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RE: Habilitation Dr. Magdalena Skurzok

This is my report on the scientific work of Dr. Magdalen Skurzok who has applied for habilitation at the Faculty of Physics, Astronomy and Applied Computer Science, Jagiellonian University.

Dr. Magdalena Skurzok has pursued a broad research program on studies of exotic nuclear matter such as meson-nucleus bound states and mesonic atoms. These are systems where one studies the strong interaction among mesons and nuclei. **Mesonic atoms** are systems where an electron in the atomic shells is replaced by a negatively charged meson, a system bound by the **electromagnetic interaction**. In this case, the additional strong interaction of the meson with the nucleus leads only to small changes in the binding energy and width of the atomic state. Nevertheless, high precision measurements of x-rays emitted from such systems provide information on the strong interaction of mesons with nuclei in the non-perturbative regime of Quantum Chromodynamics. Theoretical calculations predict also the existence of **mesic nuclei,** a new form of nuclear matter where a meson - independent of its electric charge - is bound to the nucleus by the **strong interaction**. Such states have so far not been discovered despite world-wide experimental efforts to observe them. Furthermore, Dr. Skurzok has worked on positron emission tomography developing and using the J-PET tomograph for medical applications as well as for precision tests of matter-antimatter symmetries.

The relevance of Dr. Skurzok's scientific work and her productivity are demonstrated by about 100 papers in refereed journals and about 60 conference proceedings. In addition, she has given about 50 seminars and presentations at international and national conferences and workshops; I have heard several of her lively talks. Out of these many publications Dr. Skurzok has selected 11 thematically related key papers on *investigations of exotic nuclear matter in the form of mesic and mesonic atoms* for her habilitation application.

These publications are the result of numerous experiments performed over a period of about 15 years with the WASA detector at the COSY accelerator in Jülich (Germany) and of measurements in collaboration with the SIDDHATRTA and AMADEUS groups at the DAΦNE accelerator in Frascati (Italy) during a two-year fellowship at the LNF-INFN. For the interpretation of the experimental results Dr. Skurzok established collaborations with theory groups at Bogota (Colombia) and Nara (Japan), involving several extended stays at these universities.

The results obtained can be summarized as follows: An upper limit of the total cross section for the population of η-^{4}He bound states in deuterium + deuterium collisions has been obtained by studying pion-proton pairs from the decay of the N*(1535) nucleon resonance excited in the decay of the hypothetical η-^{4}He bound state. From these measurements the real (V_0) and imaginary (W_0) part of the η-^{4}He optical potential could be constrained to $|V_0| < 60$ MeV and $|W_0| < 7$ MeV, respectively (papers H1,H2). These potential parameter values allow the existence of extremely narrow and loosely bound

η-^{4}He states although they could not be directly observed. In a search for η-^{3}He bound states, excitation functions have been measured in the proton + deuteron reaction, looking not only for pion-proton pairs but also for the γ decay of the η meson in the bound state. The latter data reveal a structure at a binding energy of 14 MeV and a width of about 30 MeV. Because of systematic uncertainties this result has, however, not been claimed as a first observation of an η-mesic nucleus and only an upper limit for the formation of η-^{3}He bound states has been deduced (papers H3-H7). The analysis of the data could only be performed by developing dedicated theoretical models in collaboration with the groups in Bogota (H3,H6) and Nara (H4). In papers H9 and H10 Dr. Skurzok summarizes her results obtained in the search for η-He bound states.

During her two-year stay at the INFN laboratory in Frascati Dr. Skurzok developed, built and installed a luminosity monitor (paper H8) for the SIDDHARTA-2 experiment which served as a trigger in the first measurements of x-rays from kaonic deuterium, essential for a significant background suppression. This measurement will allow a first determination of the K^- - neutron scattering length, relevant for estimating the composition of neutron stars. In collaboration with the AMADEUS group Dr. Skurzok studied for the first time various reactions for the absorption of K^- mesons on two or more nucleons in nuclei, important for understanding the reaction mechanisms leading to the formation of a K^-pp cluster, a first step towards mesic nuclei. Very recently, new experimental constraints on the strong K^- nucleon interaction near threshold have been obtained from measurements of K^- absorption on hydrogen atoms with a strong impact on several open questions in hadron- and astrophysics (paper H11).

In this series of experiments Dr. Skurok has become familiar with all tasks for performing research programs at accelerators. This includes preparing proposals based on simulations of the experiment, defending the beamtime applications in advisory committee meetings, installation and tests of detector components, tests of the data acquisition and participation in shifts during the data taking. Furthermore Dr. Skurzok has gained experience in the analysis of the data in comparison to dedicated Monte-Carlo simulations and in the interpretation of the results in collaboration with interested theory groups. With her experience in detector hardware and read-out electronics as well as her knowledge of programming, simulations and data analysis with large software tools and her ability to interpret complex data she meets all requirements for running a research group, devising research programs and advising PhD students as expected from a researcher with habilitation. She has already been principal investigator of several research projects and I am convinced that she will play a leading role in developing future physics research programs at the Jagiellonian University.

From the material submitted to me I see that Dr. Skurzok has also been very active in teaching courses, supervising laboratory exercises and as auxiliary supervisor of several PhD students. I personally experienced her managerial competence when attending conferences and workshops she organized as main- or co-organizer.

In view of her scientific achievements and professional experience, I strongly recommend to award Magdalena Skurzok, PhD, the degree of habilitated doctor in the field of exact and natural sciences in the discipline of physical sciences.

If you have any question do not hesitate to contact me.

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