ $0.16cpd/kg$ $1.6*10^{-5}cpd/kg$	suppression	 $1.6*10^{-10}$ $6*10^{-10}$ $6*10^{-14}$
4. exp th	Jeltema & P. counting rate	 $2.2*10^{-5}phs/cm^2/s$ $3*10^{-6}phs/s/cm^2$	 $\frac{\sigma}{M}\vert_{Tycho}$ $1\% * \alpha * \frac{\sigma}{M}\vert_{nuclear}$	 $5.6*10^{-3}cm^2/kg$ $8*10^{-4}cm^2/kg$
5. exp th	Intensity 3.5 kev $\frac{N\sigma}{M^2}$	 $10^{23}cm^2/kg^2$ $3.6*10^{22}cm^2/kg^2$	$\frac{\xi_{fS}^{1/4}}{\Delta V}$	 $0.6MeV^{-1}$ $0.5MeV^{-1}$
6. ast DAMA	Two Energies line av. en.	 3. 5 keV 3.4 keV		

- 1. Dwarf Galaxies, inverse darkness: Assuming the dust grain around the second vacuum bubble has a Hausdorff dimension of 2 or less and the ratio of the dust grain mass to that of the whole dark matter particle to be given by the total amount of metals in the gases in the space available relative to dark matter, we obtain (see equation 50)

$$\frac{M_{grain}}{M} = 1.6 * 10^{-4}. \quad (68)$$

This leads to our estimate of the low velocity inverse darkness for our pearls

$$\frac{\sigma}{M}|_{v=0,th} = 120 m^2/kg, \quad (69)$$

and should be compared to Correa's value from her analysis of dwarf galaxies [5]

$$\frac{\sigma}{M}|_{v=0,ex} = 15m^2/kg, \quad (70)$$

which would correspond to
$$\frac{M_{grain}}{M}|_{fitted} = 2*10^{-5} \quad (71)$$

- 2. Dwarf galaxies, velocity parameter: We seek to estimate the velocity scale at which the inverse darkness $\frac{\sigma}{M}$ as a function of velocity falls significantly. One seeks to estimate the velocity $v_0$at which the colliding pearls pass so undisturbed through each other that bending would not disturb the motion of the pearls enough to influence the effective interaction seen by say Correa. The first theoretical line marked "with hardening" has assumed that the dust around the pearl has been influenced by the exceptionally large homolumo gap in the bubble to become extremely much harder than normal dust. It therefore keeps a large cross section up to a much higher velocity, $77 km/s$. The second theoretical line has just used a more normal elastic modulus for the dust, and even at rather small velocities, $0.7 cm/s$ and on, the dust is just deformed and makes no effective bending of the motion of the pearl.

- 3. DAMA-LIBRA We estimate crudely the amount of kinetic energy in dark matter pearls being converted, assumed mostly into excitation of the 3.5 keV electron mode, during the stopping of the pearls in the atmosphere "air" or in the solid part of the earth "stone". Next one asks how much there would be per kg of matter in the earth if this energy were smoothly distributed over a range of depths large enough to include the 1400 m deep Gransasso laboratory. The amount of energy observed relative to this estimated available amount is denoted "suppression" and taken to be small because there are several different excitations (although with mainly 3.5 kev) of different life times. However the long life time ones require a longer time for being excited, so that the "suppression" crudely becomes the ratio of the excitation time available to the passage time down to the measurement place.

- 4. Jeltema This item estimates the amount of 3.5 keV X-ray from the Tycho supernova remnant, from which it was rather surprisingly observed by Jeltema and Profumo. We estimate the amount of energy in the supernova remnant e.g. in the form of cosmic rays and then believing that part of it hits the dark matter pearls and mainly goes into emission of electrons. However a fraction of order the fine structure constant α of the excitation energy is emitted as X-rays, which like the electrons is supposed to be mainly of the preferred energy per particle 3.5 keV. We give a more detailed discussion of the Jeltma and Profumo results in reference [14].
  After the workshop we decided that it is *hot atoms* rather than

cosmic rays that predominantly make the dark matter produce the 3.5 keV radiation. This is because the cosmic rays would stay around so long as to make star formation regions like the centre of our galaxy produce more 3.5 kev X-ray than are seen.

