Romanian Reports in Physics, Vol. 59, No. 4, P. 923–940, 2007

HAPPY 70th DUMITRU BARBU ION

Keep the game alive!

On July 25 2007, Professor Dumitru Barbu ION turns 70 years old. One of the outstanding figures of physics, D. B. ION made fundamental contributions to several areas of physics, including: unification of bosonic and fermionic degree of freedom; mesonic Cherenkov-like effects in the hadronic and nuclear matter; spontaneous and induced fission accompanied by pion emissions; nonextensive statistical effects in many body physics and complexity in quantum scattering. This issue of the journal **Romanian Reports in Physics** carries some tributes to Professor D. B. ION on the occasion of his 70th birthday. Many of the contributors to this volume are collaborators or continuators to the very prodigious and impressive scientific researches of the new phenomena and theories invented by the professor. Thank you professor D. B. ION for showing us by your example that it is possible to be a winner by hard work!

Professor Dumitru Barbu ION, born in the village Cucuieți-Sudiți, Commune Podul Pitarului in Romania, was the son of Barbu Alexandru Ion and Maria Ion Fillip. He attended the Pedagogical School in Bucharest between 1951 and 1955 receiving a teacher's diploma. After his universitary studies (at the Bucharest University between 1957 to 1962), he took a permanent position in the Institute of Atomic Physics, Bucharest, Romania. Now, he is a senior researcher in the Department of Elementary Particle Physics at the National Institute for Physics and Nuclear Engineering. He received his doctoral degree in Physics in 1971 with an original thesis entitled: *Mesonic Cherenkov-like effect as possible mechanism for meson production in hadronic interactions* (superviser Acad. Prof. Horia Hulubei). Between 1971 and 1976, D. B. Ion was a senior researcher at the Joint Institute for Nuclear Research Dubna-Moscow, Russia. His professional career includes also some temporary positions in Germany such as: Visiting Professor (BAT-I) at the Ludwig Maximilian Munchen-University, where he worked between 1990–1996 on COSY-Projects. So, at the LMU-Munchen, Prof. Dr. D. B. Ion in collaboration with Prof. Dr. Wilhelm Stocker predicted new nuclear effects, namely, the Nuclear Gamma Cherenkov-like Radiation (NGCR) and Nuclear Pionic Cerenkov-like Radiation (NPICR). These predictions on the NPICR-nuclear effect were recently confirmed experimentally with high accuracy by a Group of scientists in JINR-Dubna (Russia) [see Gogiberidze *et al.*, Phys. Lett. B 471 (1999) 257, see also E. K. Sarkisyan *et al.*, this issue].

His fundamental contributions to the development of quantum physics and numerous scientific papers include:

I. Extensions of Jordan Algebras and Superalgebras. *On Jordan Algebra of type A* [Stud. Cercet. Mathem. **17** (1965) 301], *On some properties of roots of Jordan algebras of type A* [Stud. Cercet. Mathem. **18** (1966) 309], *On some properties of structure constants of Jordan Algebras of type A* [Stud. Cercet. Mathem. **19** (1967) 1031].

II. New nuclear effects. *Coherent pion production via Cherenkov mesonic radiation in proton nucleus collisions* [Phys. Lett. B (1991)], *Possibility of coherent gamma Cherenkov radiation in relativistic heavy ion collisions* [Phys. Lett. (1991)], *Nuclear gamma Cherenkov radiation from charged projectiles as a coherent effect in nuclear media* [Ann. Phys. (N.Y.) (1992)], *Coherent pion production via the Cherenkov mechanism in nuclear media* [Acta Phys. Polon. B (1993)], *Quantum theoretical approach to meson production in nuclear media via the Cherenkov mechanism* [Phys. Rev. C(1993)], *High energy nuclear gamma Cherenkov radiation* [Phys. Lett. B (1993)], *Nuclear gamma Cherenkov radiation from charged leptons* [Phys. Lett. B (1994)]. *Nuclear pionic Cherenkov-like radiation from high energy nucleons in nuclear media* [Phys. Lett. B (1995)], *Nuclear mesonic Cherenkov-like radiation from high energy nucleons in nuclear media* [Phys. Rev. C (1995)] [see also the paper: D. B. Ion, *Generalized Super-Cerenkov Radiations in Nuclear and Hadronic Media*, Rom. Rep. Phys. 59 (2007) No. 4, this issue].

III. New nonextensive entropy, optimality and complexity in quantum physics. *Description of quantum scattering via the principle of minimum distance in space of states* [Phys. Lett. B (1996)], *Optimality entropy and complexity in quantum scattering* [Chaos Solitons and Fractals (2002)], *Isospin quantum distances in hadron-hadron scatterings* [Phys. Lett. B (1996)], *Reproducing kernel Hilbert space and optimal state description of hadron-hadron scattering* [International J. Theor. Phys. (1985)], *Reproducing kernel Hilbert spaces and extremal problems for scattering of particles with arbitrary spins* [International J. Theor. Phys. (1985)], *Scaling and S-channel helicity conservation via optimal state description of hadron-hadron scattering* [International J. Theor. Phys. (1986)], *Information entropies in pion-nucleon scattering and optimal state analysis* [Phys. Lett. B (1995)], *Nonextensive quantum statistics and saturation of PMD-SQS optimality limit in hadron-hadron scattering* [Physica A (2004)] [see also the paper: D. B. Ion and M. L. D. Ion. *The principle of minimum distance in space of states as new optimum principle in quantum physics* [Rom. Rep. Phys. 59 (2007) Nr. 4, (this issue)], *Entropic lower bound for quantum scattering of spinless particles* [Phys. Rev. Lett. (1998)], *Optimal bounds for Tsallis-like entropies in quantum scattering of spinless particles* [Phys. Rev. Lett. (1999)], *Angle-angular-momentum entropic bounds and optimal entropies for quantum scattering of spinless particles* [Phys. Rev. E (1999)], *Entropic uncertainty relations for nonextensive quantum scattering* [Phys. Lett. B (1999)], *Limited entropic uncertainty as a new principle in quantum physics* [Phys. Lett. B (2000)], *Strong* *evidence for correlated nonextensive quantum statistics in hadronic scattering* [Phys. Lett. B (2000)], *Evidence for nonextensive statistics conjugation in hadronic scatterings systems* [Phys. Lett. B (2001)], *New nonextensive quantum entropy and strong evidence for equilibrium of quantum hadronic states* [Phys. Lett. B (2001)]. *Optimality entropy and complexity in quantum scattering* [Chaos Solitons and Fractals (2002)] [see also the paper: D. B. Ion and M. L. D. Ion, *The principle of minimum distance in space of states as a new optimum principle in quantum physics*, [Rom. Rep. Phys. 59 (2007) Nr. 4, (this issue)].

IV. New kind of polarizations of interacting hadrons. *The isospin and isospin-spin polarizations of interacting hadrons* [Ann. Phys. (N.Y.) 93 (1975) 41], *The nucleon isospin polarisation and isospin bounds in pion nucleon scattering* [Ann. Phys. (N.Y.) 93 (1975) 55], *Saturation of isospin bounds and constraints on experimental data and amplitude analysis* [Ann. of Phys. (N.Y.) 95 (1975) 308], *Exact saturation and degeneracy of isospin bounds in pion-nucleon scattering* [Ann. Phys. (N.Y.) 98 (1976) 160], *The isospin bounds and phase contours in pion-nucleon scattering* [Nucl. Phys. **B** 84 (1975) 55], *Model independent tests for* $\Delta I = 1/2$ *in weak decay of sigma strange baryons* [Nucl. Phys. B 96 (1975) 67], *Pomeranchuk-like theorems on integrated cross sections and average spin polarization parameters* [Phys. Lett. B 62 (1976) 65], *The isospin constraints for spin density matrices of quasi-two-body reactions* [Sov. J. Nucl. Phys. 25 (1977) 247].

V. New nuclear radioactivities. *Spontaneous pion emission as new natural radioactivity* [Ann. Phys. (N.Y.) **171** (1986) 237], *Supergiant halos as experimental evidence for pionic radioactivity* [Phys. Lett. **B 338** (1994) 7], *Experimental evidence for dual diffractive resonances in pion-nucleus scattering* [Nucl. Phys. A (1981)] [see also the paper: D. B. Ion, R. Ion-Mihai and M. L. D. Ion, *New nuclear and subnuclear exotic decays*, [Rom. Rep. Phys, **59** (2007) Nr. 4, this issue].

I. Extensions of Jordan Algebras and Superalgebras. The unified description of all basic interactions of nature, *i.e.*, strong, electroweak, and gravitational interactions is an obsessive goal among physicists. It is widely felt that supersymmetry is a necessary ingredient in any unifying approach. Supersymmetry relates fermionic and bosonic degrees of freedom. It was discovered in 1971. *The unification of bosonic and fermionic degree of freedom was proposed in a different manner in 1965 by Professor D. B. Ion* [*see* D. B. Ion, Stud. Cercet. Mathem. **17** (1965) 301–312; Stud. Cercet. Mathem. **18** (1966) 309–313; Stud. Cercet. Mathem. **19** (1967) 1031–1937, the references [41–43] from the selective list of papers of D. B. Ion] *Related to the foundations of quantum mechanics P. Jordan has considered similar mathematical structures associated with extensions of the Jordan algebras* [see Commun. Math. Phys. **9** (1968) 279–292; **11** (1969) 293–296.].

