Topical review evaluation on "Quantum and Materials Science" at ISTA, March 22.-24. 2023

Reviewer:
Claudia Felser (chair, MPI Dresden)
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Quantum Materials Science group (QMS):

Zhanybek Alpichshev (AsstProf), Condensed Matter and Ultrafast Optics
· Johannes Fink (Prof), Quantum Integrated Devices
· Stefan Freunberger (AsstProf), Materials Electrochemistry
· Andrew Higginbotham (AsstProf), Condensed Matter and Quantum Circuits
· Onur Hosten (AsstProf), Quantum Sensing with Atoms and Light
· Maria Ibanez (AsstProf), Functional Nanomaterials
· Giorgos Katsaros (Prof), Nanoelectronics
· Misha Lemeshko (Prof), Theoretical Atomic, Molecular, and Optical Physics
· Kimberly Modic (AsstProf), Thermodynamics of Quantum Materials at the Microscale
· Hryhoriy Polshyn (AsstProf), Emergent Electronic Phenomena in 2D Materials
· Maksym Serbyn (Prof), Condensed Matter Theory and Quantum Dynamics

Executive Summary:

The evaluation report addresses the Quantum and Materials Sciences (QMS) subject area at ISTA and highlights its excellent international reputation and successful recruitment of young scientists. The report praises the excellent scientific and personal environment at ISTA and notes that the atmosphere among faculty members is excellent, but that collaboration among recently recruited QMS members could be further strengthened. External funding awarded in recent years is very impressive with more than 34 million Euros, including 9 ERC grants. The report recommends expanding the faculty into new research areas. Possible proposals for future hires could be in the areas of theory, atomic, molecular, and optical physics (AMO), additional local probes, and materials engineering, while long-term strategies could move toward quantum computing, photonics, and other applied sciences. In conclusion, the report states that QMS is a perfect fit for ISTA's goals and that the support provided by ISTA is appropriate for each group.

Report:
This report is based on the rules and questions provided by ISTA (June 2022). The review team has modified the question scheme to adapt it to the specific needs of the team of young professors being evaluated. We defined our own evaluation scale following the ERC nomenclature, with outstanding and excellent being the highest categories.

We were impressed by the scientific quality of the team of the Faculty of Quantum and Materials Sciences in general and very satisfied with its development, especially considering that all members were hired on tenure-track positions. The atmosphere between faculty members seems to be excellent, and PhD students and postdocs also comment very

positively on the scientific and personal environment at ISTA. The third-party funds obtained in recent years are very impressive at 34 million euros.

1. **What is the international standing of the Quantum and Materials Science faculty as a group?**

The international reputation of the faculty working in Quantum and Materials Sciences as a group is excellent. In particular, tenured professors are outstanding compared to other academics at the same career stage. The technology of superconducting qubits and the architecture developed by Johannes Fink and his team are unique and outstanding. Another example is the work of Giorgos Katsaros, who has very carefully repeated controversial experiments to explain the zero bias peak beyond Majorana physics (Nature 2022). ISTA is well known in the scientific community as a scientific institution, but its international visibility could be improved, especially to attract even better applications for PhD student and postdoc positions.

We congratulate ISTA for recruiting outstanding assistant professors who come from excellent universities and all of them with an outstanding performance before they joined ISTA. Most of them joined during the last years and therefore have a limited number of publications based on their work at ISTA, but their potential to perform excellent/outstanding in the future is high.

Staffing the chemistry and physics research areas only with young scientists instead of established experienced scientists was a high risk, but has proven to be successful. The atmosphere between the members of the QMS team is excellent and the first steps towards forming a team are going in the right direction. Nevertheless, there are some weaknesses that can be easily improved. The collaboration between the members of the QMS team could be improved, possibly through the shared facilities and the increased collaboration between PhD students.

The presentations that were given to the evaluators were very technical and more suitable for a conference paper than for an evaluation of the research area.

The cooperation with TU Wien also seems to work very well in this area. Five members of the QMS team are also members of the Collaborative Research Center "Correlated Quantum Materials & Solid State Quantum Systems" at TU Wien.

