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Foreword

Contributions to theory of quantum spin models: 60th anniversary of Oleg Derzhko

Oleg Derzhko, the associated editor of "Condensed Matter Physics" journal, celebrated in August 2020 his 60th anniversary. Oleg's scientific activity dates back to 1982 when he successfully completed Lviv State University. In 1988 Odesa State University conferred him PhD degree after successful defense of PhD thesis entitled "Statistical theory of partially excited systems", which Oleg elaborated under the guidance of Professor Ihor Yukhnovskii and Professor Roman Levitskii. Over the past few decades Oleg Derzhko has been scientifically working at the Institute for Condensed Matter Physics of National Academy of Sciences of Ukraine in Lviv, at first, as a research associate at the former Lviv Division of the Institute for Theoretical Physics of the Academy of Sciences of the UkrSSR (since 1982), and finally as head of Department for Theory of Model Spin Systems (2003-2016) and head of Department for Quantum Statistics (since 2016 up till now). During this period, he has also performed a long-term lecturing of several courses of theoretical physics at Ivan Franko National University in Lviv and Lviv Polytechnic National University. Oleg's scientific interests cover various modern problems of condensed matter physics and statistical physics. At the Institute for Condensed Matter Physics in Lviv Oleg Derzhko has successfully developed a research direction, which is primarily focused on the state-of-the-art problems of quantum spin models with a particular emphasis on the exactly solvable models and is already recognized worldwide. In addition to this challenging research topic in its own right, Oleg has a lot of other scientific interests including, but not limited to, unsolved problems of phase transitions of atomic liquids. It is impossible to summarize here all Oleg's achievements, so let us briefly review at least a few most important milestones of his scientific career.

Early-career scientific contributions of Oleg Derzhko were devoted to equilibrium properties of partially excited gas and an influence of resonance irradiation upon a liquid-gas phase transition [1]. He did not stop taking interest in this topic across his entire scientific career. The further research in this direction has been developing mainly in collaboration with Dr. Vasyl Myhal where their joint efforts are focused on the properties of a two-phase fluid of two-level atoms, the part of which is excited. Among other matters, Oleg and Vasyl brought a deeper understanding into the vapor-to-liquid transition, wetting under electromagnetic resonance irradiation, a microscopic theory of photonucleation with the special emphasis laid on nucleation phenomena in an electric field, surface tension, cavitation and so on [2–4].

Exactly solvable problems in general and particularly one-dimensional quantum XY models and quantum Ising models in a transverse magnetic field have apparently become Oleg's greatest scientific passion and delight, where he substantially extended the rigorous results with the help of Jordan-Wigner fermionization technique [5–19]. To this end, Oleg Derzhko and his collaborators, which were predominantly from the Institute for Condensed Matter Physics in Lviv, have nontrivially adapted the recipé originally envisaged in a seminal paper by Lieb, Schultz, and Mattis [20]. A big step forward at that time was the formulation of the exact numerical method for the calculation of time-dependent spin correlation functions and the corresponding structure factors [5–7]. Exact solutions for numerous random and periodic non-uniform versions of quantum XY and Ising models achieved by Oleg and by his research group brought a considerable progress in theoretical understanding of a lot of exciting phenomena emergent in one-dimensional quantum spin chains. For instance, in this field of study Oleg has significantly contributed to a clarification of the effect of regular nonuniformity, randomness and correlated disorder on static and dynamical properties of several exactly solved quantum XY and Ising chains [8–14]. Oleg achieved another important breakthrough in this research area by a detailed examination of spin-Peierls instabilities of a certain class of quantum XY chains [15–17], as well as, quantum phase transitions and the dynamics of exactly solved XY chains with three-site interactions [16, 18, 19].

Over the past two decades Oleg Derzhko made an important contribution to the development of a completely novel calculation method nowadays referred to as the localized-magnon theory, which he has successfully applied to diverse frustrated quantum Heisenberg and Hubbard models with completely flat one-magnon excitation bands [21–27]. His leadership in this research area can be primarily viewed in identification of a few universality classes of flat-band Heisenberg and Hubbard models, which were comprehensively described in his three excellent review articles based on the long-lasting collaboration with Professor Johannes Richter [23, 28, 29]. The mutual complementary research expertise of these two renowned scientists gave rise to numerous rewarding results, which have clarified diverse striking features of highly frustrated quantum Heisenberg spin systems in the vicinity of the saturation field such as spin-Peierls instabilities [22], exotic finite-temperature phase transitions [24], macroscopic magnetization jumps, nonzero residual entropy [21], anomalous low-temperature thermodynamics [25, 27], etc. To proceed beyond the flat-band paradigm is another invaluable idea, which was elaborated by Oleg and his coworkers when extending the applicability of the localized-magnon theory to the frustrated Heisenberg and Hubbard models with nearly flat bands due to a violation of the ideal geometry [30–32]. Oleg also deserves a special honor for the explanation of the flat-band ferromagnetism of certain repulsive flat-band Hubbard models in terms of a Pauli-correlated percolation problem [33], as well as the proof of the ground-state ferromagnetism of nearly flat-band Hubbard models that do not get into the class of Mielke-Tasaki flat-band ferromagnets [34, 35].