Here we present some important quotations of these papers.

J. Ravatin and H. Immediato, [Commun. Math. Phys. **16** (1970) 184–190.] *Représentations et extensions d'algèbres de Jordan* Commun. Math. Phys **16** (1970) 184.

«*Récents articles de P. Jordan* [Mathem **19** (1967) 1031–1037] *et Ion* [D. B. Ion, Stud. Cercet. Mathem. **17** (1965) 301–312; Stud. Cercet. Mathem. **18** (1966) 309–313; Stud. Cercet. Mathem. **19** (1967) 1031–1937] *font ressortir l'intérêt des algèbres non associatives en Physique quantique…»*

G. B. Seligman, [Math. Rev. **36**: 1504].
"In the paper [D. B. Ion, Stud. Cercet. Mathem. **17** (1965) 301–312] *the author starts with an associative algebra A over a ground field F, such that all of what follows makes sense (a full matrix algebra over a field of characteristic ≠ 2 seems to be the model). Let* $a \in A$ *be such that*

$$a : x \rightarrow [ax] = ax - xa \tag{1}$$

is diagonalizable acting in A, such that kernel of ada *is a Cartan subalgebra H of A (regarded as Lie algebra), and such that all nonzero characteristic roots of* ada *have multiplicity 1. Write* $\{xy\} = \frac{1}{2}(xy + yx)$ *and let* α *run over the nonzero roots of A relative to the Cartan algebra H. for* $h \in H,\ e_\alpha \in A_\alpha$ *one sees from*

$$[a, \{he_\alpha\}] = \alpha(a)\{he_\alpha\} \tag{2}$$

that

$$\{he_\alpha\} = \bar{\alpha}(h)e_\alpha, \tag{3}$$

$\bar{\alpha}$ *a linear functionon H. The author shows that* $\overline{-\alpha} = \bar{\alpha}$. *Moreover* $\{e_\alpha e_{-\alpha}\} \in H$, *and it is shown that for any two roots* α, β, *there is an integer g (obtained as usual from the* α*–string of roots through* β) *such that*

$$2\bar{\beta}(\{e_\alpha e_{-\alpha}\}) = g(\{e_\alpha e_{-\alpha}\}) \tag{4}$$

(This is the formula actually established; in his summary at the beginning of the paper, the author has interchanged α and β on the left).

Ju. Rjabuhin, [Math. Rev. **38**: 1136.] "The author [D. B. Ion, Stud. Cercet. Mathem. **18** (1966) 309–313.] investigates a Jordan algebra A^+ which he obtains from the associative algebra *A* of square matrices of order n over a field *F*. The characteristic *p* of field *F* is assumed to be different from 2. He defines the multiplication in A^* by the general $[x, y]_+ = \frac{1}{2}(xy + yx)$. A certain basis is chosen in algebra A^* and the structure constants corresponding to this basis are computed. For $n = 3$ the computations are carried out in full. The paper may be of interest to theoretical physicists.

Radu Iordanescu [***Jordan Structures in Geometry and Physics***, Ed. Academiei Române, 2003]
In Preface to this book: ..."*I like to mention that the interest in Jordan structures began in Romania with the papers* [229a,b,c] *by the Romanian physicist Dr. Dumitru B. Ion*"…
[229] (a) D. B. Ion, *On Jordan Algebra of type A*, Stud. Cercet. Mathem. **17** (1965) 301–312; (b) D. B. Ion, *On some properties of roots of Jordan algebras of type A*, Stud. Cercet. Mathem. **18** (1966) 309–313; (c) D. B. Ion, *On some properties of structure constants of Jordan Algebras of type A*, Stud. Cercet. Mathem. **19** (1967) 1031–1037.

II. New nuclear effects. As is already known, Prof. Dr. D. B. Ion, in his doctoral thesis developed not only a general classical and quantum theory of the mesonic (scalar, pseudoscalar and vectorial) Cerenkov-like effects in hadronic and nuclear media but also an extension of all these ideas to the baryonic Cerenkov-like effect in nuclear media. Moreover, the gamma and mesonic Cerenkov-like effects was continued and systematically investigated in collaboration with Prof. Dr. W. Stocker (at Munchen University) on COSY-projects. Then, using a Foldy-Lax formula for the refractive index of photons in nuclear media and the available experimental meson-nucleon and gamma-nucleon forward scattering amplitudes, they proved that the coherence condition for the emission of the nuclear meson and gamma Cherenkov radiation (NGCR) is fulfilled at projectile energies higher than 1 GeV/nucleon in the spectral bands 140–300 MeV, still below the delta resonance region. An extension of the Bethe-Bloch formula to the electromagnetic stopping power of nuclear medium is also derived by introducing the nuclear plasmons [see D. B. Ion and W. Stocker, Ann. Phys. (N.Y.) **213,** 355 (1992)].

I. M. Dremin. [**Cherenkov effects**, Rom. Rep. Phys. **59** No 4 (2007), this issue] *"Cherenkov effect is well known in ordinary matter. It is widely studied and applied. The speculations about such effect in the hadronic matter were proposed. Some preliminary experimental indications were found from time to time. However, only recently the observations at the nuclear pionic Cerenkov-like radiation RHIC provided more definite and quantitative data. Their interpretation still needs to be more elaborated. This is one of the fields where D. B. Ion contributed intensively".*

I. M. Dremin and A. V. Leonidov [***Theoretical search for collective effects in multiparticle production***, Uspehi Fiz. Nauk 165, (1995) 759–762, ArXiv:hep-ph/9503446 27 Mar 1995].
…"Let us mention an interesting possible analogy with a collective effect in the photon radiation. It is known, that the real part of an elastic scattering amplitude of hadrons becomes positive at large energies. In the terminology of classical physics this means, that the refractive index of the hadronic medium exceeds one. In this case the phase velocity of a colored charge in the hadron medium can be higher than the speed of light. This can lead to the "color Cherenkov radiation", which is analogous to the usual Cherenkov radiation, the theory which was developed by Tamm and Frank. A characteristic feature of such radiation will be its angular distribution with its typical "ring-like" structure [*see the review* [90] *and the papers* [91] (Ion D. B. and Stocker W.), [92]]. *…Nevertheless some events having a "ring structure" were observed in cosmic rays* [93], *and for larger statistics the processing of the experimental data of NA22 gave indication [94] on a statistically significant contribution of such events. They show up as peaks in the pion distributions at the rapidities 0.3 in the center of mass frame. Several bands of energies are claimed* [91] (Ion D. B., Stocker W.), [92] *to satisfy the requirements of "color Cherenkov radiation". The continuation of the searches for the possible manifestations of this effect would be desirable"…*
[91] Ion D. B. and Stocker W., Phys. Lett. **B 273**, 20 (1991); Ann. of Phys. **213**, 355 (1992); Phys. Lett. **B 346**, 172 (1995).

Edward K. G. Sarkisyan, Liana K. Gelovani, George L. Gogiberidze [***Cherenkov hadron production in collision of relativistic nuclei***, Rom. Rep. Phys. **59** (2007) No. 4 (this issue)]. "*The area of collective effects in particle production in high-energy collisions attracts a special interest as the hadron production process is yet far from being well understood. Possible coherent mechanisms of emission of particles are of specific interest as they provide a possibility to find the analogies and thus descriptions based on the already known and well understood mechanisms from other areas of physics, and the Cerenkov radiation is one of the most promising approaches in this sense. In series of papers, D. B. Ion with colleagues have successfully applied the features of Cerenkov radiation to particle production in high-energy physics* [1–3] *and astrophysics* [4] *Following earlier ideas of mesonic* [5] *and scalar (pionic)* [6] *radiation in particle/nuclear collisions, the systematic investigations have been made for secondary mesons* [1, 2] *and photons* [3] *scattered in nuclear medium in terms of classical quantum mechanics. Recently the studies have been further generalized and new phenomenon has been shown to be expected* [7]. *Characteristic signatures of the Cerenkov-like mechanism, such as the differential cross-sections and angle-energy correlations of produced particles, have been predicted……"Using the Dubna (JINR) data of relativistic nucleus-nucleus* *collisions, we have investigated dense groups of hadrons* [10, 11] *and found very good agreement with the predictions made by the two above discussed approaches for the coherent component of the hadroproduction process On the one hand, we analyzed distributions of the centers of spikes in the frame of the gluon-jet emission model and found two peaks as predicted. On the other hand, we investigated energy distribution within spikes for the features predicted by the nuclear pionic Cerenkov-like radiation (NPICR) approach* [1, 2] *and found the energy peak value and its width in agreement with this semi-classical approach. This coincidence, in our opinion, indicates a coherent emission mechanism to be an essential component in the hadron production process."*

