

A Short Journey from Baksan—Andyrchi – Neutrino Village, Through the Worldwide Superknown Liquid – Water – Ice Detectors to Van Hove Singularity

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Abstract:

This submitted text is connected with description of worldwide superknown site at Baksan Valley, Caucasus, Andyrchi Mountain, resp. Neutrino Village, built with goal to offer scientific and material background to realized the SAGE Project (the abbreviation Soviet American Gallium⁷¹ – Germanium⁷¹ Experiment) to detect elusive elementary particles Neutrinos on underground physical laboratory detector. These activities began implement in 70-ties. with connection of semiconductors development $Ga^{71} \rightarrow Ge^{71}$ transitions. This Article saw from underground laboratory in Baksan. The Ending part of Article is focused on quasiparticles Brown—Zak's fermions, Dirac's fermions and their application in Computational technics and Graphen Van Hove Singularity.

Keywords: Germanium—Galium, Baikal, IceCube/Amanda, Baksan, Neutrino Village, Neutrino Detectors, Dirac's fermions, quantum cryptography, quantum internet.

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1. Introduction

The Russian Cooperation for the Atomic Energy Rosatom supplies Germanium 76 crystals for the second phase Neutrino Instruments included to International Project. GERDA with detectors from ultra clear Germanium Crystals (from this comes from his name: **GER**manium **D**etector **A**rray. For this experiment is absolutely necessary used isotope of Germanium 76, which is accurately only in Nature about 7,6% naturally Germanium. The Scientists required Germanium with extremely chemically purity of with 86% content of isotope Germanium 76. Enrichment of Ge^{76} realized only one manufacturing plant in the world, Elektrochimičeskij Zavod (EČHZ), situated in KRASNOJARSK'S REGION, so called locked City / Region (KRASNOJARSK 26) in Siberia.

This enterprise belongs to corporation TVEL, which creates fuel division of Rosatom (Atomenergoprom). Enriched Ge^{70} use supplied to German Research Institute Max Planck for Nuclear Physics in Heidelberg, which is utilized into a finally form of detectors.

Germanium International Scientific Project GERDA, researches – neutrinos (ess double β (Beta) Decay, an experiment running in Italy, study phenomenon, which is an opposite (in contradiction) with The Standard Model of particle's physics, so on. Thanks to him they (scientists) could be came to the fields of New Physics, which could be may them described even the earliest phases of evolution of Our Universe.

2. The Baksan – Andyrchi SAGE Neutrino Village and Observatory

The Baksan Neutrino Observatory celebrated 50 years of success in 2017.

On 29 June 1967, the Soviet and 10 years later American government issued a document that gave the go—ahead to build a brand new underground facility for neutrino physics in the creek mountain stream Baksan valley in the region of the Northern Caucasus.

Construction work began straight away on the tunnels under the 4000 m—high peak of Mount Andyrchi, near Mount Elbrus – one of a series of peaks dominated by Europe's highest mountain (5642 m. above sea level).

The entrance to the laboratory tunnel is located in the valley below the peaks of Andyrchi and Elbrus Mountain, which is well known to mountaineers, hikers and skiers, at an altitude 1700 m.

A small village called Neutrino was built to accommodate scientists and engineers waiting for the observatory, with office and laboratory buildings, some surface installations from living quarters and related infrastructure. The 10 years later in 1977 the laboratory's first neutrino telescope started operation.

Today a varied experimental programmes continuous at the BNO (Baksan Neutrino Observatory, which operated by the Institute Nuclear Research (INR) of the Russian Academy of Science (RAS).

