Virtual Crossword of Grand Unification

D. Skripachov

Abstract

Grand unification can be considered as a virtual crossword ideas, hypotheses and theories. Compose and solve this crossword, we develop new ideas and hypotheses, which intersect with each other. The idea of space consisting of unit cells allows us to relate gravitation to the ability of unit cells to change volume, and electromagnetism to the ability of unit cells to internal movement. The ability of unit cells to form short-range order suggests that photons, leptons, mesons and baryons have structure of regular and semiregular polyhedra. Applied to dark matter, new model of elementary particles leads to the conclusion that elements of DM are non-relativistic nuclei consisting of neutrinos or antineutrinos. It is alleged that neutrinos are capable to form short-lived Cooper pairs most of which immediately decay appearing oscillation, and other fuse into nuclei of deutrinium, the lightest element of DM.

1 Introduction

It seems paradoxical that today when we know so much about the structure of the world, we still do not know why electromagnetic and gravitational interactions at the level of elementary particles so strongly differ in intensity between themselves[1]. Seeking to eliminate this lack of knowledge, we are trying to create a new theory, the "theory of everything", that would unite the fundamental interactions, explain the origin of elementary particles, and clarify the nature of dark matter and dark energy. Today we consider a new model of unification, presented by mutually intersecting theories, hypotheses and ideas. Our new approach is to use such intersections for composing and solving a virtual crossword of Grand Unification.

As the first "word" we inscribe into our virtual crossword the idea of cellular space consisting not of points but of unit cells, or cellular automata with dimensions comparable to the size of elementary particles. Unit cells are endowed the triad of fundamental properties: the ability to change the volume relative to each other, the ability to internal movement, the ability to form short-range order. All sorts of changes of unit cells consist of portions that occur synchronously throughout the space as a whole and form a sequence of tacts of universal time. Based on the characteristic size of elementary particles, we assume that unit length (linear size of the unit cell) is about 0.9×10^{-15} m, and elementary tact of time (chronon) is about 0.3×10^{-24} s.

Recently, we have figured out how gravitation works [1], and now we continue our research in an effort to clarify how bodies and particles create the curvature of space. First we will recollect early Maxwell model, where he offered an interpretation of the electromagnetic field with the help of molecular vortices, and will establish that the rotational component of the internal motion of unit cells and electromagnetic interaction are interrelated with each other. Then we'll figure out how gravitation and electromagnetic are interconnected among themselves.

The ability to form short-range order will allow us to build a new model of elementary particles-polyhedra on the faces of which lay unit cells with internal movement which completely

[1] Force of gravitational attraction between two electrons at rest is 2.40×10^{-43} on the force of electrostatic repulsion, between two protons is 8.09×10^{-37}, respectively

determines all the properties of elementary particles. New model of elementary particles will allow us to conclude that the dark matter particles must be "supersymmetric" lepton analogues of atomic nuclei, presented by nuclei of neutrinium and antineutrinium.

2 Internal motion of unit cells and cross-warp hypothesis

Clifford believed that small portions of space have inside the geometry that differs from the geometry of usual (euclidean) space [2]. Combining this idea with cellular space, we assume that unit cells have within themselves the elliptical geometry of three-dimensional space. Then, speaking of the internal motion of unit cells, we must take into account that in the three-dimensional elliptic space translational movement has one of two kinds, with right or left helicity. It means also that any internal movement of unit cells contains both translational and rotational component.

Maxwell suggested the existence of microscopic (molecular) vortices and showed how these vortices can simulate electromagnetic phenomena [3]. In our model we can easily simulate the electromagnetic field by the rotational component of the internal motion of unit cells. Let us take an electrically charged sphere. Imagine on the surface of charged sphere the unit cells of space rotate at the same frequency and have orientation of rotation axes outwards from the center of the sphere. The electric field of charged sphere is characterized by the decrease rotation of unit cells with increasing distance from the sphere. Direction of rotation axes of unit cells will correspond to the direction of the electric field lines.

Solenoid can be imagined as a cylinder composed of unit cells rotating with equal frequency and having axes oriented in one and the same direction along circles constituting the lateral surface of the cylinder. Solenoid magnetic field is characterized by decreasing rotation of unit cells with increasing distance from the solenoid. The magnetic field lines pass through the unit cells with equal speed of rotation perpendicular to their rotation axis.

