DARK MATTER FROM STABLE CHARGED PARTICLES

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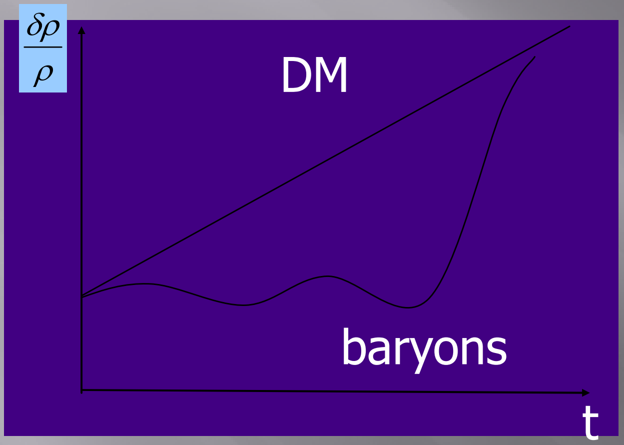
Outlines

- Physical reasons for new stable quarks and/or leptons
- Exotic forms of composite dark matter, their cosmological evolution and effects
- Effects of Composite dark matter particles in underground detectors
- Cosmic-ray and accelerator search for charged components of composite dark matter

Cosmological Dark Matter



$$\frac{\delta\rho}{\rho} \Rightarrow \frac{\delta T}{T}$$

Cosmological Dark Matter explains:

- **virial paradox in galaxy clusters,**
- **rotation curves of galaxies**
- **dark halos of galaxies**
- **effects of macro-lensing**

But first of all it provides formation of galaxies from small density fluctuations, corresponding to the observed fluctuations of CMB

To fulfil these duties Dark Matter should interact sufficiently weakly with baryonic matter and radiation and it should be sufficiently stable on cosmological timescale

Dark Matter from Charged Particles?

By definition Dark Matter is non-luminous, while charged particles are the source of electromagnetic radiation. Therefore, neutral weakly interacting elementary particles are usually considered as Dark Matter candidates. If such neutral particles with mass m are stable, they freeze out in early Universe and form structure of inhomogeneities with the minimal characterstic scale

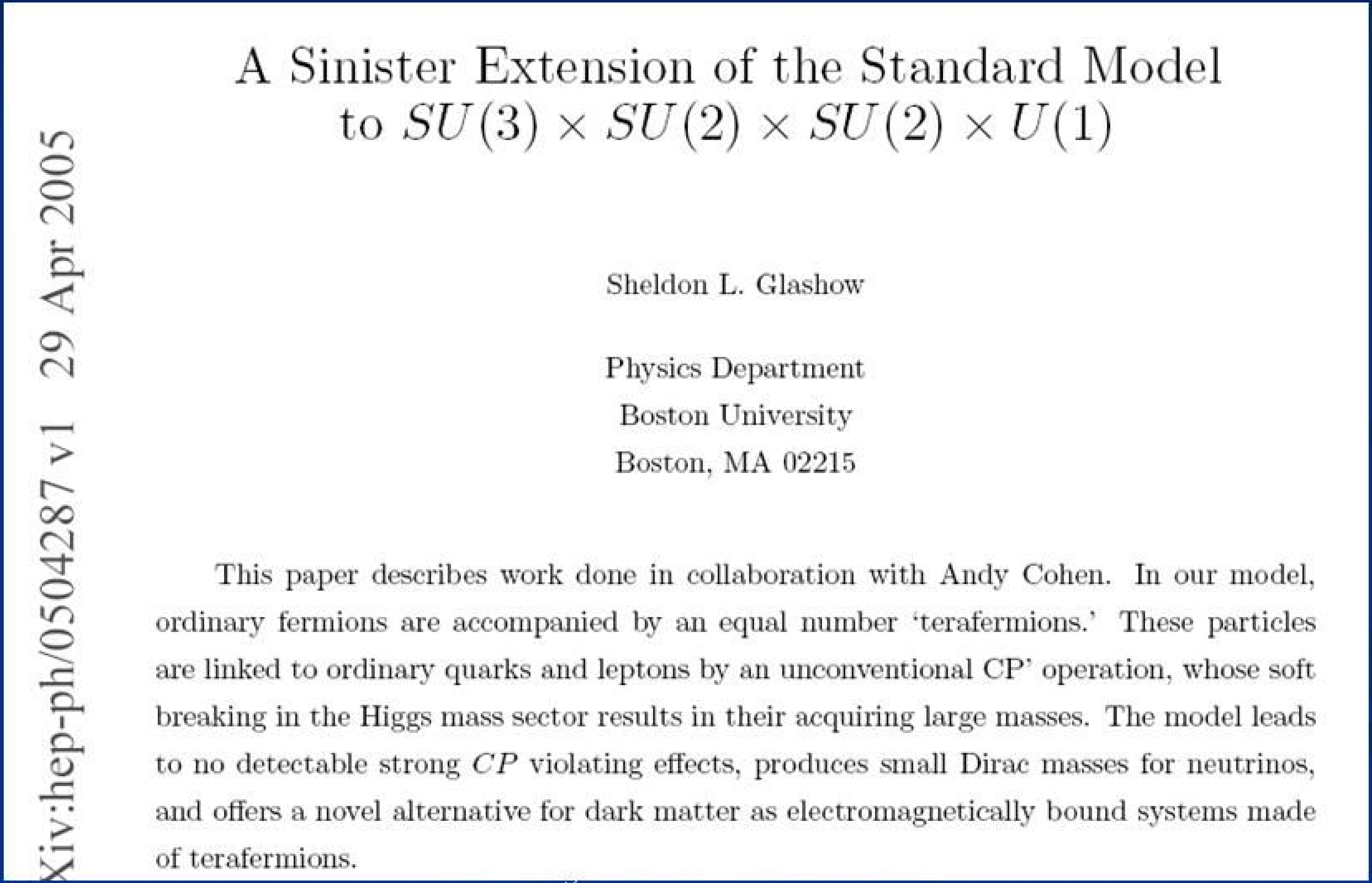
$$\boxed{M = m_{Pl}\left(\frac{m_{Pl}}{m}\right)^2}$$

- However, if charged particels are heavy, stable and bound within neutral « atomic » states they can play the role of composite Dark matter.
- Physical models, underlying such scenarios, their problems and nontrivial solutions as well as the possibilities for their test are the subject of the present talk.

Components of composite dark matter:

- Tera-fermions E and U of S.L.Glashow’s
- Stable U-quark of 4-th family
- AC-leptons from models, based on almost commutative geometry
- Techniparticles of Walking Technicolor Models
- Stable U-quark from 5th family

Sinister model solving Sea saw and Dark Matter Problems



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A Sinister Extension of the Standard Model to $SU(3) \times SU(2) \times SU(2) \times U(1)$

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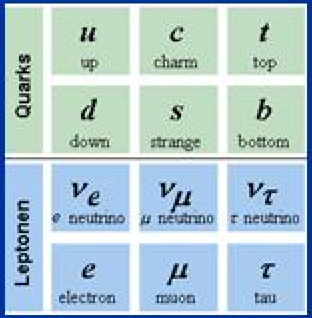
This paper describes work done in collaboration with Andy Cohen. In our model, ordinary fermions are accompanied by an equal number 'terafermions.' These particles are linked to ordinary quarks and leptons by an unconventional CP' operation, whose soft breaking in the Higgs mass sector results in their acquiring large masses. The model leads to no detectable strong CP violating effects, produces small Dirac masses for neutrinos, and offers a novel alternative for dark matter as electromagnetically bound systems made of terafermions.