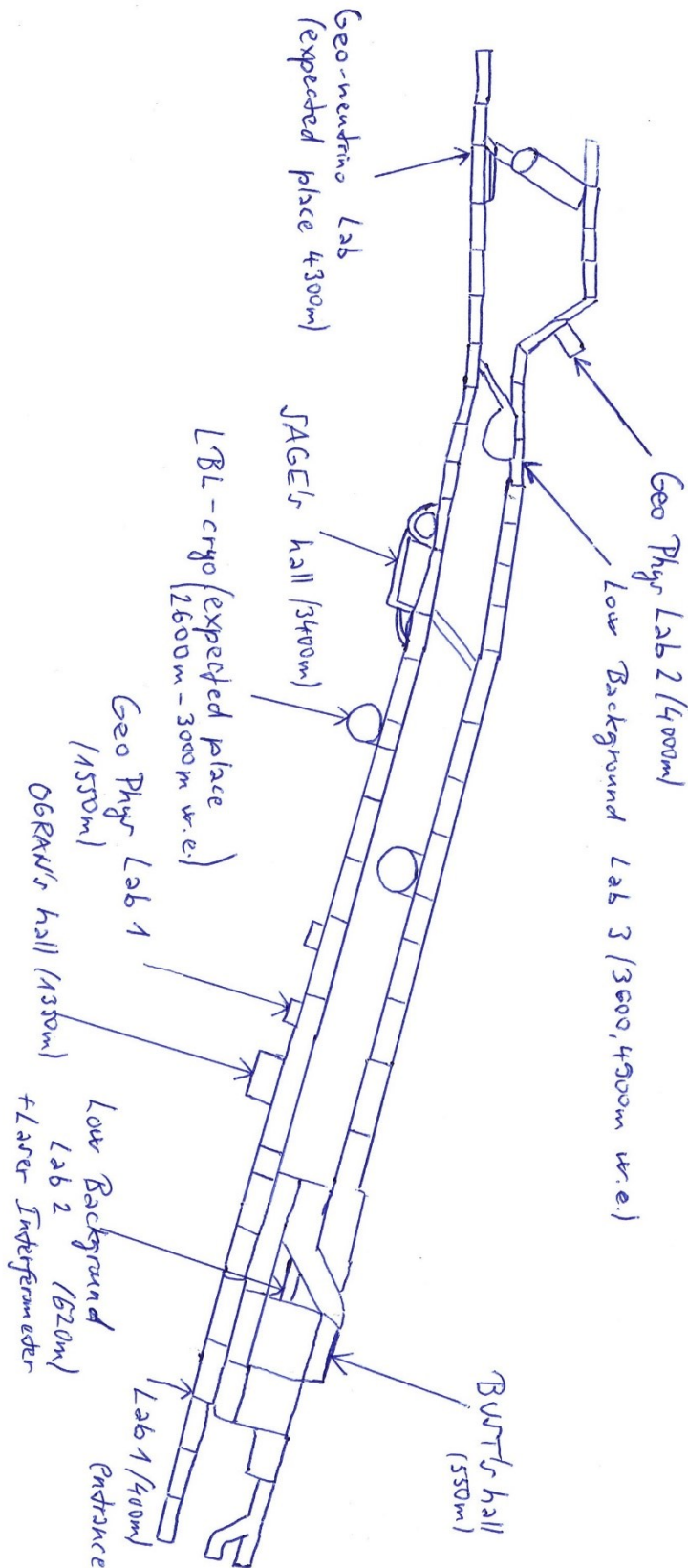


Fig. 1. Underground laboratories of the Baksan Neutrino Observatory at increasing distances from the tunnel entrance. Author of the Sketch: Imrich KRIŠTOF, M.Sc.

According to Image credit: V. Gavriljuk.



Fig. 2. View of the Andyrchi Mountain (4000 m), near Mount Elbrus (5642 m), Europe's highest mountain in the Northern Caucasus and the Neutrino Village, from across the valley: I. Krištof, M.Sc. according to Image credit: V. Petkov

3. Solar Neutrinos come from CNO (Bethe's Cycle), Confirmed

While photons are coming the way from the core of the Sun on the surface ten thousand years, neutrinos arrived to the Earth, just behind eight minutes.

The results from Borexino, in which were succeed to recognized spectrum of neutrinos comes from pp—cycle (proton—proton cycle). Already then was shown up, that is possible detection also neutrinos from subsequent reaction CNO (Bethe's) Cycle.

In them is conversion of hydrogen to helium catalysed by the heavier atoms – carbonium, nitrogenium and oxygenium,

Astrophysicists don't know representation of heavier elements than helium atoms ${}^4_2\text{He}$ and ${}^3_2\text{He}$ (α – particle) in core of the Sun (marked rich metalicity), while doing so it's very important parameter for understanding of evolution, genesis of the Stars. Clear detection of neutrinos from CNO cycle (Bethe's cycle), according to an evolution so might to help to calculate metalicity of the Sun and determined and find out in what way particle on his radiant find capacitance.

Although is flux of solar neutrinos very high (6×10^{11} on cm^2 per second), the detector Borexino their captured / intercepted only a few dozen.

