PHYSICS - GENERAL EVALUATION REPORT

COMMITTEE FOR THE EVALUATION OF PHYSICS IN ISRAEL

AUGUST 2019

Section 1: Background and Procedures

1.1 In the academic year 2018-19 the Council for Higher Education [CHE] put in place arrangements for the evaluation of study programmes in the field of Physics in Israel.

1.2 The Higher Education Institutions [HEIs] participating in the evaluation process were:

- Ariel University
- Bar-Ilan University
- Ben-Gurion University
- The Hebrew University
- Lev Academic Institute
- The Open University
- Technion – Israel Institute of Technology
- Tel Aviv University
- Weizmann Institute of Science

1.3 To undertake the evaluation, the Vice Chair of the CHE appointed a Committee consisting of[1]:

• Prof. Steven Kahn: Committee Chair	Stanford University, USA
• Prof. Laura Greene	National MagLab and Florida State University, USA
• Prof. Herbert Levine	Northeastern University, USA
• Prof. Michal Lipson	Columbia University, USA
• Prof. Yael Shadmi	Technion, Israel

Ms. Maria Levinson-Or served as the Coordinator of the Committee on behalf of the CHE.

1.4 The evaluation process was conducted in accordance with the CHE's Guidelines for Self-Evaluation (February 2018). Within this framework the evaluation committee was required to:

- examine the self-evaluation reports submitted by the institutions that provide study programs in Physics
- conduct on-site visits at those institutions participating in the evaluation process
- submit to the CHE an individual report on each of the academic units and study programs participating in the evaluation
- set out the committee's findings and recommendations for each study program
- submit to the CHE a general report regarding the evaluated field of study within the Israeli system of higher education

1.5 The evaluation committee examined only the evidence provided by each participating institution — considering this alongside the distinctive mission set out by each institution in terms of its own aims and objectives. This material was further elaborated and explained in discussions with senior management, faculty

[1] The committee's letter of appointment is attached as **Appendix 1**.

members, students and alumni during the course of each one-day visit to each of the institutions.[2]

1.6 A separate meeting was convened between the committee and the nine Heads of the departments of Physics under evaluation. This served to contextualize the panel's discussions and to identify common issues between the departments.

1.7 As the Committee gradually learned, the CHE is currently moving towards a model of Internal Quality Assurance (IQA) in some institutions. In this model, external evaluations of departments and fields will be done by the institutions, and the CHE will evaluate the institutional mechanisms and processes for QA. This change will make the departmental self-evaluation process even more valuable. In practice, however, in the current evaluation most departments did not regard the reports as self-evaluation reports, but merely as input to the Committee. In these cases, there was hardly any process of convening different groups in the department, such as faculty in different areas, students, etc, to examine practices in the department and come up with well-thought lessons. This failure was probably due to some broken communication between the CHE and the departments, and has unfortunately detracted from the potential value of the process. In future reviews of this type, it would be good to directly communicate with department heads to explain the goals, and to guide them about the process. It would also be good, though less crucial, to bring up the self-evaluation component to the attention of the committee prior to the visit. In addition, while some of the questions to the departments were very relevant (admission to the physics programs, student makeup, study programs, hiring practices etc), others were less so (general organization of the university, defining learning outcomes etc). The departments and administrations put a lot of work into parts that hardly matter for the consideration of the physics performance of the departments. The reports ended up being very long, and it was hard to sift through them for the relevant parts.

1.8 The case of Ariel University deserves special mention. At least two members of the Committee were unaware of this university's location in the occupied territories, until well after having agreed to participate in this review. Given the controversial nature of the Ariel settlement, the treatment of Ariel University as merely one of a number of Israeli universities, has been the subject of significant criticism by many members of the Israeli academic community, including the physics community. It is the Committee's view that the CHE could have been more open with us in addressing this situation in advance of our trip to Israel. In any case, the committee recognizes that the CHE has the final decision regarding the institutions included in the evaluation.

1.9 The discussion in this general chapter primarily covers the six more established research universities offering physics programs in Israel: Bar-Ilan University, Ben-

[2] Prof. Yael Shadmi did not participate in the visits to the Technion and to Ariel University or in the panel's discussions concerning the evaluation of these institutions; Prof. Herbert Levine did not participate in the visit to Bar-Ilan or in the panel's discussions concerning the evaluation of this institution; Prof. Michal Lipson did not participate in the visits to Weizmann Institute of Science, Bar-Ilan University, Jerusalem College of Technology, Ariel University and Ben-Gurion University.

