A B S T R A C T S

24th International Workshop »What Comes Beyond Standard Models«, Bled, Slovenia,

July 03 ─ July 11, 2021

Virtual Workshop July 05 ─ July 11, 2021 [ZOOM]

**Consistent Dark Matter exploration**

*Alexander Belyaev*

Abstract

The nature of Dark Matter (DM) is one of the greatest puzzles of modern particle

physics and cosmology. Although overwhelming observational evidences from

galactic to cosmological scales point to the existence of DM, after decades of

experimental effort only its gravitational interaction has been experimentally

confirmed. Currently, we do not have any clue on DM properties, such as its

spin, mass, interactions other than gravitational, symmetry responsible for its

stability, number of states associated to it, and possible particles that would

mediate the interactions between DM and the standard model (SM) particles.

If DM is light enough and interacts with SM particles directly or via some

mediators with a strength beyond the gravitational one, its elusive nature can

be decoded or constrained though combined searches: a) from direct production at

colliders b) via the relic density precisely measured through the observations

of cosmic microwave background (CMB) anisotropies by WMAP and PLANCK

collaborations; c) from DM direct detection (DD) experiments, which are

sensitive to elastic spin independent (SI) or spin dependent (SD) DM scattering

off nuclei; d) from DM indirect detection searches, that look for SM particles

produced in the decay or annihilation of DM present in the cosmos, both with

high energies observables (gamma-rays, neutrinos, charge cosmic rays) produced

in the local Universe, and by studying the effects of energy produced by DM

annihilation in the early universe on the properties of the CMB spectrum.

Decoding of unknown underlying theory of DM requires systematic

approach.Therefore we suggest the classification of Dark Matter models with

mediator multiplets of different spins charged under the weak group. This

classification allows to identify models which are already excluded and those

models and signatures which can be tested and possibly discovered at the LHC,

future colliders and non-colldier experiments. Systematic exploration of DM

models and their signatures at present creates the ground for the discovery of

DM and its identification in the near future. Several classes of those models

are discussed.

**The multi-component dark matter structure and its possible observed manifestations**

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Abstract:

Some extensions of the Standard Model predict a complex structure of the dark sector. The presence of several types of stable particles means the possibility of some specific effects due to various interactions of the dark matter components with each other and with the Standard Model fields. As an example, we consider the minimal model of vector hypercolor, in which neutral stable hyperbaryon and hyperpion with nondegenerate masses are generated by different hyperquark currents and can be interpreted as the dark matter candidates. The possibility of photon radiation with energies in the range 1-10 GeV is discussed. These photons are emitted by charged partners of the neutral hyperpion when the heavier DM components annihilate into lighter hyperpions. Such radiation can contribute to the flux of photons with energies ~10 GeV from the Galaxy Center. In addition, such radiation may indicate the existence of the dark matter clumps if the dark matter annihilation into two photons is suppressed, while the transitions between the dark matter components dominate. That is the case when the clump does not disappear, and its density remains practically unchanged. Effect of this type occurs in the scenarios where there are several dark matter components (with different masses) and their charged partners. Low-energy photon radiation may also arise if the dark matter carriers are composite states with a spectrum of excited levels.

**Numerical modelling of dark atom interaction with nuclei**

*T.E. Bikbaev*

Abstract:

The problem of direct searches for dark matter can be solved in the scenario of composite dark matter, in which hypothetical, stable, lepton-like particles having a charge of -2, (or X having a charge of -2n, where n is any natural number) avoid experimental discovery because they form with primary helium neutral atom-like states OHe (X-helium), called "dark" atoms. The solution to this problem is associated with a rigorous proof of the existence of a low-energy bound state in the interaction of a dark atom with nuclei. Such evidence must include a self-consistent explanation for nuclear attraction and Coulomb repulsion in such an interaction. The complexity of this longstanding challenge requires a consistent approach to its solution. Within the framework of our approach, we use numerical modeling to reveal the essence of the processes of interaction of OHe (XHe) with the nuclei of baryonic matter using the classical three-body problem, to which the effects of quantum physics are successively added. As a result, our approach led to the development of a numerical model of the interaction of ОНе (XHe) with a target nucleus in two approximations: in the form of the Bohr atom model and in the form of the Thomson atom model. These models describe a system of three charged particles interacting with each other by means of Coulomb and nuclear forces. In the future, our numerical model can confirm the interpretation of the results of the direct underground experimental search for dark matter from the point of view of the dark atom hypothesis.

