Several degenerate vacuua and a model for Dark Matter in pure Standard Model

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Several degenerate vacuua and a model for Dark Matter in pure Standard Model

Take it that I believe in pure Standard Model longer up in energy than almost anybody else (except for see-saw neutrinos and baryon number excess, for which even I accept new physics):

- **No new fundamental particles** (except see-saw neutrinos and possibly almost at Planck scale, but shall not talk about so high energies to day)
- For fine tuning problems we though introduce/propose a **new law of nature,** that **shall restrict the coupling constants and masses in the Standard Model**, to explain e.g. why the weak scale is so low compared to the Planck scale (or GUT scale, if it existed (take it: I do not believe in GUT)).
- New law: There are **several vacua**/phases of emty space, all having **same energy density**/cosmological constant. We call it "multiple point (criticallity) principle" = MPP.

How to escape without new physics ?

- For **Dark Matter** a rather complicated speculative model,**but in pure Standard Model**, only with help from our finetuning law “Multiple Point (criticallity) Principle” =MPP, using Higgs to buind top and anti top quarks.
- For neutrino oscillations and baryon excess **even we** have to accept **new physics** at the **see-saw scale** (presumably 10^{12} GeV, but nothing for LHC (and though nonperturbative effects)).
- For fine tuning and hierarchy problem we put in our “multiple point principle”, **which is only restricting couplings and the Higgs mass**, but gives no deviation from pure Standard Model in terms of new particles say.

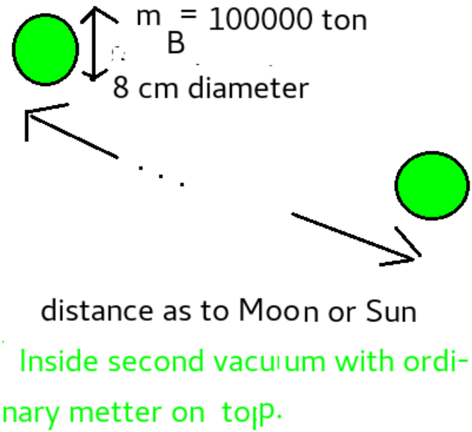
Announcements on Higgs:

- Our "Multiple Point (Criticallity) Principle" was used before the Higgs was observed to **predict the mass of the Higgs** to 135 GeV $\pm$ 10 GeV (I was even painted with the (1)35 $\pm$ 10 GeV on the picture.)
- Hypothesising **three vacua to be degenerate** in the Standard Model (again MPP) we get the right order of magnitude for the **weak scale relative** to the scale of the second minimum in the Higgs effective potential, which (happens?) to be close to the **Planck scale**.
- The **Higgs** plays a crucial role for our a bit "complicated" **dark-matter** speculation.
- About 5 **anomalies** - seeming deviations from Standard Models - are order of magnitude explanable as **non-perturbative effects** due to $g_t = 0.935$ " big".

Dark Matter ?

Main points of present talk:

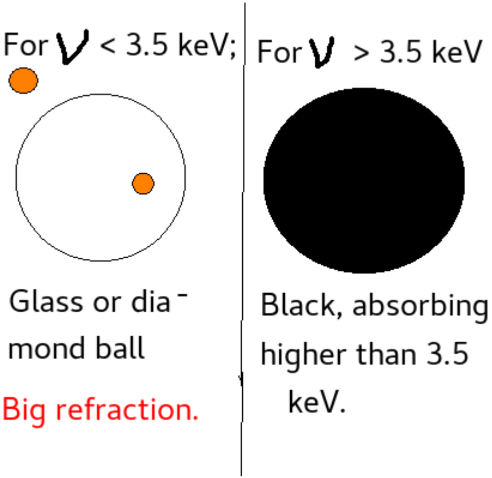
- Our dark matter model/idea of **mouse size** pearls of a new type of vacuum, to be explained by effects of **Higgs binding top quarks and antitops**.
- **Multiple Point Principle:** Several vacua with **same energy density** seperated by high tension "walls"(surfaces much like the surface of a buble of water).
- Some **non-gravity dark matter signs supports our** dark matter pearl **model**:
  - The 3.5 keV X-ray radiation.
  - positrons relative to gamma-rays from dark matter (problem)


m B = 100000 ton
8 cm diameter
distance as to Moon or Sun
Inside second vacuum with ordi-
nary metter on top.

Our pearls bubbles of new vacuum with highly compressed ordinary matter inside

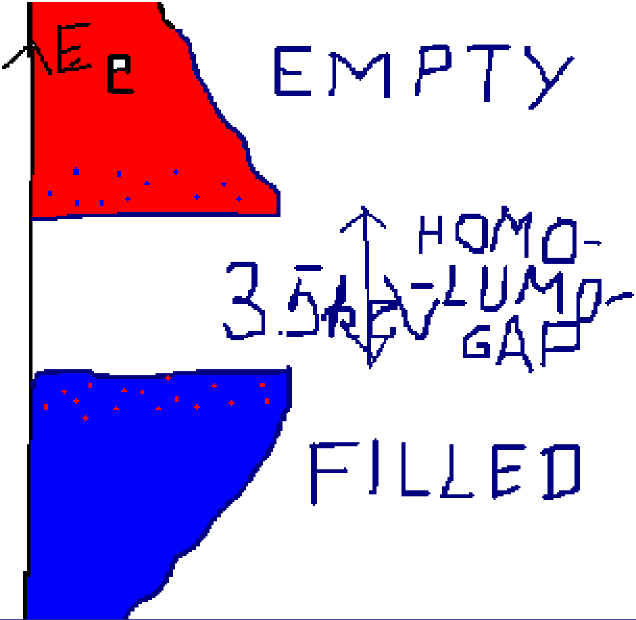
- Our main new physics assumption (which is not really new but should be a non-perturbative effect): **Higgs bosons and top quarks interact so strongly, that a phase of these particles attrackting each other had been fne tuned to get same energy density as the vacuum.**
- This gives rise to **domain walls** seperating the two phases with a tension $\sim$ an energy density which by dimensional arguments is given by the top or Higgs masses.
- Our pearls - making up the dark matter, by our hypothesis - are bubbles of this new vacuum to which has been added ordinary matter under strong pressure in order to counteract the pressure from the domaine wall.

Sharp fall in transparancy at 3.5 keV



Refracting pearl

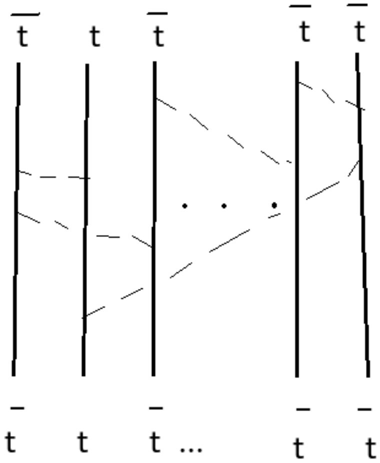

E e
EMPTY
3.5 keV
HOMO-
-LUMO-
GAP
FILLED


E
e
EMPTY
HOMO-
-LUMO-
GAP
3.5keV
FILLED

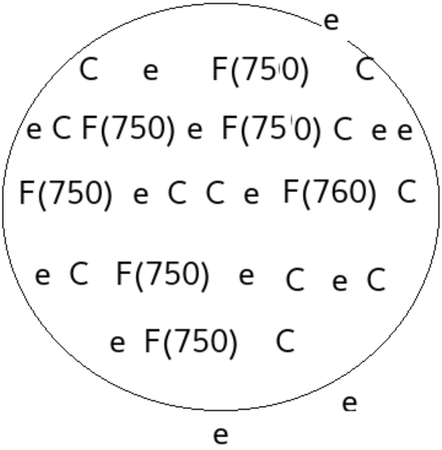
Higgs boson exchange binds top and antitop to make new vacuum

- The Higgs field is an **even order tensorfield** like the graviton field and like the latter make attracktion between ‘verything” tops and anti tops.
- The more tops and antitops you can put together the stronger they bind.
- But tops are feremions and Pauli principle limit to have more than 12 in same geometrical state.

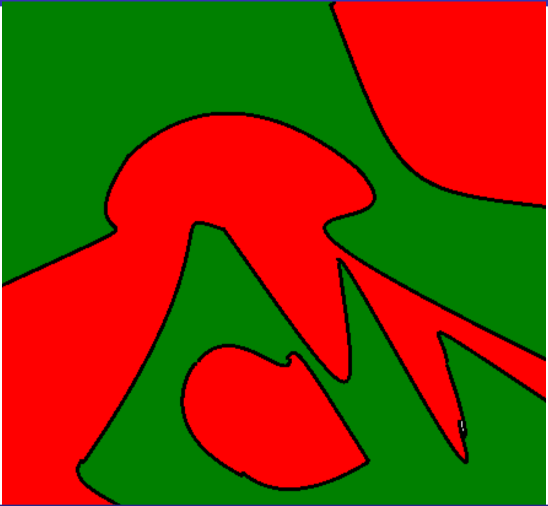
Diagram giving the binding of 12 topquarks to an "F(750)-digamma".



Inside the pearls: the bound states $F(750)$-digamma plus ordinary matter, e.g. carbon etc.



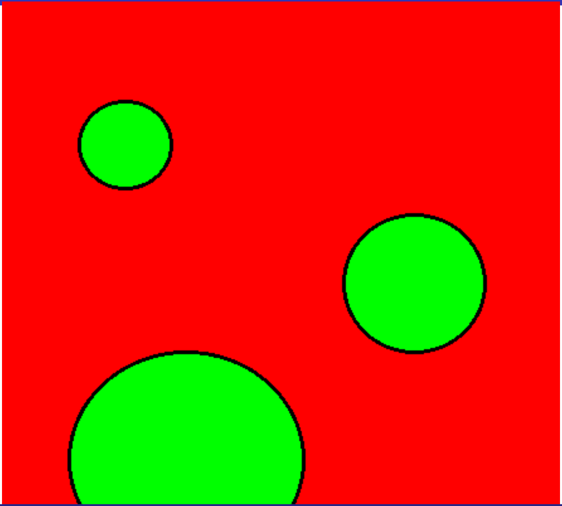
At Temperature over the scale of the walls many many walls arround



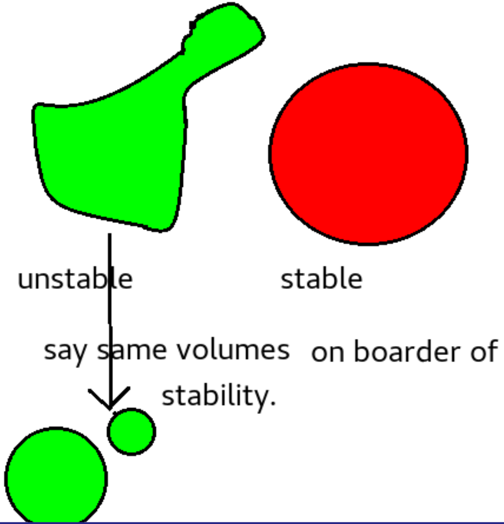
As times goes on the walls straighten out and one phase may disappear...?

- It is crucial that there is **no symmetry** - as say a spontaneously broken discrete symmetry - because that causes a catastrophic cosmology.
- With only degeneracy (MPP) there is some difference between the two or more phases(vacua) and one of them will win/take over.
- Only there is some special mechanism which can stabilize small pearls of one phase, will there survive a bit of both: In our case one phase has smaller Higgs expectation value (probably $< \psi >= 0$) and will attrackt the baryons say.
- Pearls sufficiently large that pressure is sufficiently low not to squeeze its baryons out will be stabilized and survive till today or longer.

Pearls Stabilized by Baryon and electron content get very Spherical



Only sufficiently big pearls survive



Typically $2^{4/9}\sqrt{4\pi}$ times formal minimal size needed

- Assuming the minimal energy to press a nucleon out ΔV and the tension in the domaine wall known one can estimate the minimal radius for stability.
- But to avoid breaking up in smaller pieces and thus getting unstable in the last moment a somewhat bigger size is needed.
- We estimate an reserve extra radius factor $\xi = 2^{4/9}\sqrt{4\pi}$ is needed.
  (in our first papers we ignored this factor, and only thought upon it after seeking to fit the 3.5 keV X-ray radiation intensity.)

Fry and Cline fitted data on the 3.5 keV X-ray from Dark Matter?

3

(1) Reference	(2) object	(3) ν mixing $\sin^2 2\theta_\nu$ $(\times 10^{-11})$	(4) fast decay $\langle\sigma v\rangle_f \cdot \left(\frac{10\,\mathrm{GeV}}{m_\chi}\right)^2$ $(10^{-22}\,\mathrm{cm^3 s^{-1}})$	(5) intermediate $\tau \sim 2\times10^6$y or 2×10^7y	(6) slow decay $\langle\sigma v\rangle_s \cdot \left(\frac{10\,\mathrm{GeV}}{m_\chi}\right)^2$ $(10^{-22}\,\mathrm{cm^3 s^{-1}})$	(7) v disp. $\langle\sigma_v\rangle$ (km/s)
Bulbul *et al.* [1]	clusters	6 ± 3	480 ± 250		1200 ± 600	975
Bulbul *et al.* [1]	Perseus	$(26-60)$	$(1400-3400)$		$(4000-15000)$	1280
Boyarsky *et al.* [2]	Perseus	$(55-100)$	$(1-2)\times10^5$		$(1-5)\times10^4$	1280
Urban *et al.* [8]	Perseus	$(20-100)$	$(2600-4100)$		$(1-2)\times10^4$	1280
Bulbul *et al.* [1]	CCO[a]	$(18-28)$	$(1200-2000)$		$(5100-8400)$	926
Boyarsky *et al.* [2]	M31	$(2-20)$	$(10-30)$, NFW $(30-50)$, Burkert	NFW $\rightarrow$ {unchanged; $(20-50)$}	$(370-970)$	116
Boyarsky *et al.* [4]	MW	$(10-30)$	$(0.1-0.7)$, NFW $(50-550)$, Burkert	NFW $\rightarrow$ {$(1-8)$; $(16-110)$}	$(400-3000)$	118
Riemer-Sørensen [3]	MW	$<(6-20)$	$<$ {$(0.15-1.1)$, NFW; $(80-1200)$, Burkert}	NFW $\rightarrow$ {$(2-12)$; $(24-170)$}	$<(200-2000)$	118
Anderson *et al.* [5]	galaxies	$<(2-5)$	$<(270-620)$		$<(170-420)$	100
Malyshev *et al.* [6]	dwarfs	$<(3-5)$	$<(0.2-0.3)$		$<(0.1-0.2)$	10
Bulbul *et al.* [1]	Virgo	$<(18-23)$	$<(380-670)$		$<(2.5-4.1)\times10^4$	643
Urban *et al.* [8]	Coma	$<(1.5-1.7)$	$<(130-200)$		$<(510-850)$	913

[a]Coma+Centaurus+Ophiuchus clusters

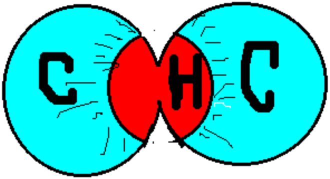
Table I: Column 3: best-fit values or upper limits on the sterile neutrino mixing angle, $\sin^2 2\theta$, assuming $\nu_s \rightarrow \nu\gamma$ for the 3.55 keV X-ray line. Column 4: corresponding values of the cross section for excited dark matter models with $\chi\chi \rightarrow \chi'\chi' \rightarrow \chi\chi\gamma\gamma$

Comparing $\frac{N\sigma}{M^2}$ to fitting of Fry and Cline

- In our model the 3.5 keV X-ray radiation comes out when two of the pearls collide out in the universe, and thus the intensity of the X-ray to be observed must be proportional to the cross section for two pearls colliding $\sigma = \pi(2R)^2$.
- It must of course also be proportional to the number of γ 's with 3.5 keV emitted per such collision N.
- For a given mass density of of the dark matter as estimated from its gravity of course the number density of pearls is proportional to the inverse mass per pearl $1/M$.
- Since the pearls shall meet to collide the rate of γ-rays must go as the **square** of the matter density and consequently as $1/M^2$.
- Thus the rate to be extracted from the fit to the observations is the combination $\frac{N\sigma}{M^2}$.