- 5. Intensity 3.5 keV In the model picture, that the bubbles of dark matter collide with one another and unite under a common skin, which contracts and thereby delivers energy and an appreciable part of this energy is emitted as the X-ray radiation with energy per photon 3.5 keV, we estimate the overall intensity of the expected 3.5 keV radiation. Cline and Frey [28] have already fitted the observed intensity from various astronomical objects of this 3.5 keV line as being proportional to the *square* D^2 of the density of dark matter D, from which one can extract what in our model is $\frac{N\sigma}{M^2}$. Here N is the number of 3.5 keV photons expected in one dark matter dark matter collision, σ the cross section, and M the mass of a dark matter particle. It turns out that our intensity quantity $\frac{N\sigma}{M^2}$ and the very energy per photon (3.5 keV) are both obtained as functions of the same parameter $\frac{\xi_{fS}^{1/4}}{\Delta V}$ - essentially the Fermi momentum of the electrons in the bubble. So indeed the two quantities "intensity" and "the 3.5 keV" are related and the values of the parameter $\frac{\xi_{fS}^{1/4}}{\Delta V}$ given in column 5 for the two quantities turn out to agree. ΔV is the binding energy of a nucleon into the inside -phase of vacuum, and ξ is the typical size of a dark matter pearl relative to the "critical size" below which it would collapse.

- 6. Two Energies By this item we call attention to the remarkable fact that the X-ray line observed in astronomy presumably from dark matter - 3.5 keV - has the same energy per particle as the average energy of the events in the DAMA-LIBRA experiment having the seasonal variation telling that they are from dark matter.

We would like pre-announce some of the progress we made since the workshop and which we hope to publish shortly:

- We have had some success assuming that the 3.5 keV X-ray radiation is not only produced in collisions between two dark matter particles, but also when a dark matter pearl collides with an appropriate ordinary matter piece of material. Actually our speculation at present takes the direction that the major production of 3.5 keV X-ray should occur when atoms of ordinary matter hit the dark matter. Then, namely, the atom can come with more that 3.5 keV energy while the energy of the electron is still under this value, so that the electron cannot penetrate into the bubble or even the hardened dust because its energy is below the homolumo gap value. This should then mean that the electron would be effectively strongly interacting with the dark matter pearl, while the atom sill has sufficient energy to excite the line 3.5 keV. The fitting of the dark ordinary interaction contribution should only dominate in three cases:

- The observation of the outskirts of the Perseus Cluster, which we previously dropped out of our fit because it produced a couple of orders of magnitude more 3.5 keV X-rays than estimated from the dark matter squared density. One shall have in mind that the dark matter density in the Perseus Cluster falls off with radius faster than the ordinary matter density, which is dominated by the so-called "X-ray gas", consisting of intra cluster hot gas or plasma revealing itself by its X-ray emission. This X-ray gas is a very large component of the ordinary matter.
- The Center of the Milky Way: Actually Jeltema and Profumo [31] claim that the distribution of the 3.5 keV line from the Milky Way Center does not at all look like coming from dark matter. If it reflects the distribution of both dark matter and ordinary matter, the chance that it would vary in the way

found observationally should be better, since the ordinary matter is distributed in a somewhat complicated way.

- Of course from the dark matter theory point of view the mysterious observation of the 3.5 keV line from the Tycho supernova remnant can only be understandable if some atoms of ordinary matter with X-ray temperatures are present in the remnant and interact with the dark matter.

We found that the ratios of these three different observations of 3.5 keV line production can very crudely be compatible with a model of our type, having both dark + dark production and dark + ordinary production.