**HS Yang-Mills-like models**

*Loriano Bonora*

Abstract:

I review an attempt to construct massless gauge field theories in Minkowski spacetime that go under the name of HS-YM. I present their actions and their symmetries. I motivate their gravitational interpretation. In particular I show how to recover the local Lorentz invariance, which is absent in the original formulation of the theories. Then I propose a perturbative quantization in the so-called frozen momentum frame. I discuss physical and unphysical modes and show how to deal with them. Finally I show the existence of a gauge symmetry hidden under such unphysical modes. This requires a

nonlocal reformulation of the theory, which is, however, characterized by an augmented degree of symmetry.

**Color Confinement, Supersymmetric Properties of Hadron Physics, and Novel Features of QCD from Light-Front Holography**

*Stanley J. Brodsky*, SLAC National Accelerator Laboratory, Stanford University

Abstract:

I will survey a number of new developments in hadron physics which can be derived from the application of superconformal quantum mechanics and light‐front holography -- its embedding in higher dimensional gravity theory. This includes new insights into the

physics of color confinement, chiral symmetry, the spectroscopy and dynamics of hadrons, as well as surprising supersymmetric relations between the masses of mesons, baryons, and tetraquarks, I also will discuss some novel features of QCD-- such as color transparency, hidden color, and intrinsic heavy-quark phenomena.

**Charge asymmetry of new stable quarks in baryon asymmetrical Universe**

*Arnab Chaudhuri*

Novosibirsk State University

Abstract:

Effects of electroweak phase transition (EWPT) in balance

between baryon excess and the excess of stable quarks of new generation

is studied. With the conservation of SU(2) symmetry and other quantum

numbers, it makes possible sphaleron transitions between baryons,

leptons and new leptons and quarks. A definite relationship between

the excess relative to baryon asymmetry is established. In passing by we

also show the small, yet negligible dilution in the pre-existing dark

matter density due the sphaleron transition.

**Gravitational waves in modified gravity**

*Sourav Roy Chowdhuri* SFEDU, Russia

Abstract: We have considered the self-interacting scalar field with the trace of the energy-momentum tensor $T^\phi$. Based on the nature of potential the structural behaviour of the scalar field may vary and we have considered the spontaneous symmetry breaking potential for our system. And how the behaviour of the scalar field varies with the phase transition. Such conjuncture with the scalar field Lagrangian leads to a new set of Friedmann equations. The number of polarization modes of gravitational waves in modified theories has been studied extensively for the corresponding fields. There are two additional scalar modes, in addition to the usual two transverse-traceless tensor modes found in general relativity: a massive longitudinal mode and a massless transverse mode (the breathing mode).

**Small Bubbles of New Vacuum Dark Matter Scenario, DAMA and Xenon1T “see” Excited Bubbles**

*C. D. Froggatt*, Glasgow University *H.B.Nielsen*, Niels Bohr Institute

Abstract:

We seek to explain both the by season variation seeming

observation of dark matter by the DAMA-LIBRA experiment and the

observation of “electron recoil” - events in which the

liquid-Xe-scintillator was excited by electrons - in excess to

expected background - by the same dark matter model. The model by

which we seek to explain these two experiments together with also the

self interactions of dark matter suggested by as- tronomical studies

of dwarf gallaxies and galaxy clusters and the X-ray line with energy

per photon 3.55 keV suggested to be emitted from dark matter, and even

at first mysteriously from the supernova remnants of the Thycho

supernova, is a development of our earlier proposed model that dark

matter consists of macroscopic pearls, bubbles of a speculated new

type of vacuum. Relative to our earlier proposed model the dark

matter pearls are much smaller than in the previous articles (except

for last years Bled-proceeding where the story of the small pearls

started), now being of the order of 10−12m, smaller than or including

an electronic cloude at most of size as atoms. Our pearls are indeed

now similar to atoms, but with the nucleus replaced by a new vacuum

bubble containing several e.g. carbon nuclei, a little highly

compressed piece of ordinary matter. This macroscopic atom-like object

is like a semiconductor with a gap between the filled and the empty

electron states (the homolumo-gap) equal to 3.55 keV - the frequency

of the X-ray observed by sattelites etc. -. Slowed down quasi-

electrons inside the pearl thus give the observed X-ray by

annihilating with slowed down holes. The main point is to explain how

the ordinary - i.e. other than DAMA- LIBRA - gound experiments looking

for dark matter - do not “see” our pearls, and that is because our

pearls are not WIMPs but only IMPs, meaning that they interact so

strongly that they get stopped in the shield- ing of the experiments,

but continue to sink slowly into the shielding. They are thus not

observable by looking for nuclei being hit by the pearsl because they

are too slow. However, they have got excited during the breaking of

their velocity and are able to emit light or electrons with the energy

of their main excitation of 3.55 keV. So they look like being electron

recoils rather than recoils of nuclei. DAMA-LIBRA does not distinguish

1 if the signal comes via electrons or nuclei, but only seperate the

dark mat- ter by the seasonal variation, so they can “see” also our

electron-emitting pearls. We get good numerical understanding of the

fitted cross section over mass ratio observed by the dawrf galaxy

study, and we correct the rates of DAMA-LIBRA and the electron recoil

observation of Xenon1T to agree very well. Also the total energy of

the dark matter pearls stopped in the shield is very reasonably

matching order of magnitudewise with the absolute observation rates of

DAMA-LIBRA and Xenon1T. By far the majority of the excited pearls

decay long before they reach down to the experimental halls, but we

think it is physically reasonable and conceiv- able, that the very

little fraction of excited pearls needed to match the observation

would survive down there. It should be stressed that accepting that

the different phases of the vac- uum could be realized inside the

Standard Model, our whole scheme could be realized inside the Standard

Model, so then no new physics needed for dark matter!

**Neutrino masses within a SU(3) family symmetry and a 3+5 scenario**

*Albino Hernández-Galeana*

*Abstract:*

Within a broken local vector-like SU(3) family symmetry, we ad- dress the problem of quark masses and mixing in a framework with five sterile neutrinos.

Heavy fermions, top and bottom quarks and tau lepton become massive at tree level from See-saw mechanisms implemented by the introduction of a new set of SU(2)L weak singlets vector-like fermions U,D,E,N, with N a neutral lepton. The fermion content also include three right handed neutrinos. Therefore, in this scenario light quarks and leptons, including active neutrinos, become massive from radiative loop corrections mediated by the massive SU(3) gauge bosons.

We update numerical results and report the non-unitary, (VCKM )4×4 and (UPMNS)4×8, quark and lepton mixing matrices.

**BSM Cosmology from BSM Physics**

*Maxim Yu. Khlopov*

Abstract:

Now Standard LambdaCDM cosmology is based on BSM physics, which in turn needs cosmological probes for its study. To resolve this vicious circle of problems the idea of messengers of new physics is developed and brief general Introduction to particular presentations at this Workshop is given, including blancing of baryon asymmetry and dark matter by sphaleron transitions, hadronic dark matter and exotic cosmic ray components, an approach to solution of puzzles of direct dark matter searches in dark atom model, antimatter in baryon asymmetrical Universe as sensitive probe for models of inflation and baryosynthesis and its possible probe in AMS02 experiment, PBH and GW messengers of BSM models and phase transitions in early Universe. These aspects are discussed in te general framework of methods of cosmoparticle physics.

**Statistical anaylses of antimatter domains, created by**

**nonhomogeneous baryosynthesis in a baryon asymmetrical Universe**

*M.Yu. Khlopov, O.M. Lecian*

Abstract:

Within the framework of scenarios of nonhomogeneous

baryosynthesis, the formation of macroscopic antimatter domains is

predicted in a matter-antimatter asymmetrical Unvierse. The

properties of antimatter within the domains is outlined; the

matter-antimatter boundary interactions are studied. The two-points

correlation functions for two astrophysical objects are calculated.

The theoretical expression in the limiting process of the two-points

correlation function of an astrophysical object and an antibaryon is

calculated.

**The flux of antihelium nuclei from a globular cluster of antimatter in the Galaxy**

*Anastasia Kirichenko*

Abstract:

At present, the AMS-02 experiment to study the characteristics of cosmic rays has been launched at the International Space Station. One of his tasks is to search for antinuclei heavier than an antiproton, including antihelium. Its registration would indicate the existence of an additional source of antimatter, since the probability of the birth of a secondary antihelium is small. One of the sources could be a globular cluster of antistars in the halo of our Galaxy, which is can be predicted by models of inhomogeneous baryosynthesis at the specific choice of its parameters.