Gurion University, Hebrew University, Technion, Tel-Aviv University and the Weizmann Institute. The remaining physics programs which this committee was asked to review each have special features, and therefore require separate discussions.

Section 2: Executive Summary

Israeli physics has a very proud history, and the state of the field at its leading universities is currently very strong. Israel is a very well recognized leader in many fields in physics worldwide.

However, there is a very high level of competition among those universities, which can lessen the impact of Israeli physics generally, especially in certain fields. We encourage greater cross-institutional discussion and collaboration nationally. We also suggest that the typical paradigm for faculty hiring be reexamined to discourage insularity and improve diversity.

The lack of diversity among the students and faculty in physics departments is an issue for Israel. A more proactive approach to the recruitment and retention of under-represented groups should be instituted. In addition, the role of women in academic positions should be studied more extensively. Women are over-represented in lower status positions, and under-represented among the regular faculty. This can and should be improved.

The undergraduate degree programs in Israeli physics departments are strong, but there are improvements which can and should be made. Attention to the value of innovative new teaching methods should be increased. Student-mentoring should be augmented, especially with respect to non-academic career options. Departments should make a greater effort to stay in contact with their alumni.

Graduate education is also very strong, but monitoring of graduate student progress toward the degree should be strengthened, with the participation of additional faculty, beyond the student advisor. We also suggest that uniform guidance be adopted in advising students whether or not to pursue the direct PhD track, as opposed to the usual route through the masters degree. The required and elective elements of the graduate curriculum should be reexamined to ensure that they make sense given the research interests of the students. Additionally, we recommend that the fate of postdocs in physics be given additional attention to ensure that they receive appropriate guidance and mentoring, and that their concerns are addressed.

Finally, we discuss a few unrelated topics that affect the overall Israeli research program in physics: (1) We recommend that the approach to funding laboratory technician support for experimental groups be reconsidered to ensure that appropriate individuals can be recruited and retained in such positions. (2) We recommend that Israel pursue membership in the European Southern Observatory to strengthen its national research effort in astrophysics. (3) We recommend that the Israeli National Physical Laboratory be significantly strengthened, with a

research component added to its mission to attract the interest of the university-based physics departments.

Section 3: Physics in Israel

Israeli contributions to cutting-edge physics research, scaled to either the size of the population or the GNP, have been far in excess of that of nearly every other country in the world. There has been a significant number of both theoretical and experimental physics achievements emanating from Israeli universities that have been paradigm-breaking for their subfields. Examples include: the definition of the Aharonov-Bohm phase, the discovery of black hole thermodynamics, the invention of the Zak transform and Zak phase, the first detailed physical models of gamma-ray bursts, the explication of how the structure of networks determines their functional behavior, the proof of the a-theorem in QFT, the development of advanced scanning probe techniques for quantum materials, and the modeling of CP-violation in the decays of fundamental particles. Clearly the "physics system" in Israel is functioning very well. From our visits to the various universities, it is also apparent to us that the next generation of young Israeli academic physicists is excellent, and that there will be many remarkable achievements yet to come.

Nevertheless, there are some characteristics of the Israeli physics community that differ, in interesting ways, from what is found in the United States and Western Europe, including the smaller countries in Europe. In particular, there is intense competition between the physics departments at the various Israeli universities. This has both positive and negative consequences. For "table-top" fields, like AMO or condensed matter physics, competition can be very healthy. It drives the individual groups to be creative and to strike out in new directions. However, in some other fields, especially in particle physics, the scale of the appropriate experimental programs favors collaboration rather than competition. The work on the ATLAS detector upgrade at WIS, TAU, and the Technion is an excellent example. For astrophysics, and for most theoretical disciplines, the appropriate balance lies somewhere in between: Competition has benefits, but frequent joint seminars and other forms of collaboration can help make the whole Israeli impact more than the sum of its parts.