In 1998 Alford, Rajagopal and Wilczek proposed a new phase of QCD with "Color-Flavour Locking" [6], and it was further argued for that in matter with high baryon density [38, 39] there should be a phase pattern with among other phases this color-flavour-locking one. A remarkable discovery was that, for a density of the order of that in neutron stars, they find a tetra-critical phase meeting point which in reality would probably be shifted into a couple of triple points, just for values of the quark masses - strange and a common light mass (the heavy quarks being ignored) - close to the phenomenologically known ones! Provided this phase diagram could be extrapolated to zero baryon number density, we could claim that these authors have already found the phase(s) we hope for to produce our dark matter bubbles.

Concerning the phase diagram involving also the quark masses as parameters - as is the most important for us, because we would like to claim that Nature via MPP would have fine-tuned the parameters, the quark masses in this case, to just let the vacuum be on the borderline among several phases, one finds in the literature the so-called Columbia-plot. The abscissa is the assumed same mass for the two light quarks u and d, while the ordinate is the strange quark mass, the heavy quarks being ignored. The main point discussed with this plot is how raising the temperature can cause phase transitions; in the lower left corner - with masses one has spontaneous symmetry breaking of the chiral symmetry and a first order phase transition as function of temperature occurs with the quark masses combination being in the corner as separated from the rest by the curve around this corner. For larger quark masses, as corresponding to the quark mass combinations, there is with raising temperature no true corresponding phase transition, but instead just a rapid variation of thermodynamical quantities. Such a situation is called a "crossover". It is our dream of realizing our MPP by the experimental quark masses lying just on the curve separating off the mentioned lower left corner. This curve represents in the vacuum - i.e. zero temperature - a second order phase transition. The Columbia plot from some time ago [40], which we reproduce in Figure 13, has the physical point - meaning the experimental quark mass combination - inside the region in the lower left corner as limited off by the phase transition curve.

However, later lattice calculation constructed Columbia plots mostly obtain this physical point to sit in the region with the "cross over". An article using a technique of Ads/CFT correspondence type [41] also got the physical point inside the lower left corner region, in spite of the lattice calculations putting it on the bulk side (i.e. with the cross over). We are tempted to take this disagreement in the literature, as to even on which side of the (second order) phase transition curve the physical point lies, as saying that the uncertainties are such that one does not really know on what side this physical point lies. In fact that means of course also then that it is within the errors possible that the physical point - as we dream - lies just on the phase transition curve.

Physics of the Vacuum Phases ?

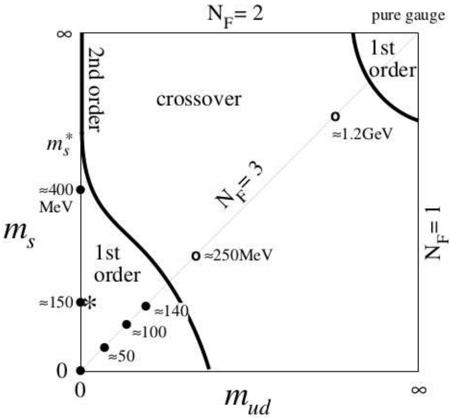

Figure: This plot is taken from [40], which with lattice calculations found the phase transition temperatures, and whether at this temperature there was a true phase transition or just a crossover. The phase transition temperatures are associated to the points in quark mass plane at which the temperature was found by their lattice calculations. The plot has the common light quark mass on the abscissa and the strange quark mass on the ordinate. They determined the physical point by looking for the correct meson masses, and interesting for us the $*$ denoting this physical quark mass combination is one the small quark mass side of the second order phase transition curve, contrary to the next figure 14.

Physics of the Vacuum Phases ?