Radiation 3.5 keV comes after collissions

3.5 keV generation



3.5 keV X-ray radiates from the edge of the hot region through the cold one C out in the outer space arround the two having collided pearls.

Comparing the intensity proportional $\frac{N\sigma}{M^2}$ with data fit.

$$\frac{N\sigma}{M^2}|_{our\ predition} = 3 * 10^{23}\frac{cm^2}{kg^2}$$

$$\frac{N\sigma}{M^2}|_{from\ Fry\ and\ Cline} = (1.0 \pm 0.2) * 10^{23}\frac{cm^2}{kg^2}$$

Similarly:

$$\text{``}frequency\text{''}|_{our\ prediction} = \text{``}homolumo\ gap\text{''} = 1.5 \pm 1.1 keV$$

$$\text{``}frequency\text{''}|_{observed} = 3.5 keV$$

(We can only expect crude order of magnitude with our estimate.)

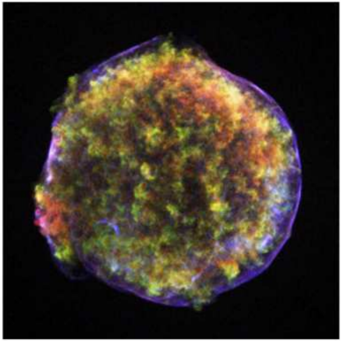
Motivation yet continued:

- Very strangely: If 3.5 keV radiation should come from big clusters of dark matter, it should NOT come **from a supernova-remnant**; but it wa seen from the Thyco Brahes super nova remnant!

In our model this may be explained by the cosmic **radiation** from the remnant of the supernova provides the pearls of ours with energy and then they radiate that out by the for excitons formed in their interior **characteristic** radiation **frequency 3.5 keV.**

Systematics?

Tycho Supernova Remnant



Credit: NASA/CXC/Rutgers/Warren, Hughes et al.

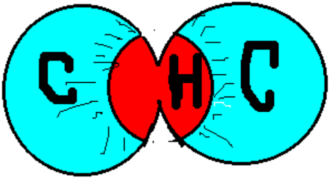
175 ksec XMM observations

Line at 3.55 keV detected:

- potassium with high abundance?
- systematics in line flux?
- *NOT dark matter*

Jeltema & Profumo 2015

3.5 keV generation



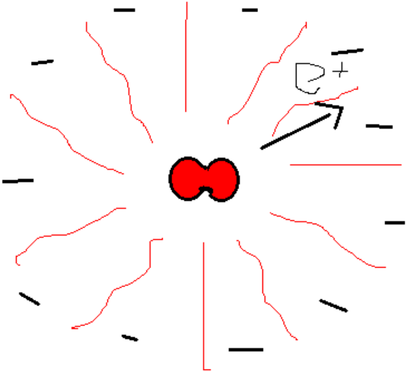
3.5 keV X-ray radiates from the edge of the hot region through the cold one C out in the outer space arround the two having collided pearls.

Qualitatively about the positrons and γ-rays from Dark matter.

- When two of our dark matter pearls collide and the skin/ the domain wall arround them contract with high tension a spot is heated to about MeV temperatures, and the in the pearl degenerate **electrons** are in large amounts **spit out**.
- Some of the electrons may run out to long distnce from the two having united pearls and they will create an electic field able to accelerate positrons, at first estimate up to a few MeV energies, but a few will get much more.

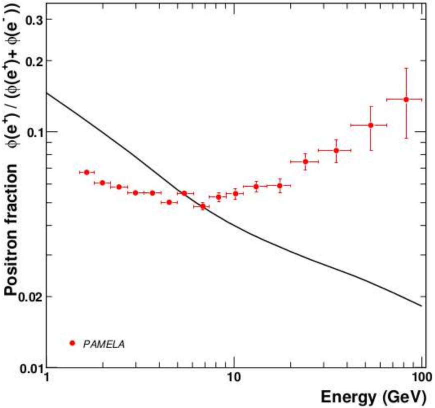
About positron to gamma ray ratio (continued)

- In any model with positrons being produced and accellerated such positrons will shake off γ-rays / light.
- The emission of such light has an intesity proportional to the square of the acceleration of the charged particle, here the positron.
- In "usual" dark matter models - a particle decaying producing the positron - the positron is accelerated over a very short distance, effectively given by the mass of the particle and quantum mechanics.
- In our model the acceleration takes place over a distance given by the extend of the from the explosion made extension of an electron cloud. At least it is "macroscopic"



Positrons accelerated over long distance relative to positrons from a decay.

PAMELA positrons versus theory of background



Data on Positrons

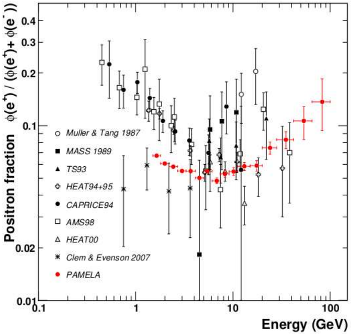


FIG. 3: **PAMELA positron fraction with other experimental data.** The positron fraction measured by the PAMELA experiment compared with other recent experimental data[24, 29, 30, 31, 32, 33, 34, 35]. One standard deviation error bars are shown. If not visible, they lie inside the data points.

- “Production and propagation of cosmic-ray positrons and electrons”, I.V. Moskalenko 1 and A.W. Strong Max-Planck-Institut f ur Extraterrestrische Physik, Postfach 1603, D-85740 Garching, Germany; arXiv:astro-ph/9710124v1 13 Oct 1997

Time needed for positron production

To have time enough for producing 10^{-14} times as much energy in positrons as the energy of the dark matter itselfwith a transformation rate "Eff. Decay rate" $= 4 * 10^{-30}s^{-1}$ one needs a time $t_{needed} = \frac{10^{-14}}{4*10^{-30}s^{-1}} = \frac{1}{4} * 10^{16}s$.
Luckily for the possibility of our model being able to explain the positrons comming from the dark matter this needed time $t_{needed} = \frac{1}{4} * 10^{16}s$ is 40 times smaller than the age of the universe, which is $10^{17}s$ (= the 13 milliard years).
But this means the survival time for positrons having been produced by the collissions of the dark matter should be at the very least 1/40 of the age of the universe, and if not all energy from the collissions should go into positrons, it should be even longer!

Positron Excess could be realized in Our Model for Dark Matter.

- If the "fraction of energy going to positrons in the collissions" times "the fraction of the universe age the positrons can keep on running arround in the neighborhood" can be bigger than $\sim 1/40$, then the observed positron excess could match our dark matter model.
- Usually a problem: γ-rays from dark matter adjusting to the positron rate gets predicting too high. It may be quite complicated and model dependent to obtain our γ-ray prediction relative to the positron production, but **because the positrons in our model are accelerated over much longer - basically macroscopic distances - distances than in simple WIMPs or the like decaying or annihilating type of models, we get much smaller acceleration square for the positrons than the "usual" type of models.**

Propaganda for "Multiple Point (Criticallity) Principle"(=MPP).

- PREdiction We - CDF and HBN - **PREdicted** the mass of the Higgs boson, before it were found form **MPP**.
- Phenomenology In some models we have **success** phenomelogically: E.g. PREdited the number of families. The top-yukawa coupling $g_t = 1.02 \pm 14\%$ agrees $g_t = 0.935$. Scale problem: Why Higgs mass $<<$ say Planck scale?
- Theory In global time perspective **theretical predictions**.

Our Multiple Point Principle Symbolized by Sluch (Ice and water together)

- arXiv:1411.2097v2 [hep-ph] 25 Feb 2015 “Multiple Point Principle of the Standard Model with Scalar Singlet Dark Matter and Right Handed Neutrinos” Kiyoharu Kawana
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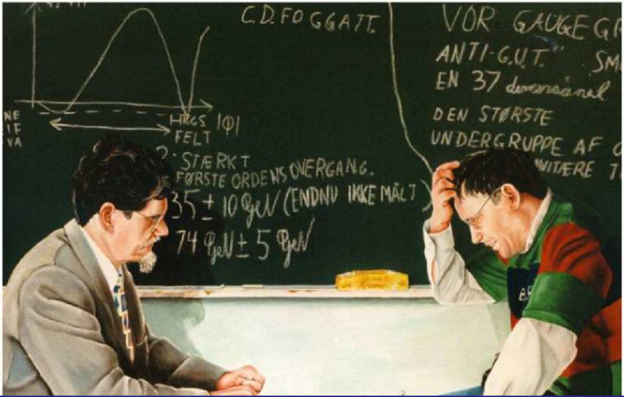
PREdicted Higgs mass

kunstmaler lars andersen http://www.23.dk/skak.htm

Lars Andersen

Historiemaler Portrætmaler Provokunstner Om Lars Andersen CV/omtale Kontakt



Gia Dvali proves that vacua of different energy density forbidden!

Dvali's abstract:
We give a simple argument suggesting that in a consistent quantum field theory tunneling **from Minkowski to a lower energy vacuum must be impossible.** Theories that allow for such a tunneling also allow for localized states of **negative mass**, and therefore, should be **inconsistent**.

Gia Dvali, "Safety of Minkowski Vacuum" arXiv:1107.0956v1 [hep-th] 5 Jul 2011

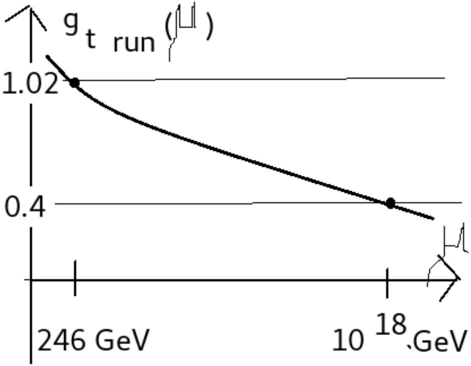
Don Bennett, Froggatt and I started with fixing Extensive quantities(say energy)

That gives microcanonical ensemble and often there will be two phases, and therefore equilibrium only at the phase transition point in say temperature (if we fixed the energy of the whole sample). This where the sklush comes in. If slush, the temperature must be zero.

But truly to get the fourdimensional model we must fix some space time integrals of Lagrangelike field expressions $\mathcal{L}_i(x)$,

$$\begin{aligned} \int \mathcal{L}_1(x) d^4x &= fixed_1 \\ \int \mathcal{L}_2(x) d^4x &= fixed_2 \\ &\vdots \end{aligned}$$

Scale-problem (similar hierarchy problem ?).



MPP enforces g_t to be 1.02 and 0.4 at respectively weak and ``Planck'' scales.

Scale problem ($\sim$ hierarchy problem ?)

- Also in our picture including the "multiple point (criticallity) principle" the Higgs mass square obtains huge **quadratic divergent** and/or finite terms, when loops are evaluated !
- **BUT** these terms are renormalized to a **theoretical** requirement of keeping the vacua degenerate.
- So the bare Higgs mass square is **tuned in exactly** to cancel the corrections by **"Multiple point principle"**.
- It is not the same as getting rid of them, as would say SUSY, but it has the same effect and makes the **getting rid** of them **superfluous.**

Conclusion

- We have presented a picture/model for
  - **Dark Matter** as 100000 ton, 6 cm big pearls.
  - Explaining the ratio of the weak to the "Planck scale"
  - Earlier **pre**dicted the Higgs mass (in terms of the expectation value) to 135 GeV $\pm$ 10 GeV, which would now be 129 GeV deviating by 3 s.d. though.

  using **only** Standard Model and "Multiple point (criticallity) principle", which only **adds information** about the parameters of the Standard Model.
- The dark matter model is very successful by matching the unsafe astronomical observations in addition to the gravitational effects:
  - The 3.5 keV X-ray radiation in intensity and frequency.
  - The positron emission,
  - The broader γ ray especially the ratio to the positrons, which is in other models a bit of a problem

Plan for Dark Matter:

- Intro Introduction.
- Model Our model of dark matter pearls,
- Collide Picturing colliding pearls, heat spreading.
- Walls Walls in cosmology giving neutrinoes etc. and contracting...
- DAMA Can we interprete DAMA-effect as due to neutrinoes from walls ?

Dark Matter in Only Standard Model (except MPP)

Contrary to everybody else, except for the poeple with primordial black holes for dark matter, we want to propose a dark matter model **inside Standard Model**, only with a certain assumption about the coupling constants in the Standard Model, that there are several vacua with finetuned same energy density. So:

- We assume a law of nature - of a bit unusual kind- "Multiple Point Principle" saying: there are **several** different **vacuum phases**, and they all have the **same energy density** (or we can include that they have ~ 0 energy density.)
- Apart then from me mentioning some attempt mainly with Yasutaka Takanishi of explaining the baryon excess, we shall use **only Standard Model**, even for dark matter!

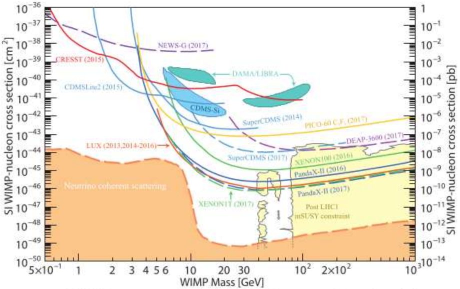


Figure 26.1: WIMP cross sections (normalized to a single nucleon) for spin-independent coupling versus mass. The DAMA/LIBRA [72], and CDMS-Si enclosed areas are regions of interest from possible signal events. References to the experimental results are given in the text. For context, the black contour shows a scan of the parameter space of 4 typical SUSY models, CMSSM, NUHM1, NUHM2, pMSSM10 [73], which integrates constraints set by ATLAS Run 1.

Argon for example).