Abstract

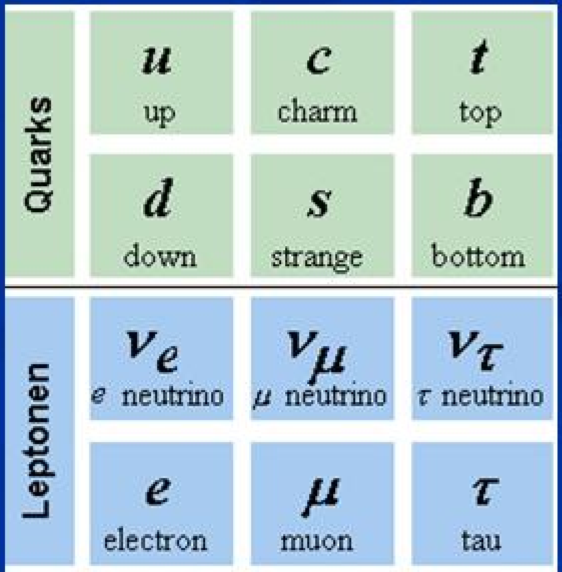
- *The role of Sinister Heavy Fermions in recent Glashow's SU(3)*SU(2)*SU(2)'*U(1) model is to offer in a unique frame relic Helium-like products (an ingenious candidate to the dark matter puzzle), a solution to the See-Saw mechanism for light neutrino masses as well as to strong CP violation problem in QCD. Their mass are million times larger than common ones*
- *The Sinister model requires a three additional families of leptons and quarks, but only the lightest of them Heavy U-quark and E-"electron" are stable.*



Quarks	u up	c charm	t top
	d down	s strange	b bottom
Leptonen	ν_e e neutrino	ν_μ μ neutrino	ν_τ τ neutrino
	e electron	μ muon	τ tau

U

E



Quarks	u up	c charm	t top
	d down	s strange	b bottom
Leptonen	ν_e e neutrino	ν_μ μ neutrino	ν_τ τ neutrino
	e electron	μ muon	τ tau

Glashow's tera-fermions

SU(3)xSU(2)xSU(2)xU(1)

Tera-fermions (*N,E,U,D*) ⇔ W′, Z′, H′, γ and g

+ problem of CP-violation in QCD

+ problem of neutrino mass

+ (?) DM as [(*UUU*)*EE*] tera-helium **<u>(NO!)</u>**

$$\begin{pmatrix} N \\ E \end{pmatrix}$$

Very heavy and unstable

m~500 GeV, stable

$$\frac{m_E}{m_e}=\frac{m_U}{m_u}=\frac{m_D}{m_d}=\frac{\mathrm{vev}'}{\mathrm{vev}}=S_6\ 10^6$$

$$\begin{pmatrix} U \\ D \end{pmatrix}$$

m~3 TeV, (meta)stable

m~5 TeV, *D → U +…*

Why Tera-helium is a good Dark Matter gas?

- Teraparticles do not have normal W and Z interactions and do not contribute into SM parameters, so they can not be excluded by precision measurements of SM parameters
- CP' symmetry of Glashow's model helps to solve strong CP violation problem in QCD.
- Tera-neutrino is unstable, because it gives Dirac see-saw mass to normal neutrino.
- UUU as the new form of hadron - bound by ChromoCoulomb forces. It's size is about 1/alpha_QCD m_U about 10^-16 cm and it weakly interacts with hadrons.

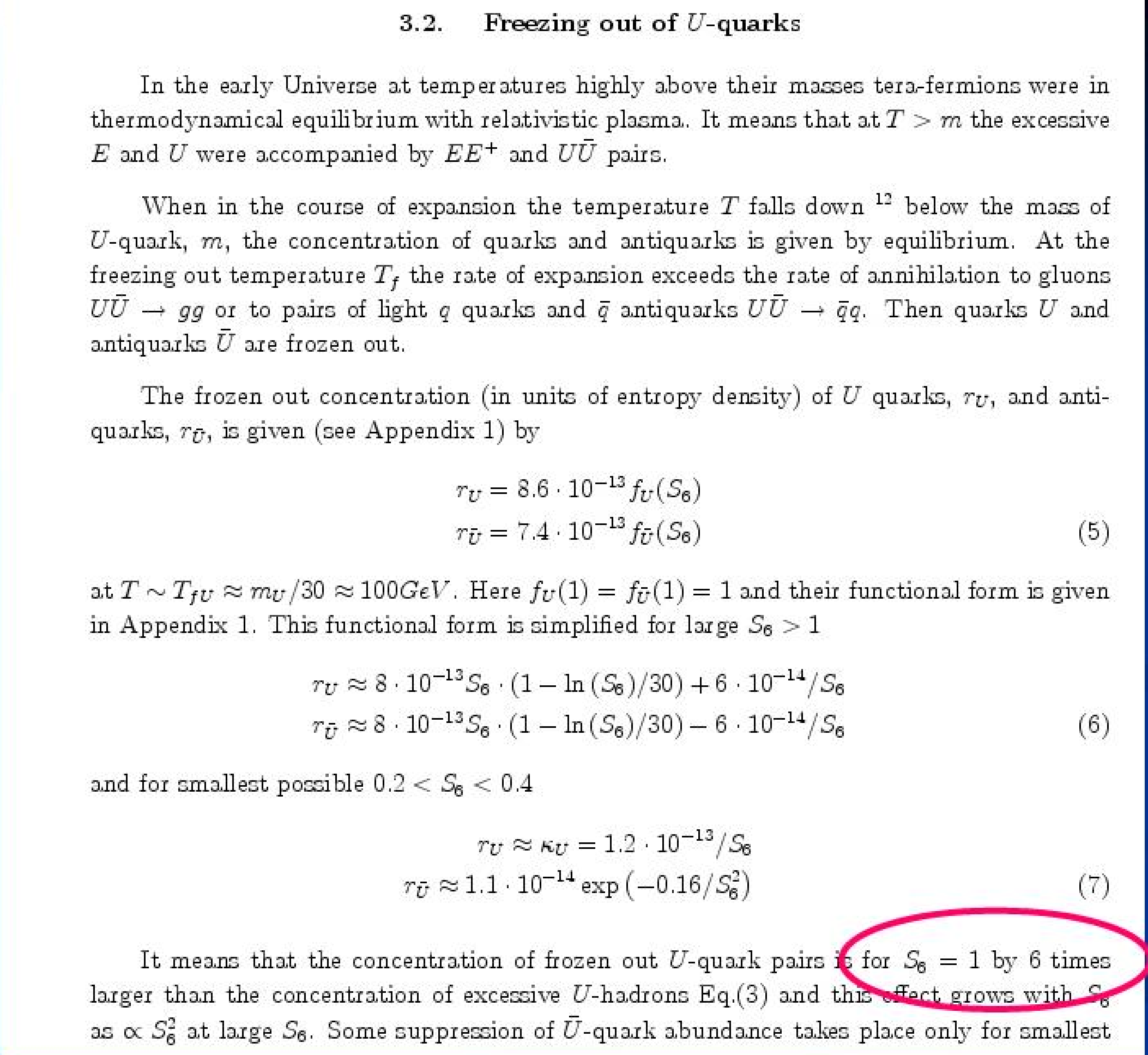
Cosmological tera-fermion asymmetry

$$\Omega_{(UUUEE)} \equiv \Omega_{CDM} = 0.224$$

$$\Omega_b = 0.044$$

- To saturate the observed dark matter of the Universe Glashow assumed tera-U-quark and tera-electron excess generated in the early Universe.
- The model assumes tera-fermion asymmetry of the Universe, which should be generated together with the observed baryon (and lepton) asymmetry

However, this asymmetry can not suppress primordial antiparticles, as it is the case for antibaryons due to baryon asymmetry



3.2. Freezing out of U-quarks

In the early Universe at temperatures highly above their masses tera-fermions were in thermodynamical equilibrium with relativistic plasma. It means that at $T > m$ the excessive E and U were accompanied by EE^+ and $U\bar{U}$ pairs.

When in the course of expansion the temperature T falls down [12] below the mass of U-quark, m, the concentration of quarks and antiquarks is given by equilibrium. At the freezing out temperature T_f the rate of expansion exceeds the rate of annihilation to gluons $U\bar{U} \to gg$ or to pairs of light q quarks and $\bar{q}$ antiquarks $U\bar{U} \to \bar{q}q$. Then quarks U and antiquarks $\bar{U}$ are frozen out.