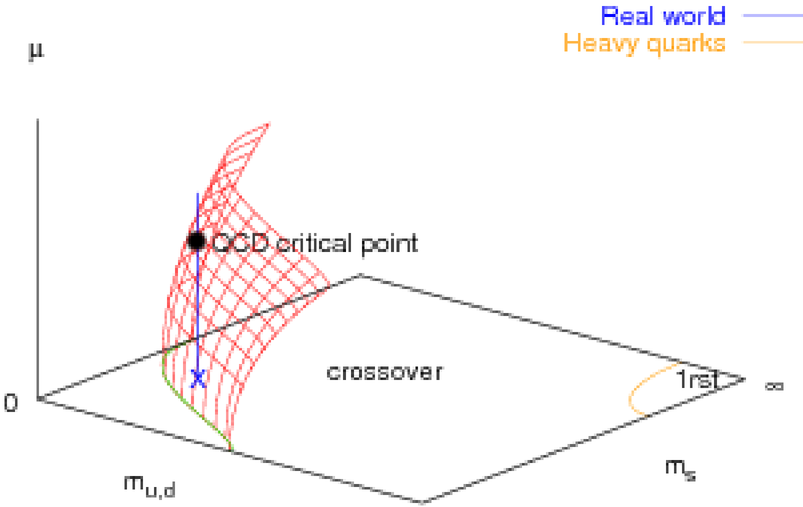

Figure: Here is a 3-dimensional phase diagram [43] in which there is imposed a chemical potential μ for baryon number along the vertical axis, while at the bottom in perspective we see the usual Columbia plot with the common u and d quark mass and the strange quark mass. The figure is based on the result that the physical masses for the quarks are to the large quark mass side of the second order phase transition. If however, as we hope for, the physical quark mass combination would be exactly on the second order phase transition curve, then the QCD critical point on this figure would have moved down to the vacuum surface at $\mu = 0$.

From the just mentioned hope for having a phase transition just at the physical quark values, we would come to think that the phases meeting at the experimental couplings are phases distinguished from each other just very tinily by the precise correlations between the Goldstone boson (the pions and the other pseudoscalar mesons) fields in the different phases. In fact we think one should imagine that in the phase in the lower left corner there is a significant correlation between the Goldstone fields at neighbouring places more than just that the fields are all over lined up corresponding to the quark mass determined directions, while in the phase in the region marked “crossover” the correlations are closer to be only given by the quark masses. There will of course still be correlations in the "crossover", also between neighbouring regions, but they will be smaller correlations of that type than in the left lower corner phase.

In later work we would hope to estimate the scale of distance at which the Nambu Jonalasinio spontaneous breakdown sets in, presumably it is order of magnitudewise given by $f_\pi = 93MeV$. Then we can understand that, when the Compton wavelengths of the pion and kaon are short compared to the scale for the spontaneous breakdown, the sigma model fields will be specified effectively alone by the quark masses at a short distance scale. When on the other hand the Compton wavelengths for the quarks are long, then in first approximation we have a true spontaneous breakdown and the quark masses only provide a weak force determining the direction of the breaking of the chiral symmetry. In the latter case we expect a first order phase transition to a situation where say due to higher temperature the spontaneous breakdown has disappeared. In the short Compton wavelength situation, however, there is no true spontaneous breaking, because there is all the time a state kept with the same orientation of the breaking even rather locally, and thus we only expect the crossover. As f_π and say the average mass for the three light quarks are not much different, the speculation of the phase transition along the second order curve just coinciding with the physical masses is not excluded.

In early work by Learmann and Owe Philipsen [42] they directly admit that they do not know on what side of the second order phase transition the physical point lies by putting question marks on their Columbia plot.

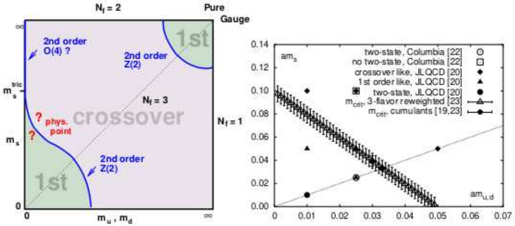

Figure 1: The phase diagram, expected (left) and lattice data (right), in the plane of strange and degenerate u,d quark masses.