In summary, the confused situation at low WIMP mass has largely been cleared up (with the notable exception of the DAMA claim). Liquid noble gas detectors have achieved large progress in sensitivity to spin independent coupling WIMPs without seeing any hint of a signal. A lot of progress has also been achieved by the PICO experiment for spin dependent couplings. Many new projects focus on the very low mass range of 0.1-10 GeV. Sensitivities down to $\sigma_{\chi p}$ of 10^{-13} pb, as needed to probe nearly all of the MSSM parameter space [39] at WIMP masses above 10 GeV and to saturate the limit

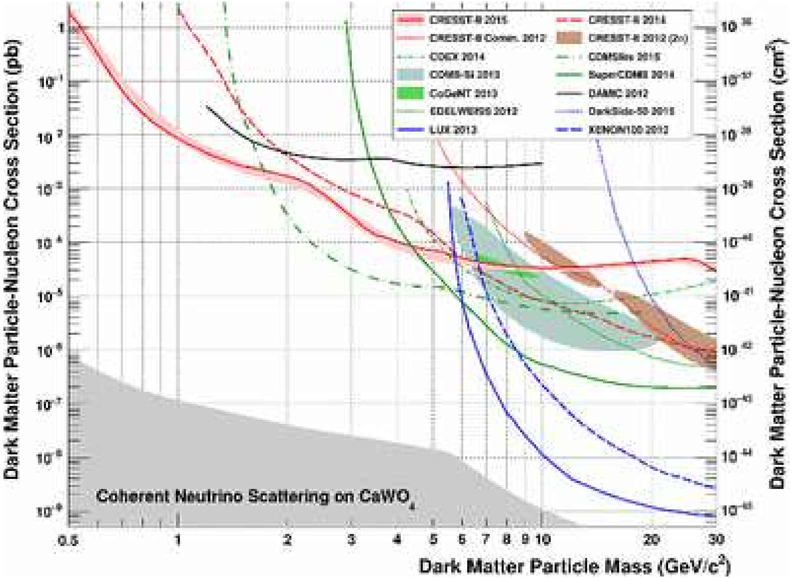
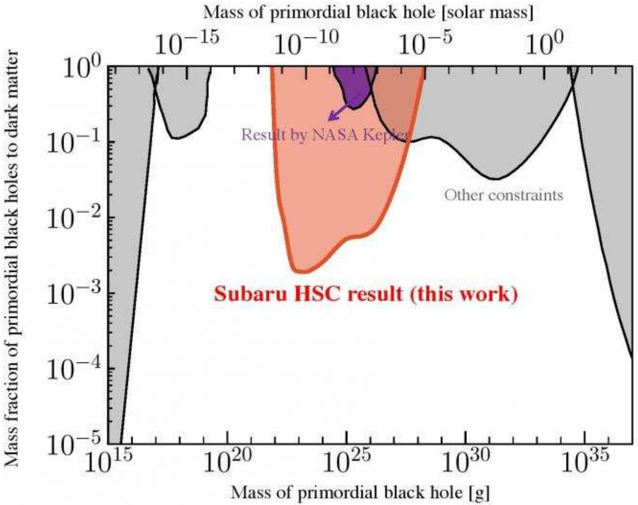

CRESST-II 2015
CRESST-II Comm. 2012
CDEX 2014
CDMS-Si 2013
CoGeNT 2013
EDELWEISS 2012
LUX 2013
CRESST-II 2014
CRESST-II 2012 (2σ)
CDMSlite 2015
SuperCDMS 2014
DAMIC 2012
DarkSide-50 2015
XENON100 2012
Dark Matter Particle-Nucleon Cross Section (pb)
Dark Matter Particle-Nucleon Cross Section (cm²)
Coherent Neutrino Scattering on CaWO₄
0.5 1 2 3 4 5 6 7 8 9 10 20 30
Dark Matter Particle Mass (GeV/c²)

Figure caption on Dark matter mass: Parameter space for elastic spin-independent dark matter-nucleon scattering. The result from the analysis presented in [5] is drawn in solid red together with the expected sensitivity (1σ confidence level (C.L.)) from a data-driven background-only model (light red band). The remaining red lines correspond to previous CRESST-II limits [4, 10]. The favored parameter space reported by CRESST-II phase 1 [11], CDMS-Si [12] and CoGeNT [13] are drawn as shaded regions. For comparison, exclusion limits (90 % C.L.) of the liquid noble gas experiments [14, 15, 16] are depicted in blue, from germanium and silicon based experiments in green [17, 18, 19, 20, 21]. In the gray area coherent neutrino nucleus scattering, dominantly from solar neutrinos, will be an irreducible background for a CaWO 4 -based dark matter search experiment [22].


Mass of primordial black hole [solar mass]
10^{-15} 10^{-10} 10^{-5} 10^{0}
Mass fraction of primordial black holes to dark matter
10^{0} 10^{-1} 10^{-2} 10^{-3} 10^{-4} 10^{-5}
Result by NASA Kepler
Other constraints
Subaru HSC result (this work)
10^{15} 10^{20} 10^{25} 10^{30} 10^{35}
Mass of primordial black hole [g]

Motivation for Our Mouse size dark matter model:

- Remarkably: **No sign of deviations from Standard Model** except neutrino oscillations and cosmological and fine tuning problems,and then ca. 5 almost not significant **anomalies** e.g violation of lepton flavour universality in B-decay (which I last year suggested to be due to **non-perturbative effects**, so that still Standard Model).
- Remarkably: **No** experiment looking for **dark matter impacts found** any, **except for DAMA**, which seemingly is in contradiction with the other experiments inside conventional models.

So seemingly dark matter with masses in the LHC and Lux, ... etc. range seem to be more and more excluded. Our model is built on ONLY Standard Model (except for MPP).

More motivation for our mouse size dark matter pearl model:

- Dark matter seems to emmit both positrons **(the positron excess from PAMELA)** and γ-rays, but **not** in the **ratio** $\#\gamma/\#e^+$ suggested by a **WIMP decaying** model. rather a slower acceleration like in a macroscopic electric field is called for.

Our model has colliding pearls surrounded by an extended electron and positron remnant plasma.

Motivation for our dark matter model further:

- "In the long run" (= in principle) we only use Standard Model but calculate **non-perturbatively**, so there should be no need for fitting parmeters; but in pracsis we cannot calculate non-perturbatively, so we have to **fit a bit**. (If time, I shall tell how we fit a little bit.)
- Only using fitting to the Tunguska event, and improving our theoretical guesses we **fit or rather predict** the **order of magnitudes** of the **frequency 3.5 keV and the intensity** of the 3.5 keV X-ray radiation suspected to be connected with dark matter.

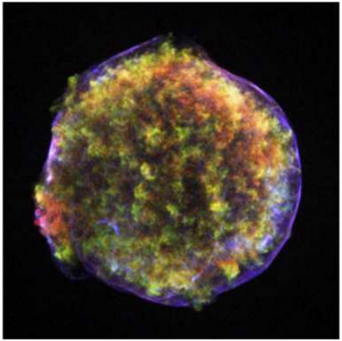
Motivation yet continued:

- Very strangely: If 3.5 keV radiation should come from big clusters of dark matter, it should NOT come **from a supernova-remnant**; but it wa seen from the Thyco Brahes super nova remnant!

In our model this may be explained by the cosmic **radiation** from the remnant of the supernova provides the pearls of ours with energy and then they radiate that out by the for excitons formed in their interior **characteristic** radiation **frequency 3.5 keV.**

Systematics?

Tycho Supernova Remnant



Credit: NASA/CXC/Rutgers/Warren, Hughes et al.

175 ksec XMM observations

Line at 3.55 keV detected:

- potassium with high abundance?
- systematics in line flux?
- *NOT dark matter*

Jeltema & Profumo 2015

Propaganda for "Multiple Point (Criticallity) Principle"(=MPP).

- PREdiction We - CDF and HBN - **PREdicted** the mass of the Higgs boson, before it were found form **MPP**.
- Phenomenology In some models we have **success** phenomelogically: E.g. PREdited the number of families. The top-yukawa coupling $g_t = 1.02 \pm 14\%$ agrees $g_t = 0.935$. Scale problem: Why Higgs mass $<<$ say Planck scale?
- Theory In global time perspective **theretical predictions**.

Our Multiple Point Principle Symbolized by Sluch (Ice and water together)

- arXiv:1411.2097v2 [hep-ph] 25 Feb 2015 "Multiple Point Principle of the Standard Model with Scalar Singlet Dark Matter and Right Handed Neutrinos" Kiyoharu Kawana
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Y. Hamada, H. Kawai and K. y. Oda, Predictions on mass of Higgs portal scalar dark matter from Higgs inflation and flat potential, JHEP 1407, 026 (2014) [arXiv:1404.6141 [hep-ph], arXiv:1404.6141].

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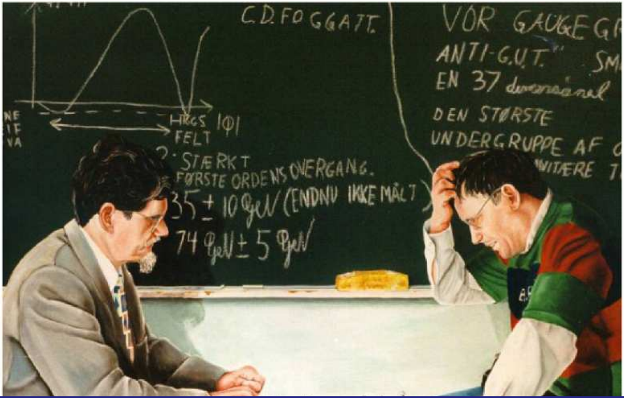
PREdicted Higgs mass

kunstmaler lars andersen http://www.23.dk/skak.htm

Lars Andersen

Historiemaler Portrætmaler Provokunstner Om Lars Andersen CV/omtale Kontakt



Gia Dvali proves that vacua of different energy density forbidden!

Dvali's abstract:
We give a simple argument suggesting that in a consistent quantum field theory tunneling **from Minkowski to a lower energy vacuum must be impossible.** Theories that allow for such a tunneling also allow for localized states of **negative mass**, and therefore, should be **inconsistent**.

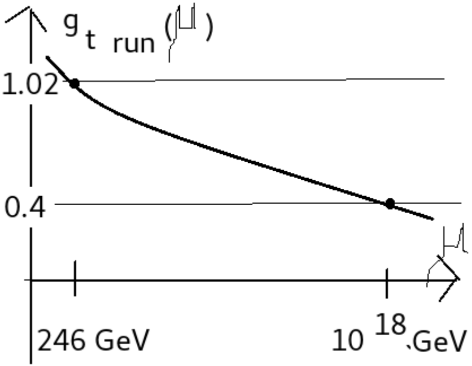
Gia Dvali, "Safety of Minkowski Vacuum" arXiv:1107.0956v1 [hep-th] 5 Jul 2011

Don Bennett, Froggatt and I started with fixing Extensive quantities(say energy)

That gives microcanonical ensemble and often there will be two phases, and therefore equilibrium only at the phase transition point in say temperature (if we fixed the energy of the whole sample).
This where the sklush comes in. If slush, the temperature must be zero.
But truly to get the fourdimensional model we must fix some space time integrals of Lagrangelike field expressions $\mathcal{L}_i(x)$,

$$\begin{aligned} \int \mathcal{L}_1(x) d^4x &= fixed_1 \\ \int \mathcal{L}_2(x) d^4x &= fixed_2 \\ &\vdots \end{aligned}$$

Scale-problem (similar hierarchy problem ?).

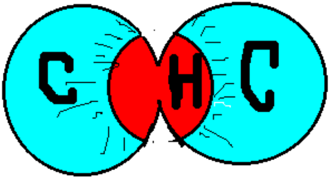


MPP enforces g_t to be 1.02 and 0.4 at respectively weak and ``Planck'' scales.

Scale problem ($\sim$ hierarchy problem ?)

- Also in our picture including the "multiple point (criticallity) principle" the Higgs mass square obtains huge **quadratic divergent** and/or finite terms, when loops are evaluated !
- **BUT** these terms are renormalized to a **theoretical** requirement of keeping the vacua degenerate.
- So the bare Higgs mass square is **tuned in exactly** to cancel the corrections by **"Multiple point principle"**.
- It is not the same as getting rid of them, as would say SUSY, but it has the same effect and makes the **getting rid** of them **superfluous.**

3.5 keV generation



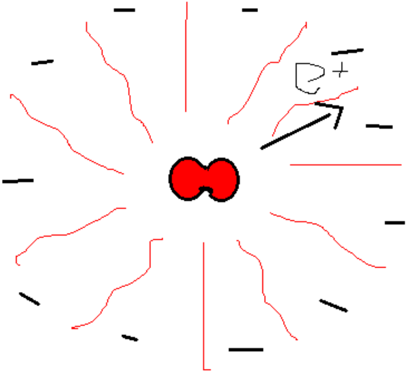
3.5 keV X-ray radiates from the edge of the hot region through the cold one C out in the outer space arround the two having collided pearls.

Qualitatively about the positrons and γ-rays from Dark matter.

- When two of our dark matter pearls collide and the skin/ the domain wall arround them contract with high tension a spot is heated to about MeV temperatures, and the in the pearl degenerate **electrons** are in large amounts **spit out**.
- Some of the electrons may run out to long distnce from the two having united pearls and they will create an electic field able to accelerate positrons, at first estimate up to a few MeV energies, but a few will get much more.

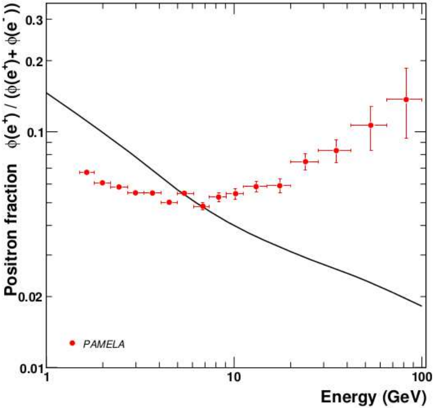
About positron to gamma ray ratio (continued)

- In any model with positrons being produced and accellerated such positrons will shake off γ-rays / light.
- The emission of such light has an intesity proportional to the square of the acceleration of the charged particle, here the positron.
- In "usual" dark matter models - a particle decaying producing the positron - the positron is accelerated over a very short distance, effectively given by the mass of the particle and quantum mechanics.
- In our model the acceleration takes place over a distance given by the extend of the from the explosion made extension of an electron cloud. At least it is "macroscopic"



Positrons accelerat ed over long distance relative to positrons from a decay.

PAMELA positrons versus theory of background



Data on Positrons

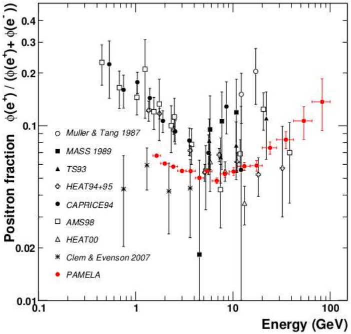


FIG. 3: **PAMELA positron fraction with other experimental data.** The positron fraction measured by the PAMELA experiment compared with other recent experimental data[24, 29, 30, 31, 32, 33, 34, 35]. One standard deviation error bars are shown. If not visible, they lie inside the data points.

"Production and propagation of cosmic-ray positrons and electrons", I.V. Moskalenko 1 and A.W. Strong
Max-Planck-Institut f ur Extraterrestrische Physik, Postfach 1603, D-85740 Garching, Germany;
arXiv:astro-ph/9710124v1 13 Oct 1997

$I(E)_e = 3.2 * 10^{-8} cm^{-2} s^{-1} sr^{-1} MeV^{-1}$ at 9 GeV.