The frozen out concentration (in units of entropy density) of U quarks, r_U, and antiquarks, $r_{\bar{U}}$, is given (see Appendix 1) by

$$\begin{aligned} r_U &= 8.6 \cdot 10^{-13} f_U(S_6) \\ r_{\bar{U}} &= 7.4 \cdot 10^{-13} f_{\bar{U}}(S_6) \end{aligned} \tag{5}$$

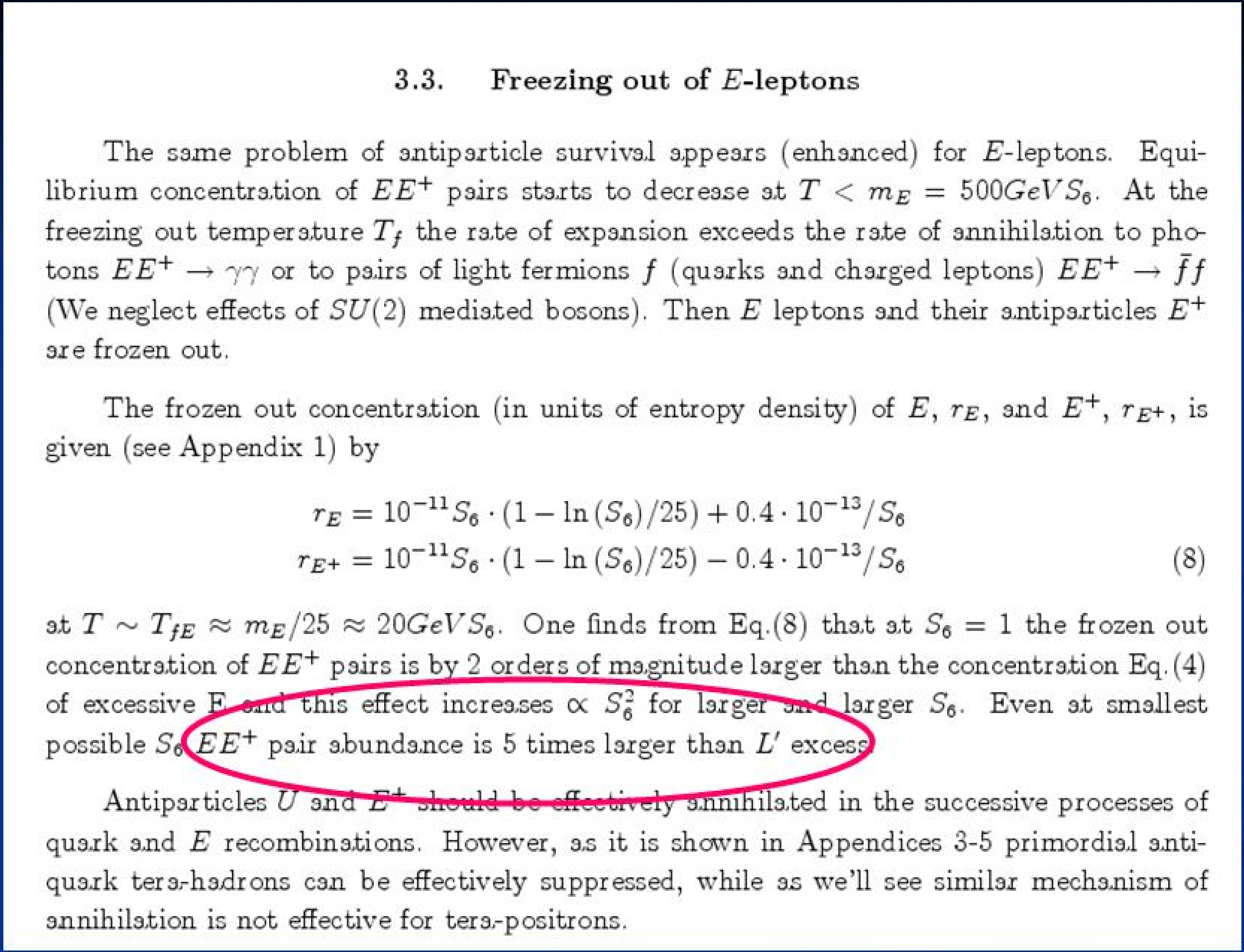
at $T \sim T_{fU} \approx m_U/30 \approx 100 GeV$. Here $f_U(1) = f_{\bar{U}}(1) = 1$ and their functional form is given in Appendix 1. This functional form is simplified for large $S_6 > 1$

$$\begin{aligned} r_U &\approx 8 \cdot 10^{-13} S_6 \cdot (1 - \ln(S_6)/30) + 6 \cdot 10^{-14}/S_6 \\ r_{\bar{U}} &\approx 8 \cdot 10^{-13} S_6 \cdot (1 - \ln(S_6)/30) - 6 \cdot 10^{-14}/S_6 \end{aligned} \tag{6}$$

and for smallest possible $0.2 < S_6 < 0.4$

$$\begin{aligned} r_U &\approx \kappa_U = 1.2 \cdot 10^{-13}/S_6 \\ r_{\bar{U}} &\approx 1.1 \cdot 10^{-14} \exp\left(-0.16/S_6^2\right) \end{aligned} \tag{7}$$

It means that the concentration of frozen out U-quark pairs is for $S_6 = 1$ by 6 times larger than the concentration of excessive U-hadrons Eq.(3) and this effect grows with S_6 as $\propto S_6^2$ at large S_6. Some suppression of $\bar{U}$-quark abundance takes place only for smallest



3.3. Freezing out of E-leptons

The same problem of antiparticle survival appears (enhanced) for E-leptons. Equilibrium concentration of EE^+ pairs starts to decrease at $T < m_E = 500 GeV S_6$. At the freezing out temperature T_f the rate of expansion exceeds the rate of annihilation to photons $EE^+ \rightarrow \gamma\gamma$ or to pairs of light fermions f (quarks and charged leptons) $EE^+ \rightarrow \bar{f}f$ (We neglect effects of $SU(2)$ mediated bosons). Then E leptons and their antiparticles E^+ are frozen out.

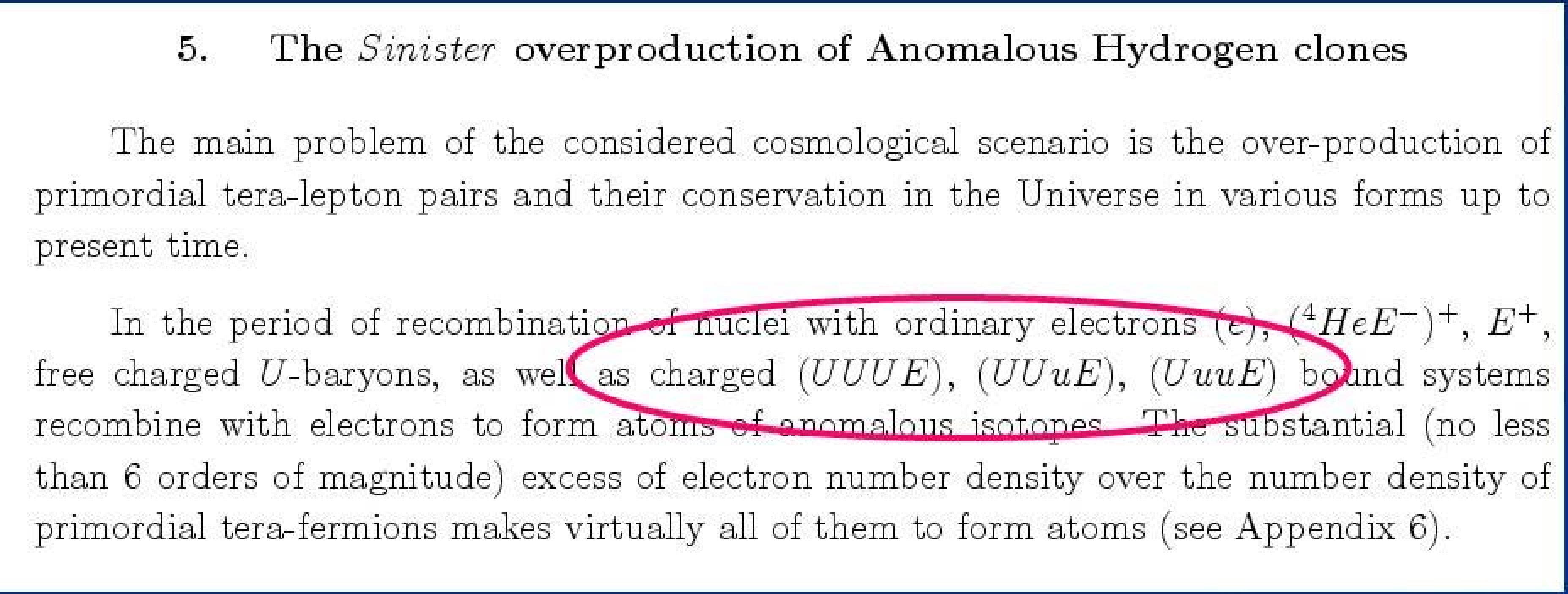
The frozen out concentration (in units of entropy density) of E, r_E, and E^+, r_{E+}, is given (see Appendix 1) by

$$r_E = 10^{-11} S_6 \cdot (1 - \ln(S_6)/25) + 0.4 \cdot 10^{-13}/S_6$$
$$r_{E+} = 10^{-11} S_6 \cdot (1 - \ln(S_6)/25) - 0.4 \cdot 10^{-13}/S_6 \qquad (8)$$

at $T \sim T_{fE} \approx m_E/25 \approx 20 GeV S_6$. One finds from Eq.(8) that at $S_6 = 1$ the frozen out concentration of EE^+ pairs is by 2 orders of magnitude larger than the concentration Eq.(4) of excessive E and this effect increases $\propto S_6^2$ for larger and larger S_6. Even at smallest possible S_6 EE^+ pair abundance is 5 times larger than L' excess.