The experience of the I-CORE program is interesting in this context. There were several I-CORE awards made to collaborations of physicists working in similar fields at different universities. It is clear that in some cases, this was very successful at fostering increased interaction and collaboration, all with positive effects. However, it is our understanding that the program was also viewed somewhat negatively, since it centralized the allocation of research resources in individual fields. In a "zero sum game," more money spent on I-CORE means less money available for individual research groups. While the I-CORE program itself may be discontinued, we suggest that it would be a mistake to completely abandon the idea of national research collaborations, and we hope that there can still be avenues for multi-institutional research awards.

The issue of collaboration versus competition also drives important strategic questions regarding how Israel should or should not invest in future experimental facilities. For the "big project" fields, the financial investment that Israel can make is unlikely to ever rival that of much bigger countries. Therefore, a choice can be made to invest instead in smaller "niche experiments" that have clear Israeli leadership. The disadvantage of following the latter route is that many important physics problems actually require the biggest facilities in the world for their solution. If Israel stays out of those projects, it will miss the opportunity to participate in some of the most important discoveries. In our view, the various Israeli physics departments should think seriously about how, as a community, they can collectively achieve maximum impact on world physics. This could come from designing and creating new smaller experiments, or from making key intellectual contributions to the big collaborations. Both approaches have merit. It will be useful for the whole community to come together to discuss such trades.

The Israel Physical Society (IPS) could provide an important vehicle for enabling such discussions. The IPS could convene regular meetings of the various physics department heads to develop concensus on issues of this nature, and also to compare and contrast successes and challenges that the individual departments have experienced on their own. The American Physical Society convenes such meetings annually in the US for physics department chairs. The IPS could also take responsibility for establishing Israel-wide schools and workshops to better facilitate interactions between students and postdocs working in similar fields at the different universities. From the various interviews we had with grad students during our visits, this would be strongly appreciated.

A second, unusual aspect of Israeli physics involves the approach taken to the hiring of new junior faculty. In most cases, new hires have been Israeli nationals, educated in Israeli universities, who then go on to prestigious postdocs in either the US or Europe, before returning to Israel to take up academic positions. There are significant negative implications for diversity that come from this paradigm, which are discussed below. In addition, the process can also facilitate inbreeding and insularity. Given the relatively small number of Israeli forefront universities, and the limited quantity of serious candidates for academic appointments in any given year, it is not uncommon for returning Israeli physicists to pursue research that is not very far removed from that of their research advisors, who are usually still active. The net result is that the community, as a whole, is over-represented in certain subdisciplines of subfields, and under-represented in others. That, in and of itself, is not necessarily bad – it may be preferable to be truly excellent in some subdisciplines, rather than mediocre in all. However, we believe that departments should not simply fall into this state without due deliberation.

Section 4: Diversity in Student Recruitment and Faculty Hiring

Diversity in physics is an issue in Israel. We learned that while about half of the high-school physics class enrolment is female, that fraction drops precipitously for physics undergraduates, and further drops even more severely in graduate school. The fraction of Arabs is low at every stage, and even lower for Ethiopians and

Haredi. In general, Israeli universities have not made strong efforts to increase the diversity of their student populations. Perhaps surprisingly, most departments do not even keep track of these numbers, or they have only started to do so recently. We were told that it is illegal to ask students to identify their ethnicities, yet given the small numbers involved, it should be feasible to track their representation, at least informally. Some departments try to improve the climate for female students by organizing or encouraging female physicists' meetings and seminars, but often these activities are initiated by the students themselves.

We recognize that the minority populations each have unique circumstances that serve to limit their enrollment in physics programs. Nevertheless, we believe that higher diversity can be achieved generally, and especially for the women. Since studies have shown that increasing diversity is not only good for society, but also for the science itself, we point out ways that have been successful in increasing diversity at US universities.

Actively recruiting women high school students would increase the number of women undergraduate physics majors.

Helping to facilitate interaction among women students, and with the faculty, where they can experience support and camaraderie, has been shown to improve the climate at institutions. Some of the Israeli universities and colleges are already taking such steps. But further efforts can still be made at the undergraduate, graduate, postdoc, tech/research scientist, and faculty levels, either separately or inclusively.

The fraction of women generally increases as you look at lower status scientific positions within Israeli universities. Although women in such positions may express satisfaction with their roles, such positive attitudes towards those types of careers can degrade with time. Similar views were held by holders of such positions in the US only a few years ago, but not so much today. It is certainly easier to hire a woman into a support role than into a full faculty position, and while she may be grateful for the job initially, it is likely to be a source of discontent in future years. Young students, both women and men, notice who holds what kinds of positions at their university. Having women selectively over-represented in support jobs further enforces stereotypes that are already there.