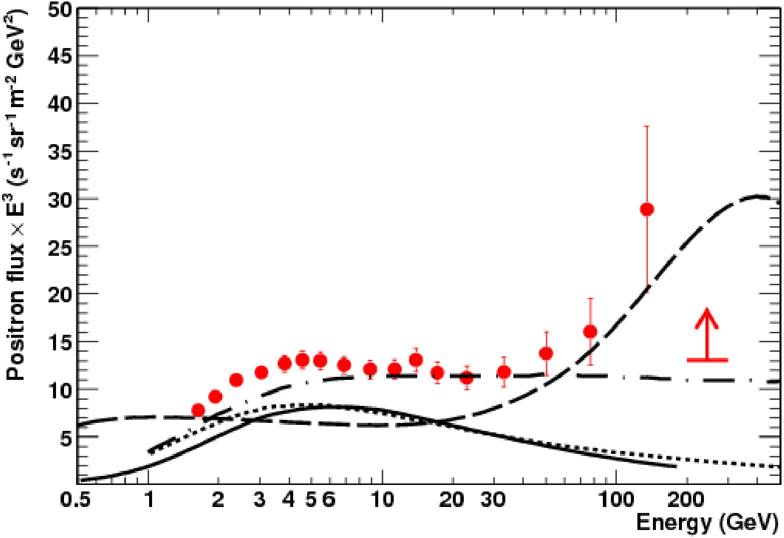
From next figure we see that for $E = 9GeV$ of a positron the

$$\text{“Positron rate”} = I(E = 9GeV)_{e^+} = \frac{12 s^{-1} sr^{-1} m^{-2} GeV^2}{E^3}$$
$$= \frac{12}{729} s^{-1} sr^{-1} m^{-2} GeV^{-1}$$
$$= 1.6 * 10^{-2} s^{-1} sr^{-1} m^{-2} GeV^{-1}$$
$$= 1.6 * 10^{-9} s^{-1} sr^{-1} cm^{-2} MeV^{-1}$$

At $E = 9GeV$ the ratio

$$\frac{I_{e^+}}{I_{e^-} + I_{e^+}} = 0.05$$

$0.05^{-1} * 1.6 * 10^{-9} s^{-1} sr^{-1} cm^{-2} MeV^{-1}$ just matches $3.2 * 10^{-8} s^{-1} sr^{-1} cm^{-2} MeV^{-1}$.


Positron flux × E³ (s⁻¹ sr⁻¹ m⁻² GeV²)
50
45
40
35
30
25
20
15
10
5
0.5
1
2
3
4
5
6
10
20
30
100
200
Energy (GeV)

Excess of Positrons

To get some numbers let us say that

$$\begin{aligned} \text{In a range:} & \quad 30GeV \text{ to } 150GeV \\ I_{e^+} \text{ is shifted} & \quad 12 \text{ to } 16E^{-3}s^{-1}sr^{-1}m^{-2}GeV^2 \text{by the ``excess''}. \\ \text{So:}Excess &= 4E^{-3}s^{-1}sr^{-1}m^{-2}GeV^2, \qquad (1) \end{aligned}$$

and at least an excess energy

$$\begin{aligned} \text{``excess energy''} &= \int_{30GeV}^{150GeV} \frac{4s^{-1}sr^{-1}m^{-2}GeV^2 * E}{E^3} dE \\ &= \left[-\frac{4s^{-1}sr^{-1}m^{-2}GeV^2}{E} \right]_{30GeV}^{150GeV} \\ &\approx 0.1s^{-1}sr^{-1}m^{-2}GeV \qquad (2) \end{aligned}$$

Energy density of Excess positrons

$0.1 s^{-1} sr^{-1} m^{-2} GeV$ translates for positrons moving with speed of light into an energy density due to excess positrons
$0.03 * 10^{-8} sr^{-1} m^{-3} GeV = 3 * 10^{-10} sr^{-1} m^{-3} GeV$.
This is when integrated over the whole sphere of 4π:
$4 * 10^{-9} m^{-3} GeV = 4 * 10^{-15} cm^{-3} GeV$
And that is 10^{14} times smaller than the density of dark matter $\rho_{DMsun} = 0.3 GeV/cm^3$ in our neighborhood.

If we have at least an excess of positrons comming from dark matter which is present with an energy density $\sim 10^{14}$ times smaller than the corresponding density of the dark matter itself in the associated region, then the rate of decay or annihilation or effective transformation to positrons over the survivel time for the high energy positrons must be 10^{-14}.
Now rate of collission of one of our pearls with another one is of the order

$$\begin{aligned} \text{"Rate of collission" for pearl} &= v * \frac{\rho_{DMsun}\pi(2R)^2}{\rho_B} \\ &= 200km/s\frac{0.3GeV/cm^3\pi(2*3.9cm)^2}{1.4*10^8 kg} \\ &= \frac{2*10^7 cm/s*0.3GeV/cm^3*200cm^2}{2*10^{35}GeV} \\ &= 6*10^{-27}s^{-1} \end{aligned}$$

where we used $1kg = 6*10^{26}GeV$.

Decay rate relative to Einstein energy Mc^2

Believing the the released energy E_S from the surface contraction once a couple of the pearls collide is

$$E_S = 0.065\% \text{ of } M_B c,$$

where M_B is the mass of one pearl a collission rate $6 * 10^{-27} s^{-1}$ means that the decay rate of the Einstein energy effectively is

$$\begin{aligned} \text{“Eff. Decay rate”} &= 6 * 10^{-27} \frac{E_S}{M_B c^2} \\ &= 4 * 10^{-30} s^{-1} \end{aligned}$$

Time needed for positron production

To have time enough for producing 10^{-14} times as much energy in positrons as the energy of the dark matter itselfwith a transformation rate "Eff. Decay rate" $= 4 * 10^{-30} s^{-1}$ one needs a time $t_{needed} = \frac{10^{-14}}{4*10^{-30} s^{-1}} = \frac{1}{4} * 10^{16} s$.
Luckily for the possibility of our model being able to explain the positrons comming from the dark matter this needed time $t_{needed} = \frac{1}{4} * 10^{16} s$ is 40 times smaller than the age of the universe, which is $10^{17} s$ (= the 13 milliard years).
But this means the survival time for positrons having been produced by the collissions of the dark matter should be at the very least 1/40 of the age of the universe, and if not all energy from the collissions should go into positrons, it should be even longer!

Radiation goes as acceleration squared of the charged object.

So:

- If acceleration of the positron say in our model takes place through a macroscopically big cloud created by strongly expelled electrons from the contraction explosion, then the acceleration is much smaller than
- if the positron is produced in a particle reaction - a decay or annihilation - taking place strictly speaking in a point (but in reality in some region of a size determined from quantum mechanics effects). So in such a particle decay model for the γ-ray radiation you get much more γ-rays relative to the amount of positrons, than in our model.

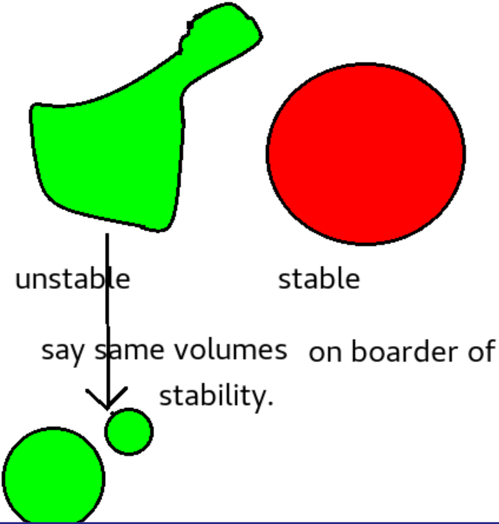
Positron Excess could be realized in Our Model for Dark Matter.

- If the "fraction of energy going to positrons in the collissions" times "the fraction of the universe age the positrons can keep on running arround in the neighborhood" can be bigger than $\sim 1/40$, then the observed positron excess could match our dark matter model.
- Usually a problem: γ-rays from dark matter adjusting to the positron rate gets predicting too high. It may be quite complicated and model dependent to obtain our γ-ray prediction relative to the positron production, but **because the positrons in our model are accelerated over much longer - basically macroscopic distances - distances than in simple WIMPs or the like decaying or annihilating type of models, we get much smaller acceleration square for the positrons than the "usual" type of models.**

Parameters of Our model for Dark Matter

The parameters of our model picture of the Tunguska particle as a ball of a new type of vacuum with a bound state condensate, filled with ordinary white dwarf-like matter and on the borderline of stability.

Fitting inspired correction of theoretical mistake:



Lower limit for stability of a pearl

For a given skin tension S (we have two ways of estimating the third root of the tension of the skin of the pearls From condensate $S^{1/3} \sim 16GeV$ and fitting to among others Tunguska event rate: in old fit $S^{1/3} \sim 28GeV$ and in new $S^{1/3} \sim 4.8GeV$) the pressure from the inside material needed to keep the ballance is

$$P \sim \frac{S}{R}. \quad (3)$$

With a potential step for a nucleon to pass out of the pearl $\Delta V \sim 10MeV$ or after our little correction also $\Delta V \sim 10MeV$ there will be a minimal size of the pearl for it to be stable. We assumed originally that roughly all the pearls had just the radius R equal to this stability bound. **But inspired by the fitting of the intesity of the 3.5 keV line, we found out that most only barely above the bound of stability pearls would decay.** This we made into a theoretical correction by a factor $2^{4/9}\sqrt{4\pi}$.

Table of parameters, Dark Matter Model

Nr.	Name	symbol	old new
1.	Time Interval of impacts	r_B^{-1}	200 years kept
2.	Rate of impacts	r_B	$1.5 * 10^{-8} s^{-1}$ kept
3.	Dark matter density in halo	ρ_{halo}	$0.3\ GeV/cm^3$ kept
4.	Dark matter solar system	$\approx 2\rho_{halo}$	$0.6 GeV/cm^3$ kept
5.	Mass of the ball	m_B	$1.4 * 10^8$ kg =140000ton $= 7.9 * 10^{40} \frac{keV}{c^2}$ kept

Parameter table (continued)

Nr.	Name	symbol	old new
6.	Typical speed of ball	v	160 km/s kept
7.	Kinetic energy of ball	T_v	$1.8 * 10^{18}$ J= 430 Mton TNT kept
8.	Energy observed, Tunguska	$E_{Tunguska}$	$(4 - 13) * 10^{16}$ J= 10 - 30 Mton TNT
9.	Potential shift between vacua	ΔV	10 MeV kept

Parameter table continued

Nr.	Name	symbol	old new
10.	$\sqrt[3]{tension}$(fit)	$S^{1/3}$	28 GeV 4.8 GeV
11.	$\sqrt[3]{tension}$(condensate)	$S^{1/3}$	16 GeV kept
12.	Ball density	ρ_B	$1.0 * 10^{14} \frac{kg}{m^3}$ $5.2 * 10^{11} \frac{kg}{m^3}$
13.	Radius of ball	R	0.67 cm 3.9 cm
14.	homolumo gap	$E_{HW} = E_H$	8.8 ± 6.2keV 1.5 ± 1.1keV

Parameter table continued

Nr.	Name	symbol	old new
15.	Frequency	$3.5 keV$	3.5 keV -
16	Released energy	E_S	$0.38\% Mc^2 =$ $=3.0 * 10^{38} keV$ $0.065\ \%\ Mc^2 =$(**??**) $5.1 * 10^{37} keV$
17.	# 3.5's if all→ 3.5	$N_{\text{all}\to\ 3.5} = \frac{E_S}{3.5 keV}$	$6 * 10^{37}$ $1.1 * 10^{37}$
18.	# 3.5's	$N = \frac{t_{spread}}{t_{raddiation}} * *N_{\text{all}\to 3.5}$	$2 * 10^{34}$ $1.0 * 10^{37}$

Parameter table continued

Nr.	Name	symbol	old new
19.	cross section, balls	$\sigma = \pi(2R)^2$	$5.8 cm^2$ $200\ cm^2$
20.	cross section per γ as if all$\rightarrow$ 3.5	$N_{all \rightarrow 3.5}\sigma$	$3.5 * 10^{38} cm^2$ $2.2 * 10^{39} cm^2$
21.	cross section per γ (with time ratio)	$N\sigma$	$1.1 * 10^{35} cm^2$ $4.6 * 10^{39} cm^2$
22.	σ per γ per M^2 (as if all $\rightarrow$ 3.5)	$\frac{N\sigma}{M^2}\|_{all \rightarrow 3.5}$	$2.6 * 10^{22} \frac{cm^2}{kg^2}$ $1.5 * 10^{23} \frac{cm^2}{kg^2}$
23.	σ per γ per M^2 (with time ratio)	$\frac{N\sigma}{M^2} = \frac{t_{spread} N_{all\ \rightarrow\ 3.5}\sigma}{t_{radiation} M^2}$	$9 * 10^{18} \frac{cm^2}{kg^2}$ $3 * 10^{23} \frac{cm^2}{kg^2}$

Parameter table continued

Nr.	Name	symbol	old new
24.	Spreading time	t_{spread}	$1.4 * 10^{-1}$ s 4.8s
25.	Corrected Spread time for $T \approx 3.5 keV$	$t_{cor.spr.} =$ $= t_{spread} * \frac{2}{6.9}$	$4.1 * 10^{-2}$ s 1.4 s
26.	Radiation time	$t_{radiation}$	430 s 2.1 s
27.	Ratio	$\frac{t_{spread}}{t_{radiation}}$	$\frac{1}{3000}$ 2.3
28.	Fit to Cline and Frey (including Boost corr.)	$\frac{N\sigma}{M^2}$	$(1.0 \pm 0.2)10^{23} \frac{cm^2}{kg^2}$ -(**??**, **??**)

Parameter table continued

Nr.	Name	symbol	old new
29.	Radius/critical R (fitted)	$\xi = R/R_{crit}$	1 5.9
30.	Radius/ critical R (speculated)	$\xi = 2^{4/9}\sqrt{4\pi}$	- 4.82
31.	Heat conductivity	$k = \frac{c^2 p_f^2}{85\alpha}$	600 $\frac{MeV^2}{c}$ 25 $\frac{MeV^2}{c}$ (??-??)

Explanations of the table

Let us here shortly review the concepts given and explain the table above: First column contains the short name of the quantity given in our model, and the third column is the formula expression for it. The fourth and the fifth columns contain suggested numerical order of magnitude values for the quantity in question: The fourth gives the value obtained with the old numbers from our previous publication [**?**], so that what could be gotten from these numbers could be considered in some sense "pre"diction.

Explanation of table (continued)

These old numbers were based in some cases on the hypothesis, that the **size of the typical pearl is such that it is just on the borderline of stability towards collapsing by the matter/nuclei inside being spit out under the pressure.** This hypothesis will, however, by nearer thinking be seen not be realistic and the actual radius R_{actual} of a pearl is instead taken to be a fitting parameter ξ times larger than the in the old work used borderline radius.

Table explanation, fitting the radius parameter ξ

Then we fit this scale parameter ξ to deliver the experimentally found intensity of the 3.5 keV X-ray radiation. This of course means that we have given up predicting the intensity of the radiation better than what we got by the old numbers in column four, which give the intensity predicted to be a factor 40000 too low compared to the fit to the Cline and Frey work.

We write the after fitting ξ numbers one line lower.