Antiparticles U and E^+ should be effectively annihilated in the successive processes of quark and E recombinations. However, as it is shown in Appendices 3-5 primordial antiquark tera-hadrons can be effectively suppressed, while as we'll see similar mechanism of annihilation is not effective for tera-positrons.

Real Trap



5. The *Sinister* overproduction of Anomalous Hydrogen clones

The main problem of the considered cosmological scenario is the over-production of primordial tera-lepton pairs and their conservation in the Universe in various forms up to present time.

In the period of recombination of nuclei with ordinary electrons (e), $(^4HeE^-)^+$, E^+, free charged U-baryons, as well as charged $(UUUE)$, $(UUuE)$, $(UuuE)$ bound systems recombine with electrons to form atoms of anomalous isotopes. The substantial (no less than 6 orders of magnitude) excess of electron number density over the number density of primordial tera-fermions makes virtually all of them to form atoms (see Appendix 6).

(Ep) catalyzer

- In the expanding Universe no binding or annihilation is complete. Significant fraction of products of incomplete burning remains. In Sinister model they are: (UUU), (UUu), (Uud), [(UUU)E], [(UUu)E], [(Uud)E], as well as tera-positrons and tera-antibaryons
- Glashow’s hope was that at T<25keV all free E bind with protons and (Ep) « atom » plays the role of catalyzer, eliminating all these free species, in reactions like

$$[(UUU)E] + (Ep) \rightarrow [(UUU)EE] + p$$

$$E^{+} + (Ep) \rightarrow (E^{+}E) + p$$

But this hope can not be realized, since much earlier all the free E are trapped by He

Tera Leptons in Glashow's Sinister Universe

- Moreover, in opposition to almost effective pair Tera-Quark U annihilations (like common proton-anti-proton), there is no such an early or late Tera-Lepton pairs suppressions, because:
- a) electromagnetic interactions are "weaker" than nuclear ones because their coupling is smaller and mainly because the cross sections is proportional to inverse square Tera-Lepton Mass
- b) helium ion 4He++ is able

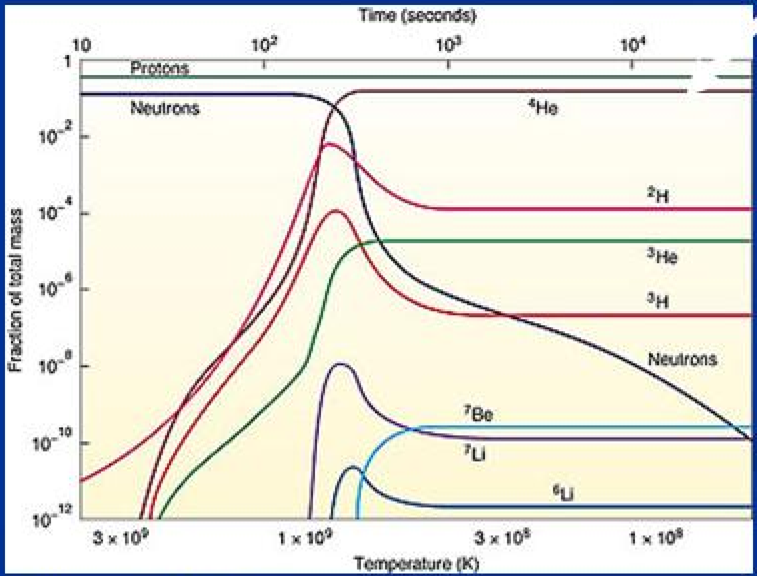
to attract and capture,

E-, fixing it into a hybrid

tera helium "ion" trap.

This takes place during the first

few minutes of the Universe



Why Grave Shadows over the Sinister universe?

- The helium ion 4He++ capture of E- leads to a pile up of relic (4HeE)+ traces, a lethal compound for any Sinister Universe.
- This capture leaves no Tera-Lepton frozen in Ep relic (otherwise an ideal catalyzer to achieve effective late E+E- annihilations possibly saving the model).
- The (4HeE)+ Coulomb screening is also avoiding the synthesis of the desired UUUEE hidden dark matter gas. The e(4HeE)+ behave chemically like an anomalous hydrogen isotope.
- Also tera-positronium (eE+) relics are over-abundant and they behave like an anomalous hydrogen atom:

HE-cage for negatively charged components of composite dark matter – No go theorem for -1 charge components

- If composite dark matter particles are « atoms », binding positive P and negative E charges, all the free primordial negative charges E bind with He-4, as soon as helium is created in SBBN.
- Particles E with electric charge -1 form +1 ion [E He].
- This ion is a form of anomalous hydrogen.
- Its Coulomb barrier prevents effective binding of positively charged particles P with E. These positively charged particles, bound with electrons, become atoms of anomalous istotopes
- Positively charged ion is not formed, if negatively charged particles E have electric charge -2.

4-th family

$$\begin{pmatrix} N \\ E \end{pmatrix}$$

m~50 GeV, (quasi)stable

100 GeV <m<~1 TeV, *E ->N l*ν,… unstable

$$\begin{pmatrix} U \\ D \end{pmatrix}$$

220 GeV <m<~1 TeV, *U -> N + light fermions* Long-living wihout mixing with light generations

220 GeV <m<~1 TeV, *D -> U l*ν,… unstable

Precision measurements of SM parameters admit existence of 4th family, if 4th neutrino has mass around 50 GeV and masses of E, U and D are near their experimental bounds.

If U-quark has lifetime, exceeding the age of the Universe, and in the early Universe excess of anti-U quarks is generated, primordial U-matter in the form of **AN**ti-**U**-**T**ripple-**I**ons of **U**nknown **M**atter (anutium).

$\Delta^{--}_{\bar{U}\bar{U}\bar{U}} \equiv \left(\bar{U}\bar{U}\bar{U}\right)$ can become a -2 charge constituent of composite dark matter

O-helium dark matter

O-Helium formation

$$I_o = Z_{He}^2 Z_\Delta^2 \alpha^2 m_{He} = 1.6 MeV$$

$$T < I_o$$

$$\left(\bar{U}\bar{U}\bar{U}\right) + {}^4He \Rightarrow \left[\left(\bar{U}\bar{U}\bar{U}\right) He\right] + \gamma$$

But it goes only after He is formed at T ~100 keV

The size of O-helium is

$$R_o = 1/\left(ZZ_{He}\alpha m_{He}\right) = 2 \cdot 10^{-13} cm$$

It catalyzes exponential suppression of all the remaining U-baryons with positive charge and causes new types of nuclear transformations

O-Helium: alpha particle with zero charge

- O-helium looks like an alpha particle with shielded electric charge. It can closely approach nuclei due to the absence of a Coulomb barrier. For this reason, in the presence of O-helium, the character of SBBN processes can change drastically.