Assume that the elementary particles correspond to the symmetric and spherically closed compositions of unit cells. Imagine an electron in the form of an octahedron, on faces of which are located unit cells. Electric charge of such an electron will be driven by rotation of unit cells located on its faces, so that all the axis of rotation pass through the center of the octahedron, and the rotation is directed, say, counter clockwise when viewed from the electron outside. Spin and magnetic moment of the electron will be determined by an additional rotation of unit cells on the faces of the polyhedron with the orientation of the axes of this rotation in any one certain direction. Assume also that the rotational speed of unit cells on the faces of the octahedron, which creates negative charge of the electron, is equal to the rotation by an angle $-\pi/3$ per one chronon, and respectively by $\pi/3$ per 1 chronon for the positron.

If electromagnetic interaction corresponds to the rotational component of the internal motion of unit cells, the mechanical movement of bodies will correspond the translational component, but only some part of it. Another part of the internal motion of unit cells will be responsible for all other properties of elementary particles. Among these properties, we need highlight the mass, which differs from other by additivity. This additivity allows us to assert that the total mass of any elementary particle is determined by the total amount of internal motion of unit cells, related to the existence and movement of given elementary particle. On the other hand, we know that any mass creates a curvature of space due to the relative increase the volume of unit cells. But how are linked between themselves the internal motion and change in volume of unit cells?

As we defined, the gravitational field acts on the bodies and particles through the change of the kinematics (relativistic) effects accompanying change in volume of unit cells by increasing or decreasing distension of curved space. Dependence of the kinematic effects from changes distension of space implies the existence of deeper relationship between the internal motion and change the relative volume of unit cells. It is obvious that the gravitational field of bodies arises as a result of the internal motion of unit cells belonging to elementary particles of attracting bodies. Take an electron at rest and assume that its 8 unit cells possess the total amount of internal motion with speed of one full length of unit cell per one chronon. At a distance of one unit cell from the center of an electron the distension of space is:

$$\Theta_{uce} = 7.5 \times 10^{-43} + 1 \tag{1}$$

The question arises, what is the mechanism of the appearance of distension of space, and why it is so small compared to generating it the amount of internal motion of unit cells? Search the mathematical relationship, giving a comparable order of smallness, leads us to the infinite cosine product integral [5]:

$$C_2 = \int_0^{\infty} cos(2x) \prod_{n=1}^{\infty} cos\left(\frac{x}{n}\right) dx \tag{2}$$

$$= 0.39269908169... \tag{3}$$

$$\frac{1}{8}\pi - C_2 = 7.407346566316950557 \times 10^{-43} \tag{4}$$

But we see that infinite cosine product integral gives a negative deviation from $1/8\pi$, while the distension of space is always greater than unity. This contradiction can be easily removed if we assume that the relative volume of unit cells is interconnected with exactly the same decrease in their absolute volume. Such an obvious interrelation allows us to formulate the following "cross-warp" hypothesis: *Internal motion of unit cells of space is accompanied by isotropic reduction of their internal length with coefficient of proportionality equal to the difference between $1/8\pi$ and the infinite cosine product integral.*

Representation of unit cells of space as cellular automata with continuous internal movement of elliptic space gives us an entirely new and promising perspective for further modeling of elementary particles. This modeling will be based on the assumption that elementary particles have the form of closed symmetric association of unit cells of space.

3 Elementary particles and regular and semiregular polyhedra

Assume that unit cells lying on the faces of the polyhedron have between them pairwise adjacent faces coming from the edges of the polyhedron. Within any such a polyhedron there is absolutely nothing, and its interior is not a unit cell of space.

Consider the distribution of elementary particles by types of polyhedra. First of all, we find that the five regular polyhedra can be compared photon, electron, neutrino, proton, and neutron. For 13 semiregular polyhedra we also find suitable conformity of mesons and hyperons. In finding of such conformities we do not have strict rules, and as selection criterion serves set of properties, such as belonging to a particular family (leptons, mesons or baryons), mass value, presence or absence of charge, probability of birth, and lifetime. Found conformities presented in Table 1. In this table were included a limited number of known elementary particles, while the majority of them (mesons and hyperons) remained outside the classification. Not included are particles with smaller probability of birth, or shorter lifetime, as well as resonances. We assume that these particles are associated with particles included in our conformity table, and represent