It is beyond the scope of the present laudatio to list here all Oleg's scientific successes and the aforementioned examples serve just to give a flavor of his research findings. Of course, Oleg has provided a great deal of other fascinating findings as for instance the magnetism-driven ferroelectricity [36], magnetoelastic manifestations of deformable quantum spin chains [17], pseudo-transitions of one-dimensional lattice-statistical models [37] just to mention a few other achievements from recent years and we all hope that many more exciting findings made by Oleg still have to come. All of us read with great pleasure new research papers by Oleg, some of which have already become cornerstones of the modern quantum theory of magnetism. The pedagogical mastery of Oleg can be corroborated by a few excellent review articles [28, 38] and book chapters [39–42] available due to their unique style of writing even to nonexperts, as well as the pedagogical article about quantum phase transitions from a variational mean-field perspective made in collaboration with Professor Johannes Richter [43] already included in the Master and PhD study programmes at several universities from Ukraine and abroad.

Oleg Derzhko enjoys a great respect in the scientific community not only because of his extraordinary intellectual abilities and competences, but all of us who have had a chance to experience his modest, peaceful and open-minded nature highly appreciate his concerns and advice. Oleg's friendly nature is for us as indispensable as his smart mind. Oleg is extremely capable of spreading his enthusiasm to solve the state-of-the-art problems of modern condensed matter physics and to provide valuable pieces of advice to our appeals. The part of this special issue of "Condensed Matter Physics" journal dedicated to Oleg Derzhko on the occasion of his 60th birthday involves a few selected contributions from his close collaborators and friends, which cover a wide range of topics closely related to Oleg's scientific interests to acknowledge his unique and valuable contributions to science. The Editorial Board of "Condensed Matter Physics" journal, all contributors of this special issue, anonymous reviewers, numerous colleagues and friends from Ukraine and abroad warmly congratulate Oleg Derzhko on the jubilee, wish him Happy Birthday and to stay in good health for many more enjoyable and productive years in science.

