A tribute to Alexander Andrianov: A life for physics

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Alexander Andreevich Andrianov

25.10. 1946 – 29.12.2023

Biography

Born in Saint Petersburg (then Leningrad) in 1946

Leningrad State University (now Saint Petersburg University)

- Undergraduate student 1964 - 1970
- Diploma(=M.Sci.) in Theoretical and Math. Physics 1970
- Candidate of Science (Ph.D.) 1978
- Doctor of Science (Habilitation) 1986
- Full Professor in Theoretical Physics 1997

M.I.T.,Cambridge, U.S.A. 1981-1982, visiting scientist

Regular visitor to: Eotvos U., Montreal, ICTP, Bologna, TRIUMF, Padova, U Mass, Nordita, LPTHE Marseille, Barcelona U., PUC Santiago, Bergen, Aachen, U. Zaragoza, INFN Naples ...

Advisor of 20+ Ph D thesis (including co-advising students in Bologna and Barcelona)

165 publications in reputed journals, ~8000 citations, h=43

Active organizer of many international conferences and workshops, including the Quark Confinement and Hadron Spectrum in Saint Petersburg in 2014

As undergraduate Sasha had obtained the Lenin Scholarship, awarded to the most brilliant students in the URSS.

Finished his PhD under the supervision of Yuri Novozhilov (Leningrad University) in 1978

QUANTIZATION OF IMPACT COORDINATES FOR THE FIXED ENERGY OF COLLIDING PARTICLES

(published in 1980)

Impact parameter representations from the point of view of the Poincare group, *Theor.Math.Phys.* 17 (1973) 1234-1249

(first publication)

IMPACT PARAMETER REPRESENTATIONS FROM THE POINT OF VIEW OF THE POINCARÉ GROUP

A. A. Andrianov

Impact parameter representations for the two-particle scattering amplitude are derived by expanding the two-particle state with respect to groups that are isomorphic to the group of motions of the plane E(2). The generators of these groups are expressed in terms of the operators of the total angular momentum and the relative momentum of two particles. As a result, the impact parameter operator and states of two particles with definite impact parameter acquire a meaning in terms of the Poincaré group.

1. Introduction

As experimental data accumulate on particle scattering at high energies and, in particular, through large angles it becomes necessary to have new kinematic expansions of the S matrix with respect to the angular variables. The reason for this is as follows: the ordinary expansion of the S matrix in the angular momentum – the expansion in partial waves – forces one to take into account an ever increasing number of partial waves with increasing energy while the cross section of scattering through large angles is appreciably smaller than the forward scattering cross section, i.e., there is a strong mutual suppression of the partial waves, as a result of which the ordinary partial-wave analysis becomes very sensitive to different approximations for the S matrix.

The basis for constructing new angular expansions of the S matrix and accordingly the scattering amplitude is the eikonal approximation for the latter [1]. In this approximation, the scattering amplitude of spinless particles of the process $1 + 2 \to 3 + 4$ has the form

$$\langle p_3, p_4 | T | p_1, p_2 \rangle = T(p, \cos\vartheta) \simeq \int_0^\infty b\, db\, J_0\left(2bp \sin\frac{\vartheta}{2}\right) T^b_{\text{eik}}(p), \tag{1.1}$$

where ϑ is the scattering angle in the center of mass system, $p = |\mathbf{p}|$ is the modulus of the cms momentum of each particle (it is assumed that $m_1 = m_3$, $m_2 = m_4$), and $J_0(x)$ is the zeroth Bessel function of the first kind. The parameter b is called the impact parameter. This is because the expansion in the angular momentum, i.e., in Legendre polynomials $P_l(\cos\vartheta)$, goes over into the expansion (1.1) for small ϑ and large l because of the asymptotic formula: $P_l(\cos\vartheta) \approx J_0[(l + 1/2)\vartheta]$. Thus, $bp \approx l + 1/2 \approx l$. It is in this manner that the impact parameter is defined in classical mechanics. Further, $T^b_{\text{eik}}(p)$ can be expressed in quantum mechanics in terms of the potential [1]: $T^b_{\text{eik}}(p) = p/i(e^{i\chi} - 1)$, where $\chi = -m/p \int_{-\infty}^{+\infty} V(\sqrt{b^2 + z^2})dz$ and $V(r)$ is the potential. Such a relationship between $T^b_{\text{eik}}(p)$ and the potential is obtained under the assumption of high energies and small scattering angles [1]. Nevertheless, this relationship is fairly simple and one therefore wishes to analyze the scattering amplitude for all energies and any angles on the basis of an expansion of the amplitude in Bessel functions, like (1.1):