Table 1: Conformity of polyhedra and elementary particles

Polyhedron	**Elementary particle**
tetrahedron	photon
octahedron	electron
cube	neutrinos
cuboctahedron	muon
truncated octahedron	neutral pion
snub cube (left and right)	charged pions
truncated cube	charged kaons
rhombicuboctahedron pseudorhombicuboctahedron	neutral kaons (long- and short-lived)
truncated tetrahedron	eta meson, eta prime meson
truncated cuboctahedron	tau lepton
icosahedron	proton
dodecahedron	neutron
icosidodecahedron	Lambda baryon
snub dodecahedron (left and right)	charged Sigma baryons (light and heavy)
truncated ikosahedron,	neutral Sigma baryon
truncated dodecahedron	charged Xi baryons
rhombicosidodecahedron	neutral Xi baryon
truncated icosidodecahedron	Omega baryon

excited states or superposition of initial elementary particles presented by polyhedra.

Consider the equations associated with the representation of polyhedra in a basis form, i.e. expressions that define polyhedra vertex coordinates on the projective sphere [9]. The following three basis forms being equated to zero, define the vertices of the octahedron, cube, and cuboctahedron, respectively:

$$t = z_1 z_2 (z_1^4 - z_2^4), \tag{5}$$

$$W = z_1^8 + 14 z_1^4 z_2^4 + z_2^8, \tag{6}$$

$$\chi = z_1^{12} - 33 z_1^8 z_2^4 - 33 z_1^4 z_2^8 + z_2^{12}, \tag{7}$$

Between these forms the following identity exists:

$$108 t^4 - W^3 + \chi^2 = 0 \tag{8}$$

The following three basis forms being equated to zero, define the vertices of the icosahedron, dodecahedron, and ikosidodekaedron, respectively:

$$f = z_1 z_2 (z_1^{10} + 11 z_1^5 z_2^5 + z_2^{10}), \tag{9}$$

$$H = -(z_1^{20} + z_2^{20}) + 228 (z_1^{15} z_2^5 - z_1^5 z_2^{15}) - 494 z_1^{10} z_2^{10}, \tag{10}$$

$$T = z_1^{30} + z_2^{30} + 522 (z_1^{25} z_2^5 - z_1^5 z_2^{25}) - 1005 (z_1^{20} z_2^{10} + z_1^{10} z_2^{20}), \tag{11}$$

Between these forms the following identity exists:

$$1728 f^5 - H^3 - T^2 = 0 \tag{12}$$

At first glance, these expressions tell us nothing about any relationship with elementary particles. But adding together the coefficients of the octahedral member t^4 in the identity (8) and icosahedral member f^5 in the identity (12), we suddenly see that the resulting number 1836 is almost exactly the same as mass ratio of the proton and electron!

Consider basis forms of semiregular polyhedra with octahedral symmetry. The following forms, being equated to zero, define vertices of the truncated octahedron, truncated cube, rhombicuboctahedron, and snub cube (left and right), respectively:

$$P = z_1^{24} + z_2^{24} - \frac{8211}{25}(z_1^4 z_2^{20} + z_1^{20} z_2^4) + \frac{51819}{25}(z_1^8 z_2^{16} + z_1^{16} z_2^8) + \frac{15134}{25} z_1^{12} z_2^{12} \qquad (13)$$

$$Q = z_1^{24} + z_2^{24} + (94 - 64\sqrt{2})(z_1^4 z_2^{20} + z_1^{20} z_2^4) + (383 + 256\sqrt{2})(z_1^8 z_2^{16} + z_1^{16} z_2^8) + \\ +(3140 - 384\sqrt{2}) z_1^{12} z_2^{12} \qquad (14)$$

$$R = z_1^{24} + z_2^{24} + (94 + 64\sqrt{2})(z_1^4 z_2^{20} + z_1^{20} z_2^4) + (383 - 256\sqrt{2})(z_1^8 z_2^{16} + z_1^{16} z_2^8) + \\ +(3140 + 384\sqrt{2}) z_1^{12} z_2^{12} \qquad (15)$$

$$S = z_1^{24} + z_2^{24} + 60.7018093(z_1^4 z_2^{20} + z_1^{20} z_2^4) + 516.1927629(z_1^8 z_2^{16} + z_1^{16} z_2^8) + \\ +2940.2108557 z_1^{12} z_2^{12} \pm 135.0932604\sqrt{-1} t^4 \qquad (16)$$