Under the number of the original numbers we put the numbers as gotten using this fit to the intensity. Predicting though is not fully given up in as far as we in subsection **??** seek to obtain the **theoretical expectation for the average radius adjusting parameter ξ to $2^{4/9}\sqrt{4\pi} = 4.8$.** In the sixth column we give a few references to formulas in the text.

Now a short review of the rows in the table:

- 1. The interval r_B^{-1} between successive impacts of our pearls on the earth as estimated from fact that so far only one "Tunguska impact" with the same slightly mysterious properties has been observed, except perhaps the Sodom and Gomorrah event known from the bible.
- 2. Just the inverse of $r_B^{-1} = r_B$.

Dark matter densities as input from astronomi

- 3. The dark matter mass density ρ_{halo} in the halo in the neighborhood of our sun on a kpc scale but away from us on a scale of the order of the solar system, It is such densities, that determine the influence of the dark matter on the motion of the stars and galaxies and it is thus an astronomically measured quantity. We use it together with the rate r_b to determine - after minor corrections using the speed v - to estimate the average or medium mass m_B of the pearls.
- 4. Using the ρ_{halo} as input we estimate / speculate the mass density of dark matter in the solar system near the earth to $\approx 2\rho_{halo}$.

Explanation table, Tunguska ...

- 5. The from the first estimates and data determined mass m_B of a single pearls. (this were already done in our earlier work [?].
- 6. Typical speed of the pearl in the region of the earth, where about half the pearls are supposed to be linked to the solar system and thus having lower speed, while about half come from the far out regions of the galactic halo. This speed is of relevance for determining how often a pearl hits the earth and thus for how to get the mass by means of the rate of impacts r_B.
- 7. The kinetic energy $\frac{1}{2}m_B v^2$ of the pearl of importance for the possible energy release by the impact of the pearl in Tunguska.

Table explanation: Tunguska and potential keeping nucleons

- 8. Energy observed as the visible explosion in Tunguska $E_{Tunguska}$, which of course should at least be smaller than the kinetic energy of the pearl available for making explosion, since an appreciable part of th energy will be deposited deeply inside the earth.
- 9. Potential shift for nucleon in passing the skin of the pearl $\Delta V \approx 10 MeV$. We presume that the potential felt by a neutron or a proton inside the pearl is ΔV lower than outside due to a lower Higgs field in the inside the pearl.

Explanation...

- 10. The force per unit length or equivalently the energy per unit area of the pearl surface/skin is denoted S. Then the value has been fitted to the hypothesis that typical pearl size is just on the borderline of stability against the nuclei being spit out, in the column four corresponding to the absolute instability border, whereas the column five, rather is the skin tension corresponding to the fit to the intensity of the 3.5 keV radiation. In both columns it is the third root $S^{1/3}$ of the tension which is given.
- 11. Here we then give the same third root but now estimated from theoretical considerations about the Higgs field and effective field for the bound state of $6t + 6\bar{t}$ speculated in our work. Basically it means that the third root is given by dimensional arguments from top-quark mass. Note that the correction in increasing ξ in going from fourth to fifth column

- 12. Ball density or pearl density ρ_B is the specific density of the bulk of the pearl, i.e. simply the ratio of the mass to the volume.
- 13. The radius R of the ball, mainly thought of as the radius of the skin sphere.
- 14. The homolumo gap calculation is the first main point of the present article and we obtain so good we can the value for the gap between the lowest unoccupied and the highest occupied electronic orbits. It is the main point of the present article that this gaps gives rise to a radiation from the dark matter with the frequency essentially equal to this homolumo gap. Since astronomers have seen a line in X-ray of 3.5 keV it is our first and most important success that this homolumo gap turn out to be order of magnitude-wise equal to 3.5 keV.
- 15. In this line we just note down the supposedly from dark matter emitted X-ray frequency being 3.5 keV.

- 16. The released energy E_S stands for the energy released when two pearls collide and their common surface contracts so as to have one combined pearl in stead of the previous two. This released energy is thus estimated as the fraction of the surface area contracted away multiplied by the surface tension S, and it is written relative to the Einstein energy of the whole pearl $m_B c^2$.
- 17. "# 3.5's as if all $\rightarrow$ 3.5" means the number of photons of energy 3.5 keV, which could be produced from the released energy E_S under the presumably not realistic assumption that all the energy went into such 3.5 keV photons. I.e. it is simply $E_S/(3.5keV)$.
- 18. "# 3.5's" then means the estimate of how many 3.5 keV photons are truly produced in one collision. The main correction relative to the "# 3.5's as if all $\rightarrow$ 3.5" consists in that we expect the emission dominantly into the 3.5 keV line takes place only during the first time t_{spread} after collision

during which period a hot spot created by the released energy E_S spreads out from a supposed very small region to reach the boundary of the pearl. The idea is that until the hot spot reaches the boundary essentially only 3.5 keV X-rays can penetrate from the outskirts of the hot spot out in the free space because the pearl material is supposed to strongly absorb at least radiation with higher frequency than the 3.5 keV line. After the heating up by the spread of the hot spot over the whole pearl and the heating up of the skin of the pearl the emission of radiation will become typically of higher frequency than the 3.5 keV. Thus the energy released gets then lost for emitting radiation in the line 3.5 kev.

- 19. The cross section $\sigma = \pi(2R)^2$ for the pearls colliding is supposed to be the geometrical cross section just given by the radii of the pearls colliding. It is of course π times the square of the sum of the radii of the two pearls.
- 20. "cross section per γ (all $\rightarrow$ 3.5)" means the cross section

that a pearl should have for hitting another pearl if there were only produced one photon (with energy 3.5 keV) per collision and under the assumption that all energy goes to the 3.5 keV.

- 21. "cross section per γ (with time ratio)" means the cross section needed for the collision, if we have to have again one collision for each photon emitted, but this time taking the more realistic amount of photons(3.5 keV) by them only being produced during the time t_{spread}.
- 22. Here we simply divide the "cross section per γ (all $\rightarrow$ 3.5)" by the mass square of the pearl $M^2 = m_B^2$.
- 23. Similarly we divide the number "cross section per γ (with time ratio)" by also $M^2 = m_B^2$. This is now the quantity, which determines the rate of 3.5 keV radiation from various objects, provided one can estimate the square of the density of dark matter in those astronomical objects.
- 24. The spreading time t_{spread} for the hot spot produced in the collision to spread over the whole pearl, so that the wall of

it get heated and energy escapes via higher frequencies than just the 3.5 keV line.

- 25. The same as 24. but taking into account that the 3.5 keV radiation gets replaced by higher frequency radiation as soon as the temperature reaches appreciably above the 3.5 keV; it does not have to get to so high temperature as the main part of the hot spot. Also the correction by a factor 2 takes into account that after the pearl cools off again a period with 3.5 keV radiation will appear.
- 26. The radiation time $t_{radiation}$ is defined as the time it would take for the released energy E_S to get emitted, if the emission goes just via emission of 3.5 keV radiation assumed to be emitted with a rate as given by the black body radiation at the temperature $T = 3.5keV$. Since this is what is expected to happen during the time interval t_{spread} the fraction of radiation send out as 3.5 keV radiation is estimated as the ratio $\frac{t_{spread}}{t_{radiation}}$.

- 27. This ratio $\frac{t_{spread}}{t_{radiation}}$ relevant for the amount of radiation 3.5 keV emitted.
- 28. The from the work of Cline and Frey extracted quantity $\frac{N\sigma}{M^2}$ for the observations, and this number should thus be considered the experimental value corresponding to the theory in item 23.
- 29. After letting the ratio ξ of the actual radius of the pearl relative to the absolute lower bound from stability free to fit we get the value $\xi = 5.9$.
- 30. But a theoretical estimate of what this ξ ratio should be provides $\xi = 2^{4/9}\sqrt{4\pi}$, which actually should be considered a successful agreement.
- 31. This is our estimated value for the heat conductivity k.

Domain walls

In theores with several phases of vacuum, you have at the surfaces where two phases meet:**domain walls**. Such domain walls typically have an energy density and a tension. Usually, e.g. in our model with multiple point principle and standard model otherwise only, the enrgy density along such domain walls is so huge, that even with only one extended wall inside each Hubble volume H^{-3}, the distance scale H^{-1} given by Hubble constant H the universe energy density quickly gets completely dominated by the energy density from such walls; **So such domain walls makes the cosmology a catastrophe!**

Cosmological problem with Domain walls

It was first noted by Zeldovich, Kobzarev and Okun that the restoration of sponta- neously broken discrete symmetries at high temperatures in the early universe poses severe problems for its subsequent evolution.

Ya.B. Zeldovich, I.Y. Kobzarev and L.B. Okun, Sov. Phys. JETP 40, 1 (1975)

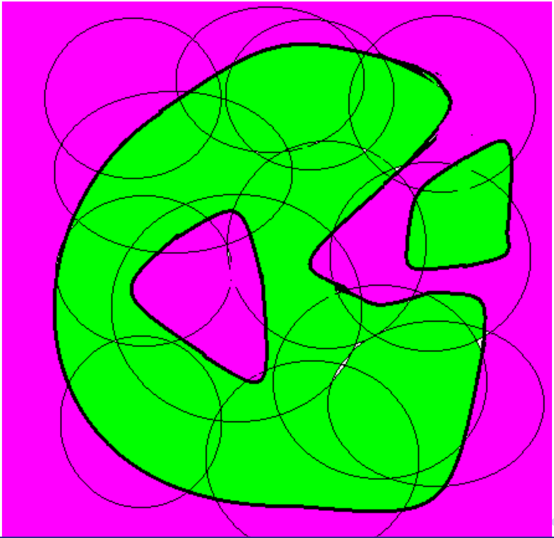
Real Catstrophe in Cosmology for Spontaneously broken discrete symmetry

Breaking some say Z_2 group symmetry leads to real catastrophe! Because of the symmetry there will in different regions not having ever communicated be 50% to 50% chanse for any of the two vacuum-phases. Thus there will over each region of order of length H^{-1} (where H is the Hubble constant at the time considered). If the density of energy over the domain wall per unit area is denoted S, then the energy density in space of the walls must at least be of the order

$$\rho_{walls} \sim \frac{SH^{-2}}{H^{-3}} = SH = \frac{S}{t}, \tag{4}$$

where $t = H^{-1}$ is the time scale given by the Hubble "constant" H, so that there is only communication during the age of the universe inside a region of size t and volume $t^3 = H^{-3}$.

Domain walls and Horizon size balls



Explanation for "Domain walls and Horizon size balls".

- Drawn as if in 2 spatial dimensions.
- The thick black lines symbolize the **domain walls**, they are of course 2-dimensional surfaces in the correct 3-dimensional space.
- These domain walls seperate regions of the two different colors lilac and green, which thus symbolize two phases of vacuum. In the case of a spontaneously broken Z_2 symmetry there is **symmetry** under permutation of green with lilac. (But in our model of MPP there is a (slight) assymmetry: say lilac has no condensate, while green has a condensate of some speculated scalar particle $F(750)$).

Further explanantion of “Domain walls and Horizon size balls”

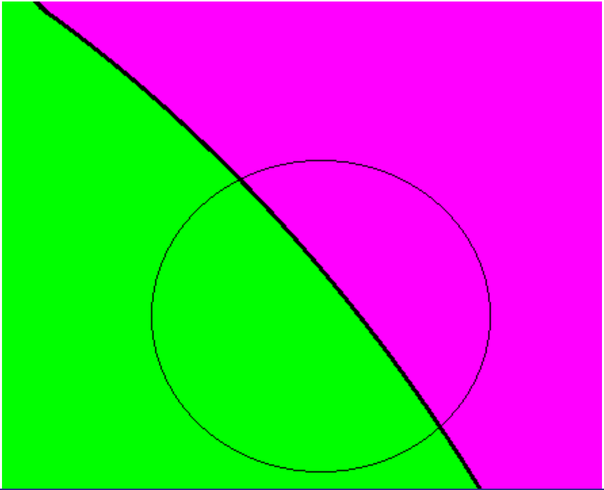
- At a given moment in cosmology we have denoted as thin black lines the surfaces arround regions which are crudely connected causally, so that the points inside such a “ball” drawn with thin line have had causally contact even ignoring inflation.
- For scales longer than the size of these “balls” of size H^{-1} (= the inverse Hubble constant at the time), there was no causal contact - except perhaps in inflation time - and whether one gets the lilac or the geen phase will occur randomly with probability 50 % for each.
- Thus of the order of unity (say 1/2) **domain wall crossing each horizon size ball cannot be prevented in the Z_2-symmetry case.**

Yet further explanation of “Domain walls and Horizon size balls”.

- This minimal number of walls per horizon size region puts severe lower limit to the number of walls in the Z_2-symmetric case.
- Denoting the energy density on the domain walls by S the energy of a domain wall piece crossing a (maximal) causally connected region (“ball”) of size $\sim H^{-1}$ will be $\sim SH^{-2}$ and thus since the volume of such causal connection region is of the order H^{-3} the density of energy in the walls must be at least

$$\rho_{walls} \geq SH^{-2}/H^{-3} = SH \tag{5}$$

With Z_2-symmetry of order 1 domain wall at least per horizon region.



The dominance at late times of the domain walls energy density.

Over longer distances than $t = H^{-1}$ thus no phase of vacuum correlation possible when there is symmetry unless it were imposed by some rather mysterious initial condition. When two different vacuum-phases thus are likely to be present with only a distance t between them, there must exist domain walls - seperating such vacuum-phases - with distances between them not much longer than $t = H^{-1}$. These must have extensions even of the order of t in distance and thus t^2 in area. Thus the domain wall energy density on average in universe at least:

$$\rho_{walls} \sim \frac{SH^{-2}}{H^{-3}} = SH = \frac{S}{t},$$

where S is the surface tension of the wall.

But What if small deviations from symmetry?

Larson, Sakar, White as well as Hindmarsh, and Coulson et al. calculated:

- "Evading the Cosmological Domain Wall Problem" Sebastian E. Larsson, Subir Sarkar and Peter L. White arXiv:hep-ph/9608319v2 21 Jan 1997 Theoretical Physics, University of Oxford, 1 Keble Road, Oxford OX1 3NP, arXiv:hep-ph/9608319v2 21 Jan 1997
- "Analytic scaling solutions for cosmic domain walls" Mark Hindmarsh May 1996 School of Mathematical and Physical Sciences University of Sussex Brighton BN1 9QH U.K. e-mail: m.b.hindmarsh@sussex.ac.uk, arXiv:hep-ph/9605332v1 16 May 1996, M. Hindmarsh, Phys. Rev. Lett. 77, 4495 (1996).
- D. Coulson, Z. Lalak and B. Ovrut, Phys. Rev. D 53, 4237 (1996).

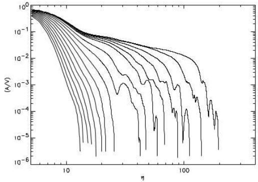


FIG. 5. Comoving area against conformal time in 3 dimensions with the bias ε in the range $0 - 0.03$.

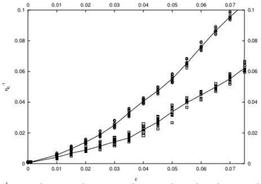


FIG. 6. η_c^{-1} against bias ε in 2 dimensions, where η_c is the conformal time at which the product of η and the comoving area density has fallen by a factor 10 (circles) or 100 (squares). The line connects the mean value of η_c over all the runs.