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References

1. Yukhnovskii I., Derzhko O., Levitskii R., Physica A, 1994, **203**, No. 3, 381–413, doi:10.1016/0378-4371(94)90006-X.
2. Derzhko O.V., Myhal V.M., J. Phys. Stud., 1997, **1**, No. 3, 402–412, doi:10.30970/jps.01.402.
3. Derzhko O.V., Myhal V.M., J. Phys. Stud., 2006, **10**, No. 3, 203–207, doi:10.30970/jps.10.203.
4. Myhal V., Derzhko O., Physica A, 2017, **474**, 293–300, doi:10.1016/j.physa.2017.01.084.
5. Derzhko O., Krokhmalskii T., Ferroelectrics, 1997, **192**, No. 1, 21–27, doi:10.1080/00150199708216167.
6. Derzhko O., Krokhmalskii T., Phys. Rev. B, 1997, **56**, 11659–11665, doi:10.1103/PhysRevB.56.11659.
7. Derzhko O., Krokhmalskii T., Phys. Status Solidi B, 1998, **208**, No. 1, 221–248, doi:10.1002/(SICI)1521-3951(199807)208:1<221::AID-PSSB221>3.0.CO;2-E.
8. Derzhko O., Richter J., Phys. Lett. A, 1996, **222**, No. 5, 338–344, doi:10.1016/0375-9601(96)00663-9.
9. Derzhko O., Zaburannyi O., Tucker J., J. Magn. Magn. Mater., 1998, **186**, No. 1, 188–198, doi:10.1016/S0304-8853(98)00070-5.
10. Derzhko O., Krokhmalskii T., Phys. Status Solidi B, 2000, **217**, No. 2, 927–938, doi:10.1002/(SICI)1521-3951(200002)217:2<927::AID-PSSB927>3.0.CO;2-5.
11. Derzhko O., Richter J., Zaburannyi O., Physica A, 2000, **282**, No. 3, 495–524, doi:10.1016/S0378-4371(00)00084-4.
12. Derzhko O., J. Phys. A: Math. Gen., 2000, **33**, No. 48, 8627–8634, doi:10.1088/0305-4470/33/48/303.
13. Derzhko O., Richter J., Krokhmalskii T., Zaburannyi O., Phys. Rev. B, 2002, **66**, 144401, doi:10.1103/PhysRevB.66.144401.
14. Derzhko O., Krokhmalskii T., Stolze J., J. Phys. A: Math. Gen., 2002, **35**, No. 16, 3573–3596, doi:10.1088/0305-4470/35/16/301.
15. Derzhko O., Richter J., Zaburannyi O., J. Phys.: Condens. Matter, 2000, **12**, No. 40, 8661–8668, doi:10.1088/0953-8984/12/40/310.
16. Derzhko O., Krokhmalskii T., Stolze J., Verkholyak T., Phys. Rev. B, 2009, **79**, 094410, doi:10.1103/PhysRevB.79.094410.
17. Derzhko O., Strečka J., Gálisová L., Eur. Phys. J. B, 2013, **86**, No. 3, doi:10.1140/epjb/e2013-30979-4.
18. Krokhmalskii T., Derzhko O., Stolze J., Verkholyak T., Phys. Rev. B, 2008, **77**, 174404, doi:10.1103/PhysRevB.77.174404.
19. Derzhko V., Derzhko O., Richter J., Phys. Rev. B, 2011, **83**, 174428, doi:10.1103/PhysRevB.83.174428.
20. Lieb E., Schultz T., Mattis D., Ann. Phys., 1961, **16**, No. 3, 407–466, doi:10.1016/0003-4916(61)90115-4.
21. Derzhko O., Richter J., Phys. Rev. B, 2004, **70**, 104415, doi:10.1103/PhysRevB.70.104415.
22. Richter J., Derzhko O., Schulenburg J., Phys. Rev. Lett., 2004, **93**, 107206, doi:10.1103/PhysRevLett.93.107206.
23. Derzhko O., Richter J., Eur. Phys. J. B, 2006, **52**, No. 1, 23–36, doi:10.1140/epjb/e2006-00273-y.
24. Richter J., Derzhko O., Krokhmalskii T., Phys. Rev. B, 2006, **74**, 144430, doi:10.1103/PhysRevB.74.144430.
25. Derzhko O., Honecker A., Richter J., Phys. Rev. B, 2007, **76**, 220402, doi:10.1103/PhysRevB.76.220402,
26. Richter J., Derzhko O., Honecker A., Int. J. Mod. Phys. B, 2008, **22**, No. 25n26, 4418–4433, doi:10.1142/S0217979208050176.
27. Derzhko O., Krokhmalskii T., Richter J., Phys. Rev. B, 2010, **82**, 214412, doi:10.1103/PhysRevB.82.214412.
28. Derzhko O., Richter J., Maksymenko M., Int. J. Mod. Phys. B, 2015, **29**, No. 12, 1530007, doi:10.1142/S0217979215300078.
29. Derzhko O., Richter J., Honecker A., Schmidt H.-J., Fiz. Nizkikh Temp., 2007, 33, No. 9, 982–996.
30. Derzhko O., Richter J., Krupnitska O., Krokhmalskii T., Phys. Rev. B, 2013, **88**, 094426, doi:10.1103/PhysRevB.88.094426.
31. Derzhko O., Krupnitska O., Lisnyi B., Strečka J., EPL, 2015, **112**, No. 3, 37002, doi:10.1209/0295-5075/112/37002,
32. Richter J., Krupnitska O., Baliha V., Krokhmalskii T., Derzhko O., Phys. Rev. B, 2018, **97**, 024405, doi:10.1103/PhysRevB.97.024405,
33. Maksymenko M., Honecker A., Moessner R., Richter J., Derzhko O., Phys. Rev. Lett., 2012, **109**, 096404, doi:10.1103/PhysRevLett.109.096404,
34. Derzhko O., Richter J., Phys. Rev. B, 2014, **90**, 045152, doi:10.1103/PhysRevB.90.045152.
35. Müller P., Richter J., Derzhko O., Phys. Rev. B, 2016, **93**, 144418, doi:10.1103/PhysRevB.93.144418,
36. Menchyshyn O., Ohanyan V., Verkholyak T., Krokhmalskii T., Derzhko O., Phys. Rev. B, 2015, **92**, 184427, doi:10.1103/PhysRevB.92.184427,
37. Rojas O., Strečka J., Derzhko O., de Souza S.M., J. Phys.: Condens. Matter, 2019, **32**, No. 3, 035804, doi:10.1088/1361-648x/ab4acc,
38. Derzhko O., J. Phys. Stud., 2001, **5**, No. 1, 49–64, doi:10.30970/jps.05.49.

39. Derzhko O., In: Order, Disorder and Criticality, Holovatch Yu. (Ed.), World Scientific, Singapore, 2004, 109–145, doi:10.1142/9789812565440_0003.
40. Derzhko O., In: Condensed Matter Physics in the Prime of the 21st Century, Jedrzejewski J. (Ed.), World Scientific, Singapore, 2008, 35–87, doi:10.1142/9789812709455_0002.
41. Richter J., Derzhko O., In: Condensed Matter Physics in the Prime of the 21st Century, Jedrzejewski J. (Ed.), World Scientific, Singapore, 2008, 237–270, doi:10.1142/9789812709455_0008.
42. Richter J., Derzhko O., Honecker A., In: Condensed Matter Theories, Vol. 23, Sa-yakanit V. (Ed.), World Scientific, Singapore, 2008, 130–145, doi:10.1142/9789812836625_0014.
43. Richter J., Derzhko O., Eur. J. Phys., 2017, **38**, No. 3, 033002, doi:10.1088/1361-6404/aa5c71,