A very large impediment to increasing the diversity of physics faculty is the “requirement” that all postdocs must be taken abroad for several years. By the time many Israelis begin a postdoc, they are married with children. Traditionally, the husband takes a postdoc overseas and the wife follows with the children. It is not so simple for a woman to take such a postdoc and have her husband and children follow, and therefore this requirement is a barrier for women to go into academia. There have been a few steps taken to alleviate this impediment: Some schools offer substantial fellowships so women can support their husbands and children during their postdocs overseas. In other cases, for both men and women, the requirement has been lowered to allow shorter trips to accommodate the postdoc’s personal issues. The committee understands the need for each faculty

member in Israel to have an international footprint, but due to the ease of travel and electronic communications, the world is much smaller now, so internationalization can be accomplished in ways that may be more family friendly. Besides the two options identified above, allowances can be made for postdocs to hold dual appointments, partially in Israel and partially outside. Bringing in distinguished international scientists for extended visits, to explicitly work with postdocs, could also help to increase the postdocs' international collaboration and visibility. Expanding opportunities for international visitors would also serve to advertise the high level of experimental and theortical physics in Israel.

Faculty recruitment in Israel is largely by word of mouth, e.g., a senior faculty member follows a student he knows to be excellent, and brings that student to the attention of his colleagues. Hiring decisions amongst such identified candidates are typically made exclusively by the senior faculty. Not only is this "old boys" network bad for improving the diversity of people, it is also bad for improving the diversity of subjects: People tend to hire in subjects that they are most familiar with, and prefer junior scientists who are most like themselves. Broadly advertising faculty positions, actively recruiting women, minorities, and people from other countries, and including existing junior faculty in the recruitment, interviewing, and decision making processes, will, over time, help to diversify the faculties in all respects. In the US, specific proactive methods of recruitment and interviewing have been conclusively demonstrated to increase diversity.

Finally, not every professor or administrator understands the meaning of "affirmative action." When we asked about diversity, a response at some institutions was "we do not have affirmative action here – we only hire the best." Affirmative action does not imply compromising standards. In actuality, it simply involves broadening the pool of applicants through advertising and active recruitment. If an outstanding diverse candidate is identified, taking into account unique challenges that person may have overcome, that candidate should be hired.

Section 5: Undergraduate Education

All physics departments in Israel have been diversifying their undergraduate tracks to include joint programs with other disciplines. Most departments have introduced more integrated and/or flexible programs, and have added life-science disciplines to the traditional physics-math and physics-engineering programs. Many students are attracted to these programs, and admission criteria are usually very high for the joint programs with EE and CS. Nevertheless, there are potential issues with the level of coordination between departments for these joint-program curricula, and their intellectual coherence varies from place to place and between programs. A greater effort should be made to understand the total set of demands placed on these students, and to ensure that the sequencing of courses, in both departments, makes sense and will not exacerbate stress.

The physics curriculum at most universities is very high-level and challenging. Many students find it difficult to complete the program in 3 years and an extention to 3.5 years might be warranted. In general, the approach to teaching still involves

traditional blackboard instruction for both lectures and sections. Some institutions have a history of using web-based tools, such as videotaped lectures, online lecture notes, and tutorial materials, while in others these are still only gradually being introduced. As a whole, there is very little experimentation with innovative instruction techniques at Israeli physics departments. In this sense, Israeli universities are behind their counterparts in the US and Europe.

Almost across the board, there seems to be a lack of formal student mentorship programs, in which physics faculty systematically track the progress of students. If such programs exist, they are usually aimed at the top students, probably motivated by the wish to keep those students locally for graduate school. Broader mentorship, however, will enhance the well-being and satisfaction of the undergraduate group as a whole, and in turn reflects positively on the experience of top students as well. We also found that while most students find the physics faculty members at their institution to be approachable, there has been little coordinated effort of supplying them with information and counseling regarding post-graduate life, whether in academia or outside academia. This is especially problematic when it comes to careers outside academia, about which individual faculty members are typically less knowledgeable.

The lack of structured mentoring probably affects female students more adversely, both because they tend to have more ``climate issues'' and because they are less likely to seek out mentoring on their own initiative. Similarly, simply because most physics faculty and graduate students are male, female undergraduates are less likely to learn about career strategies via informal, social channels.