[1] D. B. Ion and W. Stocker, Phys. Lett. **B 273** (1991) 20.
D. B. Ion and W. Stocker, Phys. Rev. **C 48** (1993) 1172.
D. B. Ion and W. Stocker, Phys. Rev. **C 52** (1995) 3332,
[2] D. B. Ion, Rom. J. Phys. **36** (1991) 587.
D. B. Ion, Rom. J. Phys. **36** (1991) 595.
D. B. Ion and W. Stocker, Rom. J. Phys. **38** (1993) 539.
D. B. Ion and A. Rosca, Rom. J. Phys. **38** (1993) 655.
D. B. Ion, A. Rosca, and C. Petrascu Rom. J. Phys. **39** (1994) 395.
W. Stocker and D. B. Ion, Acta Phys. Polon. **B 24** (1994) 1785.
D. B. Ion and W. Stocker, Rom. J. Phys. **39** (1994) 527.
D. B. Ion and W. Stocker, Phys. Lett. **B 346** (1995) 172.
[3] D. B. Ion and W. Stocker, Phys. Lett. **B 258** (1991) 262.
D. B. Ion and W. Stocker, Ann. Phys. (N.Y.) **213** (1992) 355.
D. B. Ion and W. Stocker, Phys. Lett. **B 311** (1993) 339.
D. B. Ion and W. Stocker, Phys. Lett. **B 323** (1994) 446.
[4] D. B. Ion, W. Stocker, Astropart. Phys. **2** (1994) 21.
[5] W. Wada, Phys. Rev. **75** (1949) 981.
D. Ivanenko and V. Gurgenidze, Dokl. Akad. Nauk SSSR **67** (1949) 997.
D. I. Blokhintsev and V. L. Indenbohm, ZhETF **20** (1950) 1123.
[6] W. Czyz and S. L. Glashow, Nucl. Phys. **20** (1960) 309.
G. Yekutieli, Nuovo Cim. 13 (1959) 446, 1306(E).
P. Smrz, Nucl. Phys. 35 (1962) 165.
[7] D. B. Ion and E. K. Sarkisyan, Rom. J. Phys. **49** (2004) 25.
D. B. Ion and E. K. Sarkisyan, Rom. J. Phys. **49** (2004) 671.
D. B. Ion and M. L. Ion, Rom. J. Phys. **50** (2005) 947.
D. B. Ion and M. L. Ion, Rom. J. Phys. **51** (2006) 867.

Edward K. G. Sarkisyan, Liana K. Gelovani, George L. Gogiberidze [***Cherenkov hadron production in collision of relativistic nuclei***, Rom. Rep. Phys. **59** (2007) No. 4 (this issue)]. "*In the last few years, the Cerenkov mechanism of hadron production in high-energy (nuclear) collisions attracted quite interest [24] due to the observations made at RHIC [25] and their possible interpretation. Applied to these experimental data, the model of particle production via Cerenkov-like radiation, developed by D. B. Ion with his colleagues, is expected to shed new light on the problem and to make predictions for future experiments. In conclusion, let us wish the author further interesting and, as always, fruitful work in this important direction"*.

M. Pardy [***The Cherenkov effect with radiative corrections***, Phys. Lett. **B 325** (1994) 517].
…"*The possibility of the existence of the gamma Cherenkov radiation is discussed by Ion and Stocker* [8] *in nuclear physics. The so called nuclear gamma Cerenkov radiation requires a special experimental technique in order to extract such radiation from the background produced by other mechanisms. Such coherent techniques are well known in nuclear physics and we can expect that sooner or later the existence of the gamma Cherenkov radiation in nuclear physics will be confirmed"*…

[8] D. B. Ion and W. Stocker Phys. Lett. **B 311** (1993) 339.

G. L. Gogiberidze, L. K. Gelovani, E. K. Sarkisyan [*On coherent particle production in central 4.3 A GeV/c Mg-Mg collisions,* Phys. Lett. **B 471** (1999) 257].

"*Features of dense groups, or spikes, of negative pions produced in Mg-Mg collisions at 4.3 GeV/c/nucleon are studied to search for a coherent, Cerenkov-like, mechanism of multihadron production…. A coherent component of particle production mechanism, Cerenkov-like radiation, in high energy particle collisions has been introduced a long time ego. The idea of mesonic* [1] *and scalar (pionic*) [2] *radiation has recently been a subject of systematic analysis of production of mesons in high-energy pion-nucleon scattering in nuclear medium in terms of classical quantum mechanics* [3] [D. B. Ion and W. Stocker]. *Characteristic signatures of the Cherenkov mechanism, such as the differential cross sections and angle-energy correlations of produced particles, have been predicted"…*

…"The strong signal of the coherent emission dynamics obtained allows further search for its manifestation in the energy distribution, as predicted in the NPICR approach [3] [D. B. Ion and W. Stocker]. *In this model, the energy spectrum of pions, emitted through Cherenkov-like mechanism when a few GeV proton passes the nuclear medium is predicted to have a peak. This peak is expected to appear at 260 MeV when an absorption effect is neglected and at 244 MeV otherwise."…*

"To estimate the position of the peak and its width and also to make the results more comparable with the NPICR, the E^*-distributions …. "After averaging over various spikes, the position of the peak and its width are found to have the values,

$$E_m^* = 238 \pm 3(stat) \pm 8(syst)\ MeV\ and\ \Gamma_m = 10 \pm 3(stat) \pm 5(sys)$$

respectively. The location of the obtained center of the Gaussian lies within the interval of energy expected for pions from the Cherenkov-like mechanism for incident protons of a few GeV, $224\ MeV \le E_m \le 244\ MeV$ [3] [D. B. Ion and W. Stocker]. *The value of E_m^* is similar to the position of the peak observed in the π^+p-invariant mass distribution in the analysis of coincidence measurements of (p, n)-reactions on carbon at 1.5 GeV/c in the Δ–resonance excitation region* [18] [*Ciba et al. Phys. Rev. Lett. 67 (1991, 1982)*], *the effect connected with the NPICR mechanism* [3] [D. B. Ion and W. Stocker]. *Also, the width Γ_m confirms an observation of the Cherenkov radiation signal expected to be $\Gamma \le 25\ MeV$"*.....*Recapitulating, in order to search for a coherent, Cherenkov-like emission mechanism of particle production, a study of spikes in relativistic nuclear collisions is carried out with negative pions from central Mg-Mg collisions at a momentum of 4.3 GeV/c per incident nucleon"…*

[3] D. B. Ion and W. Stocker, Phys. Rev. C 48 (1993) 1172; Phys. Rev}. C 52 (1995) 3332, and refs. terein.

G. L. Gogiberidze, E. K. Sarkisyan and L. K. Gelovani [***Coherent particle production in collisions of relativistic nuclei***, Nucl. Phys. Proc. Suppl. **92** (2001) 75–82, ArXiv:hep-ph/0010190 v2 19 Oct 2000, **Torino Conference-2000**].*"The aim of this report is to present our recent results on investigations of spikes in relativistic nucleus-nucleus collisions [6–8]. …we investigate energy distribution within spikes to find the features predicted by the nuclear pionic Cerenkov-like radiation (NPICR) approach.* [3] [D. B. Ion and W.Stocker]"…

"The strong signal of the coherent emission dynamics obtained allows further search for its manifestation in the energy distribution, as predicted in the NPICR approach [3] [D. B. Ion and W. Stocker]. *In this model, the energy spectrum of pions, emitted through Cherenkov-like mechanism when a few GeV proton passes the nuclear medium is predicted to have a peak. This peak is expected to appear at 260 MeV when an absorption effect is neglected and at 244 MeV otherwise."…*

"In summary, in order to search for a coherent, Cherenkov-like emission mechanism of particle production, a study of spikes in relativistic nuclear collisions is carried out with charged particles from central C-Cu collisions at momentum of 4.5 A GeV/c and with negative pions from central Mg-Mg collisions at a momentum of 4.3 GeV/c per incident nucleon". … "The dynamical effect in the spike-center distributions is reveleated in a comparison with an independent particle-emission

model, where no peaks are seen. The coherent character of particle production is confirmed by studying energy distributions. The inclusive energy spectra show monotonic exponential decrease with two specific temperatures, while the in-spike energy distributions are obtained to exhibit a peak at a position and of a width both consistent with the values expected from the theoretical calculations based on the hypothesis of nuclear pionic Cherenkov radiation."...

[3] D. B. Ion and W. Stocker, Phys. Rev. **C 48** (1993) 1172; Phys. Rev. **C 52** (1995) 3332, and refs. terein.

III. New nonextensive entropy, optimality and complexity in quantum physics

Complexity as a phenomenon is omnipresent in natural, social, business, artificial, engineered or hybrid systems. Cells, organisms, the ecosystem, companies, supply networks, markets, societies, governments, cities, regions, countries, large scale software and hardware systems, the Internet, all are examples of complex systems. Despite this omnipresence there is no commonly accepted, crisp and robust definition or classification of complex systems and one might ask why we would expect commonalities among such systems despite their obvious differences.