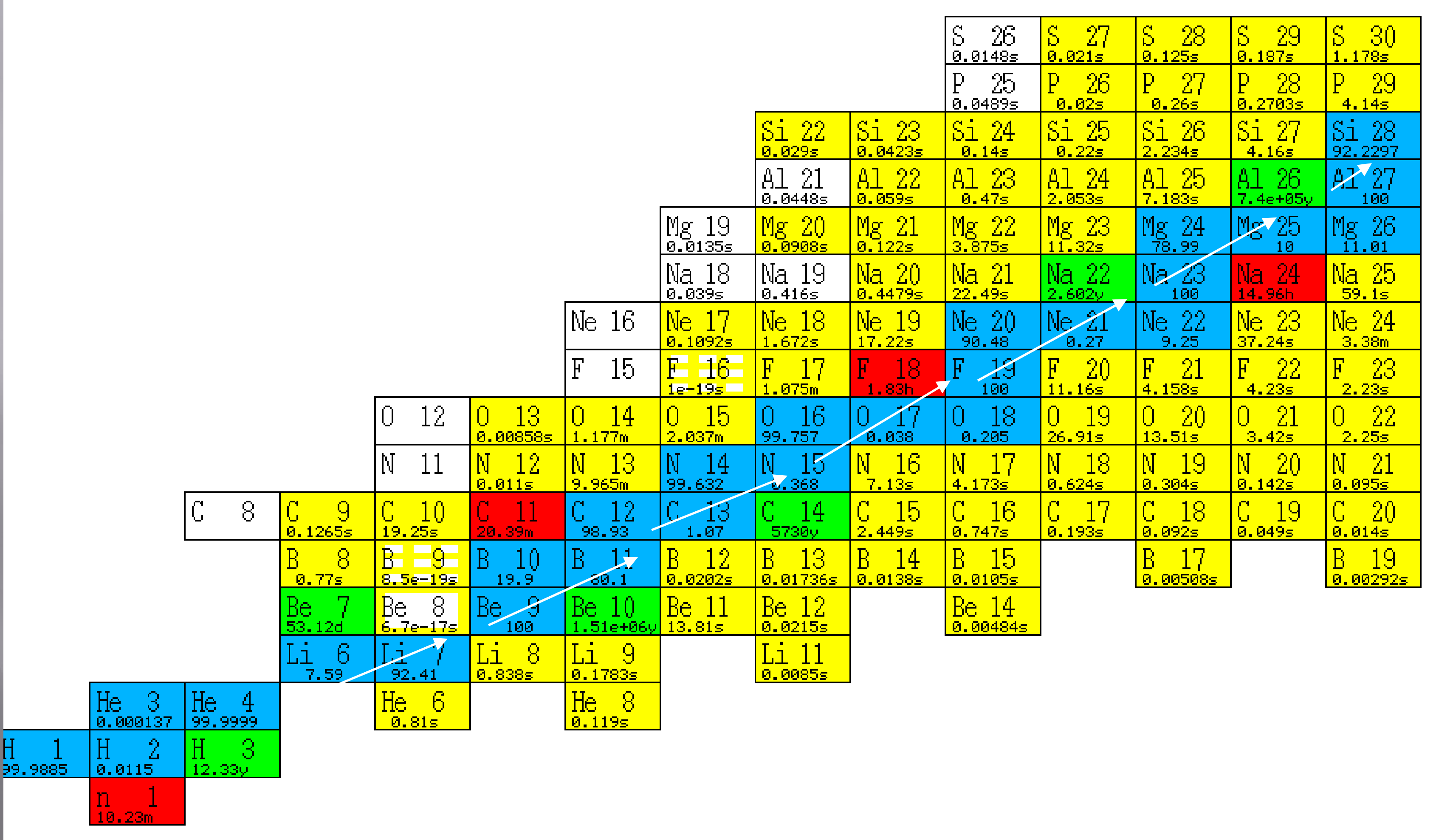
$$(A,Z)+\left[\left(\bar{U}\bar{U}\bar{U}\right)He\right]\rightarrow(A+4,Z+2)+\left(\bar{U}\bar{U}\bar{U}\right)$$

- This transformation can take place if

$$M(A,Z)+m_{He}-I_{o}>M(A+4,Z+2)$$

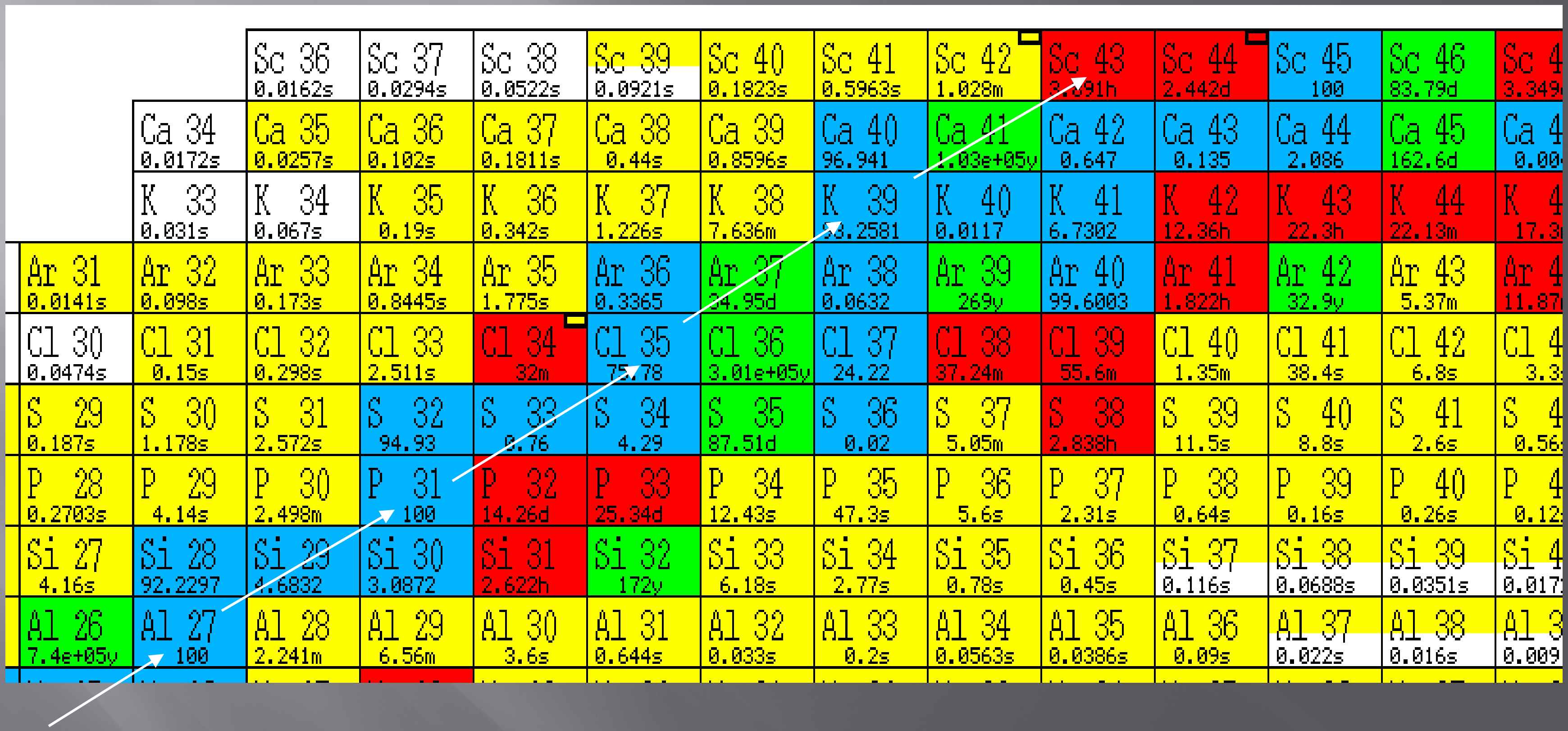
This condition is not valid for stable nuclids, participating in SBBN processes, but unstable tritium gives rise to a chain of O-helium catalyzed nuclear reactions towards heavy nuclides.

OHe catalysis of heavy element production in SBBN



										S 26 0.0148s	S 27 0.021s	S 28 0.125s	S 29 0.187s	S 30 1.178s
										P 25 0.0489s	P 26 0.02s	P 27 0.26s	P 28 0.2703s	P 29 4.14s
								Si 22 0.029s	Si 23 0.0423s	Si 24 0.14s	Si 25 0.22s	Si 26 2.234s	Si 27 4.16s	Si 28 92.2297
								Al 21 0.0448s	Al 22 0.059s	Al 23 0.47s	Al 24 2.053s	Al 25 7.183s	Al 26 7.4e+05y	Al 27 100
							Mg 19 0.0135s	Mg 20 0.0908s	Mg 21 0.122s	Mg 22 3.875s	Mg 23 11.32s	Mg 24 78.99	Mg 25 10	Mg 26 11.01
							Na 18 0.039s	Na 19 0.416s	Na 20 0.4479s	Na 21 22.49s	Na 22 2.602y	Na 23 100	Na 24 14.96h	Na 25 59.1s
						Ne 16	Ne 17 0.1092s	Ne 18 1.672s	Ne 19 17.22s	Ne 20 90.48	Ne 21 0.27	Ne 22 9.25	Ne 23 37.24s	Ne 24 3.38m
						F 15	F 16 1e-19s	F 17 1.075m	F 18 1.83h	F 19 100	F 20 11.16s	F 21 4.158s	F 22 4.23s	F 23 2.23s
				O 12	O 13 0.00858s	O 14 1.177m	O 15 2.037m	O 16 99.757	O 17 0.038	O 18 0.205	O 19 26.91s	O 20 13.51s	O 21 3.42s	O 22 2.25s
				N 11	N 12 0.011s	N 13 9.965m	N 14 99.632	N 15 0.368	N 16 7.13s	N 17 4.173s	N 18 0.624s	N 19 0.304s	N 20 0.142s	N 21 0.095s
		C 8	C 9 0.1265s	C 10 19.25s	C 11 20.39m	C 12 98.93	C 13 1.07	C 14 5730y	C 15 2.449s	C 16 0.747s	C 17 0.193s	C 18 0.092s	C 19 0.049s	C 20 0.014s
			B 8 0.77s	B 9 8.5e-19s	B 10 19.9	B 11 80.1	B 12 0.0202s	B 13 0.01736s	B 14 0.0138s	B 15 0.0105s		B 17 0.00508s		B 19 0.00292s
			Be 7 53.12d	Be 8 6.7e-17s	Be 9 100	Be 10 1.51e+06y	Be 11 13.81s	Be 12 0.0215s		Be 14 0.00484s				
			Li 6 7.59	Li 7 92.41	Li 8 0.838s	Li 9 0.1783s		Li 11 0.0085s						
	He 3 0.000137	He 4 99.9999		He 6 0.81s		He 8 0.119s								
H 1 99.9885	H 2 0.0115	H 3 12.33y												
	n 1 10.23m													