$$T(p, \cos\vartheta) = \int_0^\infty b\, db\, J_0\left(2bp \sin\frac{\vartheta}{2}\right) T^b(p). \tag{1.2}$$

A. A. Zhdanov Leningrad State University. Translated from Teoreticheskaya i Matematicheskaya Fizika, Vol. 17, No. 3, pp. 407-421, December, 1973. Original article submitted November 20, 1972.

Alexander and Vladimir Andrianov at a conference in Protvino during the 80's

In 1980, he received a Fulbright scholarship for an internship in the United States at the Massachusetts Institute of Technology (MIT) in Cambridge, USA.

His scientific supervisor was Roman Jackiw, with whom he was and remained not only scientific colleagues, but also friends throughout almost his entire life.

While at MIT (1981-1982), he co-authored a finite-mode regularization method for fermionic integrals with anomaly, as a complement (or alternative) to the Vergeles-Fujikawa regularization method (1979-1981) for fermionic functional integrals.

PHYSICAL REVIEW D VOLUME 26, NUMBER 10 15 NOVEMBER 1982

Regularized functional integral for fermions and anomalies

A. Andrianov,* L. Bonora,† and R. Gamboa-Saraví‡

Center for Theoretical Physics, Laboratory for Nuclear Science and Department of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139

(Received 24 May 1982)

The regularization of fermionic functional integrals is investigated with the method of finite-dimensional approximations. The conditions for preserving gauge invariance in these approximations are stated. This regularization is applied to describe the divergences of vector and axial-vector currents.

This was the first of a series of collaborations with Loriano Bonora (SISSA). The study of anomalies was going to be a persistent activity in years to follow:

“Finite-mode regularization of the fermion functional integral (I)”
A Andrianov, L Bonora, Nuclear Physics B 233 (2), 232-246 1984.

“Finite-mode regularization of the fermion functional integral (II)”
A Andrianov, L Bonora, Nuclear Physics B 233 (2), 247-261 1984

“Anomalies, cohomology, and finite-mode regularization in higher dimensions”
A Andrianov, L Bonora, P Pasti, Annals of Physics 158 (2), 374-391 1984

This led in a natural way to the issue of bosonization…

In fact, in 1986, Alexander Andrianov defended his Habilitation (Doctor of Science in the Russian system) dissertation on the topic:

Chiral bosonization and the limit of high symmetries in elementary particle physics

This was based on a remarkable series of works:

“Singlet Bosonization In QCD And Lagrangian For Pseudoscalar Mesons”

Alexander A. Andrianov, Leningr. Univ., Fiz. 25 (1985) No. 4, 76-78.

“Bosonization in four dimensions due to anomalies and an effective lagrangian for pseudoscalar mesons”.

AA Andrianov, Physics Letters B 157 (5-6), 425-429 1985.

“Chiral bosonization in non-abelian gauge theories”.

AA Andrianov, Y Novozhilov, Physics Letters B 153 (6) 422-426, 1985.

“Condensates and the low-energy region in quantum chromodynamics”

AA Andrianov, VA Andrianov, YV Novozhilov, VY Novozhilov, JETP Letters 43, 1986

“Complete bosonization of quark currents or quantum theory completely based on anomalies”.