Alone detector is built by spherical nylon tank with diameter 4,25 m and with 280 tons of liquid scintillator. Detector is situated under the mountain Gran Sasso in Italy. (G.S. is a limestone mountain massif in Abruzzian Apennines lying in mid Italy, in. Region Abruzzo approximately 50 km from coast of Adriatic Sea, the highest peak 2914 m). His situation reduced background from cosmic radiation approximately by a million times.

In a view of the fact that the flux of solar neutrinos is very high (6×10^{11} on cm^2 per second) and on the fact of low numbers of detections. Influenced by a very small effective cross section of reactions (neutrinos) is very special need to have a very low and very clearly defined background of a measured signal.

In the case of neutrinos from CNO (Bethe's) cycle was shown like a critically background from contamination of scintillator by a radioactive Polonium (^{210}Po) and bismutium (^{210}Bi).

Was a need an ensure a stable temperature of scintillator and thereby eliminate a formation of streams in liquid, which be led to a leaching of Polonium and Bismutium from walls of a vessel.

3.1 Solar Neutrinos Originated from CNO (Bethe's) Cycle Confirmed

After an installation of heat insulation, which was supplied in year 2015, did well stabilized a temperature of a detector.

There are still yet observed seasonal changes $/0,3 \text{ }^\circ\text{C}/6$ months, these already didn't have find out effect on a detector background stabilization of temperature lead to decrease of background from ^{210}Po , in the scintillation was discovered region with an extremely low values. This region of values may enabled clear exact determined also background originated from isotop ^{210}Bi :

$$\begin{aligned} R(^{210}\text{Po})_{\min} &= 11,5 \pm 1,0 \\ &\text{events per a day on 100 tones of scintillator,} \\ R(^{210}\text{Bi}) &\leq 11,5 \pm 1,3 \\ &\text{events per a day on 100 tones of scintillator.} \end{aligned}$$

Carefully analyses of data reproduced by the research of CNO and pepv at Borexino discovered intensity of neutrinos 7,2 per a day and on 100 tones of scintillator originated from CNO (Bethe's) cycle. Into the calculus was chosen region with highest sensitivity – this region responded energy of neutrinos 780 – 885 keV.

After counting of neutrinos from pp cycle going on results, that solar energy comes of 99% from proton—proton cycle and of 1% from CNO (Bethe's) cycle. CNO – The Carbon – Nitrogen – Oxygen (CNO) fusion.

According the observations of neutrinos from CNO cycle is our looking back closed.

And what will be a looking back for this year? Certainly, very interesting, how about it testified for example the recently experiments in Fermilab (Batavia), which exactly defined a value so called g—factor of muon (muon g—2) – we certainly have to enjoy to new discoveries of particle physics.

Usually: on April 7, 2021 the results of the experiment were published:

$$a_\mu = 116592040(54) \times 10^{-11}.$$

The new experimental world-average results announced by the Muon g—2 collaboration are

$$\begin{aligned} \text{g—factor: } &2.00233184122(82), \\ \text{anomalous magnetic moment: } &0.00116592061(41). \end{aligned}$$

This factor is very sensitive test of Standard Model of Particles and shows new horizons in Physics Beyond the Standard Model.

If could be observed during the Experiment Neutrinoless Double Decay β (Beta), what is a rare phenomenon, it will be mean, that neutrinos and antineutrinos are one and the same particle.

The first time this phenomenon was predicted by Italian Scientist Ettore Majorana in 1937, but until these days this effect wasn't confirmed. The Record of this phenomenon could be mean, that Standard Model of Particle Physics, which describes individual particles and their mutually interactions, are not satisfactorable and The Scientists have must still search / seek a more fundmanetal principles, to understand to what was happened in the first moments after The Big Bang.

4. The Underwater and The Underground Neutrino Detection Projects (Baikal, Ice Cube, Sage (Baksan)) – Neutrino Village

4.1 Baikal Neutrino Telescope

The Russian Telescope searches 1 kilometer underwater (Baikal neutrinos the most mysterious particles of Contemporary Physics). In early April 2015, scientist of the "Baikal" collaboration deployed and put into operation the first substructure of a unique experimental complex – the deep underwater neutrino telescope Baikal—GVD.

This sub—detector was named "DUBNA" according the Institute for Nuclear Research of the Russian Academy of Sciences, the Joint Institute for Nuclear Research (JINR). Baikal GVD (Gigaton Volume Detector) will be at the cubic—kilometer scale.