This trend continues with alumni. Traditionally, departments have had virtually no connection with their alumni, and know little about where their alumni end up, especially if they pursued careers outside academia. Some departments have recently started to create databases with alumni information, and to invite them back to the department. The alumni we met were very positive about the prospect of maintaining some ties with their alma maters. They were also willing and happy to contribute their experience and wisdom to informing students about career prospects outside academia. The alumni represent an extremely valuable and untapped resource, which could help compensate for the lack of faculty counseling that is present at most institutions.

Virtually all students we met expressed the view that a physics BSc is insufficient for careers outside academia. This is a major reason for pursuing a dual physics engineering, or physics-CS degree, and alternatively, for continuing towards graduate studies in physics. It is unclear to us how accurate this perception is, and it probably merits further study and thought by the departments, perhaps with the leadership of the IPS. The situation is markedly different in the US, where physics graduates are perceived as problem solvers and innovators, since they are taught ``how to think''. Indeed, the alumni we met said that the top people in their companies are often physics graduates. It would be a good idea for the departments to engage with their alumni, and with industry leaders, in order to try

to better understand this problem, and potentially change the current perception of physics studies.

Section 6: Graduate / Post-Graduate Training

In general, graduate student training is one of the high points of the Israeli physics community. Israelis are sought after for leading postdoctoral positions worldwide. This is because of the accurate realization that they are among the best-trained graduate students anywhere. Nevertheless, there are still some areas for improvement. Our discussion below is not focused on recommending major changes, but on suggestions for how to make this system even stronger. In some cases, practices already in place at one or two institutions could serve as models of better practices elsewhere. In other cases the entire community might want to rethink some aspects of the graduate student program.

Research Monitoring: One issue that came up in many departments concerns monitoring of progress towards a successful thesis, either at the PhD or MSc levels. In all departments, students submit a PhD thesis proposal to a committee, some of whose members are in the same field of research. In a minority of institutions, this committee tracks student progress throughout the thesis research, meeting several times with the student and his/her advisor before the final defense. We believe that this practice should be made more universal. At places that do not have this type of monitoring system, misunderstandings between the student and the advisor can lead to major problems if not handled appropriately and expeditiously. Having other faculty members formally tasked with keeping track of student progress can be very important for rare difficult cases. We also feel, with a lesser degree of urgency, that similar monitoring practices would be useful for the thesis part of the MSc program.

Direct-track PhD option: The situation with respect to the availability and desirability of the direct PhD track seems to us to be rather haphazard. Decisions are made by individual faculty members, in some cases, without any existing departmental policy or oversight. We believe that there are good arguments in favor of each of the two possibilities, of the traditional MSc with thesis versus the accelerated approach. The argument for the latter is mainly speed, since a student who is already firmly attached to a research group can save a half to one year with no loss of thesis completeness or excellence. However, for students who are less certain of their path, doing the MSc thesis creates a natural breakpoint. They can decide whether or not to directly proceed to the PhD program, or whether their current research direction is the best choice for their future studies. Given that different paths may suit different students and different research groups, we do not feel that there should be a unique choice made available by any institution. Instead, the department should have clear guidelines about these possibilities and offer information and guidance to all incoming students to enable the best outcomes. Also, gathering statistics regarding outcomes for these different paths might help optimize the overall system in the years to come.

Curriculum: A final point, regarding graduate education, concerns curricular issues. The field of physics is constantly reinventing itself. New areas of research (e.g. molecular and cellular biophysics, machine learning, climate science and remote-sensing, foundations of quantum mechanics) are attracting much more interest then would have been the case several decades ago. The same is true in reverse for other subfields. It has typically been difficult for the core and elective aspects of the curriculum to adapt to these developments at a fast enough rate. This presents challenges for the individual departments: Some of their required courses may no longer have much relevance to the research topics of many of their students. On the other hand, courses that such students might require, may not be available, or may be taught only irregularly as electives. Students who work on interdisciplinary projects, or who want to move towards industrial applications, may find it difficult to take desired courses from non-physics faculty. We therefore urge Israeli institutions to find ways to make their curricular requirements and options more flexible. Possible steps include lowering the barriers to taking courses from other departments or faculties, making it easier for students to take courses at other institutions or on-line, and revisiting the basis for the selection of required courses. Information about how best to proceed can be gathered from targeted discussions with advanced students and interested faculty.