AA Andrianov, YV Novozhilov, Physics Letters B, 181. №1-2. 129-133. 1986

As is well known, bosonization is exact in two dimensions, but this is not so in 4D. The choice of boson variables to express the QCD partition function is based on the chiral non-invariance of the generating functional under the local chiral transformations of external fields (chiral anomaly)

$$\int \mathcal{D}G\, \mathcal{D}\psi \mathcal{D}\bar{\psi} \exp(-S_{QCD}(\bar{\psi},\, \psi,\, G;\;\, V, A, S, P)) = \int \mathcal{D}U \exp(-S_{eff}(U;\;\, V, A, S, P))$$

$$U = \exp(i\Pi(x)/F_\pi) \quad F_\pi \approx 93 MeV.$$

The derivation of the effective chiral action is produced by integration of the generating functional over the group of local chiral rotations

$$Z_{inv}^{-1} = \int \mathcal{D}U\, Z_\psi^{-1}(V^U, A^U, S^U, P^U)$$

where Z_ψ is the quark part of the generating functional before integrating over gluons. The integration is carried out over the local SU(3) group with invariant measure. Thus, we obtain the chiral invariant part of the generating functional.

$$\ll Z_\psi(V, A, S, P) \gg = \ll Z_\psi(V, A, S, P)\, Z_{inv} \int \mathcal{D}U\, Z_\psi^{-1}(V^U, A^U, S^U, P^U) \gg =$$

$$\int \mathcal{D}U \ll Z_{inv} Z_\psi(V, A, S, P) Z_\psi^{-1}(V^U, A^U, S^U, P^U) \gg = \int \mathcal{D}U \ll \Delta(U, V, A, S, P)\, Z_{inv}(V, A, S, P) \gg$$

The calculation of the fermion loops is conceptually simpler in the large N limit

$$F_0^2 = \frac{N_c}{4\pi^2}(\Lambda^2 - M^2), \qquad F_0^2 B_0 = \frac{N_c}{2\pi^2}(\Lambda^2 M - \frac{1}{3}M^3) \qquad < \bar{\psi}\psi > = -F_0^2 B_0$$

The results from bosonization were applied to phenomenology

"Joint chiral and conformal bosonization in QCD and the linear sigma model"
AA Andrianov, VA Andrianov, VY Novozhilov, YV Novozhilov. Physics Letters B 186 (3-4), 401-404, 1987.

"Scalar meson-dilaton in QCD"
AA Andrianov, VA Andrianov, VY Novozhilov, YV Novozhilov. Pis' ma v Zhurnal Ehksperimental'noj i Teoreticheskoj Fiziki 43 (12), 557-559, 1986.

Comment on "Predicting the Proton Mass From ππ-Scattering Data"
Alexander A. Andrianov, Vladimir A. Andrianov, V.Yu. Novozhilov, Phys. Rev. Lett. 56 (1986) 1882.

VOLUME 56, NUMBER 17 PHYSICAL REVIEW LETTERS 28 APRIL 1986

Comment on "Predicting the Proton Mass from $\pi\pi$ Scattering Data"

The phenomenological justification of Skyrme-type Lagrangeans is of great importance because such Lagrangeans can provide the description of baryons and of low-energy pion physics on the same footing. In an interesting paper[1] the recent investigation of phenomenological π-meson Lagrangeans[2] from $\pi\pi$ data was used to correct the Skyrme-Witten model for baryons. The crucial point of the paper[1] was a suggestion of applicability of the perturbation theory starting from the Adkins-Nappi-Witten (ANW) solution.[3] We have found that the perturbation theory works unsatisfactorily.

According to Refs. 1 and 2, the Lagrangean of the chiral model in the massless limit has the form

$$L = \tfrac{1}{4}F_\pi^2 \operatorname{Tr}(\partial_\mu U\, \partial^\mu U^\dagger) + (1/32e^2)\operatorname{Tr}\{[(\partial_\mu U)U^\dagger, (\partial_\nu U)U^\dagger]^2\} + (\gamma/8e^2)[\operatorname{Tr}(\partial_\mu U\, \partial^\mu U^\dagger)]^2. \quad (1)$$