The report proposes a method for calculating the flux of antihelium nuclei injected from a source in the halo into the interstellar medium, in the vicinity of the Solar System. For this, the trajectory of antinuclei is simulated in the magnetic fields of the Galaxy and in interstellar matter, which leads to a change in the energy spectrum of these antiparticles. The data obtained will be used to interpret the results of experimental searches for antinuclei in cosmic rays and to study the mechanism of the origin of the baryon asymmetry of the Universe.

**Skewness, Number of Families**

*Astri Kleppe, H.B.Nielsen*, Niels Bohr Institute

Abstract:

We develop an old work by one of us and Niels Brene that the Standard

Model group is very skew in the sense of having relativly few automor-

phisms to argue that very generally assuming some “local” worm holes

or baby universes the various symmetries of the theory get broken, and

thus the surviving theory should have exceptionally little number of

sym- metries. That we call it is “skew”. E.g. for the standard model

to avoid having CP-symmetry it was already proposed by Kobayashi and

Maskawa to have at least three families.

**New cosmic particles from dark matter physics**

*Anastasia Kovalenko*

Abstract

Physics of dark matter can lead to existence of new components of cosmic rays. These components may be related with hadronic form of dark matter, which can consist of new stable neutral particles, involving stable heavy quark, or dark atoms, in which new stable heavy lepton-like multiple charged particles with charge −2𝑛 are bound by Coulomb interaction with 𝑛 nuclei of primordial helium [1]. Various types of processes leading to formation of fluxes of new particles are consider in this work. Interaction cross sections were calculated in both cases. Quark-quark scattering [2] was considered for a stable neutral hadron and photon exchange — for a dark atom.

The purpose of the work is calculating the energy distribution of final dark matter particle or its heavy constituent in the case of dark atom in the process of cosmic rays proton scattering on dark matter particle.

References

[1] M.Yu. Khlopov. Composite dark matter from stable charged constituents. arXiv:astro- ph/0806.3581v1, 2008.

[2] М. Е. Peskin, D. V. Schroeder. An Introduction to Quantum Field. Addison-Wesley Publishing Company, 1995.

**Main features of hadronic dark matter scenario**

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Abstract:

The origin and quark structure of new heavy hadrons as dark matter candidates are considered. We describe the hadronic dark matter evolution in the traditional approach and with an account

of chromo-Coulomb interaction. This effect can significantly modify the dark matter evolution near freeze out stage and affect on the estimation of the new hadron mass. Main properties of the new heavy mesons are described in the framework of the Heavy Quark Effective Theory. We also study the low-energy interactions of new hadrons with leptons and nucleons in the effective approach. Most important experimental constraints for the hadronic dark matter scenario are presented and discussed.

**Mass as a dynamical variable**

*Martin Land*, Hadassah College, Jerusalem

Abstract

In developing his model of antiparticles as particles propagating backward in

time, Stueckelberg recognized that a classical relativistic mechanics describing

such trajectories must relax the mass shell constraint for individual particles.

Further work by Piron and Horwitz established a covariant Hamiltonian mechanics

on an 8D phase space with unconstrained position and momenta, leading to an U(1)

gauge field theory that mediates the exchange of mass between particles. While

total mass of particles and fields is conserved, the mass of individual

particles mass plays the role of a Noether current, conserved under a certain

class of interactions. Moreover, in a recently developed extension of general

relativity, consistent with the Stueckelberg-Horwitz-Piron approach, the

spacetime metric evolves in a manner that permits the exchange of mass across

spacetime through the gravitational field. Mechanisms that restrict mass

exchange between particles have also been identified. In classical

electrodynamics, a radiative self-interaction tends to restore particle masses

to their on-shell values, while in quantum mechanics, the interaction structure

leads to a cut-off of the mass exchange. Nevertheless, mass exchange remains

possible under certain circumstances and may have phenomenological implications

in particle physics and cosmology.

**Understanding nature with the *spin-charge-family theory*:**

*N.S. Mankoč Borštnik*

Abstract:

*How far has so far the spin-charge-family theory succeeded to*

*offer the explanation for the observed phenomena included in the*

*standard model assumptions, in the second quantization of fermion*

*fields, in the matter-antimatter asymmetry, in the appearance of the*

*dark matter,...., making several predictions?*

Fifty years ago *the standard model* offered an elegant new step towards

understanding elementary fermion and boson fields, making several

assumptions, suggested by experiments. The assumptions are still waiting

for an explanation.