Postdoctoral Researchers: Our impression is that the size of the postdoctoral population in Israeli physics is growing. This is generally a good sign, as it means that physics departments are becoming more international, and are more able to recruit researchers in competition with overseas institutions. But there are also challenges presented by this trend. The majority of the postdocs have no familiarity with Israeli society when they arrive, and they typically need significant help adjusting. Most institutions seem aware of this problem, and have programs run through their international centers available for foreign postdocs. However, there may be aspects to this that still require further consideration. For example, it is unclear to us how much help is offered to postdocs to prepare them for the ends of their terms. Typically, they will have to move elsewhere for an additional postdoc, or perhaps for a more permanent position.

A second issue is more delicate: In many fields, and at many institutions, Israeli postdoctoral positions are still not competitive with the best such positions in the US and Europe. That means that in many groups, there will be a perception, perhaps accurate, that the postdocs are not as promising or even as skilled as the domestic Israeli students. In such situations, it takes special attention to ensure that the postdocs are not treated as second-class citizens. We did not have the opportunity to meet with postdocs as a separate group at most of the institutions we visited, so we are unclear how extensive this problem may be. In any case, we encourage the Israeli departments to create channels for postdocs to air their concerns, to do a better job tracking career paths for ex-postdocs, and to impress upon the faculty that making the postdoctoral experience as positive as possible will clearly help make the overall recruitment more successful in the future. The IPS could also play a role in looking at ways to improve the physics postdoc experience nationally.

Section 7: Other Miscellaneous Topics

Laboratory Support for Experimental Groups

Our understanding is that with the exception of WIS, experimental groups at the various universities are provided support at the level of 0.5 technicians per group. In some cases, groups have bonded together to share a single individual, while in others, a single group has supplemented the half-salary provided by the university with research funding, so as to come up with the full salary. While all groups are appreciative of the support they have been given, there are a number of problems with this system that could threaten the success of the experimental programs.

First and foremost, we were told that the salaries provided for such positions are low, and that in general they cannot be augmented, even if additional resources are available. Our understanding is that this limitation applies to tenured university positions, only, and that more flexibility might be possible when these are treated as pure soft money positions. In any case, the two possible alternatives of job security and low salary, or higher salary without job security, make these positions unattractive to qualified candidates, compared to what they can easily get in high tech industry. The net result is that it is difficult to recruit and retain key people.

A second issue is that, for many groups, what is really needed is an experienced, knowledgeable PhD scientist, familiar with the particular experimental apparatus, rather than a simple technician. This makes it difficult to share individuals between groups. In addition, more senior scientists, with these characteristics, are usually less inclined to want to take jobs with few opportunities for individual leadership. This is a problem even for WIS, where staff scientists are not permitted to apply for grant funding on their own. They must work through a faculty member.

This problem has many facets to it, some of which may be intractable, but we highlight it primarily because it appears to be generic at most of the universities. Creative solutions at the institutional level must be found to make these positions attractive.

Membership in the European Southern Observatory

An issue that has been of particular interest to the astrophysics community in Israel, over many years, has been whether Israel should pay for membership in the European Southern Observatory (ESO). The costs are significant, so this is not an easy question, but the benefits to the community could be enormous, and possibly even crucial to the future of this field within the country. Astrophysics is an observational discipline, and, to meaningfully address some of the most pressing questions in the field, it is essential to have access to “big glass.” Even for those university groups that are primarily theoretical, the ability to occasionally conduct observational investigations to test theoretical predictions is key to their success.

Membership in ESO provides a nearly ideal opportunity to meet this need. It has emerged as the leading ground-based optical/infrared facility in the world, and it will eventually provide the most advanced capabilities for faint object imaging and spectroscopy when the European Extremely Large Telescope is completed. Membership in ESO would enable Israeli physicists to not only pursue cutting edge observational programs, but it could also allow Israeli instrumentalists to play key roles in designing and constructing the world's most advanced astronomical instruments.

