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RESEARCH PROFILE
Dmitri N. Voskresensky

Most generally, the theme of my research during the whole period of work can be termed **"Properties of many-body systems".** The research included description of:

(i) many-particle effects related to Bose and Fermi vacuum instabilities in strong electromagnetic, nuclear, gluon, and gravitational fields,

(ii) phase transitions in different systems, in particular, to inhomogeneous ($k \neq 0$) state, superconductivity and superfluidity, pion, kaon, rho-meson condensations, etc.,

(iii) quantum particle transport of resonances, and non-ideal hydrodynamics,

(iv) of particular interest for me are many-particle effects in neutron stars, including neutrino radiation problem and problem of equation of state and

(v) many-particle effects in nucleus-nucleus collisions, including effects of finite particle widths in non-equilibrium nuclear matter.

My current interests continue to be focused on description of the in-medium effects in applications to heavy ion collisions and neutron stars.

QED and QCD of the strong fields (1976 - 1993):
I studied *quantum electrodynamics of strong fields and a possibility of exotic nuclear states (pion condensation).* Quasiclassical description of relativistic electrons and the pion field in strong electromagnetic, nuclear and gravitational fields was developed, cf. [1–8, 10–12, 15, 21]. Results were applied to the positron production in low-energy heavy ion collisions, cf. [11], to the description of pion condensate in strong magnetic fields of neutron stars, cf. [12, 13], and to exotic pion condensate anomalous nuclei, cf. [3]. Also I worked on description of gluon and quark degrees of freedom [17]. Works [1, 2, 17] demonstrated possibility of fermion (electron/quark) condensation in the corresponding strong fields and the many-particle quasiclassical treatment of this phenomenon was developed.

The results obtained to 1977 were summarized in my Candidate of Sciences thesis. The title of my candidate (Ph. D.) thesis was "Charge distribution in abnormal nuclei" (Theoretical and Mathematical Physics). This work was done under the guidance of academician A.B. Migdal, prof. MEPhI and ITF Landau.

Then I studied a part of *the fermion vacuum reconstruction* in the zero-charge and asymptotic freedom problems *in QED and QCD* [36,42]. Fermion condensates which appear in strong fields, cf. [2, 17], were taken into account in electric/colour charge distributions near bare electric/colour charges resulting in similar electric/colour screened distributions both in QED and QCD.

Pion condensation:
Pion condensation at non-zero temperature was studied in [9, 14, 16]. Neutrino reactions in neutron stars in the presence of the pion condensate (including correlation effects) were considered in [18, 23]. Pion condensation in strong magnetic fields in application to neutron stars was studied in [12, 13].

Pion degrees of freedom in equilibrium and non-equilibrium nuclear matter:
I studied *in-medium effects in equilibrium and non-equilibrium dense nuclear matter taking into account the softening of pion modes in dense matter with application to relativistic heavy-ion collisions and to neutron stars.* Nuclear Fermi liquid Landau–Migdal approach has been applied and extended to the description of hot [9,14,16] and non-equilibrium nuclear matter, cf. [38,46]. Optic theorem formalism in non-equilibrium diagram technique was formulated in terms of full

Green's functions and used within the quasiparticle approximation [24] and then beyond the quasiparticle approximation [49, 50, 62].

The results concerning constructed description of the *pion degree of freedom in dense equilibrium hot and non-equilibrium nuclear matter* were reviewed in Phys. Rep. 192 (1990) No 4, 5, 6, p. 179 - 437, in the book: "Pion degrees of freedom in nuclear matter" (Moscow, Nauka, 1991, in Russian) written in collaboration with A.B. Migdal, E.E. Saperstein and M.A. Troitsky, and in refs [38, 58]. At the same time I worked on description of *non-homogeneous phase transitions in condensed matter.* A quasiclassical model for the description of the phase transitions to inhomogeneous states has been constructed [20, 41, 119].

The works on pion degrees of freedom in nuclear matter formed the basic part of my Doctor-of-Science thesis (analogous to habilitation) entitled "Pion degrees of freedom in hot and dense nuclear matter". It was presented in 1991.

Neutron Stars:

The problem of neutrino radiation from neutron stars
has been studied with inclusion of in-medium reaction channels, cf. [18, 23–27, 47, 54, 58, 74, 89, 92, 96, 101, 104, 109, 117, 125]. "Nuclear medium cooling scenario" has been constructed, where essential role is played by medium effects in non-superfluid and superfluid nuclear matter. Relations between cooling, medium effects and the value and density dependence of the $3P_2$ neutron gap were discussed in [89, 96, 101].

Pion condensate phase transition in magnetic fields of neutron stars and superconductivity of charged pion condensate
were considered in [10, 12]. Peculiarities of the phase transition to non-homogeneous condensate state have been analyzed.

Kaon kondensation, ρ-meson condensation, mixed phases and their influence on properties of neutron stars have been studied [48, 59, 72, 75–77, 81, 86, 87, 93, 95, 97–100, 105, 106].

Strong phase transition and neutrino burst.
Possible phase transition to pion condensate state together with a neutrino burst in applications to supernova explosions were studied in [26, 27].