Figure: Here Learmann and Owe Philipsen have left question marks to tell that they do not know on what side of the second order phase transition the physical combination of quark masses lie. The right hand figure shows the second order phase transition determined from their lattice simulations with the lattice constant multiplied by the relevant quark mass along the axes.

So indeed we believe that from these works it is not overly optimistic to suggest that some different phases in QCD really can exist if the quark masses just take the right values for that, and these right values are indeed very close to the experimental quark masses.
If this is how our speculated phases come about then the scale of this physics is surely the strong interaction scale, say 0.4 GeV or so. However, we shall probably take into account this difference in correlations, which we just suggested will be very small differences between the different phases and therefore we would expect that compared to a simple dimensionality argument - giving say 0.4 GeV as the scale - the tension S will be exceptionally small. So instead of expecting the cubic root $S^{1/3}$ to be 0.4 GeV we expect

it to be somewhat smaller.

Now partly because, for dimensional reasons, we must consider the cubic root $S^{1/3}$ and partly because the mass of course goes as the cube of the the linear distance scale, the mass M of our dark matter pearls depend as the ninth power on this cubic root $S^{1/3}$ of the tension. Thus putting in cubic roots of the tension only deviating by one order of magnitude we get masses deviating by 9 orders of magnitude. Thus our prediction of the mass M from the order of magnitude estimate of $S^{1/3}$ taken to be of the strong interaction energy scale allows a rather large range in masses; indeed e.g.

$$S^{1/3} = 1\, GeV \quad \Rightarrow \quad M = 24\, ton \tag{72}$$

$$\text{while} \quad S^{1/3} = 100\, MeV \quad \Rightarrow \quad M = 24\, mg \tag{73}$$

$$\text{and} \quad S^{1/3} = 10\, MeV \quad \Rightarrow \quad M = 2.4 * 10^{-14}\, kg = 1.4 * 10^{13} u \tag{74}$$

Here u $\sim$ GeV is the atomic unit.

The $M = 24\,mg$ value would correspond to about 400 km between the pearls in the solar system region, while $M = 24\,ton$ would lead to a 1000 times longer distance, i.e. 0.4 million km between the pearls. To reach the mass required for making the DAMA experiment see enough separate particles, given above as the mass $M \leq 5 * 10^{-9} kg = 5\,\mu g$, requires an $S^{1/3}$ value less than the 100 MeV by a factor of the ninth root of 5000, which means $39\,MeV$. This $39\,MeV$ is thus the upper limit to the "strong interaction scale" allowed for our model to work, but as already suggested the weakness of the phase transition probably means a somewhat low tension so reaching 39 MeV would be quite o.k.

In the article about our dark matter in the next workshop [19] on " Tensions in Cosmology", we calculate that one has the possibility of getting rid of the cosmological constant and effectively replacing it by domain walls. To achieve this modification of cosmology we need roughly

$$S^{1/3} \sim 30\, MeV, \qquad (75)$$

which fits very well with a bit diminished strong interaction scale 0.4 GeV, as well as with the requirement of being less than 39 MeV.

This tension corresponds to a mass of our dark matter bubbles of $\sim 10^{-9} kg \sim 10^{18} GeV$.

When as in this paper we take serious the very well established observations of DAMA-LIBRA, it is of course a little problem that the experiment Anais [34] set up to test the DAMA-Libra experiment with now three standard deviations disagree with DAMA-LIBRA by **not** finding any dark matter by the same method. A priori this disagreement with Anais - if it is not just statistical - is even harder to explain than the disagreement with the xenon experiments, because Anais is also using a NaI

scintillator.
One idea, which we can propose though is that the dark matter pearls of ours could happen to have just such a size that they with their 300 km/s incomming velocity would first get stopped after having reached the depth 1400m of DAMA-LIBRA. If so then they would yet run with appreciable speed in a laboratory, which like Anais were not lying quite as deep as the DAMA-experiment. It should so to speak be so that DAMA-LIBRA should just have that lucky depth at which the dark matter particles get stopped in the earth shielding. Experiments higher up towards the earth surface would still see the dark particles running so fast as to deliver much less radiation than they can in DAMA. Perhaps even the experiments which are deeper than the 1400 m of DAMA would get the particles delayed and if they should also not see any dark matter, it might be explained by the radiation from the dark matter having burned out when the particles after the ca 1400 m

have begun running so slowly that it takes so much time that they get burned out.