OHe induced tree of transitions



		Sc 36 0.0162s	Sc 37 0.0294s	Sc 38 0.0522s	Sc 39 0.0921s	Sc 40 0.1823s	Sc 41 0.5963s	Sc 42 1.028m	Sc 43 3.891h	Sc 44 2.442d	Sc 45 100	Sc 46 83.79d	Sc 4 3.349
	Ca 34 0.0172s	Ca 35 0.0257s	Ca 36 0.102s	Ca 37 0.1811s	Ca 38 0.44s	Ca 39 0.8596s	Ca 40 96.941	Ca 41 1.03e+05y	Ca 42 0.647	Ca 43 0.135	Ca 44 2.086	Ca 45 162.6d	Ca 4 0.00
	K 33 0.031s	K 34 0.067s	K 35 0.19s	K 36 0.342s	K 37 1.226s	K 38 7.636m	K 39 93.2581	K 40 0.0117	K 41 6.7302	K 42 12.36h	K 43 22.3h	K 44 22.13m	K 4 17.3
Ar 31 0.0141s	Ar 32 0.098s	Ar 33 0.173s	Ar 34 0.8445s	Ar 35 1.775s	Ar 36 0.3365	Ar 37 34.95d	Ar 38 0.0632	Ar 39 269y	Ar 40 99.6003	Ar 41 1.822h	Ar 42 32.9y	Ar 43 5.37m	Ar 4 11.87
Cl 30 0.0474s	Cl 31 0.15s	Cl 32 0.298s	Cl 33 2.511s	Cl 34 32m	Cl 35 75.78	Cl 36 3.01e+05y	Cl 37 24.22	Cl 38 37.24m	Cl 39 55.6m	Cl 40 1.35m	Cl 41 38.4s	Cl 42 6.8s	Cl 4 3.3
S 29 0.187s	S 30 1.178s	S 31 2.572s	S 32 94.93	S 33 0.76	S 34 4.29	S 35 87.51d	S 36 0.02	S 37 5.05m	S 38 2.838h	S 39 11.5s	S 40 8.8s	S 41 2.6s	S 4 0.56
P 28 0.2703s	P 29 4.14s	P 30 2.498m	P 31 100	P 32 14.26d	P 33 25.34d	P 34 12.43s	P 35 47.3s	P 36 5.6s	P 37 2.31s	P 38 0.64s	P 39 0.16s	P 40 0.26s	P 4 0.12
Si 27 4.16s	Si 28 92.2297	Si 29 4.6832	Si 30 3.0872	Si 31 2.622h	Si 32 172y	Si 33 6.18s	Si 34 2.77s	Si 35 0.78s	Si 36 0.45s	Si 37 0.116s	Si 38 0.0688s	Si 39 0.0351s	Si 4 0.017
Al 26 7.4e+05y	Al 27 100	Al 28 2.241m	Al 29 6.56m	Al 30 3.6s	Al 31 0.644s	Al 32 0.033s	Al 33 0.2s	Al 34 0.0563s	Al 35 0.0386s	Al 36 0.09s	Al 37 0.022s	Al 38 0.016s	Al 3 0.009

After K-39 the chain of transformations starts to create unstable isotopes and gives rise to an extensive tree of transitions along the table of nuclides

O-helium warm dark matter

$$T < T_{od} = 1 keV$$

$$n_b \langle \sigma v \rangle \left(m_p / m_o \right) t < 1$$

$$T_{RM} = 1 eV$$

$$M_{od} = \frac{T_{RM}}{T_{od}} m_{Pl} \left(\frac{m_{Pl}}{T_{od}} \right)^2 = 10^9 M_{\odot}$$

- Energy and momentum transfer from baryons to O-helium is not effective and O-helium gas decouples from plasma and radiation
- O-helium dark matter starts to dominate
- On scales, smaller than this scale composite nature of O-helium results in suppression of density fluctuations, making O-helium gas Warmer Than Cold (WTC) dark matter

Anutium component of cosmic rays

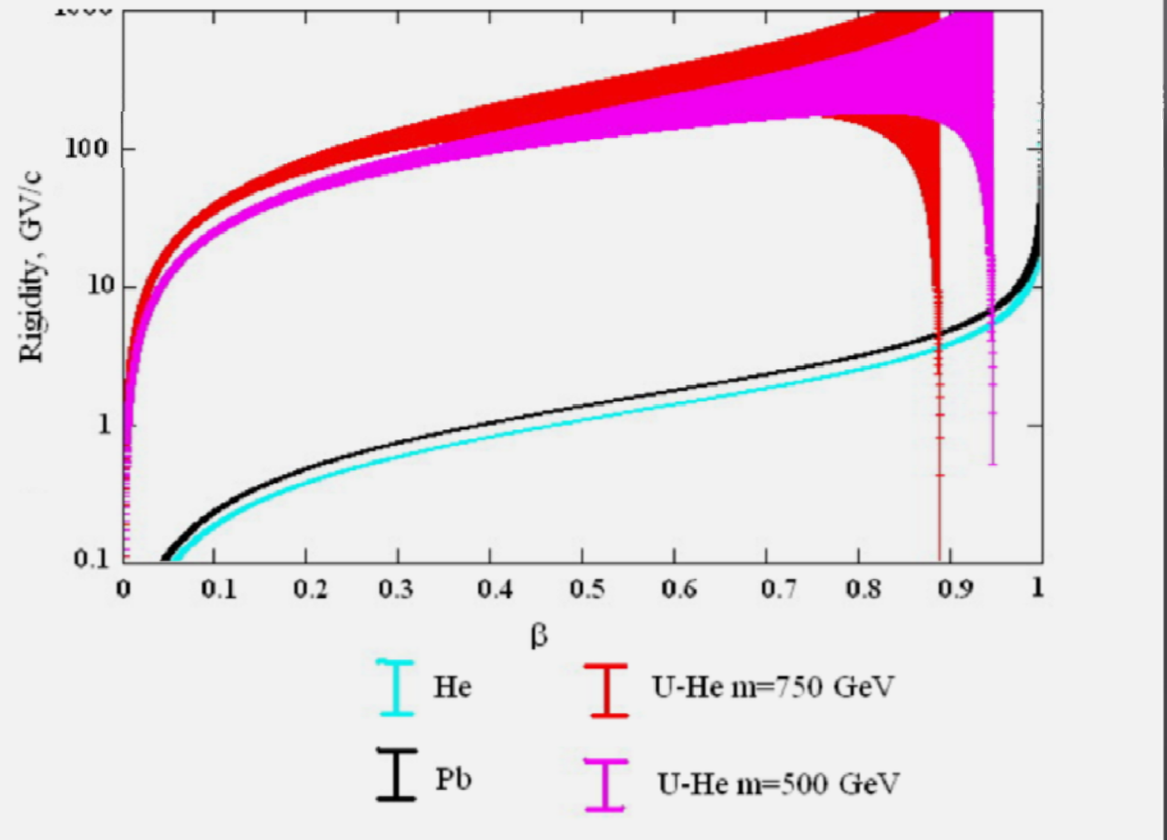
$$\frac{\left(\bar{U}\bar{U}\bar{U}\right)}{{}^{4}He} < 10^{-7}$$

- Galactic cosmic rays destroy O-helium. This can lead to appearance of a free anutium component in cosmic rays.

Such flux can be accessible to PAMELA and AMS-02 experiments

Rigidity of U-helium component

Difference in rigidity provides discrimination of U-helium and nuclear component



O-helium in Earth

- In the reaction

$$\left(A,Z\right)+\left[\left(\bar{U}\bar{U}\bar{U}\right)He\right]\rightarrow\left(A+4,Z+2\right)+\left(\bar{U}\bar{U}\bar{U}\right)$$

The final nucleus is formed in the excited [He, M(A, Z)] state, which can rapidly experience αlpha decay, giving rise to (OHe) regeneration and to effective quasi-elastic process of (OHe)-nucleus scattering.