For the slowly rotating soliton solution $U = A^{-1}(t)\exp[iF(r)\hat{\mathbf{x}}\cdot\boldsymbol{\tau}]A(t)$ the Lagrangean (1) reduces to

$$M[F] = \frac{8\pi F_\pi}{e}\int_0^\infty \tilde r^2\, d\tilde r \left\{\frac{1}{8}\left[(F')^2 + \frac{2\sin^2 F}{\tilde r^2}\right] + \frac{\sin^2 F}{2\tilde r^2}\left[\frac{\sin^2 F}{\tilde r^2} + 2(F')^2\right] - \frac{1}{2}\gamma\left[(F')^2 + \frac{2\sin^2 F}{\tilde r^2}\right]^2\right\}. \quad (2)$$

Let us analyze whether γ in (2) may be treated as a perturbation to the ANW solution. We observe that the exact γ dependence of $M[F]$ can be obtained if we make the dilatation of the ANW solution $F(r) \to F(\alpha r)$, and then minimize $M[F]$ with respect to α. In this way we get $\alpha = (1-\gamma D/I)^{1/2}$ and $M - \alpha M^{\rm ANW}$, where

$$I = \int_0^\infty d\tilde r[(\sin^4 F)/2\tilde r^2 + (F')^2\sin^2 F], \quad D = \tfrac{1}{2}\int_0^\infty d\tilde r\, \tilde r^2[(F')^2 + 2(\sin^2 F)/\tilde r^2]^2,$$

and $M^{\rm ANW}$ is the ANW result,[3] $M^{\rm ANW} = 73F_\pi/e$. Numerical estimations of I and D yield the following result on the ANW solution: $D/I = 3.1$, which is 2 times higher in comparison with the coefficient in the perturbation expansion of M in Ref. 1.

In the same manner we get

$$\lambda = \frac{\pi}{3e^3F_\pi}\int_0^\infty \tilde r^2\, d\tilde r \sin^2 F\left\{\left[1 + 4\left((F')^2 + \frac{\sin^2 F}{\tilde r^2}\right)\right] - 8\gamma\left((F')^2 + \frac{2\sin^2 F}{\tilde r^2}\right)\right\} \equiv \frac{\pi}{3e^3F_\pi}[\alpha^3 J_1 + \alpha(J_2 - \gamma\Omega)], \quad (3)$$

$$J_1 = \int_0^\infty d\tilde r\, \tilde r^2 \sin^2 F, \quad J_2 = 4\int_0^\infty d\tilde r \sin^2 F[(\tilde r F')^2 + \sin^2 F], \quad \Omega = 8\int_0^\infty d\tilde r \sin^2 F[(\tilde r F')^2 + 2\sin^2 F].$$

We note that the last term in the formula (3) has the opposite sign in comparison to Eq. (10) in Ref. 1. The explicit γ dependence of α leads to the essentially different value of λ from that quoted in Ref. 1, even in perturbation theory: $\lambda = \lambda^{\rm ANW}(1 - 4.4\gamma + \ldots)$, where $\lambda^{\rm ANW}$ is the ANW result,[3] in comparison with $\lambda = \lambda^{\rm ANW}(1 + 1.1\gamma + \ldots)$ in Ref. 1.

Using experimental data of $\pi\pi$ scattering lengths quoted in Ref. 1, Eq. (16), we obtain $\gamma = 0.154$, $M = 0.559$ GeV, $\lambda^{-1} = 1.5$ GeV, and $M_p = 1.12$ GeV. The alternative set of data exploited in Refs. 1 and 2 gives $\gamma = 0.30$, $M = 0.197$ GeV, $\lambda^{-1} = 18.63$ GeV, and $M_p = 7.18$ GeV. Thus the low-energy phenomenological pion Lagrangean (1) is not suited for the description of the proton as a soliton. Moreover, the variational investigation shows the instability of the soliton for such modification of the Skyrme model when $\gamma > 0.12$.

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PACS numbers: 11.30.Rd, 11.40.Fy, 12.70.+q, 14.20.Dh

[1] J. F. Donoghue, E. Golowich, and B. R. Holstein, Phys. Rev. Lett. **53**, 747 (1984).
[2] J. Gasser and G. Leutwyler, Ann. Phys. (N.Y.) **158**, 142 (1984).
[3] G. Adkins, C. Nappi, and E. Witten, Nucl. Phys. **B228**, 552 (1983).