The notation of Larsson Sakar and White

These authors perform the computation in a **comoving** e.g. area A, which means it is measured relative to the size parameter a for the universe, and they use a **conformal time** η defined by $d\eta = dt/a(t)$ which measures the comoving distance traversed by light since the big bang.

The bias ϵ:

For concreteness we consider the Z_2 case where there are only two distinct vacuua and we generate the initial configuration with a probability

$$p_+ \quad = \quad 0.5 + \epsilon$$

that each initial domain is in the $+$ phase, where $\epsilon > 0$ is called the bias.

Examples read off from the curves of Larsson, Sakar and White.

The fig 5 have different curves corresponding to different values of the bias ϵ with which the one of the by symmetry equivalent vacua $+$ and $-$ has been overrepresnted to make assymmetry in the initial state. These curves give the comoving A/V (area over volume measured in the universe size a) as function of the conformal time η.

Results for when the domain walls decay away

- For a shift $\delta\rho$ between the energy densities of the two phases the walls will decay away exponentially at a typical size of the walls R reaching a critical limit

$$R_c = \frac{S}{\delta\rho}. \quad (6)$$

- With a bias ϵ in the initial condition probability for radiation dominated universe the critical time for decay is

$$t(R) \sim \epsilon(R)^{-3}. \quad (7)$$

(The varibles R attached denote that it is effective values for averaging over regions of size R).

Lemaitre-Friedmann-Robertson-Walker Equations

$$\left(\frac{\dot{a}}{a}\right)^2 + \frac{kc^2}{a^2} - \frac{\Lambda c^2}{3} = \frac{8\pi G}{3}\rho \tag{8}$$

$$2\frac{\ddot{a}}{a} + \left(\frac{\dot{a}}{a}\right)^2 + \frac{kc^2}{a^2} - \Lambda c^2 = -\frac{8\pi G}{c^2}p. \tag{9}$$

Here a is scale of universe length size, ρ the density and p the pressure (isotropy and homogeneity assumed). Dot denotes derivative w.r.t. time t; k is the curvature index.

Interpretation of LFRW equations

The LFRW-equations are equivalent to the following two equations - wherein though the curvature index k has become an integration constant:

$$\dot{\rho} = -3\frac{\dot{a}}{a}\left(\rho + \frac{p}{c^2}\right) \quad (10)$$

$$\frac{\ddot{a}}{a} = -\frac{4\pi G}{3}\left(\rho + \frac{3p}{c^2}\right) + \frac{\Lambda c^2}{3} \quad (11)$$

The first is the energy conservation equation and the second gives the acceleration of the size if universe a as the gravitational effect of mass/energy and pressure; they both decellerate, while the cosmolgical constant accelelrate the expansion.

In radiation case:

$$\rho_{rad} = 4/c * \int_0^\infty d\nu \int_0^{\frac{\pi}{2}} d\theta \int_0^{2\pi} d\phi \, B_\nu(T) \cos(\theta) \sin(\theta)$$
$$= 4/c * \sigma T^4 \qquad (12)$$

where

$$\sigma = \frac{2k_B^4 \pi^5}{15c^2 h^3} \approx 5.670400 \times 10^{-8} \, \mathrm{J\,s^{-1}m^{-2}K^{-4}} \qquad (13)$$
$$p = c^2 \rho / 3 \qquad (14)$$

Here the temperature T scales with size a of the universe as

$$T \propto \frac{1}{a} \qquad (15)$$

and σ is Stefans constant.

In radiation dominance $a \propto \sqrt{t}$; for walls $a \propto t^2$

One solves the LFRW equations for the radiation case with

$$a(t) \quad \propto \quad \sqrt{t} \tag{16}$$

for t the time and ignoring cosmological constant Λ.

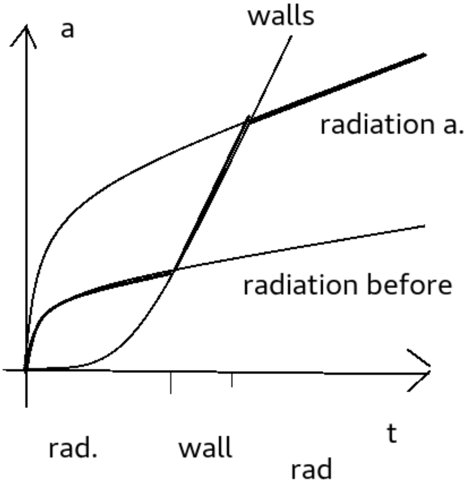
In the wall-dominance case:

$$\rho \quad \propto \quad \sigma * a^2/a^3 = \frac{\sigma}{a} \tag{17}$$

$$p \quad = \quad -\frac{2}{3}\rho \propto 1/a \tag{18}$$

$$a \quad \propto \quad t^2. \tag{19}$$

Universe size with walls intermesso



Reference on Wall cosmology.

Brazilian Journal of Physics Print version ISSN 0103-9733On-line version ISSN 1678-4448 Braz. J. Phys. vol.33 no.4 So Paulo Dec. 2003 http://dx.doi.org/10.1590/S0103-97332003000400039 "Evolution of perturbations in a domain wall cosmology" Jlio Csar Fabris; Srgio Vitorino de Borba Gonalves

Strongly filtered neutrinos from the domain wall era.

(New idea that may end up making much of the already written stuff of this talk irrelevant or hopeless)

- With the parameters which we have earlier fitted our dark matter pearl theory with for the energy density of the domain wals we hope for, an energy density of the wall being called S with $S^{1/3} \sim 30 GeV$, we expect the domain walls -if they ever become dominant in the cosmology - to do so when universe is about 1 year old.
- Then in a time of that order the walls collide dramatically and release huge amounts of energy into some high energy particles, which we would essentially consider cosmic rays.
- But this happens in an appreciable background plasma with say a temperature of the order of 100 keV. In the - were it not for the walls - otherwise radiation dominace.

Strongly filtered neutrinos (continued)

- Most of the cosmic ray like particles produced from the few year old universe time we expect to be stopped in the plasma and just heat it up, so that we get increased the background radiation, but at first other signs tend to be hitten in the heated plasma, which may get into thermodynamical equilibrium again.
- Except though that very low energy neutrinos will have a low cross section even in such a plasma; so the signal about such a domain wall era might be most importantly the neutrinos that are so low energy that they are not absorbed in the plasma.
- Since the neutrinos as well as other particles to reach us from such an early time as about a one year old universe have to pass a lot of material, especially in the early times when density was much higher, we expect that the neutrino spectrum surviving will have an extremely sharp upper energy

A sharp energy cut off give close to the cut off energy a strong seasonal effect.

For the seasonal variation seen by the DAMA experiment a very sharp cut off in energy could be very important. If you namely measure the energy to be just above say the cutoff you will see a lot when the earth moves towards the rest frame of the neutrinos while you see nothing for instance with zero relative velocity if you look above and the cut off is sharp.

Is the Hubble constant tension indication of extra radiation

[23] consider changes in the early time physics and reconstruct the late time expansion history using BAO and SN Ia data. They find that dark radiation with an additional effective number of species around 0.4 could relieve the Hubble tension, but note that preliminary Planck CMB polarization data disfavours this solution. At low redshifts ($z \leq 0.6$), the recovered expansion history deviates less than 5 % from the CDM model.

J. L. Bernal, L. Verde, and A. G. Riess. "The trouble with H_0" . JCAP, 10:019, October 2016.

Domain Walls and Bayron Assymmetry

Now we want to look a bit on the possible significance of domain walls on the production of an assymetry so as to get more bayons than antibaryons in the universe:
We see two ways that appearance of walls could influence a typical type of lepton number assymtry and thereby get a baryonnumber assymmetry:

- Energy density: The existence of two phases seperated by walls, which above some temperature melt together to one high temperature phase, can be said to mean that at the high temerature there are a lot of walls arround, basically covering space rather densily.
  This means then effectively an extra contribution to energy density in the high temperature situation, not much different from what an extra term in the cosmological constant gives.

Bayon number and Domain walls (contnued)

- Energy density (continued)
  Such an extra term in cosmological constant would influence the expansion rate in eras wherein it may be important and thus could influence baryon assymmetry creation.
- Hard collissions: If we have a cooling down of a situation with walls, these walls will still collide and move themselves due to their - as temperature gets lower relative to the temperature enormous tension -, and in the clashes of domain wals or when they unite and allow a strong diminishing of their area relative to the temperature at that time very high energy particles might be emitted.
  If appropriate see-saw neutrinos are produced and decay in a cold era sya B-L assymmetry could easily be produced in relatively big amounts.

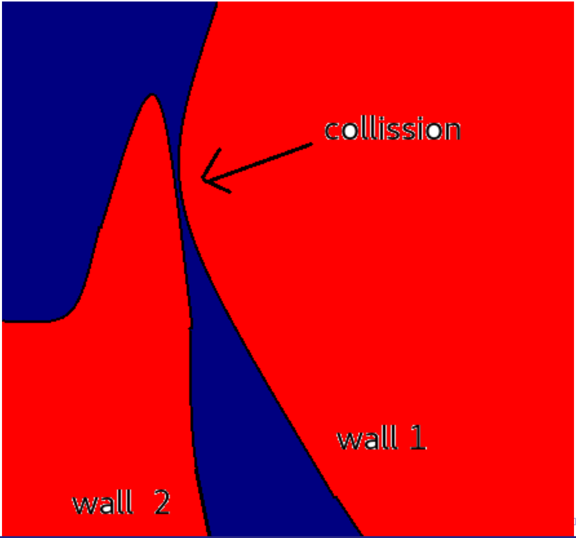
Crude description of Domain walls activity:

- If the walls start in a rather random and chaotic high temperature situation, they will as they get coold down straingt themselves out more and more, and this means releasing energy.
- Under the motion caused for parts of the domain wall(s) we must imagine that they could quickly come to run with speeds comparable to the speed of light unless the radiation or plasma arround them is able stop their motion.
- If they move randomly, they will typically collide.

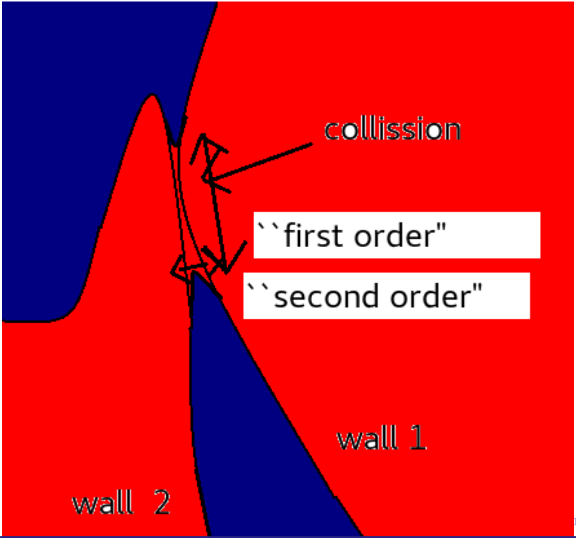
Crude description of domain wall activity (continued)

- When two pieces of domain walls collide at first, they must be touching tangentially at first.
- This leaves to be able to make a partial annihilation of each other in the neighborhood point where they first met.
- By a relatively little disturbance - of "second order" - a little piece of extension of "first order" can be annihilated.
- If by dimensional arguing the tension/energy density along the wall is large compared to say the temperature the energy and heat from the collissions will seem very big.
- In a given cosmolgical temperature era we can with surviving domain walls expect that at collissions particles otherwise only presnt in an earlier and more hot era can be produced.

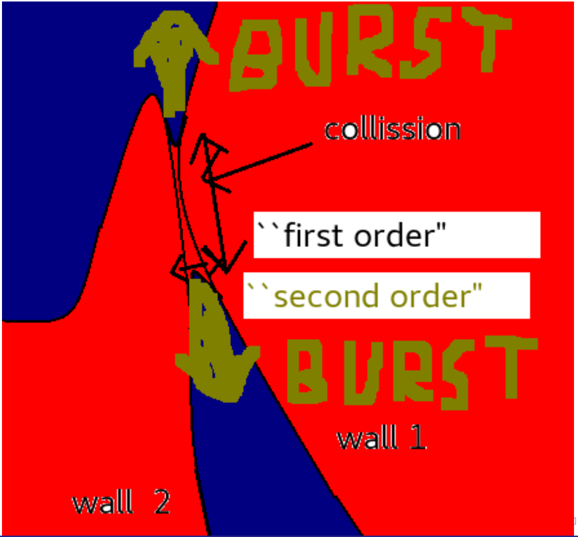
Walls first touch tangentially.



Large piece of walls can be contracted away.



Wall collissions bursts of high energy particles



Restating hope (number 2) for making B-L assymmetry by walls

- 1. At temperatures above say top mass scale, there are walls of the condensate-our phase type, but they are termally fluctuating and even colliding gives only particles of the energy scale of the temperature. (so not so important)
- 2. When temperature comes below the scale of top quark mass assumed to be that of the domain walls we we just now discuss, there are still domain walls although fewer than at the higher temperature; **but now they have tension and energy density along them high compared to surrounding temperature, and thus now they are important.**

Restating hope for B-L from walls (contniude)

- 3. When in the colder era than the walls-scale temperature the surving domain walls collide, there is released energy of a compared to the temperature arround very high scale.
- 4. In the collissions and associated contractions of pieces of domain walls there will be released so much energy that possibly particles of sorts too heavy to still be arround in the cold era are produced in these collissions anyway.
- 5. For instance see-saw neutrinos may be produced in such collissions **even when surrounding temperature is lower than say top-mass.**

Speculated help for getting more Baryons

- The problem at least for our old model of Y. Takanishi, H.B.N. (and C.D. Froggatt) whith the characteristic of seeking to getting the B-L excess from next to lowest mass see-saw neutrino decaying time-reversal invariance violating, was that it did not produce sufficient excess, because the excess was washed away by essentially the lowest mass see-saw neutrino, which stayed arround in cosmological times too long and allowed B-L violation in approximate equilibrium.
- If we could have got the cooling down faster it would have helped to prevent this wash out.
- If one can get a local warming up in the wall collission in a time when it is already colder, the cooling of the locally heated material will be much faster than if the whole universe is just cooled by the Hubble expansion.

Order of magnitude estimate of energy per particle from Wall collissions

What are the realistic energies per particle obtainable by domain wall collissions from the era wherein the walls are getting of importance but no longer lying so densely in the universe?
Let us estimate:

- A priori A priori the energies per particles are expected to be given by the wall-energy scale E_{wall} , which gives roughly both the thickness of the wall ("thickness" $\sim E_{wall}^{-1}$) and energy density per area of the wall $S \sim E_{wall}^3$.
- γ But now if in the collissions the walls have achieved enormous velocities, so that they have say γ's much bigger than unity then even higher energy per particle seem likely.