It may be difficult to estimate precisely how big the dark matter bubbles should be to just stop after 1400 m earth, but we have in earlier works - when working with the very large cm-size pearls - used the drag-equation with a drag coefficient of order unity. This means that a particle stops roughly when the amount of the shielding it has ploughed through equals in mass the mass of the pearl itself. Now we expect that our bubbles - which is only part of the dirty pearl supposed to reach into the earth - to have about 10^{11} times as high mass density as material like the one in the Earth. This means that the size of the bubbles in order to just reach and stop at DAMA should be 10^{11} times smaller in thickness than the depth 1400 m. That is to say,

$$\text{Size of bubble } R = 1400m/10^{11} \quad (76)$$
$$= 1.4 * 10^{-8} m. \quad (77)$$

It is a remacable coincidence that the size of the bubbles suggested by the going for the domain walls able to replace the cosmological constant by the effect of the domain walls instead gices the mass of the bubbles to be $10^{-9} kg$ to which corresponds a mass very similar to the number $1.4 * 10^{-8} m$.

In fact using

$$\text{Bubble density } \rho_B = 5.2 * 10^{11} kg/m^3 \quad (78)$$

$$\text{Mass } M = \frac{4\pi}{3} * R^3 * 5.2 * 10^{11} kg/m^3 \quad (79)$$

$$\text{For no CC. mass } M_{no\ CC} = 10^{-9} kg \quad (80)$$

$$\text{we get } R_{no\ CC} = \sqrt[3]{\frac{3 * 10^{-9} kg}{4\pi * 5.2 * 10^{11} kg/m^3}} \quad (81)$$

$$= 7.7 * 10^{-8} m. \quad (82)$$

So in fact the essentially same size of the pearls get us rid of the cosmolgical constant (= dark energy) and to just get the pearls stop in the depth of the DAMA experiment and thus explain the seemingly exceptional success of just this experiment DAMA-LIBRA.

If we believe in the above story that DAMA-LIBRA has got special

luck by being just in the depth where the dark matter bubbles get stopped and thus spend enough time to emit enough X-ray electrons to be seen, then away to check the story should be to make a new DAMA-like experiment, but in the same effective depth as DAMA - to get any counts -, but in a different true depth to make it impressive for the story we tell. That is to say that putting the density of the stone in the mountains above DAMA to $3g/cm^3 = 3000kg/m^3$ one should make the new experiment with a shielding of say water, that would effectively be equally deep as DAMA, and that would mean on $3 * 1400m$ deep water. This might be difficult but not impossible, but rather interesting from the point of view of our model. In the sea the bubbles would first stop at this depth, because of the less resistence of the water than of the stone.
We have again presented and developed our long-standing model for dark matter as macroscopic composites of ordinary matter kept

together and concentrated by means of a new type of vacuum- another phase of the vacuum. We think that our model solves some problems that are very difficult in other models and, in addition, has some good order of magnitude agreements suggesting that our model is very likely on the right track. E.g. the most mysterious fact that DAMA-LIBRA seemingly saw the dark matter while several Xenon based experiments do not - even with significantly more sensitivity - see it. Supposing dark matter is something moving through the apparatuses with a speed quite different for a solid NaI apparatus as in DAMA-LIBRA, where the dark matter pearls can get stopped and thus spend more time in the apparatus than in the fluid xenon apparatuses, where they will fall quickly through. Also it is a great achievement of our model, that because it is so difficult e.g. to see new vacua, we have essentially no new physics and thus cope wonderfully with the fact that LHC has seen nothing of the dark matter. We have even since