In parallel, Alexander Andrianov had gotten himself interested since his early career in the large N approximation; e.g.

“The large N expansion as a local perturbation theory”

AA Andrianov, Annals of Physics 140 (1), 82-100, 1982

This interest re-appears systematically in later works. It already played an important role in his studies on bosonization (low-energy coefficients are computed in the large N limit)

Large N is closely tied to later studies on the OPE, resonances, duality, etc.

ELSEVIER

Annals of Physics

Volume 140, Issue 1, 15 April 1982, Pages 82-100

The large *N* expansion as a local perturbation theory ☆

A.A Andrianov †

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Abstract

The partition function of an $O(N)$-invariant vector anharmonic oscillator is generated by a set of Hamiltonians describing one-component oscillators in double-well potentials at negative coupling constant. The large *N* expansion appears as a conventional perturbation theory for auxiliary scalar Hamiltonians. An extension of the approach to rotationally invariant vector field theories is considered in the framework of the bilocal formalism.

For instance:

“Structural Vertices of Extended SU(3)-Chiral Lagrangians in the Large-N_c Approach”

Workshop on Chiral Perturbation Theory and other Effective Theories, Krraebeksminde (DK) September 1993

This was a nice workshop organized by colleagues (Poul Damgaard et al) from the NBI in Copenhagen

I first met Sasha Andrianov in this meeting

The 90s...

The fall of the iron curtain had suddenly opened many possibilities for Andrianov to travel and visit colleagues. He took good advantage of this and established during that decade many scientific relations outside Russia. A main interest at the beginning of this period were Nabu-Jona-Lasinio -like models

"Gauge Nambu-Jona-Lasinio model as a low-energy approximation of QCD".

Alexander A. Andrianov, Vladimir A. Andrianov, Theor.Math.Phys. 93 (1992) 1126

"Structure of effective fermion models in symmetry breaking phase".

Alexander A. Andrianov, Vladimir A. Andrianov, Int.J.Mod.Phys. A8 (1993) 198

"Effective fermion models with dynamical symmetry breaking".

Alexander A. Andrianov, Vladimir A. Andrianov, Theor.Math.Phys. 94 (1993) 3

"Fermion models with quasilocal interaction in the vicinity of the polycritical point".

Alexander A. Andrianov, Vladimir A. Andrianov, V.L.Yudichev, Theor.Math.Phys.108 (1996)1069

"Quasilocal quark models as effective theory of non-perturbative QCD".

A.A. Andrianov, V.A. Andrianov, Int.J.Mod.Phys. A20 (2005) 1850

"Matching meson resonances to OPE in QCD".

A.A. Andrianov, S.S. Afonin, D. Espriu, V.A. Andrianov, Int.J.Mod.Phys. A21 (2006) 885

"Domain wall generation by fermion selfinteraction and light particles".

A.A. Andrianov, V.A. Andrianov , P. Giacconi, R. Soldati, JHEP 0307 (2003) 06.

"Brane world generation by matter and gravity".

A.A. Andrianov, V.A. Andrianov, P. Giacconi, R. Soldati, JHEP 0507 (2005) 003.

"On the stability of thick brane worlds non-minimally coupled to gravity".

A.A. Andrianov, Luca Vecchi, Phys.Rev. D77 (2008) 044035

In this period Andrianov's activity extended to other fields of research with a lot of success:

"Generalized Schmidt decomposition and classification of three-quantum-bit states"

A Acín, A Andrianov, L Costa, E Jané, JI Latorre, R Tarrach, PRL 85 (2000) 1560

"Higher-derivative supersymmetry and the Witten index"

AA Andrianov, MV Ioffe, VP Spiridonov, Physics Letters A 174 (1993) 273

"The factorization method and quantum systems with equivalent energy spectra"

AA Andrianov, NV Borisov, MV Ioffe, Physics Letters A 105 (1984) 19

"SUSY quantum mechanics with complex superpotentials and real energy spectra"