2. **In the near future, specifically with regard to new hires: Shall ISTA focus on its existing strengths or expand into new subfields**

The future strategy should be defined by the members of the QMS Group. The QMS team has already developed a compelling short-term strategy. In principle, we support the QMS team's hiring strategy as described in the report. The primary criterion for hiring new faculty is scientific excellence. Possible suggestions for futures hires could be in the following following areas:
-Theory (theorists in atomic, molecular, and optical physics (AMO), quantum information, and condensed matter).
-AMO (possible directions are Rydberg atoms, molecules or photonics, directions not represented in Austria).

-Additional probes/techniques: spatially resolved probes, angle resolved photoemission.
-Material breeding really breeding? Is this a technical term? : identification and breeding of new quantum materials are very active scientific areas worldwide; this also allows easy access to new quantum materials for all experimenters

Additionally, we strongly encouraged the QMS team to develop a long-term strategy for the research area and to think also about potential future scientific direction of ISTA. Recognizing that the number of ISTA faculty will double in the next few years, the QMS team has also already developed a few ideas for new academic directions. As also mention in the the report, this includes:
- Cryogenic Electronics for Quantum Computing
- Photonics
- Metamaterials
- Materials engineering or chemical engineering, e.g., related to energy materials for energy conversion and storage.

Expansions into engineering directions associated with existing QMS groups on campus are also recommended in the spirit of the T=Technology in ISTA's name. However, this does not mean that a new engineering department needs to be created, concepts that keep the societal impact in the existing areas in mind may also be a way to go.

[Note from Academic Affairs about pages 3-9: The sections on individual professors of the review report are treated in the same way as confidential review letters. Hence, they are not included in this version of the report.]

4. How does QMS fit into the larger goals and culture of ISTA?

Quantum materials science is an emerging scientific area and fits therefore perfectly into the goals of ISTA. Other countries including Germany and Switzerland have invested heavily into the field of quantum technologies. In Austria especially the activities in cold atoms and ion traps are well known. The activities of QMS at ISTA are complementary and partially world leading in the specific field. It is important to distinguish here again the tenured professors from the recently hired assistant professors. Strengthening this area with new professorships in the area of QMS is highly recommended.

The support for each group provided by ISTA is appropriate, infrastructure is excellent, and there were no complains about the group size limitation for the QMS teams (15 group members). Concerning the doctoral education at ISTA, in particular the multidisciplinary PhD program related to QMS, more basic lectures could be helpful to bring all students to the same required level.

Additional points recognized by the panel:

The faculty as a whole

In general, there is an excellent atmosphere at ISTA, and the young faculty members enjoy the constant support of the leadership of ISTA. The Institute's financial support for assistant professors is very generous and allows them to reach their full potential as young scientists. However, without experienced professors, the young faculty members would have needed more mental support and mentoring, which was reflected for example in their presentations, as mentioned earlier. The evaluation panel acknowledged that a generous start-up package and a simultaneous ERC grant can be overwhelming for an assistant professor at the beginning. Focusing on a few promising experiments can be more beneficial for jump starting a scientific career.

Permanent research scientists:

The idea of permanent researchers working independently of the professors was critically discussed by members of the evaluation panel. There is positive recognition that research assistants have the freedom to pursue their own research interests, but there is also concern that their opportunities may be limited and that they may not have a clear career path. Although they have the opportunity to pursue scientific endeavors such as obtaining grants, attending conferences, and continuing their education, frustration is likely to set in over time. Allowing scientists to be evaluated after five years before being granted permanent status will allow for better evaluation of candidates. We agree with the President that using the position to address the dual career problem is not a good solution.

Feedback of PhDs and postdocs

Students and postdocs enjoy living on campus, especially during corona time. There were no real complaints about support, access to infrastructure, or equipment and materials. One minor criticism from some chemists was about the service structure, which is still more focused on biological research. However, we are sure that this is only a matter of time and will improve with the hiring of more chemistry professors.

However, during the evaluation we found that the quality of the students is very good, but not yet at the level one would expect from a world-class university.