In the equation of snub cube the sign "+" in the last member corresponds to the left cube, whose square faces are turned to the left, and the sign "−" corresponds to the right cube, whose square faces turned to the right. From the basis forms of semiregular polyhedra with octahedral symmetry we can write the following identities:

$$P = \chi^2 - 262.44 t^4 \qquad (17)$$

$$Q = \chi^2 + 69.49033 t^4 \qquad (18)$$

$$R = \chi^2 + 250.50967 t^4 \qquad (19)$$

$$S - \bar{S} = 270.18652\sqrt{-1} t^4 \qquad (20)$$

Here we see that the coefficients of the member t^4 in the first and last identities fairly close repeat masses of the neutral and charged pions. And the chirality of snub cube additionally indicates that his right and left forms correspond to the charged pions. Remaining truncated cube and rhombicuboctahedron we match to the charged and neutral kaons, respectively. The presence of a special kind of rhombicuboctahedron, pseudorhombicuboctahedron, suggests that these two polyhedra correspond to the neutral kaons which are characterized by a combination of long- and short-lived particles.

Analogous equations of the basis forms for the hyperons do not give similar coincidence between any coefficients and masses of elementary particles. But there is another interesting dependence of hyperons masses from the proton mass expressed in the following formula:

$$m_{hyp} \approx 2^{n/12} m_p \qquad (21)$$

Profile index n takes the following values: $n = 3$ for Lambda baryon, $n = 4$ for Sigma baryons, $n = 6$ for Xi baryons, and $n = 10$ for Omega baryon. We note also that splitting the mass in the quartet of charged Sigma baryons should be related to the chirality of snub dodecahedron.

Representation of elementary particles by polyhedra allows to consider the interaction between elementary particles without participation of any kind of intermediate particles. So interconversion of elementary particles can be regarded as the result of a continuous competition between real elementary particles and their virtual opponents exactly the same polyhedra tries on the unit cells of space belonging to the actually existing particles. Once the virtual particles gain an advantage, the transformation occurs, the virtual particles go into real ones, and real go into virtual. In opposite case, when interconversion is unprofitable, and competition for unit cells gives way to their joint use, appear stable unions of elementary particles, i. e. atomic nuclei. Assume that icosahedra and dodecahedra corresponding protons and neutrons are combined in the atomic nucleus along the edges and form a carcass. Then every two unit cells bordering on the common edges of polyhedra in the carcass, lose their adjacency, and at the same time each of them becomes common to its pair of polyhedron.

Similar manner the idea of joint association of elementary particles along the edges of polyhedra can be applied to dark matter, suggesting that DM particles are carcasses composed of cubes corresponding neutrino or antineutrino. Unlike neutrino, DM nuclei should be non-relativistic particles.

4 Brief overview of DM properties arising from the carcass model

Suppose that the ability of neutrinos to unite in the nuclei appears at particle energies comparable to the electron rest mass, and that neutrinos in the nuclei have approximately the same dependence of the binding energy of the mass number as nucleons in nuclei of chemical elements. Assume also that the binding energy between neutrinos is about 2000 times less than the binding energy of nucleons, and that the neutrinium nuclei in most cases consist of 2-20 neutrinos and have rest mass of 1-10 MeV. We will assume that neutrinium nuclei are elastically scattered on atomic nuclei, elastically interact with leptons, elastically and inelastically between themselves. By analogy with neutron matter, we assume that DM has its own density limit, conditionally taken 1840 times less than neutron density of collapsars.

Suppose that at rapprochement of neutrinos among themselves at a distance of about 10^{-11} m arises neutrino Cooper pair (NCP), which almost immediately decays, having existed for no more than 10^{-19} s, or undergoes a quantum transition, becoming boson nucleus of deutrinium. Internal fusion of neutrino Cooper pairs (npf-process) will occur on condition that the virtual collision energy significantly will not exceed the binding energy of neutrinos in the nuclei of DM. Fusion of neutrinos must be accompanied by the emission of photons in energy range from radio to soft X-ray. Allowing the possibility of NCP we also allow the possibility of electron-neutrino, electron-antineutrino, positron-antineutrino and positron-neutrino Cooper pairs. Decay of neutrino-lepton Cooper pairs will be accompanied by energy exchange between the particles and change the internal state, which determines the type of neutrino. Perhaps that is a quasi-elastic interaction during formation and decay of neutrino Cooper pairs leads to the appearance of neutrino oscillations.