R. G. Newton [Math. Rev. 86k: 81140]. *In this paper* [D. B. Ion and H. Scutaru, International J. of Theor. Phys. **24** (1995) 355–366] *it is shown that the reproducing kernel Hilbert spaces are adequate variational spaces for the description of the scattering amplitude in terms of a minimum norm principle. Then, the optimal scattering states as the solution of the minimum norm problems are introduced and the essential characteristic features of the hadron-hadron scattering in the optimal state dominance limit are established*.

P. Rochus (**Saloray-Argenteau**) [**Math. Rev. 87b: 81137**]. "*The author* [D. B. Ion, International J. Theor. Phys. **24** (1985) 1217] *considers each helicity amplitude of two-body scattering of particle with arbitrary spins as an element of a special class of Hilbert spaces H. This space which is called reproducing kernel Hilbert space (RKHS) has many special properties that appear to make it a natural space of functions to associate with scattering helicity amplitudes....The reproducing kernel of H is characterized as solutions to certain extremal problems. It is then shown that the optimal state from the RKHS of helicity amplitudes is analogous to the coherent state from the RKHS of the wave functions. The essential characteristic features of the scattering of particles with arbitrary spins in optimal state dominance limit are established. An important alternative to the partial wave helicity analysis interms of a fundamental set of optimal states is presented. Some of the theoretical predictions are satisfied experimentally toasurprising accuracy, for* [*PP*, $\pi^{\pm}P$, $K^{\pm}P$]*-scatterings at all energies higher than 2 GeV*".

P. Rochus (**Saloray-Argenteau) [Math. Rev. 88e: 81153].** "*This paper* [D. B. Ion, International J. Theor. Phys. **25** (1986) 1257–1279] *is a continuation and an extension of the author's previous work in which he consider the two-body scattering amplitude as an element of a functional Hilbert space called reproducing kernel Hilbert space(RKHS). Using RKHS methods, two important physical laws of hadron-hadron scattering the scaling of angular distributions and S-channel helicity conservations are derived via optimal state dominance"…*

R. Iordanescu, "**JORDAN STRUCTURES IN GEOMETRY AND PHYSICS"**, Editura Academiei Romane, Bucharest, 2003.

…"Ion and Scutaru [230], and Ion [229,d,e] introduced new scattering theories via optimal states. These states are reproducing kernels in Hilbert spaces of scattering matrices, just as the coherent states are reproducing kernels in the Hilbert spaces of wave functions"

[229d] D. B. Ion, International J. Theor. Phys. **24** (1985) 1217–1231.

[229e] D. B. Ion, International J. Theor. Phys. **25** (1986) 1257–1279.

[230] D. B. Ion and H. Scutaru, International J. Theor. Phys. **24** (1985) 355–366.

Dmitry Shepelsky (Kharkov) [**Ion, D. B.; Ion, M. L. D.**, ***Optimality, entropy and complexity for nonextensive quantum scattering***, Chaos Solitons Fractals 13, No. 3, 547–568 (2002), Zentralblatt MATH Data 2007 European Mathematical Society, FIZ Karlsruhe & Springer-Verlag 1011.81078]
"In the paper by introducing Tsallis-like entropies, the optimality, the complexities, and the nonextensive statistical behavior of quantum states in hadronic scattering are studied. A measure of complexity of quantum scattering in terms of Tsallis-like entropies is proposed. The nonextensivity indices are determined from the experimental entropies by a fit with the optimal entropies. The latters are obtained from the principle of minimum distance in the space of states. The experimental evidence for the nonextensive statistical behavior of the (J, θ)-quantum scattering states is interpreted as a manifestation of the presence of quarks and gluons. (http://www.sciencedirect.com/science/journal/ 09600779)

J. S. Rno [Proceeding International Colloq. on Group Theory in Math. Phys., Seul, 26–30 August 1985, pp. 598–601. …*"The harmonic analysis is an effective tool to study... It also play a major role in the formulation of stochastic quantum mechanics…. In addition, the reproducing kernels are adequate for description of the hadron-hadron scattering [7] as well as for the treatment of various problems [8] in mathematics and Physics"…*
[7] D. B. Ion and H. Scutaru, International J. Theor. Phys. 24 (1985) 355.
[8] See references in [7].

A. Lavagno and P. Quarati [***Non-extensive statistical effects in nuclear many-body problems***, Rom. Rep. 59 (2007) No. 4 (this issue)]
…"In the last years, there was a growing interest to nuclear scattering and high energy physics applications of non-extensive statistics effects due to non-ideal many-body interactions.
In different pioneer works Ion and Ion [10] *have obtained entropic lower bound for quantum scattering of spinless particles in the framework of Tsallis thermostatistics. In Ref.* [11]*, the authors have shown experimental evidence for non-extensive quantum statistical behavior in hadron-hadron scattering. As stated by the authors, this behavior can be interpreted as an indirect manifestation of the strong-coupling long-range regime in QCD. Furthermore, several authors outline the possibility that experimental observations in relativistic heavy-ion collisions can reflect non-extensive features during the early stage of the collisions and the thermalization evolution of the system* [12, 13, 14, 15].
It is common opinion that hadrons dissociate into a plasma of their elementary constituents, quarks and gluons (QGP), at density several times the nuclear matter density and at temperature above few hundreds MeV (typically above 200 MeV) which is the critical temperature T_c of transition from the QGP phase to the hadronic gas phase. Such a QGP can be found in early universe, dense and hot stars, neutron stars, nucleus-nucleus high energy collisions where heavy ions are accelerated to relativistic energies to collide"…
[10] D. B. Ion and M. L. D. Ion, Phys. Rev. Lett. **81,** 5714 (1998); M. L. D. Ion and D. B. Ion Phys. Rev. Lett. **83,** 463 (1999); D. B. Ion and M. L. D. Ion, Phys. Rev. **E 60,** 5261(1999).
[11] D. B. Ion and M. L. D. Ion, Physica **A 340,** 501 (2004).

P. Grigolini, C. Tsallis and B. West [***Classiccal and Quantum Complexity and Non-extensive Thermodynamic Entropic nonextensivity***, Proceeding of the International Workshop on Classical and Quantum Complexity and Non-extensive Thermodynamics, Denton, Texas, 3–6 April, 2000, Eds. P. Grigolini, C. Tsallis and B. J. West), Chaos, Fractals and Solitons, **13** (2002) 367–370].
"The papers of contributors to the conference refer to the following topics:
A. Hamiltonian Systems with long-range interactions.
B. Quantum Information. C. Information Theory.
D. Turbulence and Intermitent Processes.
E. Equilibrium Statistical Mechanics and Thermodinamics
F. High-Energy Physics.
G. Gravitational Systems.
The subject of high-energy physics is topic of three papers. The first, by Ion and Ion, shows a compelling experimental evidence for non-extensive statistical behavior of the pion-nucleus and pion-nucleon scattering…

All the papers in this issue, taken together, contribute significantly to the area of non-extensive thermodynamics. Further, aside from certain technical considerations, the editors do agree that these papers shall contribute significantly to the Science of Complexity. …

1. Tsallis C. Entropic non-extensivity: A possible measure of complexity.

2. Antonioni M, Hinrichsen H, Ruffo S. On the microcanonical solution of a system of fully coupled particles.

3. Latora V, Raspidra A. Dynamical quasi-stationary states in a system with long-range forces.

………………

21. Ion D. B., Ion M. L. D. *Optimality, entropy and complexity for none-extensive quantum scattering.*

22. Lavagno A,Quarati P. Classical and quantum non-extensive statistics effects in nuclear many-body problems.

23. Wilk G, Wlodarczyk Z. The imprints of non-extensive statistical mechanics in high energy collisions.

C. Tsallis [“***Entropic nonextensivity: A possible measure of complexity”***, Proceeding of the International Workshop on Classical and Quantum Complexity and Non-extensive Thermodynamics, Denton, Texas, 3–6 April, 2000, Eds. P. Grigolini, C. Tsallis and B. J. West), Chaos, Fractals and Solitons, **13** (2002) 371–391].

“Wilk, in Warshaw, and collaborators [110–112], *as well as Walton and Rafelski in Tucson* [113], *have provided further evidences of applicability of the present ideas to high energy physics, where non-Markovian processes and long range interactions are commonly hypothesis.* ***Consistent evidence for nonextensive quantum statistics has been provided by Ion and Ion, in Bucharest, very especially in hadronic scattering*** **[114–118]**”.

[114] D. B. Ion and M. L. D.Ion,, Phys. Rev. Lett**. 81**, 5714 (1998);

[115] M. L. D. Ion and D. B. Ion, Phys. Rev. Lett. **83**, 463 (1999);

[116] D. B. Ion and M. L. D. Ion, Phys. Rev. **E 60,** 5261 (1999);

[117] D. B. Ion and M. L. D. Ion, Phys. Let. **B 482,** 57 (2000);

[118] D. B. Ion and M. L. D. Ion, Proceeding of the “*International Workshop on Classical and Quantum Complexity and Nonextensive Thermodynamis*”, Denton, Texas, 3–6 April, 2000, Eds. P. Grigolini, C. Tsallis and B. J. West, Chaos Solitons and Fractals, **13** (2002) 547–568.