AA Andrianov, MV Ioffe, F Cannata, JP Dedonder, IJMPA 14 (1999) 2675

"Second order derivative supersymmetry, q deformations and the scattering problem"

AA Andrianov, MV Ioffe, F Cannata, JP Dedonder, IJMPA 10 (1995) 2683

"Lorentz and CPT violations from Chern-Simons modifications of QED"

AA Andrianov, P Giacconi, R Soldati, Journal of High Energy Physics 2002 (02) 030

"Three-qubit pure-state canonical forms"

A Acín, A Andrianov, E Jané, R Tarrach, Journal of Physics A 34 (2001) 6725

Physics Letters B

Volume 663, Issue 5, 5 June 2008, Pages 450-455

On the possibility of *P*-violation at finite baryon-number densities

A.A. Andrianov [1], D. Espriu

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https://doi.org/10.1016/j.physletb.2008.04.043 Get rights and content

Abstract

We show how the introduction of a finite baryon density may trigger spontaneous parity violation in the hadronic phase of QCD. Since this involves strong interaction physics in an intermediate energy range we approximate QCD by a σ model that retains the two lowest scalar and pseudoscalar multiplets. We propose a novel mechanism based on interplay between lightest and heavy meson states which cannot be realized solely in the Goldstone boson (pion) sector and thereby is unrelated to the one advocated by Migdal some time ago. Our approach is relevant for dense matter in an intermediate regime of few nuclear densities where quark percolation does not yet play a significant role

Back in 2008 we came to realize that given some out-of-equilibrium conditions it would be possible to have a phase of QCD where parity could be violated

The clearest mechanism is by producing (for a short period of time) a chiral imbalance due to gluon fluctuations that temporarily create topological fluctuations

$$\Delta T_5 = T_5(t_f) - T_5(t_i) = \frac{1}{8\pi^2}\int_{t_i}^{t_f} dt \int_{\text{vol.}} d^3x \mathrm{Tr}\left(G^{\mu\nu}\widetilde{G}_{\mu\nu}\right). \quad (2)$$

We will assume that, temporarily, as a consequence of a topological fluctuation of gluon fields or some other nechanism an effective *CP*- odd large θ term is generated. We will suppose that this region eventually grows in he hadronic phase to a sufficiently large size. We will also assume that this situation can be treated by equilibrium ield theoretical methods.

For *peripheral* heavy ion collisions such a situation may lead to the Chiral Magnetic Effect[10] whereby a large θ erm, combined with the large magnetic field due to the colliding nuclei, generates a large electric field and originates harge separation.

For *central* collisions (and light quarks) a large θ term will trigger an ephemeral phase with axial chemical potential $\mu_5 \neq 0$. This comes about because the PCAC equation predicts an induced axial charge to be conserved in the chiral $(m = 0)$ limit:

$$\frac{d}{dt}\left(Q_5^q - 2N_f T_5\right) \simeq 0, \quad Q_5^q = \int_{\text{vol.}} d^3x \bar{q}\gamma_0\gamma_5 q = \langle N_L - N_R \rangle, \quad (3)$$

Some selected papers:

“Spontaneous P-violation in QCD in extreme conditions”
A.A. Andrianov , V.A. Andrianov, D. Espriu . Phys.Lett. B678 (2009) 416.

“Dilepton excess from local parity breaking in baryon matter”.
A.A. Andrianov, V.A. Andrianov, D. Espriu, X. Planells, Phys.Lett. B710 (2012) 230-235.

“Spontaneous parity violation under extreme conditions: an effective lagrangian analysis”.
A.A. Andrianov,, V.A. Andrianov, D. Espriu, Eur.Phys.J. C74 (2014) 2932.

“Analysis of dilepton angular distributions in a parity breaking medium’
Alexander A. Andrianov, Vladimir A. Andrianov, Domenec Espriu, Xumeu Planells, Phys.Rev. D90 (2014) 034024.

Broadening and possibly enhancement of vector resonances emerges from the fact that polarizations have different Breit-Wigner profiles due to the parity breaking induced by a non-zero chiral charge.