It will allow studying in detail the natural neutrino flux at high energy. Having passed through Earth, β neutrino can, with some probability, interact in the clear water of Lake Baikal (the deepest World lake – cryptodepression -1625 m depth under Earth surface (Equipotential line-sphere), and generate a cascade of charged particles (Cherenkov radiation from charged particles (superrelativistic positrons, electrons, neutrinos and antineutrinos and photons)) propagates through the water and is detected with "optical modules" – photomultipliers with cascade diodes, etc. The DUBNA cluster comprises 192 optical modules arranged at depth down to 1.300 m.

It is now one of the three largest neutrino detectors in the world. This will be comparable to the sensitive volume of the world leader – the Neutrino Telescope IceCube. The Other Neutrino Telescopes are situated for example in Ice Crust and in the SALT CAVES.

4.2 Future Neutrino Projects

ARIANNA

Antarctic Ross

Ice—Shelf Antenna Neutrino Array

MOON

Molybdenum Observatory

Neutrino for double β decay

Project aims at studies of double Beta Decays

with a high sensitivity of

$\langle m_{\tau} \rangle \approx 0.03$ eV and

$| m_{\nu} | \approx 0.03$ eV

real—time studies of low—energy solar neutrinos.

Two β rays from ^{100}Mo are measured in coincidence for $0\nu\beta\beta$ studies.

Supernemo collaboration



MOON

Molybdenum Observatory of Neutrinos

Sensitivity ν_e : $\nu_e + {}^{100}\text{Mo} \rightarrow {}^{100}\text{Te} + e^-$

${}^{100}\text{Mo}$ (1kt)

+ MoF_6 (gas)

scintillation 168 keV

location: Washington, United States.

4.3 Liquid or Water Future Neutrino Experiments

- ANNIE (Accelerator Neutrino Neutron Interaction Experiment)
location: SciBooNe Hall, Illinois, U.S.A.
Operation: Future
- ARIANNA (Antarctic Ross Ice—Shelf Antenna Neutrino Array)
sensitivity: ν_e, ν_μ, ν_τ
location: Ross Ice Shelf Antarctica:
Operation: Future.
- BDUNT (NT 2004) Baikal Deep Underwater Neutrino Telescope
Sensitivity: $\nu_e, \nu_\mu, \nu_\tau \approx 10$ GeV
Water (H_2O)
Cherenkov
Location: Lake Baikal, Russia
Operation: 1993 –
- NEMO Telescope Neutrino Mediterranean Observatory
location: Mediterranean Sea, Italy
Operation: 2007 –
- NEVOD Cherenkov water detector
sensitivity: ν_μ
 $\nu_\mu + n \rightarrow \mu^- + p$ Cherenkov ≈ 2 GeV
 $\nu_\mu + p \rightarrow \mu + n$
water (H_2O)
location: Moscow, Russia
operation 1993 –

4.4 Baikal Neutrino Detector

The worldwide first deep underwater neutrino telescope NT 200 was constructed in the years 1993 – 1998. It comprised 192 photodetectors grouped into eight vertical strings placed at the depth of 1100 – 1200 m and enclosing about 100 000 cubic meters of fresh water.

The experimental data of 1994 already showed neutrino events – the first in the world—wide race of deep underwater and deep—ice experiments in the Northern Hemisphere. Limits were derived on the flux of magnetic monopoles and of muons from dark matter annihilation in the center of the Earth and the Sun.

BAIKAL– GVD were designed to a monitored volume of about 1 cubic kilometer water. The telescope is formed from functionally independent sub—structures—clusters of vertical strings of optical modules. The cluster contains 192 photodetectors positioned on 8 vertical strings, each 345 m long, and is one of two powerful neutrino high—energy detectors in the Northern hemisphere. In 2020 was planned to develop a facility of 10—12 clusters, with a total volume of about 0,5 cubic kilometer (comparable to the sensitive volume of IceCube and to register high energy neutrinos of astrophysical origin). Beyond that, we envision a second stage of GVD with 27 clusters and a total volume of about 1,5 cubic kilometers.

5. Van Hove Singularity

ARE THE ELECTRONICS AND STRUCTURAL PROPERTIES OF GRAPHENE.

Fermion—Fermion (Neutrino—Neutrino or Electron-Electron on Neutrino-Electron interactions, and quarks—leptons interactions, subnuclear Proton—Neutron interactions).

$\mu = \pm t$ van Hove Singularity Conditions, HARD TO OBTAIN IN CLEAR GRAPHENE. In consequences with spin—tronic technologies are hopefully seen also like antiferromagnetic materials, also known like spin—tronic metamaterials.