There are many proposals in the literature for the next step.

The spin-charge-family theory is offering the explanation for not only all

by the standard model assumed properties of quarks and leptons and

antiquarks and antileptons, with the families included, of the vectors gauge

fields, of the Higgs's scalar and Yukawa couplings, but also for the second

quantization postulates of Dirac and for cosmological observations, like

there are the appearance of the dark matter, of matter-antimatter

asymmetry, making several predictions.

This theory proposes a simple starting action in $ d\ge (13+1)$-dimensional

space with fermions interacting with the gravity only (the vielbeins and the

two kinds of the spin connection fields), which manifest in $d=(3+1)$ as the

vector and scalar gauge fields.

Using the odd Clifford algebra ''basis vectors'' to describe the internal space

of fermions enables that the creation and annihilation operators for fermions

fulfill the anticommutation relations for the second quantized fields without

Dirac's postulates: Fermions single particle states already anticommute.

I present in this talk a short overview of the spin-charge-family theory,

illustrating shortly on the toy model the breaks of the starting symmetries

in $d=(13+1)$-dimensional space, which are triggered either by the scalar

fields --- the vielbeins with the space index belonging to $d>(3+1)$ --- or by

the condensate of the two right handed neutrinos, with the family quantum

number not belonging to the observed families.

Several predictions discussed in this talk:

a. The existence of the fourth family to the observed three families of quarks

and leptons, and antiquarks and antileptons.

b. The existence of several scalar fields, determining masses of the observed

three families and of the predicted fourth family.

c. The existence of the second group of four families of quarks and leptons

and antiquarks and antileptons which gain masses from scalar fields coupled

to different family quantum numbers than the lower four families. The neutrons

of the stable fifth family form the dark matter with properties, which are in

agreement with cosmological observations as well as with the direct

measurements.

d. The existence of the scalar fields, which are triplets or antitriplets with

respect to the space index, offering explanation for the matter-antimatter

asymmetry in the universe.

e. Describing the internal space of fermions with the odd Grassmann algebra,

''Grassmann fermions'' carry integer spins and charges in adjoint representations.

Could we observe the integer spin fermions?

f. And others.

**B-L, The Next Symmetry of Nature**

*Rabindra N. Mohapatra*

Abstract: There are several compelling reasons to think that B-L is the next local symmetry of Nature beyond the standard model. In this talk, I summarize the motivations for this symmetry,its different realizations and implications. I will outline some tests in current and future colliders. I describe how the B-L breaking Higgs particle of this model can serve as a dark matter particle. This will be a minimal unified theory of dark matter and neutrino masses.

**Bound States of Infinitely Many Constituents of Strings - Symmetry Considerations -**

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Abstract:

By very doubtful speculations we set up a general pattern for scattering of bound states consisting of very high numbers of constituents. The main point is that for extremely many constituents of course most of them will not hit any constituent in the colliding particle and thus in the limit of very large numbers of constituents we can ignore the scattering of the constituents on each other and only take into account the exchange of constituents between the bound states / the bunches of constituents scattering on each other.

With many consituents the different consituents will presumably have great similarities and we model what symmetries between the constituents could be reasonable to consider and appear at essentially the Mo ̈bius group as known from string theory. We argue that under such a symmetry assumption the constituents are ordered like the points of a projective line for some field. In the case of the field of real numbers we have the string theory with the constituents being the “objects” form our earlier published “Novel String Field Theory”. The goal is to obtain a Veneziano- like scattering as a general approximation for scattering of bound states with enormously many constituents.

**Galactic model with a phase transition from dark matter to dark energy**

*Igor Nikitin*

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Abstract:

This work continues the construction of the model presented

at the last Bled 2020 conference ``What Comes Beyond the Standard

Models?''. In this model, the sources of dark matter are Planck cores,

objects of Planck density located inside the black holes. These

objects constantly emit particles of dark matter, originally of Planck

energy and Planck flux density. In this work, massless particles will

be considered as quanta of dark matter. The particles are also

sterile, that is, they do not enter into any interactions other than

gravitational. Radiation occurs in a T-symmetric way, into the future

and into the past, so no energy is consumed for the radiation, and

such objects retain their mass. Radiation occurs in the radial

direction, therefore, the considered flows have no transverse

pressure. We denote this type of matter as null radial dark matter

(NRDM).