Presumably, in our Galaxy, as well as in galaxies of the Local Group and Virgo Supercluster, diffuse DM consists mainly of nuclei of antineutrinium. This means that the nuclei of deutrinium arising from fusion of solar neutrinos must annihilate in collisions with nuclei of galactic antineutrino DM. Annihilation will be accompanied by the emission of continuous spectrum with photon energy of tens keV to several MeV. And if it really is true, then we can assert that the solar corona exists due to the energy released during synthesis of solar deutrinium and its annihilation with nuclei of galactic antineutrino DM.

Consider the effect of annihilation of solar deutrinium and diffuse DM on the anomalous precession of Mercury's orbit. Passing of Mercury through diffuse DM is accompanied by gravitational lensing of the oncoming flow of DM, resulting in behind planet arises a plume with higher density of DM. This leads to the fact that in the rear part of the planet is created a constant excess energy of annihilation, released in the form of X-ray and gamma radiation. Anisotropy of energy DM annihilation around Mercury generates acceleration from the effect of thermal recoil, similar to the one that arises from the accumulation of heat in the surface layer of the planet in the aphelion.

Continuing, we can assume that the galactic ridge X-ray emission is formed due to DM annihilation in stellar coronas. But in stellar coronas annihilates only part of stellar deutrinium (SD). Another part of SD continues annihilate with diffuse antineutrino DM at greater distance, that is possible to cause giant gamma-ray bipolar bubbles of Galaxy.

During DM annihilation must be released neutrinos and antineutrinos with a relatively low energy. Some of these neutrinos and antineutrinos will form Cooper pairs with free electrons in the galactic halo. In this case part of the total momentum of neutrinos and antneutrinos will be transferred to the electrons, that will generate an electrical current, whose direction will be exactly the same as the direction of the galactic DM currents. And this electric current will induce the galactic magnetic field.

Reducing the amount of solar neutrinos as a result of their fusion may explain the missing part of the solar neutrino deficit which is not explained by only one oscillation. A similar deficit of reactor antineutrinos [22, 23] can be also explained partly by oscillation, and partly by diminution during npf-process. Nuclei of antideutrinium synthesized from reactor antineutrinos can connect to the nuclei of diffuse galactic DM, forming antineutrinium nuclei of larger mass number. Then in the emission spectrum must be present more or less defined peak corresponding to the binding energy of neutrinos in DM nuclei. Perhaps annual modulations in the energy range 2-6 keV identified by DAMA/LIBRA collaboration [26, 27] as well as CoGeNT collaboration [28], are associated with events of the fusion reactor antideutrinium and galactic antineutrino DM nuclei. On the scale of galaxies synthesis of heavier nuclei of neutrinium and antineutrinium just as well must be accompanied by an increased intensity of X-rays in the same range. So, recently discovered new emission line at E $\sim$ 3.52-3.57 keV in X-ray spectra of galaxies [34, 35], as well as an earlier announcement about the new line at E $\sim$ 2.51 keV [33], indicate the synthesis DM nuclei with mass number 4 and up, i. e. heavier nuclei neutrinium from SD, and heavier nuclei antineutrinium from antideutrinium arising at splitting galactic DM nuclei by their partial annihilation with SD.

5 Conclusions

In virtual crossword we were looking for the intersection of ideas, hypotheses and theories and tried to find an explanation of unity of fundamental interactions and elementary particles. Idea of cellular space led us to a new level of understanding of the nature of gravitation and electromagnetism. We considered a new model of elementary particles-polyhedra and came to a new hypothesis that the dark matter consists of nuclei of neutrinium and antineutrinium, arisen as a result of internal fusion neutrino and antineutrino Cooper pairs into boson DM nuclei and subsequent synthesis of DM nuclei with larger mass number. The new model of DM explained to us a number of phenomena, including the annual modulation in DAMA/LIBRA experiment, solar neutrino deficit, solar corona, and new emission line in the X-ray spectrum of galaxies. Representing the Grand Unification as a virtual crossword, we got a fascinating puzzle game. And solving this puzzle continues.