C. Tsallis, E. P. Borges and F. Baldovin [***Mixing and equilibration: Protagonists in the scene of nonextensive statistical mechanics***, Physica **A 305** (2002) 1].

…“*To make connection with nature, it is mandatory to mention that the present formalism has been successfully applied to a considerable variety of systems, such as Levy [28] and correlated [29] anomalous diffusions, peculiar velocities in spiral galaxies [30], turbulence in electron plasma [31], fully developed turbulence [32–35], citations of scentific papers [36], linguistics [37], reassociation in folded proteins [38], quantum entanglement [39, 40], electron-positron annihilation [41], quark-gluon plasma [42], cosmology [43, 44], hadronic scattering [45], motion of Hydra viridissima [46], low-dimensional maps [47, 48], inertial clasical planar rotators feromagnetically coupled at long distances [49, 50], among other.”…*

[45] D. B. Ion and M. L. D. Ion, Phys. Rev. Lett. **81**, 5714(1998); M. L. D. Ion and D. B. Ion, Phys. Rev. Lett. **83** 463 (1999); D. B. Ion and M. L. D. Ion , Phys. Rev. **E 60**, 5261 (1999); D. B. Ion and M. L. D. Ion, Chaos, Solitons and Fractals, 13 (2002) 547; D. B. Ion and M. L. D. Ion, Phys. Lett. **B 474**, 395 (2000); D. B. Ion and M. L. D. Ion, Phys. Lett. **B 482**, 57 (2000); D. B. Ion and M. L. D. Ion, Phys. Lett. **B 503**, 263 (2001).

G. Wilk and Z. Wlodarczyk, [*The imprints of nonextensive statistical mechanics in high energy collisions*, Proceeding of the “International Workshop on Classical and Quantum Complexity and Nonextensive Thermodynamics”, Denton, Texas, 3–6 April, 2000), Eds. P. Grigolini, C. Tsallis and B. J. West, Chaos, Fractals and Solitons, **13** (2002) 581–594].

…“The last Section contains final remarks together with a list of other possible hints of nonextensivity not discussed in detail here (including topics from quark gluon plasma (QGP)-physics

*[**12**] and nonextensivity manifested in the statistics of the quantum states produced in the scattering processes such as pi -nucleon or pi -nucleus scatterings* [16–18]"…

…*"The are also other imprints of nonextensivity which we shall only mention. One is connected with recent analysis* [12] *of the equilibrium distributions of heavy quarks in Focker-Plank dynamics. It was demonstrated that thermalization of charmed quarks in a QGP proceeding via collisions with light quarks and gluons results in a spectral shape which can be described only by Tsallis distribution* [39]. *On the other hand in* [16–18] *the quantum scattering process such as* π*-N and* π*-A-scattering were analyzed using Tsallis-like entropies and strong evidence for nonextensivity were found there when analyzing experimental data on the respective phase shifts"…*

…*"To summarize, it has been demonstrated that multiparticle process bear also some signs of nonextensivity observed in other branches of physics, which shows up only as small deviations from the expected behavior. These deviations were already explained by invoking some additional mechanisms and, because of this, the use of q-statistics is not so popular or known in this field as in others discussed in* [1]. *The advantage of the use q-statistics is probably best seen from the information theoretical point of view. The new parameter q can be regarded then as a kind of compactification of all processes into one single number* [47]"…

…*"Although in the examples discussed here the values of the parameter q were quite close to unity, they can vary in quite large range in other applications, cf. for example, B. M. Boghosian, Phys. Rev. **E53** (1996) 4754; C. Anteodo and C. Tsallis, J. Mol. Liq.**71** (1997) and* [16–18]."…

[16] M. L. D. Ion and D. B. Ion, Phys. Lett. **B 482**, 57 (2000).
[17] M. L. D. Ion and D. B. Ion, Phys. Rev. Lett.**83**, 463 (1999).
[18] M. L. D. Ion and D. B. Ion, Phys. Rev.**E 60**, 5261 (1999).

Constantino Tsallis, Andrea Raspisarda, Vito Latora and Fulvio Baldovin [***Nonextensivity: from low dimensional maps to Hamiltonians systems,*** Lecture Notes in Physics, No. 602/2002, 140-162, published also in the book: *Dynamics and Thermodynamics of Systems With Long Range Interactions*, **by T. (Thierry), Dauxois – 2002, pp. 142–153,** 2002, Springer;. ArXiv: cond-mat/ 209168 32 Sept 2002].

"*We shall not address here the many applications of nonextensive statistical mechanics available in the literature. The interested reader may refer to [15] for various reviews. Just as an illustration, let us mention some of those applications: turbulence [16, 17], electron-positron annihilation [18], diffusion of Hydra viridissima [19], diffusion of quarks in gluon plasma [20], Levy and correlated anomalous diffusion [21], linguistic [22], economics [23,24], fluxes of cosmic rays [25], solar neutrinos [26], high energy particle collisions [**27**], self-organized criticality [28], among others. In one way or another, these phenomena seem to share long-range correlations in space/time, either long range microscopic interactions, or long-range microscopic memory (nonmarkovian processes) or (multi)fractal boundary conditions, or, generically speaking, some mechanism which creates a scale invariant hierarchical structure of some sort."…*

[**27**] D. B. Ion and M. L. D. Ion, Phys. Rev. Lett. **81,** 5714 (1998); Phys. Rev. Lett. **83**, 463 (1999); Phys. Rev. **E 60**, 5261 (1999); Phys. Lett. **B 474**, 395 (2000); Phys. Lett. **B 482**, 57 (2000); Phys. Lett. **B 503**, 263 (2001).

V. Majernik and H. Majernikova [***The determination of bounds of*** **β*-entropic sum of two noncommuting observables***, Reports on Mathematical Physics, **47** (2001) 381–392]

"D. B. Ion and M. L. D. Ion applied Tsallis-like entropy to study quantum scattering. They have investigated the angle-angular-momentum entropic lower bounds in a more general form by introducing Tsallis-like entropies for quantum scattering of spinless particles [3–6]."…

[3] D. B. Ion and M. L. D. Ion, Phys. Rev. Lett. **81** (1998) 5714.
[4] M. L. D. Ion and D. B. Ion, Phys. Rev. Lett. **83** (1999) 463.
[5] D. B. Ion and M. L. D. Ion, Phys. Rev. **E 60** (1999) 5261.
[6] M. L. D. Ion and D. B. Ion, Phys. Lett. **B 482** (2000) 57.

S. Abe, S. Martinez, F. Penniani, and A. Plastino [***Entropic uncertainty relation for power-law wavepackets***, Phys. Lett. **A 295** (2002) 74–77, ArXiv:quant-ph/0007011, 5 Jul 2000]
…*"In addition, discussions are developed in Refs*. [18, 19] *[D. B. Ion and M. L. D. Ion, quotations] about the possibility of utilizing the Tsallis entropy as a measure of quantum uncertainty. Investigation in this direction are expected to contribute to a deeper understanding of the uncertainty principle and to further reveal physical properties of power-law quantum wave packets*."…
[19] D. B. Ion and M. L. D. Ion, Phys. Rev. Lett. **81**, 5714 (1998).

C. Tsallis [Comment on "A Kac-potential treatment of nonintegrable interactions" by Vollmayr-Lee and Luijten, ArXiv:cond-mat/0011022 v1, 1 Nov 2000].
"However, the concepts involved in nonextensive statistical mechanics have been successfully applied to many other systems. These include fully developed turbulence [22, 23] granular matter [24], electron-positron anihilation and other high-energy systems [25], Levy and correlated types of anomalous diffusions [26], low-dimensional nonlinear dynamical systems [27], self-organized criticality [28], reasociation in folded proteins [29], quantum entanglement [30], to quote but a few.
Ref. [**25**] includes the papers:
D. B. Ion and M. L. D. Ion, Phys. Rev. Lett. **81**, 5714 (1998);
M. L. D. Ion and D. B. Ion, Phys. Rev. Lett. **83**, 463 (1999);
D. B. Ion and M. L. D. Ion, Phys. Rev. **E 60,** 5261 (1999);
M. L. D. Ion and D. B. Ion, Phys. Lett**. B 482** (2000) 57;
D. B. Ion and M. L. D. Ion, Optimality entropy and complexity in quantum scattering, to appear in Proceeding of the "International Workshop in Classical and Quantum Complexity and Nonextensive Thermodynamics" Denton, Texas, 3–6 April, 2000, Eds P. Grigolini, C. Tsallis and B. J. West, Chaos, Solitons and Fractals}, **13** (2002) Nr. 3, 547–568.