If quasi-elastic channel dominates the in-falling flux sinks down the center of Earth and there should be no more than

$$r_o < 5\cdot 10^{-23}$$

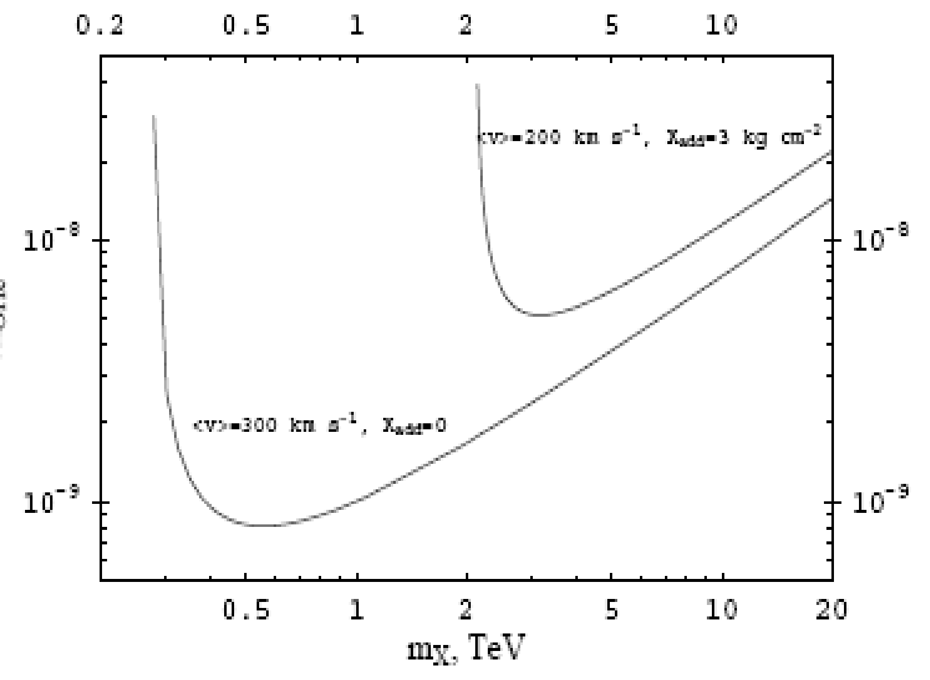
of anomalous isotopes around us, being below the experimental upper limits for elements with $Z \geq 2$.

O-helium experimental search?

- In underground detectors, (OHe) “atoms” are slowed down to thermal energies far below the threshold for direct dark matter detection. However, (OHe) destruction can result in observable effects.
- O-helium gives rise to less than 0.1 of expected background events in XQC experiment, thus avoiding severe constraints on Strongly Interacting Massive Particles (SIMPs), obtained from the results of this experiment.

It implies development of specific strategy for direct experimental search for O-helium.

Superfluid He-3 search for O-helium



- Superfluid He-3 detectors are sensitive to energy release above 1 keV. If not slowed down in atmosphere O-helium from halo, falling down the Earth, causes energy release of 6 keV.
- Even a few g existing device in CRTBT-Grenoble can be sensitive and exclude heavy O-helium, leaving an allowed range of U-quark masses, accessible to search in cosmic rays and at LHC and Tevatron

O-helium Universe?

- The proposed scenario is the minimal for composite dark matter. It assumes only the existence of a heavy stable U-quark and of an anti-U excess generated in the early Universe to saturate the modern dark matter density. Most of its signatures are determined by the nontrivial application of known physics. It might be too simple and too pronounced to be real. With respect to nuclear transformations, O-helium looks like the “philosopher’s stone,” the alchemist’s dream. That might be the main reason why it cannot exist.
- However, its exciting properties put us in mind of Voltaire: “Se O-helium n’existai pas, il faudrai l’inventer.”

O-helium solution for DAMA/CDMS controversy?

In underground detectors equilibrium concentration of O-helium is reached at a timescale of a day. Therefore it should possess annual modulations due to Earth’s motion.

The inelastic process

$$(A,Z) + (He\zeta) \rightarrow [(A,Z)\zeta^{--}] + He$$

changes the charge of the nucleus (A,Z) from Z to (Z-2) with the corresponding change of electronic 1S levels. It results in ionization energy

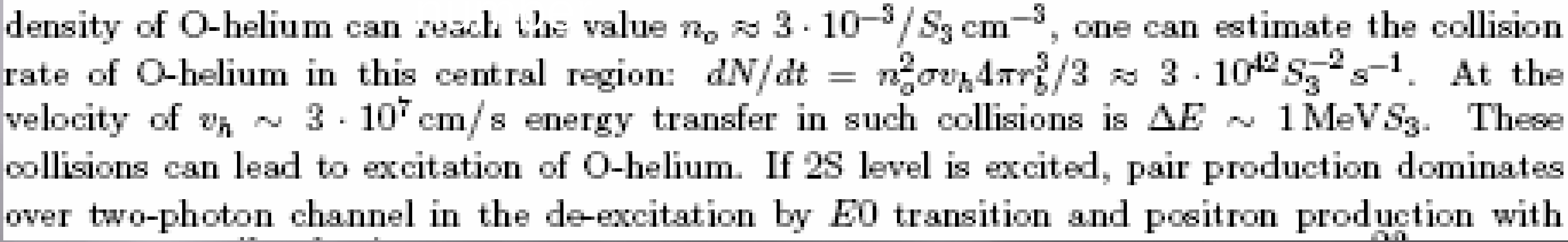
$$\Delta E = Z^2\alpha^2 m_e/2 - (Z-2)^2\alpha^2 m_e/2] \approx Z\alpha^2 m_e$$

which is about 2 keV for I and 4 keV for Tl.

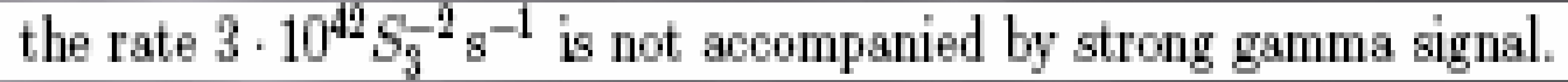
This inelastic process does not lead to phonon effect in CDMS and thus can be masked as background in direct searches for WIMPs

OHe solution for positron annihilation in bulge

In the galactic bulge



density of O-helium can reach the value $n_o \approx 3 \cdot 10^{-3}/S_3\,\mathrm{cm}^{-3}$, one can estimate the collision rate of O-helium in this central region: $dN/dt = n_o^2 \sigma v_h 4\pi r_b^3/3 \approx 3 \cdot 10^{42} S_3^{-2}\,\mathrm{s}^{-1}$. At the velocity of $v_h \sim 3 \cdot 10^7\,\mathrm{cm/s}$ energy transfer in such collisions is $\Delta E \sim 1\,\mathrm{MeV}\,S_3$. These collisions can lead to excitation of O-helium. If 2S level is excited, pair production dominates over two-photon channel in the de-excitation by $E0$ transition and positron production with

