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REPORT

Dr Serge Franchoo, Habilitation, Université Paris-Saclay

It is my pleasure to write a report on the habilitation thesis for Serge Franchoo. I can confirm that Dr Franchoo is not a collaborator of mine, and I have no research connection, or any other relevant connection with him, and I consider myself to be well placed to make an independent judgement.

The first thing to say is that the subject matter of the research project that Dr Franchoo has led is one of much contemporary interest in the field of nuclear structure physics. It tackles one of the most crucial topics in modern physics – the robustness, or otherwise, of the well-known single-particle shell closures (the magic numbers) as one moves away from the line of stability and the evolution and development of alternative shell structures with neutron-proton asymmetry. Tackling this topic requires the gathering of multiple pieces of information from many experimental approaches and their interpretation through the development of state-of-the-art theoretical models. It is a complex research field, with many moving parts, and it is Dr Franchoo's original work in this important field that has been presented for his habilitation.

It is clear from the submission, and the collection of research papers, that Dr Franchoo has made a significant original contribution to the field. Leading successful experiments of this kind at world-leading facilities such as GANIL and RIKEN (both world leaders in the field) already demonstrates considerable standing in the field. The papers presented in this habilitation represent a considerable body of work.

The habilitation thesis presents a compelling and comprehensive narrative that guides the reader through the complex story of shell-evolution in exotic nuclei. The introductory chapter lays an excellent foundation that could be considered essential reading for anyone trying to navigate through the shell-evolution story. The chapter lays a foundation starting from the early development of the shell model through to the development of modern shell-model techniques. The chapter also very nicely highlights the delicate interplay between the various physical phenomena at play in shell evolution (the tensor force, T=0 couplings, deformation etc) and brings out the key points that the reader needs to interpret the experimental and theoretical results that follow. This introductory chapter demonstrates an excellent contextual understanding of the field.

In order to prepare the ground for the results that follow, chapter 2 presents a comprehensive and exhaustive (in the good sense of the word) review of the state of knowledge of the states in question as the evolution takes place towards the ^{78}Ni region. A detailed analysis of the structure of the $3/2^-$ and $5/2^-$ states is presented, through a compilation of the relevant spectroscopic data from stripping and pickup reactions and from Coulomb excitation data. This is important to help understand how the $p_{3/2}$ and $f_{5/2}$ states flip at, and beyond, ^{75}Cu. The study of the 1/2$^-$ level for example helps demonstrate the delicate interplay between the single-particle and collective effects at play here. The study of these three levels, and how they evolve along the copper isotopic chain represents a comprehensive study that brings together all the relevant measurements. This is an impressively detailed analysis.

The section on collectivity and shape co-existence nicely presents the experimental and theoretical developments that led to the understanding of the influence of the potential sub-shell N=40 closure. The chapter culminates in a very interesting evaluation of the understanding of the N=50 shell closure as ^{78}Ni is approached, culminating in the recent spectroscopy of ^{78}Ni itself at RIBF where, again, conflicting evidence about the robustness of the shell closures is found. All of this has provided an excellent context into which the original work presented by Dr Franchoo in the habilitation can be placed.

The underpinning theoretical developments are explained extremely well in chapter 3: again there are many theoretical approaches, but the key developments, and the models tested by the experimental data presented in the papers are well covered. Indeed, it was extremely helpful to have such a full survey of the contributions to shell-evolution, and the discussion of the Type-I and II evolution was very helpful to the reader.

The thesis concludes with the sequence of published works led by Dr Franchoo. They are focussed on understanding the evolution of nuclear structure in the upper-*fp* and *fpg*-space, especially the evolution of shells from Z=28 through to N=40 and 50 through studies of ^{69}Cu, ^{71}Cu (GANIL) through to the outstanding spectroscopy of ^{79}Cu at RIKEN. This sequence of experiments presents an exceptional systematic study that evaluates the robustness of the Z=28 and N=50 gaps and places the analysis in the context of both the state-of-the-art models and, importantly, the wealth of experimental and theoretical results that map the behaviour of nuclei in this region.

It is my professional opinion that the work presented is of a sufficient standard, in terms of originality, scope and contribution to meet the criteria, as I understand them, for the purpose of *Habilitation à diriger des recherches*. I am content that this should proceed to the public presentation and examination.

Yours sincerely

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