Constantino Tsallis and Ernesto P. Borges [*Nonextensive statistical mechanics: Applications to nuclear and high-energy physics*, To appear in the proceedings of 10th International Workshop on Multiparticle Production: Correlations and Fluctuations in QCD (CF2002), Crete, Greece, 8–15 Jun 2002. Published in ****Crete 2002, Correlations and fluctuations**** 326–343; e-Print: **cond-mat/0301521.** *"A significant amount of systems, e.g., turbulent fluids ([5, 6] and references therein), electron-positron znnihilation [7, 8], collision of heavy nuclei [9–11], solar neutrinos [12, 13], quark-gluon plasma [14], cosmic rays [15], self-graviting systems [17], …, and others, are known nowadays which in no trivial way accommodate ithin BG statistical concepts. Systems like these have been handled within the functions and concepts which naturally emerge within nonextensive statistical mechanics [2, 32, 33]."*
[11] D. B. Ion and M. L. D. Ion, Phys. Rev. Lett. **81,** 5714 (1998); Phys. Rev. Lett. **83**, 463 (1999); Phys. Rev. **E 60**, 5261 (1999); D. B. Ion and M. L. D. Ion, in *Classical and Quantum Complexity and Nonextensive Thermodynamics*, Eds P. Grigolini, C. Tsallis and B. J. West, Chaos, Solitons and Fractals}, **13** (2002) Nr. 3, 547 (Pergamon-Elsevier, Amsterdam 2002), Phys. Lett. **B 474**, 395 (2000); Phys. Lett. **B 482**, 57 (2000); Phys. Lett. **B 503**, 263 (2001).

Tsallis Bibliography [**Nonextensive Statistical Mechanics and Thermodynamic**, variant from 3 August 2007, (**http://tsallis.cat.cbpf.br/biblio.htm**)]

The papers selected are as follows:

[831] D. B. Ion and M. D. Ion*, Entropic lower bound for the quantum scattering of spinless particles*, Phys. Rev. Lett. **81**, 5714 (1998).

[832] M. L. D. Ion and D. B. Ion*, Optimal bounds for Tsallis-like entropies in quantum scattering, Phys*. Rev. Lett. **83**, 463 (1999).

[833] D. B. Ion and M. D. Ion*, Angle-angular-momentum entropic bounds and optimal entropies for quantum scattering of spinless particles*, Phys. Rev. **E 60**, 5261 (1999).

[834] D. B. Ion and M. D. Ion*, Optimality, entropy and complexity for nonextensive quantum scattering*, to appear in Proceeding of the "International Workshop on Classical and Quantum

Complexity and Nonextensive Thermodynamics" Denton, Texas, 3–6 April, 2000, Eds P. Grigolini, C. Tsallis and B. J. West, Chaos, Solitons and Fractals, **13** (2002) 547.

[835] D. B. Ion and M. D. Ion, *Limited entropic uncertainty as a new principle of quantum physics*, Phys. Lett. **B 474**, 395 (2000).

[836] M. L. D. Ion and D. B. Ion, *Strong evidences for correlated nonextensive quantum statistics* , Phys. Lett. B **482**, 57 (2000).

[837] D. B. Ion and M. D. Ion, *Evidences for nonextensivity conjugation in hadronic scattering systems*, Phys. Lett. **B 503**, 263 (2001).

[838] D. B. Ion and M. D. Ion, *Nonextensive statistics and saturation of PMD-SQS-optimality limits in hadron-hadron scattering,* Physica **A 340** (2004) 501.

IV. New kind of polarizations of interacting hadrons. In physics, and specifically, particle physics, **isospin (*isotopic spin, isobaric spin*)** is a quantum number related to the strong interaction. Isospin was introduced by Werner Heisenberg to explain several related symmetries. Heisenberg's contribution was to note that the mathematical formulation of this symmetry was in certain respects similar to the mathematical formulation of spin, from whence the name *isospin* derives. The isospin is a property that is characteristic of families of related subatomic particles differing principally in the values of their electric charge. The families of similar particles are known as isospin multiplets: two-particle families are called doublets, three-particle families are called triplets, and so on. There are actually two kinds of isospin: (i) the *strong isospin* (usually denoted by a capital ***I***) which is conserved in strong interactions and (ii) the *weak isospin* (***T***) which is conserved in weak interactions. Just as is the case for usual spin, the isospin is described by two numbers, I, the total isospin, and I_3, the component of the spin vector in a given direction and T and T_3 respectively for weak isospin. For example, the proton and neutron belong to isospin doublet and have $I = 1/2$. The proton has $I_3 = +1/2$ or *isospin-up*, and the neutron has $I_3 = -1/2$ or *isospin-down*. The pions, belonging to the isospin triplet, and have $I = 1$, and π^+, π^0 and π^- have, respectively, $I_3 = +1, 0, -1$. In 1975, at IUCN-Dubna, Prof. Dr. D. B. Ion (in collaboration with Prof. Dr. A. Mihul) for the first time introduced and developed *the theory of the isospin- and isospin-spin polarizations of interacting hadrons*. Here, we present some Abstracts of the published papers related to these new dynamical variables of the subatomic particles.

D. B. Ion and A. Mihul [The Isospin and Isospin-Spin Polarizations of Interacting Hadrons, Annals of Physics (N.Y.), 93 (1975) 41–54]. "*In this paper we introduce two new dynamical variables: the isospin polarization and isospin-spin polarization of a hadron in the final state of a given reaction. As an application, the nucleon isospin polarization in pion-nucleon scattering is studied. The numerical results for nucleon isopolarization, determined from $\pi^{\pm}P \to \pi N$ elastic and charge exchange reactions, are discussed.*"

D. B. Ion and A. Mihul [The Nucleon Isospin Polarization and Isospin Bounds in Pion-Nucleon Scattering, Annals of Physics (N.Y.), 93 (1975) 55–67] *"The nucleon isospin-polarization parameter and its isospin bounds are determined from the experimental data of $\pi^{\pm}P \to \pi N$ elastic and charge exchange reactions. The saturation of the isospin bounds is explained in terms of the resonance poles and zeros of the isospin exchange amplitudes in the s, t, and u channels.*

D. B. Ion [Saturation of Isospin Bounds and Constraints on Experimental Data and Amplitude Analysis in Pion-Nucleon Scattering, Annals of Physics (N.Y.), 95 (1975) 308–325]. *"In this paper we prove new and interesting isospin bounds in pion-nucleon scattering and we investigate their saturations using the CERN-phase shift analysis. These isospin bounds are saturated exactly along certain lines in the (PLAB, cos*θ*-plane and impose strong constraints on experimental data and amplitude analyses. Also, we obtain all constraints on data and amplitude analysis when different isospin bounds are saturated".*

D. B. Ion [The Isospin Bounds and Phase-Contours in Pion-Nucleon Scattering, Nuclear Physics, B84 (1975) 55–69]. *"In this paper we investigate the isospin constraints on differential and integrated (unpolarized and polarized) cross sections in pion-nucleon scattering. Defining* Σ_n*-integrated cross sections and using the classical Minkowski and Holder inequalities we obtain a large class of isospin bounds. The saturation of the isospin bounds is investigated using dispersion relation predictions and a CERN theoretical solution for the phase shifts."*

D. B. Ion [Exact Saturation and Degeneracy of Isospin Bounds and Zeros Trajectories in Pion-Nucleon Scattering, Annals of Physics (N.Y.), 98 (1976) 160–176]. *"In this paper the exact saturation and degeneracy of the isospin bounds, in terms of the zeros trajectories (ZT) of Im Nij [Nij-specific bilinear forms] are systematically discussed. The topology of the zeros trajectories and near degeneracy of the isospin bounds in the pion-nucleon scattering are investigated using the CERN-theoretic and CERN experimental solutions for the phase shifts. The interpretation of the experiments in terms of (ZT)-topology as well as certain tests for the possible isospin breaking."*

D. B. Ion [Pomeranchuk-Like Theorems on Integrated Cross Sections and Average Spin Polarization Parameters, Physics Letters **B62** (1976) 65–681]. *"Pomeranchuk-like theorems on the integrated cross sections and on the average spin polarization parameters of different meson-baryon reactions are obtained by using the improvements of the usual triangular isospin inequalities on integrated cross sections".*

V. New nuclear radioactivities [see the paper D. B. Ion, R. Ion-Mihai and M. L. Ion, Rom. Rep. Phys. **59** (2007) Nr. 4 (this issue)]. The traditional picture of the nucleus as a collection of neutrons and protons bound together via the strong force has proven remarkable successful in understanding a rich variety of nuclear properties. However, the achievement of modern nuclear physics that not only nucleons are relevant in the study of nuclear dynamics but that pions and the baryonic resonances like Δ's and N* play an important role too. So, when the nucleus is explored at short distance scales the presence of short lived subatomic particles, such as the pion and delta, are revealed as nuclear constituents. The role of pions, deltas, quarks and gluons in the structure of nuclei is one of challenging frontier of modern nuclear physics. This modern picture of the nucleus bring physicists to the fascinating idea [1] to search for new exotic natural radioactivities such as: (π, μ, Δ, N^*, etc.)-emission during the nuclear fission in the region of heavy and superheavy nuclei. So, in 1985, the Professors D. B. Ion, R. Ion-Mihai and M. Ivascu, initiated the investigation of the nuclear spontaneous pion emission as a new possible nuclear radioactivity called *nuclear pionic radioactivity* with possible essential contributions to the instability of heavy and superheavy nuclei.. Moreover, new exotic radioactivities such as new mode of nuclear fission (*deltonic fission* and *hyperfision*), was also suggested and investigated.