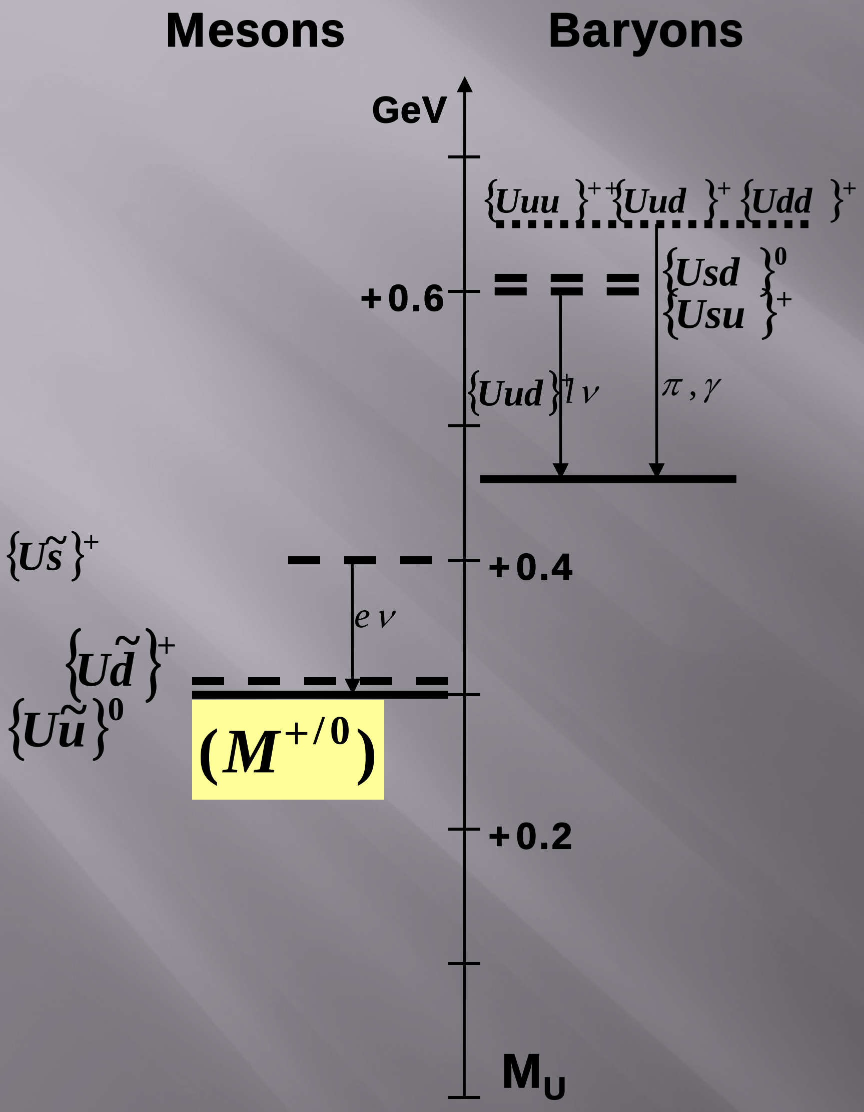


the rate $3 \cdot 10^{42} S_3^{-2}\,\mathrm{s}^{-1}$ is not accompanied by strong gamma signal.

It can explain the observed positron annihilation rate.

A series of gamma lines from excitations with nonzero orbital momentum is predicted

Expected mass spectrum and physical properties of heavy hadrons containing (quasi)stable new quarks.



The same for Ū-hadrons

(Λ_U^{+})

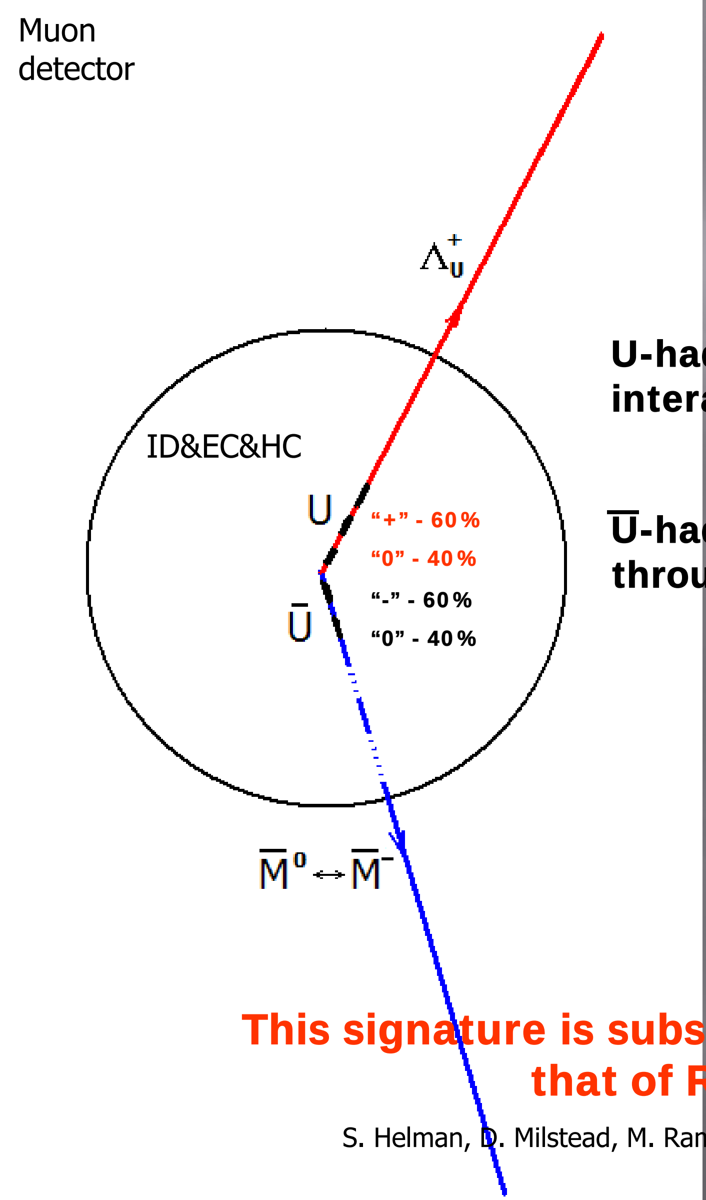
Yields of U-hadrons in ATLAS

$\{Uud\}^{+}$	8%
	40%
$\{U\tilde{d}\}^{+}$ $\{\tilde{U}d\}^{-}$	40%
$\{U\tilde{s}\}^{+}$ $\{\tilde{U}s\}^{-}$ $\{U\tilde{u}\}^{0}$	12%
$\{Usq\}^{+/0}$ $\{\tilde{U}\tilde{s}\tilde{q}\}^{-/0}$	~1%

$\{\tilde{U}\tilde{u}\tilde{d}\}^{-}$

$\{\tilde{U}u\}^{0}$

Expected physical properties of heavy hadrons
Possible signature.



Particle transformation during propagation through the detector material

U-hadron does not change charge (+) after 1-3 nuclear interaction lengths (being in form of baryon)

Ū-hadron changes its charge (0<->-) during propagation through the detectors (being in form of meson)

Ū-baryon will be converted into U-meson

$\tilde{\Lambda}_U^- + N \to \tilde{M}^{0/-} + \pi, \ldots$

Ū-mesons will experience inter-conversion

$\tilde{M}^{0/-} + N \leftrightarrow \tilde{M}^{0/-} + N, \ldots$

$\to \tilde{\Lambda}_U^- + N + N, \ldots$ suppressed

U-baryon will not be converted

$\Lambda_U^+ + N \to M^{0/+} + N + N, \ldots$ suppressed

U-mesons will experience inter-conversion and convert to U-baryon

$M^{0/+} + N \leftrightarrow M^{0/+} + N, \ldots$

$\to \Lambda_U^+ + \pi, \ldots$

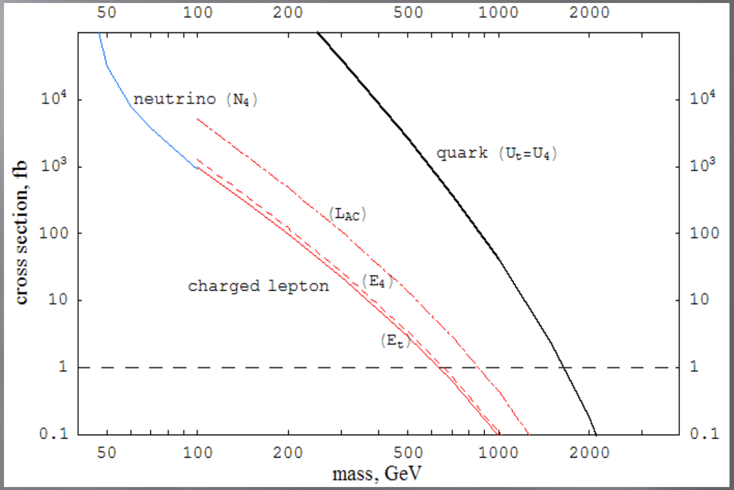
Strange U-hadrons will get the form

$\{Usd\}^0 \leftrightarrow \{Usu\}^+$ and $\{\tilde{U}s\}^-$

This signature is substantially different from that of R-hadrons

S. Helman, D. Milstead, M. Ramstedt, ATL-COM-PHYS-2005-065

LHC discovery potential for components of composite dark matter



- In the context of composite dark matter search for new (meta)stable quarks and leptons acquires the meaning of crucial test for its basic constituents
- The level of abscissa axis corresponds to the minimal level of LHC sensitivity during 1year of operation

Conclusions

- Composite dark matter and its basic constituents are not excluded either by experimental, or by cosmological arguments and are the challenge for cosmic ray and accelerator search

- Small fraction or even dominant part of composite dark matter can be in the form of O-helium, catalyzing new form of nuclear transformation

- It can resolve DAMA/CDMS controversy (which taken seriously EXCLUDES WIMP-like solutions) and the puzzle of positron annihilation in bulge

- The program of test for composite dark matter in cosmoparticle physics analysis of its signatures is available