the workshop speculated on the so-called Columbia plots, which suggest some phase transitions as a function of the quark masses. if this were established, we would really have the chance to avoid LHC having had to see anything concerning the dark matter - so to speak our model can live with *no new physics.*
Let us repeat the suggestion for a experiment looking for supporting our model or obtain further insight into the mysteries concerning the dark matter undergroundd observations:
Insert into the xenon-type underground experiments, which do NOT see the dark matter so far, some solid thin objects, some think sticks say, which could hopefully stop or slow down the dark matter paticles so as to stay sufficiently long in the apparatus as to give 3.5 keV electrons - or perhaps even photons - which could be "seen" by scintillation in the xenon. It would be our prediction that such solids inside the xenon tank could increase the rate of observation of event. Presumably it would be "electron recoils

events" one would see if this succeeded since we believe our pearls to emit electrons or photons, but they are too slow to excite any nuclei, and they will not themselves emit nuclei.
Another further experiment which we propose is to make a new DAMA-type experiment in the same *effective* depth but in a different genuine depth. Since DAMA has the depth with stone over it of 1400 m, an effective equivalent experiment could be at 4.2 km water or with some exceptionally dense material cover at smaller depth. The point is that we by reading about the Anais experiment not seeing any dark mater come to wonder that the dark matter only is easily seen in the depth in which the pearls stop.
We now give a series of points about our model:

- We have put forward a model for dark matter consisting of nm size bubbles of a *new vacuum* with a mass inside of $2 * 10^{-15} kg \sim 10^{12}\ GeV$ and using, apart from this vacuum speculation, *only the Standard Model.* (But recently we got the idea, that if one wants to change cosmology by avoiding the dark energy - and thus putting the cosmological constant to zero - there is a chance of getting approximately the same effects from domain walls on the borderlines of the different vacua. This requires though that the pearls become tremendously big. In such a case the size of the bubble should be of the order of the dust grain size, 10^{-7} m, rather than the nm size, we believed at the time of the workshop in Corfu 2022.)

- The interaction of the dark matter particles in outer space - especially in dwarf galaxies, where Correa estimated it - is for low velocities given by a *dust grain* sitting around the pearl of the new vacuum. Using the relative amount of "metals" to dark matter as also giving the ratio of the masses of the grain of dust to the dark matter in the dark matter particles, we get only an order of magnitude deviation from the low energy "inverse darkness" estimated by Correa:

$$\frac{\sigma}{M}_{v-->0} = 120m^2/kg \quad \text{against Correa:} \quad \frac{\sigma}{M}_{v-->0} = 15m^2/kg \qquad (82)$$

- Because of the lesser darkness than ideal dark matter (having only gravitational interactions) - i.e. larger inverse darkness $\frac{\sigma}{M} \sim 10^{-3}m^2/kg$, even after blowing off the attached dust grain, than the "usual" WIMPs - our dark matter particles get stopped in the atmosphere. This explains why the Xenon-experiments, which only look for nuclei recoil events when expecting dark matter, do not see any dark matter giving nuclei.
- The highly compressed "ordinary matter " (in the new vacuum) inside the bubble has, compared to usual chemistry, a very high energy gap - homolumo gap - between the highest

filled state, *HOMO*, and the lowest unoccupied state, *LUMO*, speculated to be just $3.5 keV$. This leads to the dark bubble having a "preferred" *emission energy for photons and electrons given by the gap height 3.5 kev*.

- It is this emission of 3.5 keV electrons (and photons) after excitation of the "ordinary" material inside the bubble, which we suppose is observed by DAMA.
- It is a remarkable accident supporting our model that both the direct observation at DAMA-LIBRA and the X-ray radiation observed from galaxy clusters and galaxies supposedly coming form dark matter both have the average energy per event of 3.5 keV.

Both of us thank our institutes for our status as emeriti, and one of us in addition thanks the Niels Bohr Institute for economic support for the visit to the Corfu Workshop where this talk was presented, as well as for support to the Workshop in Bled which

was also supported even with a contribution for printing and where one of the subjects was similar to this talk.

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