The solution of Einstein's field equations with such matter term has a

structure different from Schwarzschild's one. These solutions do not

have an event horizon, instead, at the gravitational radius a deep

gravitational well is formed. Calculations for realistic astrophysical

scenarios show the redshift value $z \sim 10^{49}$, that leads to a

shift of emitted dark matter from Planck to ultra-high wavelengths

$\lambda \sim 10^{14}$ m, respectively, ultra-low energies $E \sim

10^{-20}$ eV. Such extreme values complicate direct detection of

isolated dark matter particles. Nevertheless, the total number of

emitted quanta corresponds to the initially high Planck values. The

energy density and radial pressure of such radiation creates hidden

mass distribution corresponding to the observed rotation curves of

galaxies. In this configuration, the total mass contained in the

radiation, due to its extension in space, significantly exceeds the

own mass of the emitting object within its gravitational radius. The

geometric mass density profile $\rho \sim r^{-2}$ typical for the

radial radiation creates a linearly growing mass profile $M \sim r$

and flat rotation curves $v^2=GM/r=Const$. Taking into account the

contributions of all black holes in the galaxy, supermassive and

stellar ones, the distributions are modulated, and the model

reproduces the observed non-flat rotation curves of the galaxies with

good accuracy. In addition, a consideration of astrophysical scenario

with the fall of an asteroid onto the Planck core leads to a flash of

electromagnetic radiation with the characteristics of Fast Radio

Bursts.

In this work, the main attention will be paid to the following

question. If we treat the massless dark matter as homogeneous (hot

dark matter, HDM), then the solution of Friedmann equations will

correspond to the radiation epoch and will not coincide with the

current evolution, which in the Standard Model corresponds to the

mixture of contributions from uniform cold dark matter (CDM) and dark

energy (DE). However, in the model under consideration, the

distribution of matter is not homogeneous, and, as we will see, this

allows the construction of models that are in agreement with

experiment. This question was raised at the last Bled 2020

conference. NRDM mimics CDM at the cosmological level. The

macro-particles of CDM are galaxies with massive halos surrounding

them.

In more detail, we will consider several scenarios for the connection

of galaxies in NRDM configuration with a uniform background. For the

background, the following cases were considered: a vacuum, CDM and a

matter with DE equation of state. In the first two cases, totally

uniform DE contribution can be also added. The connection criteria

were hydrostatic equilibrium of the system and the correspondence of

the densities to the observed $\Omega$-parameters. It turned out that

of the considered scenarios, only NRDM-DE connections satisfy the

selection criteria. Such scenarios can be interpreted as a phase

transition of dark matter from NRDM state inside galaxies to DE state

outside. A specific mechanism for such transition could be

Bose-Einstein condensation (BEC).

In addition, we will consider the question, what happens if the dark

matter particles are not exactly sterile, for example, are photons of

the Standard Model.

**Entropy production in Electroweak Phase Transition (EWPT) in the early universe**

*Shiladitya Porey*

Abstract:

We have estimated the percentage of entropy production if Electroweak Phase Transition (EWPT) happens in the early universe as a strong first-order phase transition in the real type-1 2HDM framework. We have chosen some benchmark values from the parameter space of the 2HDM potential with the aid of a C++ software package (BSMPT) and calculated the entropy generated. We have shown that the amount of entropy production in this framework is more than the EWPT in the standard model.

**Dynamics and mergers of primordial black holes in a cluster**

*Viktor Stasenko*

Abstract:

We consider the dynamics of the primordial black holes in the cluster with total mass $10^5 \, M\_{\odot}$, which forms in the early Universe at $z \sim 10^4$. Our calculations also take into account the effect of accretion of dark matter, as a result of which a massive dark halo is formed around the cluster. We estimate the merger rate of black holes in the cluster in the modern era and show that the fraction of these clusters in dark matter is $\lesssim 0.01$.

**Ultraviolet divergences in supersymmetric theories regularized by higher derivatives**

*Konstantin Stepanyantz,* Moscow State University

Abstract:

Structure of quantum corrections in N=1 supersymmetric gauge

theories is investigated in the case of using the regularization by

higher covariant derivatives. It is demonstrated that this

regularization allows revealing some interesting features which lead

to the exact relations between the renormalization group functions. In

particular, it is proved that the NSVZ equation, which relates the

beta-function to the anomalous dimension of the matter superfields,

naturally appears in this case. We present the all-loop derivation of

this equation and a simple renormalization prescription under which it

is valid.