References

[1] D. Skripachov, A New Model of Gravitation, viXra:1404.0463 (2014)

[2] W. K. Clifford, On the Space-Theory of Matter. Proceedings of the Cambridge philosophical society (1876), Wikisource, The Free Library (retrieved in March 2013)

[3] J. C. Maxwell, On physical lines of force. Philosophical Magazine and Journal of Science, London (1861)

[4] L. de Broglie, Ondes et quanta. Comptes Rendus **177**, 507 (1923)

[5] E. W. Weisstein, Infinite Cosine Product Integral. From MathWorld – A Wolfram Web Resource, (retrieved in January 2012)

[6] M. Requardt, Discrete Mathematics and Physics on the Planck-Scale exemplified by means of a Class of 'Cellular Network Models' and their Dynamics. arXiv:hep-th/9605103

[7] C. R. Shalizi, K. L. Shalizi, Quantifying Self-Organization in Cyclic Cellular Automata. Proceedings of SPIE **5114**, 108 (2003), arXiv:nlin/0507067

[8] B. J. MacLennan, Continuous Spatial Automata. Department of Computer Science Technical Report CS-90-121, Knoxville (1990)

[9] F. Klein, Vorlesungen über das Ikosaeder und die Auflösung der Gleichungen vom fünften Grade. Tübner, Leipzig (1884)

[10] E. C. G. Sudarshan, Elementary Particles. Encyclopedia of Physics, R. M. Besancon (ed.), Reinhold Pub. Corp., New York (1966)

[11] F. Reines, C. L. Cowan, Jr., On the Detection of the Free Neutrino. LANL, Los Alamos (1953)

[12] M. L. Perl, Evidence for, and properties of, the new charged heavy lepton. Proc. Rencontres de Moriond, SLAC-PUB-1923 (1977)

[13] A. Kupsc, What is interesting in eta and eta' Meson Decays? AIP Conf. Proc. **950**, 165 (2007), arXiv:0709.0603

[14] J. F. Beacom, N. F. Bell, S. Dodelson, Neutrinoless Universe. Phys. Rev. Lett. **93**, 121302 (2004), arXiv:astro-ph/0404585

[15] D. N. Spergel, P. J. Steinhardt, Observational evidence for self-interacting cold dark matter. Phys. Rev. Lett. **84**, 3760 (2000), arXiv:astro-ph/9909386

[16] R. Jr. Davis, D. S. Harmer, Solar Neutrinos. Brookhaven National Laboratory, Upton, New York (1965)

[17] J. N. Bahcall, M. H. Pinsonneault, S. Basu, Solar Models: current epoch and time dependences, neutrinos, and helioseismological properties. ApJ **555**, 990 (2001), arXiv:astro-ph/0010346

[18] J. N. Abdurashitov, et al., (SAGE Collaboration), Measurement of the solar neutrino capture rate with gallium metal. III: Results for the 2002–2007 data-taking period. Phys. Rev. C **80**, 015807 (2009), arXiv:0901.2200

[19] G. Bellini, et al., (Borexino Collaboration), Precision measurement of the 7Be solar neutrino interaction rate in Borexino. Phys. Rev. Lett. **107**, 141302 (2011), arXiv:1104.1816

[20] V. Antonelli, L. Miramontia, C. Peña-Garay, and A. Serenelli, Solar Neutrinos. Advances in High Energy Physics, vol. 2013 (2013), arXiv:1208.1356

[21] M. M. Nieto, A. C. Hayes, C. M. Teeter, W. B. Wilson, W. D. Stanbro, Detection of Antineutrinos for Non-Proliferation. Nucl. Sci. Engin. **149**, 270 (2005), arXiv:nucl-th/0309018

[22] K. Eguchi, et al., (KamLAND Collaboration), First Results from KamLAND: Evidence for Reactor Anti-Neutrino Disappearance. Phys. Rev. Lett. **90**, 021802 (2003), arXiv:hep-ex/0212021

[23] F. P. An, et al., (Daya Bay Collaboration), Improved Measurement of Electron Antineutrino Disappearance at Daya Bay. Chinese Phys. C **37**, 011001 (2013), arXiv:1210.6327

[24] M. Altmann, et al., (CRESST Collaboration), Results and plans of the CRESST dark matter search. X International Symposium on Lepton and Photon Interactions at High Energies, Rome (July 2001), arXiv:astro-ph/0106314

[25] G. Angloher, et al., Results from 730 kg days of the CRESST-II Dark Matter Search. Eur. Phys. J. C **72**, 1971 (2012), arXiv:1109.0702