The problem of existence of light resonances below pion-nucleon threshold
has been considered in [73] in connection with the consequences of the light dibaryon, N' resonance and light pion states for nuclei, neutron stars and heavy ion collisions.

The relation between lattice QCD and properties of quark stars
is studied in [94]. The QCD motivated models with parameters with parameters adjasted to reproduce the lattice-QCD equation of state is extrapolated from region of high temperatures and moderate baryon densities to the domain of high baryonic densities and zero temperatures. These models exclude the possibility of hybrid (hadron-quark) stars. Pure quark stars are possible and have low masses, small radii and very high central densities.

Heavy-Ion Collisions:

An expanding fireball model of heavy ion collisions which included in-medium pion and kaon propagation was suggested, cf. [22, 28–32, 34, 35, 37–39, 44, 122]. The works [88, 111] studied properties of the hadron liquid at small baryon chemical potential. The blurring of the hadron vacuum and its consequences were discussed. The works [108, 110] generalized the model of equation of state developed in [93] with scaled effective hadron masses and coupling constants to the case of hot and dense nuclear matter and applied it to description of particle rates in heavy ion collisions in a broad collision energy range.

Pion Gas:

I studied the possibility of the turbulence and Bose–Einstein condensation of pions with dynamically fixed chemical potential in non-equilibrium pion gas in application to ultrarelativistic heavy–ion collisions at CERN and RHIC energies [43, 51, 56, 57].

Phase Transitions:

Phase transitions in nuclear matter

were considered, as pion condensation [9,14,16], kaon kondensation [48,76] and liquid–gas phase transition [19, 114], ρ-meson condensation [59, 93], hadron-quark phase transition [112, 114].

General description

of phenomenology of inhomogeneous phase transitions in condensed matter was developed in [20, 41].

Mixed Phase

was considered in [72, 75, 77, 81, 86, 87, 95, 97–100, 105, 106] with taking into account of screening effects. It was shown that the Coulomb (unscreened) limit is not achieved for the realistic values of parameters. Different mixed phases were studied: hadron–quark mixed phase, hadron–kaon condensate mixed phase and nuclear pasta.

Čerenkov radiation and condensates in moving media:

I considered possible formation of *the condensate of excitations in moving medium* in application to different systems [40]. Also a Cherenkov-like radiation in relativistically moving hot Fermi liquids was analyzed [52] and a possibility to observe the pion and kaon instabilities in peripheral nucleus–nucleus collisions was discussed [45, 55].

Kaon and ρ meson properties:

Then, the P-wave *kaon–baryon interaction in dense matter* was studied. The possibility of kaon condensation in P-wave state in neutron stars was suggested and the kaon spectra in nuclear matter were discussed. Various manifestations of strangeness modes in neutron stars, heavy-ion collisions and nuclei were considered [48, 53, 55, 62, 66, 76, 81]. Brown - Rho scaling idea led me to the suggestion of the possibility of the charged rho-meson condensation in asymmetric baryon matter [59]. These ideas were then ellaborated within relativistic mean field models in [93]. Equivalence between a variety of models was arued for and the models fitting the Urbana-Argonne equation of state including the symmetry energy were constructed.

Radiation problem and Landau–Pomeranchuk–Migdal effect:

A general description of the radiation from a piece of strongly interacting matter has been constructed [24, 49, 50, 62]. A closed diargam technique for non-equilibrium full Green functions was introduced. The *many body description of bremsstrahlung in dense matter* with inclusion of finite particle [49, 50] width effects due to multiple particle collisions (Landau–Pomeranchuk–Migdal effect) was suggested in [49, 50].

Diquark condensates:

The works [64, 68, 69, 74, 78, 84, 90–92, 102, 104] are devoted to a part of a possible color superconductivity in dense interiors of some neutron stars and its manifestation via cooling history and repulsion of the magnetic field. Works [80, 83, 85] discuss possible consequences of fluctuations of the diquark order parameter in application to heavy-ion collisions.

Non-equilibrium:

I also continued to study generalized kinetic description of non-equilibrium nuclear matter with inclusion of retardation effects, cf. [46]. Then a *self-consistent kinetic scheme* based on Φ-derivable method of Baym, generalized to Schwinger–Keldysh contour was suggested [60, 61, 63, 65, 71, 79, 103]. Method allows to treat self-consistently finite particle width effects in the framework of generalized kinetic approach. Expression for the kinetic entropy flow at non-equilibrium was found. In [112, 114] hydrodynamical description of the hadron-quark first order phase transition is constructed. Analytical and numerical solutions are presented. In [113] a non-local form of the generalized kinetic equation is suggested and a physical meaning of the time delays and advances is discussed. Refs. [115, 116] studied viscosity effects in heavy ion collisions.

Constraints on the EoS:

Constraints on the EoS of hot and dense nuclear matter have been studied in [29, 31, 33, 37, 38, 93, 107, 108, 110].

LIST OF PUBLICATIONS
# of D. Voskresensky
on 05.2010 number of citations about 1650, h-index 21 following SPIRES-HEP database

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