Referee's report on the habilitation thesis "Many-body aspects of neutron star physics" by Dr. Evgeny Kolomeytsev

Dr. Evgeny Kolomeytsev is an internationally well recognized expert in hadron physics and physics of neutron stars. He has been working in the field for more than 25 years. During his career he has worked in several prestigious institutions, such as ZfK Rossendorf, GSI Darmstadt, ECT* Trento, Niels Bohr Institute Copenhagen, University of Minnesota. He has collaborated with distinguished physicists, e.g., B. Kaempfer, M.F.M. Lutz, N. Kaiser, W. Weise, J.M. Lattimer, A. Ohnishi, B. Tomasik, to name just few. He is an author of numerous highly cited papers published in leading journals, including Phys. Rev. Letters and Phys. Letters B. His publications on kaon behavior in nuclear matter and hadron resonances in terms of the chiral SU(3) Lagrangian could be considered crucial for hadron physics.
Clearly, Dr. Kolomeitsev has an excellent publication and citation record. He has proved his profound knowledge of hadron physics, field theory and processes relevant to proper description of neutron stars and their characteristics already long ago. I should admit here that I was taken aback by a low number of citations given in the attached supplementing material (CV and list of publications including citations). I found much higher number, about 2500 citations in total, in WOS.

The habilitation thesis under review concerns the study of neutron stars, particularly in-medium modifications of hadrons in dense nuclear matter present in inner regions of neutron stars and how these modifications affect observed characteristics – their masses, radii, rotation and cooling. The thesis is based on 13 selected papers which represent just a small fraction of the authors' publications on quite diverse problems. It demonstrates his high expertise on one side, and his significant contribution to the field on the other side. The thesis is well written and carefully organized. It consists of 5 main chapters, bibliography and appendix with a collection of selected papers. It is to be noted that the publications which form the basis of the thesis have passed through a regular, strict per review process in leading scientific journals, which guarantees their high scientific standard.
The introductory part of the thesis is devoted to a short discussion of the underlying theories – the quantum chromodynamics and effective field theories, as well as experimental studies of nuclear matter under extreme conditions and important role of neutron stars in our quest for better understanding of the strong interaction. The arrangement of the thesis including contents of its chapters is given here as well.
The first chapter is devoted to a short historical overview, classification of pulsars and introduction of neutron star characteristics under discussion – its mass, radius, structure and

composition, rotation frequency, temperature and age. This chapter, written very concisely, lays out basis and notation for the following parts of the thesis.
In each of the next 3 chapters, a short overview of studied issues is given first, followed then by a brief presentation of the main results of the enclosed authors' paper(s). I appreciate here that the author succeeded to select the most relevant pieces of information and did not overburden the habilitation thesis by superfluous details.

However, I should add few words of criticism as well: Though the thesis deals with highly topical issues which attract considerable attention recently, it gives the impression as if it was written several years ago and submitted with delay. Namely, the papers, which the thesis is based on, were published about 10 years ago (only 2 of them were published in 2015). Moreover, the list of references corresponds to that fact as well – out of 291 quoted references only a few were published less than 5 years ago. In this respect, I miss a conclusion which summarizes the current status in underlying hadron physics (meson baryon interaction models based on chiral approaches, hyperon interactions with nucleons (YN) and hyperons (YY), three body YNN forces, etc.), our current knowledge of neutron star characteristics, and which also provides some outlook in the field.

I have the following questions for the author:
1) In view of state-of-the-art 'chirally inspired' models of meson-baryon interactions, what is the current opinion about the presence of kaon condensation in the neutron star interior?
Has been repulsion among kaons taken into account in the considerations about kaon condensate and if yes, how has it been determined?

2) What are the recently considered ways/approaches to solve the "hyperon puzzle"?
In view of current knowledge of YN, YY, and three-body YNN interactions, are the Λ, Σ and Ξ hyperons expected to be present in neutron stars?

3) What is the reason for describing the NN interaction via one pion exchange (long range part of the NN interaction) in the study of neutron star cooling via the Urca processes? Is it legitimate to exclude other exchanges including short range repulsion?

I would like to conclude that I found the habilitation thesis of Dr. Kolomeytsev very interesting, well organized and written, despite some criticism spelled above. I highly esteem his work and the thesis has merely confirmed my firm opinion of significant and valuable contributions of Dr. Evgeny Kolomeytsev to all publications selected in the thesis and development of our knowledge of neutron stars and hadron physics in general. By his scientific activities - including numerous, abundantly cited publications - he has clearly proved his high expertise and profound knowledge of the physics processes involved. Therefore, I am convinced that the requirements for habilitation are easily met.

In summary, I recommend without hesitation the habilitation thesis of Dr. Kolomeytsev to be presented in front of the Scientific Board of the Faculty of Mathematics, Physics and Informatics of Comenius University Bratislava. In my opinion, Dr. Evgeny Kolomeytsev fully deserves promotion to docent status.

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