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Foundation of Polish Science
Alexander von Humboldt Polish Honorary Research Scholarship Programme

Wroclaw, September 29, 2021

Subject: Nomination of Prof. Gerd Röpke for the Alexander von Humboldt Polish Honorary Research Scholarship Programme 2021

To whom it may concern:

With this letter, I wish to nominate Prof. Dr. Dr. h.c. Gerd Röpke for the Alexander von Humboldt Polish Honorary Research Scholarship Programme of the year 2021.

Justification:
Prof. Gerd Röpke has enriched the field of Quantum Many-Body Theories with conceptual work devoted to the effects of exchange symmetry (Pauli blocking) for the formation of strong correlations (clusters) and its application to many-particle systems with electromagnetic and/or strong interactions.
His most important contributions concern the occurrence of strong few-body correlations in finite and infinite many-particle systems. The credo of his work is the development of non-perturbative many-body Greens function and Path Integral techniques for the description of bound state and cluster formation in warm dense matter and their dissolution within a Mott transition under compression and heating.
Gerd Röpke has developed the quantum cluster virial expansion as a sufficiently general method for the investigation and solution of the highly nontrivial problems in this context. He has applied this method to a broad range of systems in his multi-facetted oevre of more than 500 publications and 6 monographs.
These works range from general theory of many-body systems to applications in atomic physics, solid state and plasma physics as well as to finite nuclei, nuclear matter and quark matter systems.
These outstanding achievements warrant awarding Prof. Gerd Röpke with the Alexander von Humboldt Polish Honorary Research Scholarship for pursuing the vigorous and highly topical research program he suggested for his visit and collaboration at the University of Wroclaw.

I want to explain a few highlights of his research career more in detail.
After his habilitation in Dresden 1973 on strongly correlated electron systems and non-equilibrium statistical mechanics (a textbook emerged from this, which after the German and Russian Editions recently also appeared in English at Wiley & Sons), Gerd Röpke accepted in 1977 a lecturer position (Docent) at the University of Rostock in the group for theoretical plasma physics where he immediately made a decisive contribution to the development of a theory of two-particle bound states (excitons) in the electron-hole plasma [Röpke, Kilimann, Kraeft, Kremp, Zimmermann, pss (b) 88, K59 (1978) & the exteded version „five-men-work" in the same journal, same year]. Gerd Röpke's merit in this work is the elucidation of the role of Pauli blocking, which partly compensates the effects of dynamcal self-energy and dynamical screening of the interaction for the bound states. This entails their Mott dissociation beyond a critical density. The striking effect of

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the Mott transition is on the conductivity of nonideal plasmas. Therefore, Gerd Röpke published in the following year a work on the „Influence of two-particle states (excitons) on the dielectric function of the electron-hole plasma". This became a classical work in this field and its result carries now the name of its author, the „Röpke-Der dielectric function" [pss (b) 92, 501-510 (1979)].

In the beginning of the 80-ies Gerd Röpke laid the groundwork for the application of his techniques to determine quantum statistical effects on cluster abundances to strongly interacting many-particle systems, like nuclear matter. In 1982-1984 he published a cycle of three works on „Particle clustering and Mott transitions in nuclear matter ..." [Nucl. Phys. A 379, 536 (1982); 399, 587 (1983); 424, 594 (1984)] which resulted in studies of nuclear cluster abundances from heavy-ion collision experiments to astrophysics, including supernova explosions and cosmic element abundances. A recent publication on this topic has earned more than 450 citations [S. Typel, G. Röpke, et al., Phys. Rev. C 81, 015803 (2010)]. The main contribution of Gerd Röpke in this field of science is the derivation of the Pauli blocking energy shifts using his quantum statistical metods as the essential in-medium effect for short-ranged strong interaction which modifies the cluster abundances in dense matter relative to the simple mass-action law of a conventional statistical equilibrium picture. At high densities, the Pauli blocking results in the Mott dissociation of all clusters and explains their absence in uniform nuclear matter, e.g., in the cores of neutron stars.