Collectively behavior of electrons opens the way to superconductivity, graphene can improve also ordinary copper.

2D transistors on surfaces liquid metals (for example Gallium) which have that melting point already in room—temperature (approx. 21 °C).

In layers of graphene and further 2D metamaterials consequently discovers whole order of nowadays superknown quasiparticles → **BROWN—ZAK'S FERMIONS**.

Quasiparticles are responsible for collectively behavior of electronics and holes they have even near relativity to SUPERCONDUCTIVITY.

The last few years oneself from **MAGNONS** have turned out well realized even Gavré logical elements (half Binary adder), which normally provide classically transistors.

SKYRMIONS ARE FOR CHANGE LOCAL VORTEXES OF MAGNETIC FIELDS, WHICH ENCLOSE / CONVERSE SOUNDS ON ANOTHER PLACE. IT'S POSSIBLY TO USED TO RECORD OF DATA, WHEN INFORMATION BRINGS A VORTEX EVEN HIS SPIN.

In the structure from graphene and nitrid of BORUM for example scientists detected so—called **BROWN—ZAK FERMIONS** DE FACTO ELECTRONS, ON WHICH naturally behind certainly conditions non—reign magnetic fields.

SO CALLED **DIRAC FERMIONS** IN GRAPHENE ARE ONESELF CHARACTERISED LIKE “SOMETHING VERY SPECIAL BETWEEN” PHOTONS AND ELECTRONS (WHAT IS POSSIBLE EXPLAINED MAYBE LIKE **ELECTRONS WITH ZERO EFFECTIVE MASS** (MASSLESS), which, then respond velocity of their motion.

2D MATERIALS (METAMATERIALS, TOPOLOGICAL MATERIALS) ARE CONDUCTORS WHICH CONDUCT FLOW OR FLOW OF ELECTRONS ON THE EDGE AND OTHER IN AN INNER SURROUNDINGS.

5.1 Spintronics

HI—TEC SCIENCE BASED ON **MAGNONS** AND SKYRMIONS, MAGNONS ARE QUASIPARTICLES WHICH ARE SOME KIND OF WAVES, WHICH DURING THE TRANSITION IN MATERIALS REVERSED SPIN.

6. One Purposed Quantum Computers (Emulators) by Internet / Cloud

Program language Silq determined for programming quantum systems and **program language MICROSOFT Q#** and relevant QDK. **Google, Intel or IBM** going on development of quantum processors / computers based on **SUPERCONDUCTORS WITH HARD QUBITS**.

Is possible speculate about development **fotonic quantum computers**, when for example in frame **Chinese Project of QUANTUM SYSTEM Jinzhang**, which calculated for 200 seconds role, which will be calculate actually by the most speedy computers (according the top 500 Fugaku) involved approximately 600 million years, so that significant proof of that, is called like a **QUANTUM SUPREMACY**, (walked on about problemma from tech. science field **FOTONICS**—EFFECTIVE QUANTUM ALGORITHMS – OPTIMALIZED ALGORITHMS BASED ON SYSTEMS **D—WAVE**).

7. Conclusions

NOWDAYS **QUANTUM REVOLUTION** OFFERS SURPRISING POSSIBILITIES IN HI—TEC SCIENCE AND COSMIC RESEARCH, NAMELY IN **MEDICINAL AND BIOLOGICAL BRANCHES OF THE MODERN SCIENCE**, POSSIBILITIES CALLED LIKE **QUANTUM IMMORTALITY** OF WHOLE **MANKIND AND UNIVERSE OR MULTIVERSUM**. FOR THE NEXT LONGER CALCULATION WILL BE NECESSARY QUANTUM COMPUTERS NOT ONLY COOLING UNTIL TO THE ABOUT ZERO TEMPERATURE, ALSO BUT CAPTURED THEM TO THE SPECIAL ISOLATED SURROUNDINGS (LIKELY IN THE **DETECTORS OF NEUTRINOS**).

WHOLE FLUENTLY DURING DEVELOPMENT OF **QUATUM INTERNET**, THIS IS BASED ON **QUANTUM CRYPTOGRAPHY**, RESPECTIVELY ON OUR ABILITIES CONVERSED DIFFERENT TYPES OF QUBIT AND CLASSIC BITS BETWEEN THEM. MORE AND MORE IS USED A TECHNOLOGY OF, SO CALLED QUANTUM DOTS—ESPECIALLY CREATED LOCUSES FOR EXACTLY MANAGING OF ELECTRONS.

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