1. Motivation of local parity breaking

It is well known that parity is a well established global symmetry of strong interactions. However, some time ago, it was proposed that the QCD vacuum can possess metastable domains leading to P violation. Accordingly, there is no reason to think that this symmetry cannot be broken in a finite volume. It is conjectured that the presence of non-trivial angular momentum (or magnetic field) in heavy ion collisions (HIC) then leads to the so-called Chiral Magnetic Effect (CME) [1].

Last decade several experiments in central HIC have indicated an abnormal yield of e^+e^- pairs of invariant mass < 1 GeV. This is the case of the PHENIX experiment in Brookhaven National Laboratory's Relativistic Heavy Ion Collider (RHIC) (see Fig. 1). It has been well established that such an enhancement is certainly a nuclear medium effect when compared to proton-proton collisions. The abnormal dilepton yield (enhanced by a factor of ∼ 4.7) has not been yet explained by any of the available mechanisms in hadron phenomenology. In this context, we want to stress that both CME and dilepton excess may be complementary effects related to the formation of a new phase in QCD where parity is locally broken. Our goal, with all the machinery developed for the study of local parity breaking (LPB) in HIC, consists in giving a qualitative answer to the PHENIX anomaly.

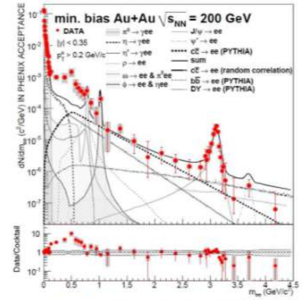


Figure 1: Anomalous dilepton yield in Au+Au collisions in PHENIX as compared with p+p [3].

2. Axial baryon charge and chiral chemical potential

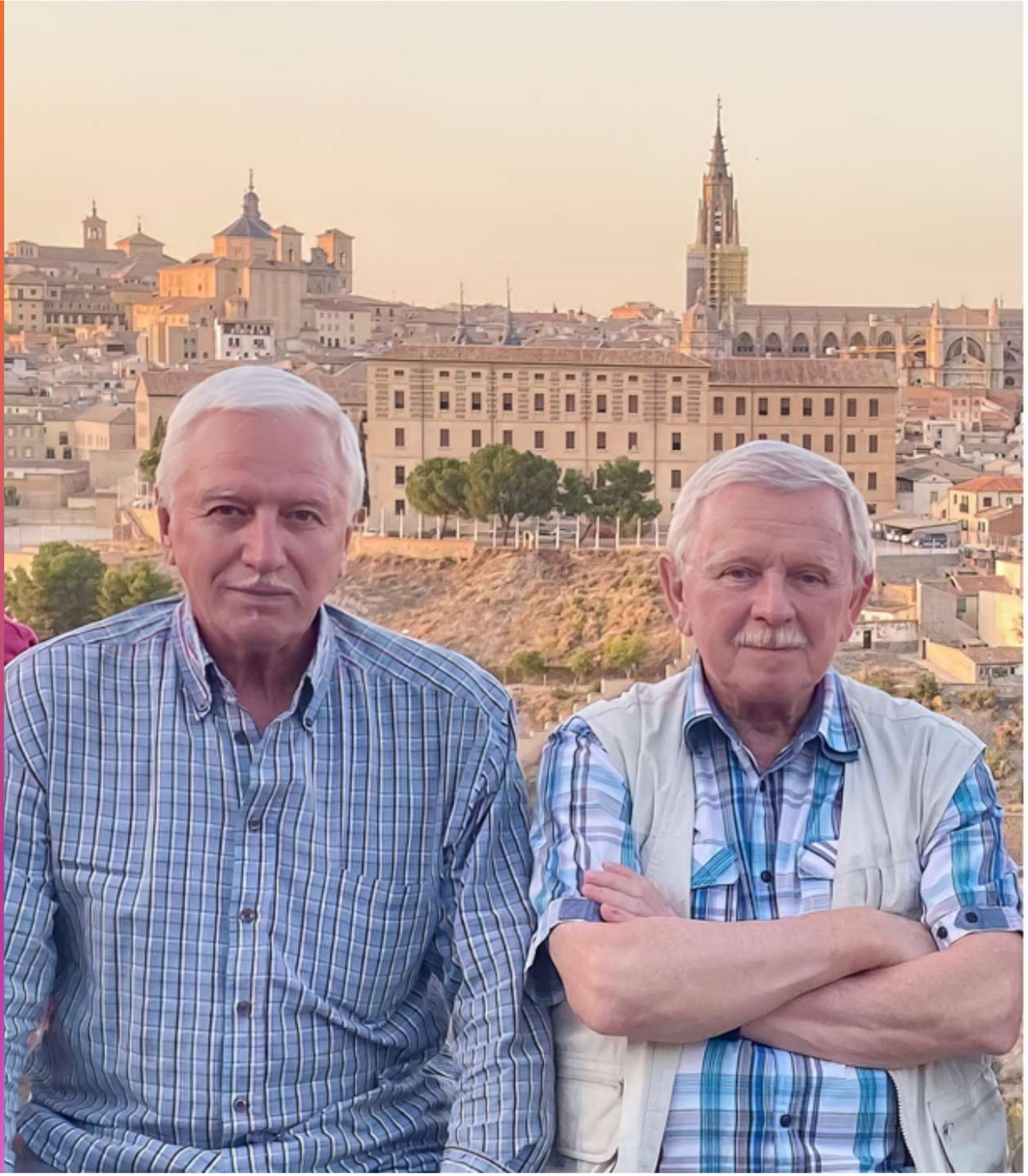
The strong interaction shows a highly non-trivial vacuum energy due to its non-abelian character. Such a behaviour allows different topological sectors to be present in the vacuum state, separated by high energy barriers. Nevertheless, these non-equivalent configurations may be connected due to large quantum fluctuations of the vacuum state in the presence of a hot medium via sphaleron transitions. The topological charge T_5 in a finite volume associated with a fireball reads