Further estimating velocity-γ for wall pieces

- Situation In the cosmological situation in which the typical distance between the domain walls is (already) the Hubble distance $H^{-1} \sim t \propto a$ the walls run in times of the order of magnitude this Hubble time $t \sim H^{-1}$ and accellerate - seen from the average rest frame of the bulk of the plasma whatever arround. During this time a piece of wall of radius r say gets accellerated by a force of the order $r * E_{wall}^3$ and has a rest mass $r^2 * E_{wall}^3$, so that it reaches a time t a momentum of the order $t * r * E_{wall}^3$. Assumming the velocity of order unity, in units with light velocity unity, the relativity theory $\gamma \sim t/r$.
- Max γ It makes no sense to have smaller wall-pieces than of order $r \sim E_{wall}^{-1}$ and thus the biggest typically reached γ is $t * E_{wall}$.

Still estimating energy per particle from wall collissions

- Biggest The biggest typical - there will with exponentially small probability be much higher energy particles produced - particle energy produced in the wall collisions were estimated to $t * E_{wall}$ meaning that it corresponds to an era wherein the temperature were t times larger than in the era with the temperature being the wall scale $T \sim E_{wall}$.
- Era redone The era the particles of which may thus be re-created by wall collissions is thus an era with temperature $T \sim t * E_{wall}$.
- Radiation case In the case that in the times with the walls the dominant material were still radiation so that $T^2 * t \sim conctant$ one would in an era with temperature T say a factor E_{wall}/T lower than the wall-scale E_{wall} have a Hubble scale $t \sim H^{-1}$ being $(E_{wall}/T)^2$ times bigger than the

The DAMA/Libra experiment saw some (Controversial) Dark Matter

Fitting the signal of counting events by the time expression

$$R(t) = S_0 + S_m \cos(\omega(t - t_0)) \quad (20)$$

they find

$$t_0 = 152.5 day \quad (21)$$
$$\text{with } T = \frac{2\pi}{\omega} = 1yr$$

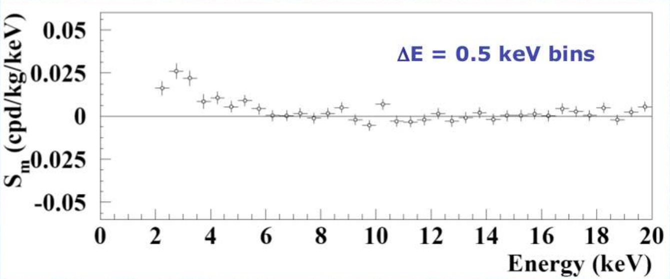
they find in region of energy up till 6 keV an S_m of order 0.01 count/day/kg/keV.

Energy distribution of the modulation amplitudes
Max lik analysis

$$R(t) = S_0 + S_m \cos[\omega(t - t_0)]$$

here $T=2\pi/\omega=1$ yr and $t_0= 152.5$ day

DAMA/NaI (7 years) + DAMA/LIBRA (6 years)
total exposure: 425428 kg×day ≈1.17 ton×yr



A clear modulation is present in the (2-6) keV energy interval, while S_m values compatible with zero are present just above

The S_m values in the (6–20) keV energy interval have random fluctuations around zero with χ^2 equal to 27.5 for 28 degrees of freedom

Our NOT SO SUCCESSFUL speculation for DAMA

- What DAMA "sees" is neutrinoes in an energy range where ONLY electrons are excited. (So nobody else can see it, because background in electrons excited is too high.)
- These neutrinoes should come from collissions of WALLS.
- To have any chanse to come even close to fitting: We need for same density of the inside pearl matter VERY SMALL PEARLS of radius R of nuclear size. (Otherwise they do not collide enough to just come close to the observed rate)

"Neutrinos" solve the conflict with the other experiments

The point proposed that neutrinos interact only with electrons at low energy is actually not true when **neutral current** is included: Neutral currents namely allow **both nuclei and electrons** to have **elastic** scattering with neutrinos.
But if you adjust the energy $\approx$ momentum for the neutrinos to give say a few keV recoils of electrons, then for nuclei it is much less and the latter would not be observed.
With slow heavy particles it is different: The nuclei get the bigger recoil energy than the electrons.

Some ratios: cross section / energy or mass; crudely

DAMA:

$$\left(\frac{\sigma}{m}\right)_{DAMA\ 1.} = 10^{-41}\frac{cm^2}{GeV} \quad (22)$$

$$\left(\frac{\sigma}{m}\right)_{DAMA\ 2.} = 5 * 10^{-42}\frac{cm^2}{GeV} \quad (23)$$

$$\left(\frac{\sigma}{m}\right)_{DAMA\ naive} = 10^{-40}\frac{cm^2}{GeV} \quad (24)$$

Neutrino on electron:

$$\frac{\sigma(\nu e)_{CC}}{E_\nu} = 0.4 * 10^{-41}\frac{cm^2}{GeV} \quad (25)$$

$$\frac{\sigma(\nu\ nucleon)}{E_\nu} = 6 * 10^{-38}\frac{cm^2}{GeV} \quad (26)$$

$$(27)$$

Some ratios: cross section / energy or mass; crude orientation, continued

Bounds on DM interaction:

$$\left(\frac{\sigma}{m}\right)_{\text{Böehm}} = 10^{-33}\frac{cm^2}{GeV} \quad (28)$$

$$\left(\frac{\sigma}{m}\right)_{Cluster-collission...} = 2 * 10^{-24}\frac{cm^2}{GeV} \quad (29)$$

Our dark matter model:

$$\left(\frac{\sigma}{m}\right)_{\text{Our pearls}} = 10^{-33}\frac{cm^2}{GeV} \quad (30)$$

$$(31)$$

Crude observation and Suggestive Speculation:

- Real crucial difference between DAMA/ LIBRA and the disagreeing experiments is that DAMA can "see" **also** collissions of something with the **electrons**.
- The Standard model candidate for interacting only with electrons would be **neutrinoes with so low energy that they could not produce quarks or excite nucleons** but only sctter elastically with electrons.
- Since the σ/m observed by DAMA/LIBRA is extremely close to the one for neutrinoes interacting with electrons, the energy density of a swarm of neutrinoes producing the DAMA-effect would have to have very similar density as the Dark matter in the neighborhood of the sun, which the data seems to fit so wonderfully.
- But neutrinoes of that order is outrageous (crazy).

So easy to get only electrons hit with relativistic particles

A comment to the suggestion of electrons being hit:
With a relativistic ($\sim$ massless) impact on a massive particle remaining non-relativistic after collission, the energy take up is of the order

$$E_{taken\ up} \quad \sim \quad \frac{p_{rel}^2}{(2)m}. \tag{32}$$

Thus the energy taken up $E_{taken\ up}$ is 2000 times bigger for an electron than for a proton, let alone a nucleus.
Electron hit dominate the nucleus hit for relativistic impacts.

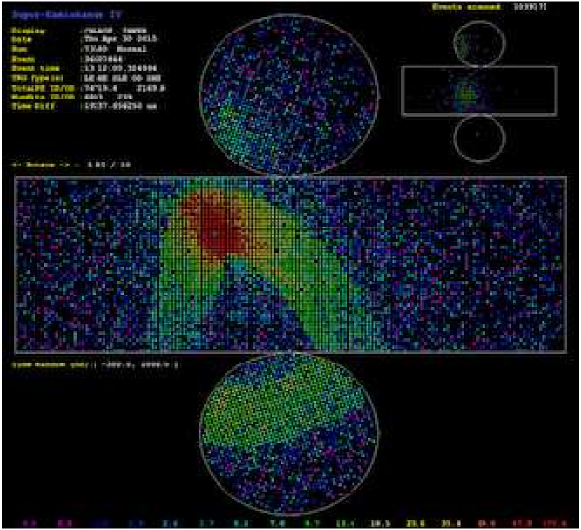
Energy range for relativistic impact particle $\sqrt{(2)}m_e * 3keV = 50keV$.

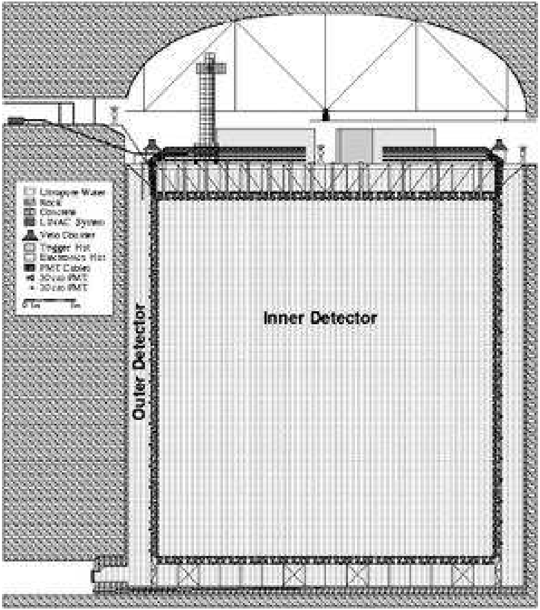
Assuming the material observed by DAMA/LIBRA to be **relatistic** particles with momenta(= energy) $\sim 50keV$ we would get energy release for hitting **electrons** of the order of **few keV**, while the hit on nuclei would give much lower energy take up $\sim (50keV)^2/GeV \sim 1/40keV$ quite unobservable by all the dark matter experiments.(So even neutral currents and an outrageous number of neutrinos in this range could not excite e.g. LUX.)

First candidate for relativistic particle even w.r.t. electron are neutrinos.

In standard model the only low crossection - so that it could penetrate into the Grand sasso mountains - particle relativistic even at scales of the electron (mass) are the neutrinos.
So our suggestion for the DAMA finding:
Either neutrinos or some very low mass phantasy particle with momenta in the range 50 keV.
(Photons cannot penetrate the mountain.)

Before going on: Would Kamiokande not see it?




Inner Detector
Outer Detector

A cross-section of the Super-Kamiokande detector

(foregoing slide) were due to: **S. Fukuda** Source (WP:NFCC# 4): http://www.sciencedirect.com/science/article/pii/S016890020300425X
Date of publication: 2003, April 1
Use in article (WP:NFCC# 7): Super-Kamiokande Realtime supernova monitor
Purpose of use in article (WP:NFCC# 8): For visual identification of the object of the article. The article as a whole is dedicated specifically to a discussion of this work.

50 keV/c momentum electrons cannot compete with speed of light even in water.

Because the 50 keV neutrinos we propose to be the guilty in the DAME/LIBRA effect only give the electorns hit speeds of the order of 1/1000 of speed of light in vacuum, they cannot even compete with the velocity of light in water (as is in the Kamiokande detector), and thus they cannot produce Cherenkov radiation.
So by the main method of Kamiokande one "sees" no 50 keV/c momentum elctrons and thus neither the suggested neutrinos

Is the masslessness of the neutrino a problem for observing it the DAMA-way?

Unfortunately Yes, it is a problem, but it does not make it totally impossible.
Generally every state that in the rest frame of the looked upon matter on the average has

$$\begin{aligned} \vec{p} &= \vec{0} \\ \text{and } Energy &= E \\ \text{gets in a boosted} & \quad \text{coordinate system by velocity } v \\ \vec{p}' &= v\gamma E \\ E' &= \gamma E \end{aligned}$$

Using temperature T the increase by the running of the earth is the same whatever the matter, but...

So if in the "rest system" we have a statistical distribution of the Boltzman form $Prob(E) \propto \exp(-\frac{E}{T}$, then the distribution, which one will find in the say "earth system" in which the E' is the energy will be

$$\begin{aligned} Prob(E') &\propto \exp -\frac{E}{T} \propto \exp -\frac{\gamma^{-1}E'}{T} \\ \text{i.e. effective temperature} &= \gamma * T \end{aligned}$$

So just from Lorentz invariance temerature always increase by the factor γ.

For Conventional Dark Matter $T \sim m_{DM} * (300km/s)^2$ is proportional to the mass of the dark matter particles.

If one used that philosophy that the neutrinos should have only 300 km/s - which is of course nonsense - one would get a priori $T = 0$ but then there would be no neutrinos with energy 50 keV. We cannot hope for temperature much lower than $T \sim 1/50keV$ if any neutrinos shall be left.
Using the usual formula $T \sim m_{DM}(300km/s)^2$ as a standard insertion of $T \sim 50keV$ would give the effective conventional dark matter mass $M_{DM\ simulating\nu}$ as

$$M_{DM\ simulating\nu} \sim \frac{50keV}{(300km/s)^2} = \frac{50keV}{(10^{-3})^2} = 50GeV. \quad (33)$$

Even massless neutrinos with true temperature 50 keV give effect similar to 50 GeV ordinary dark matter.

This number 50 GeV is actually not so outrageously different from conventional speculations on dark matter and numbers speculated in such searches. So such an effective mass for a neutrino simulating dark matter means that it would not be impossible with an optimistic true temperature 50 keV to see yearly variation from neutrinos if there were enough of them.

A temperature T of same order as the energy E corresponds to a power law for intensity of the neutrinos

If the power law is very steep it would correspond to the temperature being low compared to the energy, if it is flat it means the temperature is low compared to the energy at which we work. Cosmic rays usually has a rather steep fall in intensity with energy as a third power. If this allowed us to decrease the temperature describing the neutrinos by a factor 3, the corresponding effective mass for the usual dark matter particle would go down by a factor 3 from the 50 GeV to 17 GeV.
In addition there is for neutrinos the special that the cross section goes up linearly with energy.

Even most optimistically, is it at all possible to get a neutrino energy density of the order of that of solar region dark matter ?

Comparing energy densities to day:

$$\text{Critical density to day: } \rho_{crit} = 10^{-29}\frac{g}{cm^3} = 6*10^{-6}\frac{GeV}{cm^3}$$

$$\text{DM density in solar region: } \rho_{DMsun} = 2*10^{-24}\frac{g}{cm^3} = 0.3\frac{GeV}{cm^3}$$

$$\text{DM av. universe: } \rho_{DM} = 24\%\rho_{crit} = 2.4*10^{-30}\frac{g}{cm^3}$$

$$= 1._5*10^{-6}\frac{GeV}{cm^3}$$

$$\text{Ordninary matter: } \rho_B = 4\%\rho_{crit} = 4*10^{-31}\frac{g}{cm^3}$$

$$= 2*10^{-7}\frac{GeV}{cm^3}$$

Concentration into smaller regions in universe of the Neutrinos needed

To keep it below ρ_{crit} we **need** a **concentration** in the solar region of order of $\frac{0.3}{6*10^{-6}} = \frac{1}{2} * 10^5$. The dark matter is concentrated by $\frac{0.3}{1.5*10^{-6}} = 2 * 10^5$ in the solar region.

Also need to compensate for Hubble expansion

Even concentrating the neutrinoes or the source for them by the factor $\frac{1}{2} * 10^5$ would not be enough, because the radiation parts of the energy density - to which also neutrinoes would belong - were **reduced relative to the critical density of the time by a factor** 10^{-4}. We would need a concentration facror of the neutrinoes hoped to be seen by DAMA/LIBRA by a factor $\frac{1}{2} * 10^5 * 10^4 = 5 * 10^8$.
So a priori we need to get the neutrinoes hoped for at least concentrated in the universe by a factor $5 * 10^8$.
Since the ordinary matter indeed is concentrated in our neighborhood by a factor 10^8 we see that if we could make a model that the cosmic radiation ending up as the neutrinoes seen by DAMA followed the ordinary matter under its concentration by gravity etc., then only be off by the 5 in $5 * 10^8$ versus 10^8.