In recent years, Gerd Röpke has advanced the topic of clusters and quantum condensates in finite nuclei with particular emphasis on alpha-particle clusters that determine the structure of the lower density regions of a nucleus, namely its skin. For lighter nuclei like carbon, nitrogen, oxygen etc. this concerns the whole nucleus which may be considered as composed of alpha clusters. The basic symmetry principles, due to exchange of nucleons among the alpha clusters, however, need to be obeyed! This is accomplished by the THSR wave function, another result of Gerd Röpke's research that carries his name! [Phys. Rev. Lett. 87, 192501 (2001)]. This work is of utmost importance for understanding, e.g., the Hoyle state in 12C which is essential for the element synthesis in stars and the emergence of life in the Universe. This is meanwhile the most cited of Gerd Röpke's publications. Most recent work of Gerd Röpke is devoted to the application of his alpha-cluster approach to finite nulcei for a deeper understanding of the alpha decay of heavy nuclei with pioneering results for the 212Po nucleus. One may speculate about the future role of these studies in the investigation of superheavy nuclei (which are all alpha emitters) and the suspected „island of stability".

A further domain of the application of Gerd Röpke's cluster virial expansion techniques is the study of quark deconfinement in dense nuclear matter where the nucleons themselves are considered as three-quark clusters and the mesons, mediating their interactions, are two-particle states of quark and antiquark. No fundamental progress in this domain is possible wthout accounting for the confining nature of the strong force between quarks which leads to an extreme case of tight-binding: the complete clusterization of quark matter at low densities. In this situation, the account for the Pauli-blocking effect between hadrons (nucleons and mesons) at increasing densities gives a theoretical foundation for understanding quark deconfinement, i.e., the dissociation of hadrons at ultimate densities, like in modern heavy-ion collision experiments and in the cores of neutron stars. Gerd

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Röpke has given pioneering contributions in this field too [Phys. Rev. D 34, 3499 (1986)], but due to the relativistic nature of these systems a field-theoretic formulation on the basis of the Path-Integral approach had to be developed [Ann. Phys. 348, 228 (2014)] before their application to the above situations can be attacked and the cluster virial expansion techniques and the related generalization of the Beth-Uhlenbeck approach [Ann. Phys. 202, 57 (1990)] can develop their full potential in triggering breakthrough developments in this field too.

It is not the place here to praise adequately Gerd Röpke's merits in the big transformations in science related to the changes in Eastern Europe in the 90-ies. He organised as last president of the Physical Society of the GDR its fast fusion with the German Physical Society; worked as an ordinary member of the Scientific Council of Germany (5 members) for the evaluation of Eastern German Institutes and became the Director of a Research Unit on „Theoretical Many-Particle Systems" of the Max-Planck Society at the University of Rostock (1992-1996). In 1994-1997 he was elected Vice-Director of the prestigious Bogoliubov Laboratory for Theoretical Physics at the JINR Dubna (Russia). Gerd Röpke organised and directed the DFG Graduate School „Strongly Correlated Many-Particle Systems" (1999-2006) at the University of Rostock where he developed an extraordinary activity as an academic teacher and founder of a school of theoretical physicists working now in different countries, e.g., Prof. Dr. Dr. h.c. Sebastian Schmidt (Director Helmholtz Zentrum Dresden-Rossendorf, Germany), Prof. Dr. Sibylle Günter (Director Max-Planck Institute for Plasma Physics Garching), Prof. Dr. Ronald Redmer, Privatdozent Dr. hab. Heidi Reinholz (University of Rostock), Prof. Dr. Dr. Frank Schweitzer (ETH Zuerich, Switzerland), and myself (University Wroclaw, Poland).

In conclusion, I find it timely to award Prof. Gerd Röpke with the Alexander von Humboldt Polish Honorary Research Scholarship 2021.

Prof. Dr. Dr. h.c. David Blaschke
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