[26] R. Bernabei, P. Belli, F. Cappella, et al., First results from DAMA/LIBRA and the combined results with DAMA/NaI. Eur. Phys. J. C **56**, 333 (2008), arXiv:0804.2741

[27] R. Bernabei, et al., Final model independent result of DAMA/LIBRA-phase1. 16th Lomonosov Conference, Moscow (August 2013), arXiv:1308.5109

[28] C.E. Aalseth, et al., (CoGeNT collaboration), Results from a Search for Light-Mass Dark Matter with a P-type Point Contact Germanium Detector. Phys. Rev. Lett. **106**, 131301 (2011), arXiv:1002.4703

[29] S. Chang, J. Liu, A. Pierce, N. Weiner, I. Yavin, CoGeNT Interpretations. JCAP **08**, 018 (2010), MCTP-10-16, arXiv:1004.0697

[30] E. Armengaud, et al., (EDELWEISS Collaboration), A search for low-mass WIMPs with EDELWEISS-II heat-and-ionization detectors. Phys. Rev. D **86**, 051701 (2012), arXiv:1207.1815

[31] E. Aprile, et al., (XENON100 Collaboration), Response of the XENON100 Dark Matter Detector to Nuclear Recoils. Phys. Rev. D **88**, 012006 (2013), arxiv:1304.1427

[32] R. Agnese, et al., CDMSlite: A Search for Low-Mass WIMPs using Voltage Assisted Calorimetric Ionization Detection in the SuperCDMS Experiment (2013), arXiv:1309.3259

[33] M. Loewenstein, A. Kusenko, Dark Matter Search Using Chandra Observations of Willman 1, and a Spectral Feature Consistent with a Decay Line of a 5 keV Sterile Neutrino. APJ **714**, 652 (2010), arXiv:0912.055

[34] E. Bulbul, M. Markevitch, A. Foster, R. K. Smith, M. Loewenstein, S. W. Randall, Detection of An Unidentified Emission Line in the Stacked X-ray spectrum of Galaxy Clusters (2014), arXiv:1402.2301

[35] A. Boyarsky, O. Ruchayskiy, D. Iakubovskyi, J. Franse, An unidentified line in X-ray spectra of the Andromeda galaxy and Perseus galaxy cluster (2014), arXiv:1402.4119

[36] L. Wolfenstein, Neutrino oscillations in matter. Phys. Rev. D **17**, 2369 (1978)

[37] A. Yu. Smirnov, The MSW effect and Solar Neutrinos, 10th workshop on Neutrino Telescopes, Venice (March 2003), arXiv:hep-ph/0305106

[38] K. Abe, et al., (T2K Collaboration), Indication of Electron Neutrino Appearance from an Accelerator-produced Off-axis Muon Neutrino Beam. Phys. Rev. Lett. **107**, 041801 (2011), arXiv:1106.2822

[39] P. Adamson, et al., (MINOS Collaboration), Electron neutrino and antineutrino appearance in the full MINOS data sample. Phys. Rev. Lett. **110**, 171801 (2013), arXiv:1301.4581

[40] A. Valinia, F. E. Marshall, RXTE Measurement of the Diffuse X-ray Emission From the Galactic Ridge: Implications for the Energetics of the Interstellar Medium. ApJ **505**, 134 (1998), arXiv:astro-ph/9804012

[41] R. Krivonos, M. Revnivtsev, E. Churazov, et al., Hard X-ray emission from the Galactic ridge. A&A **463**, 957 (2007), arXiv:astro-ph/0605420

[42] Meng Su, T. R. Slatyer, D. P. Finkbeiner, Giant Gamma-ray Bubbles from Fermi-LAT: AGN Activity or Bipolar Galactic Wind? APJ **724**, 1044 (2010), arXiv:1005.5480

[43] E. Carretti, R. M. Crocker, L. Staveley-Smith, et al., Giant Magnetized Outflows from the center of the Milky Way. Nature **493**, 66 (2013), arXiv:1301.0512

[44] M. Haverkorn, V. Heesen, Magnetic fields in galactic haloes. Space Science Reviews **166**, 133 (2012), arXiv:1102.3701

[45] Z. Berezhiani, A. D. Dolgov, I. I. Tkachev, Dark matter and generation of galactic magnetic fields. EPJ C **73**, 2620 (2013), arXiv:1307.6953