The pionic radioactivity, introduced for the first time in 1985, in the Laboratory of High Energy Physics from IFIN-HH, in Bucharest, was experimentally investigated in the following important Laboratories: Oak Ridge National Laboratory (ORNL), Triumf-Vancouver, Los-Alamos National Laboratory (LANL), Kurciatov Institute (Moscow), CEN-Saclay, Laboratories Souterrain de Modane (France), British University Columbia (Canada), Tokio University (Japan), Comenius University (Slovachia), LIPPE Obninsc (Russia), Polithechnic Institute Tomsc (Russia), Gran Saso (Italy), Bucharest University and IFIN-HH**.** The following papers as well as the quotations of Prof. D. B. Ion's results are all significant in this sense:

K. Janko and P. Povinec [***Search for Spontaneous Pion Emission in Fission of 257-Fm***, Proceedings of 14th Europhysics Conference on Nuclear Physics, Rare Nuclear Processes, (Bratislava, Czecho-Slovakia 22–26 October 1990, (Ed. P. Povinec, World Scientific), pp. 121–129].

"The pion emission in spontaneous fission of heavy nuclei has been suggested as a new type of natural radioactivity [1]. The creation and emission of pions from the ground state of a nucleus is energetically possible only via two-body or many-body fragmentation of the parent nucleus with Z > 80. The process is expected to proceed as an accompanying process of spontaneous fission of heavy nuclei…,. The probability of pion emission in spontaneous fission is given by Ion et al. [2] in a compact form by the formula:

$$\Gamma_\pi / \Gamma_{SF} = 10^{m_\pi(\delta M - 6.13)\gamma A^{2/3}}$$

where delta δM is the deviation of the ground state mass from the reference mass surface and the parameter $\gamma = 0.71$ *MeV. The best* π^0*-emitters are* ^{258}Fm ($\Gamma_\pi/\Gamma_{SF} = 7.410^{-14}$, $^{258}No(7.910^{-2})$, $^{244}Fm(8.910^{-4})$, $^{256}Cf(1.110^{-6})$, *and* $^{259}Fm(5.010^{-2})$. *However, for* ^{256}Fm *256-Fm the yield is only* $5.9{\cdot}10^{-13}$ *and for* $^{252}Cf(1.310^{-14})$ *252-Cf. The predicted pion yield have been verifyied by applying the same fission-like model to the light-charged-particle (LCP) emission during fission, where a good agreement has been observed.* π^-*–yields are expected to be several times higher, on other hand* π^+*–yield should be about an order of magnitude lower… The best limit has been recently reported for 252-Cf by Bellini et al. [6]. This value is close to the theoretical prediction [2]" … "In the present paper we discuss the data of Wild et al. [9] on light-charged-patrticles used as a by-product for search of charged pion emission in spontaneous fission of* ^{257}Fm*"…*

"If we supose that 22 events registred in B peak in Fig. 3 might indicate emission of π^+ *mesons accompanying spontaneous fission of* ^{257}Fm *we can calculate the emission probability to be* $\Gamma_\pi/\Gamma_{SF} = 7.510^{-5}$ *…. The kinetic energy of pions is estimated to be* $E_\pi = (2.1 + 0.4)$ *MeV" … "The estimated pion yield* 7.510^{-5} *may be treated as an upper limit on the pionic radioactivity, …*

[1] D. B. Ion, M. Ivascu and R. Ion-Mihai, Annals of Phys. (N.Y.) **171** (1986) 237.
[2] D. B. Ion, R. Ion-Mihai and M. Ivascu, Rev. Roum. Phys. **34** (1989) 359; Rev. Roum. Phys. **32** (1987) 1037; Rev. Roum. Phys. **33** (1988) 1071; Rev. Roum. Phys. **33** (1988) 1075.

J. N. Knudson *et al.* [***Search for neutral pions from the spontaneous fission of 252-Cf,*** Phys. Rev. C 44} (1991) 2869–2871]

"A search for π^0 *decay arising from the spontaneous fission of* ^{252}Cf *was conducted at Clinton P. Anderson Meson Physics Facility (LAMPF) using the LAMPF pi-zero spectrometer* [1]. *The basis of this investigation is the recent work by Ion, Ivascu, and R. Ion-Mihai* [2, 3], *which has given rise to the interesting suggestion that natural pionic radioactivity occurring as a branch of spontaneous fission may be observable. ...Our results are consistent with an upper limit to this process of* $\Gamma_\pi/\Gamma_{SF} = 1.3710^{-11}$, *and do not contradict a theoretical estimate* $\Gamma_\pi/\Gamma_{SF} = 1.010^{-14}$ [3]. *This experiment represents the ultimate capability of the present spectrometer; a second-generation* π^0*-spectrometer [13] presently under construction may have the capability of reaching the* $\Gamma_\pi/\Gamma_{SF} = 1.010^{-13}$ *level in similar runing times".*

[2] D. B. Ion, M. Ivascu and R. Ion-Mihai, Annals Phys. (N.Y.) 171 (1986) 237; Rev. Roum. Phys. 31 (1986) 205; Rev. Roum. Phys. 31 (1986) 209; Rev. Roum. Phys. 31 (1986) 559; Rev. Roum. Phys. 32 (1987) 299; Rev. Roum. Phys. 32 (1987) 1037; Rev. Roum. Phys. 33 (1988) 109; D. B. Ion, R. Ion-Mihai, and M. Ivascu, Rev. Roum. Phys. 33 (1988) 239.

[3] D. B. Ion, R. Ion-Mihai and M. Ivascu,Rev. Roum. Phys. 33 (1988) 1071.

V. Bellini *et al.* [***Search for Spontaneous Pion Emission***, Proceedings of 14th Europhys. Conf. on Nuclear Physics, Rare Nuclear Processes, Bratislava, Czecho-Slovakia 22–26 October 1990, pp. 116–120] *"The pionic nuclear radioactivity or spontaneous pion emission by a nucleus from its ground state was investigated by D. B. Ion et al* [1] *... The authors [1] showed that the spontaneous pionic emission is favoured for elements with Z = 92–106 and give an estimation for the ratio* $\Gamma_{\pi^0}/\Gamma_{SF} = 10^{-12} - 10^{-14}$. [...] *An experiment was carried out at Modane, (Laboratories Souterrain de Modane, France) to determine* $\Gamma_{\pi^0}/\Gamma_{SF}$ *with a Cf source. The very small cosmic ray rate allowed to assign an upper limit of* $3{\cdot}10^{-13}$. *Moreover, high energy events were detected in coincidence. Nevertheless, emission of high energy gamma is not excluded."*
Reference [1] is as follows:

[1] *D. B. Ion*, M. Ivascu, and R. Ion-Mihai *"Spontaneous pion emission as new natural radioactivity"*, Ann. Phys. (N.Y.) **171** (1986) 237; D. B. Ion, M. Ivascu, and R. Ion-Mihai *"Predictions for pionic radioactivity of even-even parent nuclei"*, Rev. Roum. Phys **33** (1988) 1071.

V. Khriachkov *et al.* [*A Spectrometer for Investigation of Ternary Nuclear Fission*, Instr. and Exp. Tech. Vol 45 No 5 (2002) 615-625]. "*Nonstandard detection methods are also required for the search for a theoretically predicted decay of a heavy nucleus into two fragments and a pion [5]" … "Analyzing spectrum in Fig. 9 has shown that, in the space between the electron and proton regions there are events that cannot be explained by an external background or effect of neutrons. A detailed analysis of the parameter Sf does not allow us to assign these events to protons or electrons. We estimate these events as an indication of the possibility of existence of a ternary nuclear decay with the participation of charged mesons. Subsequently, it is suggested to study the lattter problem on our facility. Contrary to previous attempts to discover this new type of decay [17, 18], our facility has a number of substantial advantages"…*

[5] Ion, D. B., Ivascu, M., Ion-Mihai, R, Ann. Phys (N.Y.), 1986, Vol 171, No. 2, p. 273]

A. S. Iljinov and M. V. Mebel [***Induced Nuclear Fission Accompanied by Pion Emission***, Phys. of Atomic Nuclei, Vol **64** Nr. 8 (2002) 1463]. "*It is well known that neutrons, photons, protons, and extremly light nuclei (d, t, alpha) are emited in nuclear fission* [1]. *At the same time, energy relased in nuclear fission (about 200 MeV) is suficient for pion production. That pion can be emitted in the spontaneous fission of heavy transuranic elements was predicted in* [2]"…

[2] D. B. Ion et al., Ann. Phys. (N.Y.) **171** (1986) 237 ; Rev. Rom. Phys. **31** (1986) 205; Rev. Rom. Phys. **31** (1986) 209 ; Rev. Rom. Phys. **31** (1986) 551; Rev. Rom. Phys. **32** (1987) 1037; Rev. Rom. Phys. **33** (1988) 239; Rev. Rom. Phys. **33** (1988) 1071; Rev. Rom. Phys. **34** (1989) 261; D. B. Ion et al., Rev. Rom. Phys. **34** (1989) 359.