Neutrinoes difficult to concentrate, they run with speed of light

- A priori neutrinoes run all over with speed of light and are very **difficult to get concentrated** by a factor $\frac{0.3}{6*10^{-6}} = \frac{1}{2} * 10^5$ as is the very least needed if the neutrinoes found shall be allowed inside the critical density.
- The neutrinoes **must come from a production or scattering no longer ago than the size of the region in which to concentrate them**. So if we speculate concentration in the Galaxy to distnce of our sun from the Center they must have scattered or been produced no more than 26000 years ago. (Suns distance to center 26 kly)

Concentration of ordinary matter in galactic disk $\sim 10^8$

The galacitc disk in the Milky Way:

- Thickness = 2 kly $=2*10^3*10^{16}m = 2*10^{19}m$.
- Diameter = (150 to 200) kly $= (150\ to\ 200)*10^{19}m \sim 2*10^{21}m$.
- Mass of galaxy $= 10^{12}M_\odot = 10^{12}*2*10^{30}kg = 2*10^{42}kg$.
- Volume of disk $= \frac{\pi}{4}(150\ to\ 200)^2 * 2kly^3 \sim 50000*(10^{19})^3 m^3 \sim 5*10^{61}m^3$.
- If all in disk, density $= 2*10^{42}kg/(5*10^{61}m^3) \sim 4*10^{-20}kg/m^3 \sim 2.4*10^7 GeV/m^3 = 24 GeV/cm^3$
- Critical density $\sim 10^{-29}g/cm^3 \sim 6*10^{-6}GeV/cm^3$,
- Average ordninary matter density $2.4*10^{-7}GeV/cm^3$.
- So concentration $= 10^8$ of ordinary matter.

Even with the extreme optimism of concentration we would need of same order as the rest of radiation matter being of the "new" type giving the DAMA-effect.

- We would need in some era to obtain e.g. from domain wall collissions so many high energy particles as needed to produce the neutrinos with at least an energy density at the time of the wall collissions of the same order as all the radiation density at that time, would require about about 30 steps:
- If 1/15 were "rescued" per step, a big part of the energy would be rescued into being carried by neutrinos;

Crude estimate of into neutrinos “ rescued” part of cosmic ray.

If 30 times - corresponding to splitting the energy into say 2 half as energetic particles - about 1/15 of the energy goes to a high energy neutrino (and only collides little more), then the part of the original beam energy ending up as non-neutrino energy, perhaps in the microwave background radiation, is

$$\text{“non-neutrino energy part”} \sim (1-\frac{1}{15})^{30}$$
$$\approx \exp -30/15 = \exp -2 \approx \frac{1}{7}.$$

If this is right, rather much energy is rescued into neutrinos, namely $\approx 6/7$.

With such Optimistic "rescue": ~ 6 times as much "high energy" neutrinos as Radiation (including microwave background energy)

- Assuming that really about **half the baryon matter** to day is **missing,**
- and that 6/7 of the from domain walls added cosmic ray like energy density goes to neutrinos, while only 1/7 ends up in background radition,
- we can for doubling the back ground compared to the standard cosmological model get 6 times as much neutrino energy density as the radiation density $\Omega_{rad} \sim 10^{-4}$.
- This would leave us to **need a factor** 6 **less concentration** of the neutrinos to be observed by DAMA.

Some "trap" for cosmic ray found by HESS and NASAs Fermi Gamma-ray Space Telescope

Our results suggest that most of the cosmic rays populating the innermost region of our galaxy, and especially the most energetic ones, are produced in active regions beyond the galactic center and later slowed there through interactions with gas clouds, said lead author Daniele Gaggero at the University of Amsterdam in Netherlands

Galaxy Center, white spot real center.

Reference for the “trapping of cosmic rays”

- PRL 119, 031101 (2017) PHYSICAL REVIEW LETTERS week ending 21 JULY 2017 “Diffuse Cosmic Rays Shining in the Galactic Center: A Novel Interpretation of H.E.S.S. and Fermi-LAT gamma-Ray Data”
  D. Gaggero, 1, D. Grasso, 2, A. Marinelli, 2, M. Taoso, 3, and A. Urbano 4, 1. GRAPPA, University of Amsterdam, Science Park 904, 1098 XH Amsterdam, Netherlands 2 INFN Pisa and Pisa University, Largo B. Pontecorvo 3, I-56127 Pisa, Italy 3 Instituto de Fsica Terica (IFT), UAM/CSIC, Cantoblanco, 28049 Madrid, Spain 4 CERN, Theoretical Physics Department, 1211 Geneva, Switzerland

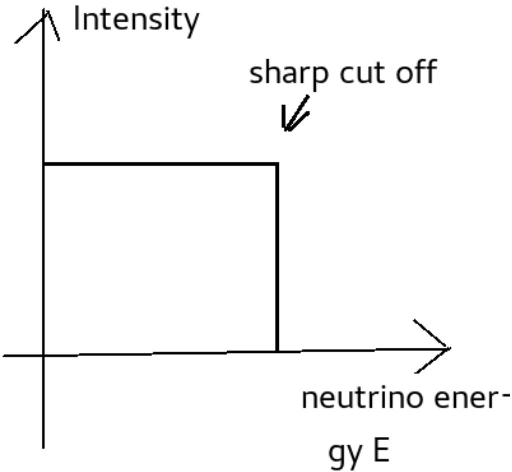
Sharp Neutrino Energy Cut Off Story

- If really a lot of neutrinos come to us - and to DAMA - from the era of the radiation dominance in the cosmological development, then these neutrinos has passed though a lot of (ordinary) matter and for the large part of it in the beginning a very **homogeneous medium** of ordinary matter and radiation.
- Because of the neutrino cross section raising with energy - essentailly linearly - the **mean free path** of a neutrino will go **inversely with the energy** of the neutrino.
- The number of surviving neutrinos will fall **exponentially with the "length of passage" divied by the mean free path.**

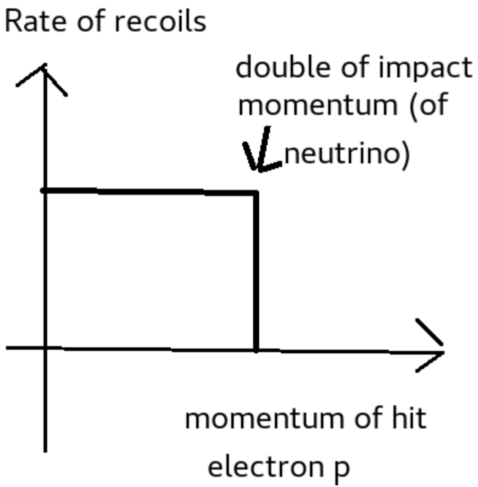
Very sharp cut off in energy because of very long run.

- The amount of matter past by going through the much higher density in the radiation dominated era is very high and will cause exponential cut off of the surviving neutrino energy distribution that leasves an extremely sharp cut off at some neutrino energy E_{cut}.

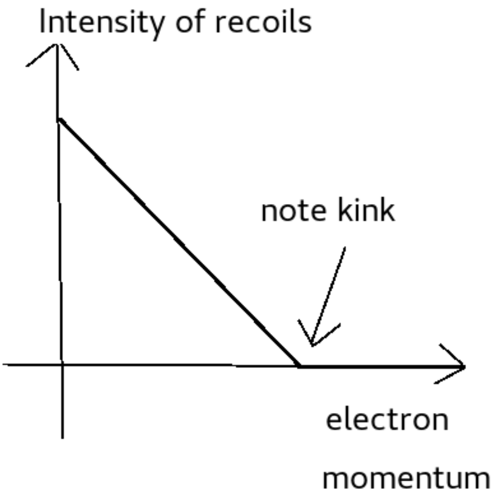
Long passage in radiation: Sharp spectrum cut off



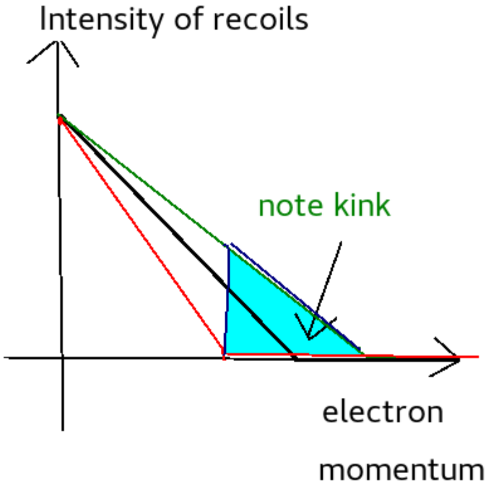
Isotrop scattering recoil momentum spectrum



Convoluted spectrum for recoil



Forward and backward ν's relative Earth movement oppositely corrected recoil



Effect of Earth moving relative to Neutrino Back ground

- The neutrinos hitting the relative to the neutrino-background moving apparatus/Earth/electron frontally cause collision a bit more offen and up to a bit more electron-recoil momemtum (the green line), while the neutrinos hitting from behind give less recoils momentum and less energy to the recoil (the red line).
- The sum of the two compensating effects of the earth relative to neutrino-background for hitting frontally and from behind almost cancel out. But the little triangle drawn in blue is the remaining excess.
- This eccess goes with the **square of the relative velocity.**
- So there will be a bigger excess when the Earth move towards the frame of the neutrinos than when in the same direction as the neutrinos.

Cummulative Distribution for single hits

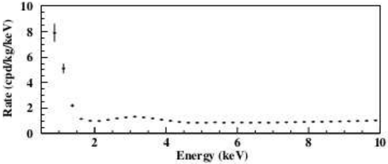


Figure 1: Cumulative low-energy distribution of the *single-hit* scintillation events (that is each detector has all the others as veto), as measured by the DAMA/LIBRA detectors in an exposure of 0.53 ton × yr. The energy threshold of the experiment is 2 keV and corrections for efficiencies are already applied.

bility is negligible), as measured by the DAMA/LIBRA detectors in the 0.53 ton×yr exposure.

Cummulative Distrbution a Problem for Neutrino Interpretation

- For "normal" dark matter Wimps the ratio of the modulated signal S_m compared the cummulative one is given to be of the order of $(v_{earth}/v_{DM})^2$, i.e. of the square of the velocity ratio of the earth to the velocity of the dark matter relative to the sun.
- When we have neutrinos instead of WIMPs the role of the dark matter velocity is taken over by the light velocity c, and this ratio gets very small.
- This means that for neutrnos the predicted amount of cummulative events for a given S_m signal gets very large.
- Thus the cummulative data does NOT fit neutrinos!

Trouble for Neutrino Interpretation fromCummulative measurement

While the modulated signal is of the order

$$\begin{aligned}
\text{Modulated sign.} S_m &\sim 0.01 cpd/Kg/keV \\
\text{then} & \\
\text{Cummulative single} S_0 &\sim 1 cpd/kg/keV \\
\text{Meaning the ratio } S_m/S_0 &\sim 1/100 \\
\text{agrees w. sqd. v-ratio } (v_{earth}/v_{DM})^2 &\sim [(30 km/s)/(300 km/s)]^2 \\
&= 1/100. \\
\text{then } (v_{earth}/c)^2 &\sim (30/300000)^2 = 10^{-8}
\end{aligned}$$

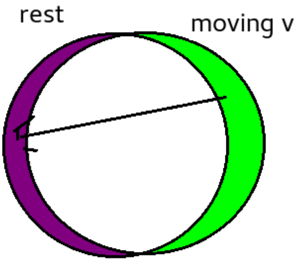
means that **neutrinos completely disagree.**

BUT Degenerate Neutrinos a Way Out

Degenrerate netrinos may help:

- The problem with the non-degenerate neutrinos is that one gets a relatively large cummulative signal even if the laboratory were perfectly at rest compared to the average motion of the neutrinos.
- With degenerate neutrinos there will be no counts, when the laboratory is at rest compared to the average neutrino velocity; there will be no energy available at all: the degenerate fermi-sea of neutrinos and the electron to be potentially hit are namely together in their ground state (of energy).
- Only due to relative velocity can there be an excitation making a scattering possible.

Motion of Degenerate neutrions relative electron makes scattering possible



Fermi-volume for resting and moving bunch of degenerate neutrinos. Resting electron can achieve energy from neutrino going green to lilla.

See on figure of Fermi-surfaces

We see on the figure above:

- When the Fermi-sea of neutrinos move relative to the electron - to be potentially hit - a scattering CAN take place and deliver a bit of energy to the electron.
- A neutrino can namely go from the front rim (green) to the back rim (lilla) delivering excess energy to the electron.
- The volumes in neutrno momentum space are fraction of the total filled momentum space of order of the velocity v_ν/c.
- the whole probability for transfer goes as this velocity squared: $(v_\nu/c)^2$
- This is same form as for non-relativistic dark matter particles and gives the same ratio of modulated to cummulative signal.

Conclusion for our Dark Matter Pearl model

- Qualitatively our dark matter model has good chanse for: Positron excess, Gamma rays, as supposed to come from dark matter generally.
- Concentrated on the 3.5 keV line as phenomenologigally fitted by Frye and Cline for a dependence going like the square of the dark matter density, as if from annihlation or collission (but a little worse you can also have an only linear dependence). And it fitted well even with our order of magnitude intensity prediction!
- We had to throw one Perseus cluster measurement totally out!
- We also considered the frequency value 3.5 keV order of magnitude predicted from our model.

Coclusion on the Dark Matter (continued)

- The highly for dark matter interpretation otherwise fatal observation from supernova remnant is actually the almost prove that our model is right.

Sad Conclusion on Neutrinos making the DAMA-effect.

It is **not** working for several reasons that the DAMA/LIBRA effect of seeming recoils varying with season could be due to ordinary neutrinos, even if in huge amounts:

- Unmodulated back ground Even though a buch of neutrinos can have a center of mass and thus specify a certain reference frame their typicla velocity individually in this frame will always be the speed of light anyway - unless their masses are significant -. When we then look for the seasonal effect it turns out that the velocity of the dark matter particles inside the dark matter cloud in the usual dark matter picutre is for the neutrinos order of magnitudewise replaced by the **light velocity**. ...

Continued Sad Conclusion on Neutrinos making DAMA-effect.

- Unmodulated background (continued) Since the effect goes with the square of the ratio of the earth velocity relative to the typical velocity of the individual dark matter particle, i.e. $\propto (v_{Earth}/v_{DMindiv.})^2 \approx 10^{-2}$ it is in wonderful agreement with the modulation signal being of order $0.01 cpd/kg/keV$ while the unmodulated/ cummulative part is about $1 cpd/kg/keV$. But for the neutrinos with $v_{DMindiv}$ replaced by c we get the ratio to be of order $(v_{Earth}/c)^2$ and then there is found by far too little single hit in the unmodulated component.

Consideration of light particle in the matter hitting.

- We can achieve that only electron hittings are seen by the material having light enough constituents and not to high momentum. E.g. 50 keV neutrinos would be seen on electrons with the possibility of seeing a few keV but on the nuclei the recoil energy would be less and would not see anything in the keV-detection. So the conflict with LUX etc. would be overcome by lighter than usually assumed WIMPs that could hit only electrons in the detectable range. Neutrinos would be an example, BUT then the modulation part relative to unmodulated part gets predicted too small.