$$T_5 = \frac{1}{8\pi^2}\int_{\text{vol.}} d^3x\, \varepsilon_{jkl} \mathrm{Tr}\left(G^j\partial^k G^l - i\frac{2}{3}G^j G^k G^l\right), \quad (2.1)$$

which is not a gauge invariant object under large gauge transformations. However, its jump can be associated to the integral of a gauge-invariant quantity. Then, in order to examine LPB in nuclear matter, we can integrate the local PCAC and connect T_5 and the quark axial charge Q_5^q:

$$Q_5^q = \int_{\text{vol.}} d^3x\, \bar{q}\gamma_0\gamma_5 q, \qquad \frac{d}{dt}(Q_5^q - 2N_f T_5) \simeq 0,\ m_q \simeq 0. \quad (2.2)$$

In the chiral limit, thus, the exact conservation of the axial current states that the presence of a non-trivial topological charge in a finite volume is directly related to the emergence of a quark axial charge, a clear indication LPB.



The Russian- Spanish joint meetings

A political initiative: it was decide that 2011 was going to be the Russia-Spain Dual Year...

Why not to take advantage of that in order to foster collaboration in Nuclear and Particle Physics?

Binational meetings were held every two years

2011 Barcelona

2013 Saint Petersburg

2015 Madrid

2017 Dubna

2019 Santiago

2021 cancelled due to the pandemia

2023 was due in Kaliningrad, but...

11th Conference on Quark Confinement and Hadron Spectrum

Saint Petersburg, Russia 8 – 12 September 2014

EDITORS
Aleksandr Andrianov
Nora Brambilla
Sergei Kolevatov

Part A

American Institute of Physics

In recent years A.A. Andrianov had to endure very difficult personal circumstances after the successive and untimely losses of his daughter and his wife.

His health became very frail in recent times.

He visited the University of Barcelona during November and December 2023. He was rebuilding his life, but his health was far from optimal.

When he tried to return to Saint Petersburg on 15 December, the current tensions forced him to take a long detour that seriously impacted on him.

In a way he was one more collateral victim of the Russian-Ucranian war, a war that he personally suffered as his family background was partly Ucranian.