A. S. Iljinov and L. N. Latisheva [***Induced Nuclear Photofission Accompanied by Pion Emission***, Phys. of Atomic Nuclei, Vol. **66** Nr. 9 (2003) 1700]. "*It is well known that that the fission nuclei into fragments is accompanied by emission of neutrons, photons, protons, and extremly light nuclei (d, t, alpha)* [1]. *Since a rather large amount of energy (about 200 MeV) is relased in the fission of a heavy tranuranium nuclei, the emission of a pion is also possible, however. The emission of a pion upon the spontaneous fission of heavy transuranium nuclei was predicted in* [2]"…

[2] D. B. Ion et al., Ann. Phys. (N.Y.) **171** (1986) 237; Rev. Rom. Phys. **31** (1986) 205; Rev. Rom. Phys. **31** (1986) 209; Rev. Rom. Phys. **31** (1986) 551; Rev. Rom. Phys. **32** (1987) 1037; Rev. Rom. Phys. **33** (1988) 239; Rev. Rom. Phys. **33** (1988) 1071; Rev. Rom. Phys. **34** (1989) 261; D. B. Ion et al., Rev. Rom. Phys. **34** (1989) 359.

Исследования деления ядер протонами,
сопровождающегося рождением пионов
(http://www.inr.ru/mmf/ideljap.html)

Экспериментальное обнаружение и исследование свойств теоретически предсказанного канала деления тяжелых ядер протонами средних энергий, сопровождающегося рождением пиона, может составить новое важное направление в области изучения деления атомных ядер.

С помощью разработанной каскадно-испарительно-делительной модели был предсказан весь набор характеристик канала вынужденного деления ядер с эмиссией пиона протонами с энергией 150-600 МэВ, необходимый для проведения эксперимента по поиску этого процесса на Московской мезонной фабрике. Модель основана на предположении о рождении пиона вблизи порога на первой каскадной стадии процесса во взаимодействии налетающего протона с внутриядерным нуклоном с последующем делением возбужденного остаточного ядра. Эта модель предсказывает полные сечения канала деления ядер U-238 с рождением пиона 8.43, 43.8 и 119.4 мб для энергий протонов 250, 325 и 400 МэВ, соответственно. Кроме того, были проведены теоретические исследования другого возможного механизма деления с вылетом пиона, когда часть энергии осколков деления уже на завершающей стадии процесса расходуется на рождение пиона. Такой когерентный механизм может давать существенный вклад в подпороговой области при энергии протонов менее 290 МэВ, когда элементарный процесс рождения пиона на отдельном внутриядерном нуклоне энергетически запрещен. За основу для предсказания относительных вероятностей такого механизма была выбрана статистическая модель, использованная авторами работы [Ion D. B., Ivascu M. and Ion-Mihai R.// Ann.of Phys.-1986.P.171, 237].

L. Arrabito, D. Autiero, E. Barbuto, C. Bozza, S. Cecchini, L. Consiglio, M. Cozzi, N. D'Ambrosio, Y. Declais, G. De Lellis, G. De Rosa, M. De Serio, D. Di Ferdinando, A. Di Giovanni, N. Di Marco, L. S. Esposito, G. Giacomelli, M. Giorgini, G. Grella, M. Hauger, M. Ieva, *D. B. Ion*, I. Janicsko, F. Juget, I. Laktineh, G. Mandrioli, S. Manzoor, A. Margiotta, P. Migliozzi, P. Monacelli, M. T. Muciaccia, L. Patrizii, C. Pistillo, V. Popa, G. Romano, G. Rosa, P. Royole_Degieux, S. Simone, M. Sioli, C. Sirignano, G. Sirri, G. Sorreno, M. Spurio, V. Tioukov, ["*Search for spontaneous muon emission from lead nuclei*", E-Preprint ArXiv hep-exp/0506078, June 2005, EXP. **OPERA-Collaboration**, CERN-Geneva].

"In the late 80's, some theoretical works was dedicated to investigate possible exotic type of nuclear radioactivity, consisting in emission of light particles such as pions or muons from heavy nuclei [1, 2]. *Although the theoretical estimates indicated a larger branching ratio for spontaneous (or neutron induced) muon emission than for pions, the experimental searches were mostly dedicated to the pionic radioactivity* [3, 4], *since detection conditions were more favourable with the used experimental set-ups. None of the experiments could prove the existenceof the pionic or the muonic radioactivities,but some of them produced indications in support of these hypotheses* [5]. *Some experimental indications for pionic radioactivity come. Some experimental indications for pionic radioactivitycome from the interpretation of radioactive super-giant halos in crystals; however, cannot give precise informations concerning the nature of the source or allow cantitative estimates of branching rati, lifetimes, etc. A short review of the theoretical problems and of the experimental results obtained, mostly for the pionic radioactivity, may found in ref.* [7].

Muons or pions could be emitted by nuclei through the decay [2]:

$$(A, Z) \to \mu^{\pm} + \nu_{\mu}(\overline{\nu}_{\mu}) + (A_1, Z_1) + (A_2, Z_2) + ... + (A_n, Z_n) \quad (1)$$

$$(A, Z) \to \pi^{\pm}(\pi^{0}) + (A_1, Z_1) + (A_2, Z_2) + ... + (A_n, Z_n) \quad (2)$$

where for reason of energy and momentum conservation, the number of fragments n is $n \geq 2$*"....*

"In ref. [2] *some nuclear charge thresholds for different possible spontaneous particle emission were listed:*

(*i*) $\mu^{\pm}$ (*prompt muons*) for $Z \geq 72$

(*ii*) $\pi^{\pm}$ (*prompt pion* $\to$ *delayed muon*) for $Z \geq 76$

(*iii)* $2\mu^{\pm}$ (*prompt muon pair*) for $Z \geq 91$
(*iv)* $2\pi^{\pm}$ (prompt pion pair $\rightarrow$ delayed muon pair) for $Z \geq 100$"
……
"A search for a Pb muonic decay can be made as by product of OPERA-experiment [8].

[1] D. B. Ion, R. Ion-Mihai and M. Ivascu, Ann. Phys. **171** (1986) 237.
[2] D. B. Ion, R. Ion-Mihai and M. Ivascu, Rev. Roum. Phys. **31** (1986) 209.
[3] M. Ivacscu et al., Rev. Roum. Phys. **32** (1987) 937.
[4] Yu. Adamchuk et al., Sov. J. Nucl. Phys. **49** (1989) 579.
[5] D. B. Ion, R. Ion-Mihai and M. Ivascu, Rev. Roum. Phys. **32** (1987) 299.
[6] D. B. Ion and R. Ion-Mihai, Phys. Lett. **B338** (1994) 7
[7] D. B. Ion et al., Romanian Reports in Physics **55** (2003) 370."

We could just stop here. We think that the scientific activities and results listed so far are more than enough to fill a lifetime. Fortunately however, Professor D. B. Ion has not stopped there, he is involved in the greatest projects: discovering the forces that cause the universe to function, indeed, to exist. It is work done not for the momentary profit of one man but rather for the gain of all of us and the generations still to come. Though his contributions are already immense, Prof. D. B. Ion continues to further our ability to understand the universe through his work on "*The Principle of Minimum Distance in Space of States*", work which may some day lead to a unified theory of all the forces in nature.

Prof. D. B. Ion is a highly creative personality when solving problems, he is ***insightful*** and tends to do ***divergent thinking***, developing a variety of unusual, new responses. He is a ***flexible person and is willing to be different***. ***Personality factors*** contributing to Prof. D. B. Ion's high creativity include the ***willingness to defy convention, openness to new ways of seeing things and a willingness to take risks and overcome obstacles.*** As a creative personality D. B. Ion has intense ***intrinsic motivation,*** loves what he does and works hard to achieve goals. He is dedicated to his work, has ***high standards of excellence*** and ***strong self-discipline. Independent, internally self-motivated,*** Prof. D. B. Ion does not need external motivation or social approval when he solves original scientific problems.

Prof. Dr. D. B. Ion has been married to Prof. Dr. Reveica Constantin Mihai since December 3, 1965. They have two children: Alexandru-Christian, born on 24 December 1967, and Mihai-Laurian (Ph.D. in Physics), born on 13 September 1969. All of them are physicists and work together.

On his anniversary, we wish Professor D. B. Ion a long and healthy life, many successes and accomplishments in his scientific activity and family life.

H. SCUTARU

Member of the Romanian Academy
National Institute for Nuclear Physics and Engineering
P.O. Box MG-6, RO-077125, Bucharest-Magurele, Romania
E-mail: scutaru@theory.nipne.ro