The case for Israeli membership in ESO is similar, in some respects, to that which motivated Israeli membership in CERN, with hardware involvement in ATLAS. The achievements of the Israeli ATLAS group are numerous, and have been well worth the investment, in our view. There are actually more astrophysicists in Israel who would be positively impacted by ESO membership, than there are experimental high energy physicists. Given the ingenuity and creativity of Israeli astrophysicists, we have no doubt that they will make outsized achievements to science with ESO as well.

We are aware that the topic of Israeli membership in ESO has been under discussion for a while. However, we believe that the time has come to take this proposal more seriously. Most of the Israeli universities now have observers on their faculty. Taking this step will have a very positive impact on an important component of the Israeli physics enterprise.

The Israeli National Physics Laboratory (INPL)

The role of the INPL is to maintain the Israeli standards for metrology, and also to take responsibility for calibrating the equipment used to verify those standards by all labs that provide services for industry and trade in Israel. In that sense, it is not unlike the US National Institutes for Standards and Technology (NIST). Such organizations are crucial to any country with a high-tech economy, so that standards are kept to the highest level. A vice president of Boeing, the largest exporter in the US, stated that without NIST they could not sell airplanes. Since Israel is strong in high-tech overall, the INPL is crucial to Israeli production and the Israeli economy.

This vision for the INPL is complex, and there are many potentially challenging roles and responsibilities. However, the current state of the organization is clearly subcritical. With only four employees, one of whom is the Director, INPL cannot suitably meet its desired goals. Significantly increased support from the Israeli government is essential.

A way to follow through on getting advice for a useful path to strengthen the INPL would be to become more involved with the International Union of Pure and Applied Physicists (IUPAP), of which Israel is a member. Commission 2 (C2) is devoted to standards, and its title is Commission on Symbols, Units, Nomenclature, Atomic Masses & Fundamental Constants (SUNAMCO). Their mandate is "to promote the exchange of information and views among the members of the

international scientific community in the general field of Fundamental Constants." A list of their members can be found here: http://iupap.org/commissions/commission-on-symbols-units-nomenclature-atomic-masses-and-fundamental-constants/members/

We were asked to evaluate what if any role the Israeli universities might play in helping INPL evolve into a topflight institution, commensurate with its counterparts in other countries. In general, we would not expect any of the existing physics departments to take a strong interest, if the INPL portfolio continues to be restricted to making a limited series of measurements using well-established techniques. However, if the INPL program could develop a more research-oriented component, leading to the invention of new more advanced techniques for precision metrology, then this could become attractive. Given its physical proximity to HUJI, it would make sense to conduct such discussions with the Racah Institute, but there might also be other institutions, most notably BIU, who could also be interested.

Section 8: **Recommendations**

CHE/PBC

- Encourage greater collaboration among the Israeli physics community. The Israel Physical Society should be engaged to convene regular meetings of physics department chairs, where topics of common interests, and strategies to strengthen the impact of Israeli physics worldwide, could be discussed. The PBC should make some funding available for cross-institutional research efforts on topics of common interest.
- Provide funding to enable Israel to join the European Southern Observatory. This should be an essential element of the national strategy for Israeli astrophysics moving forward. All of the universities now have significant astrophysics programs, and enabling a world-competitive observational capability for these groups is crucial for their future success.
- Reexamine the approach taken to provide technician support for experimental physics groups at universities. The present allocation, 0.5 technicians per group, and the salaries allowed for these positions, are not sufficient to recruit and retain individuals with the necessary skillset to keep these groups functioning optimally. For many groups, the necessary support will involve PhD-level scientists, familiar with the equipment and advanced techniques. Such scientists require some level of recognition and independence for their professional fulfillment.
- Work with other government funding agencies to improve the state of the Israeli National Physical Laboratory, and its connection to the university-based physics community. The INPL is subcritical in its current state, and requires a substantial increase in funding to become viable. In order to engage the university departments, a research-component of the INPL mission, leading to the development of new techniques for precision metrology, must be instituted. Some guidance in bringing this about can be obtained from Commission 2 of the International Union of Pure and Applied Physics.

Institutions

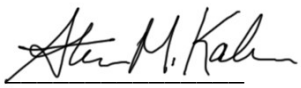
- Take proactive steps to increase the diversity of the student and faculty populations. Affirmative action does not mean lowering standards. Concrete approaches to extended outreach to underrepresented groups will result in their increased representation. There are numerous "best practices" that have been developed in the US and other countries for this, and they have proven success.
- Consider modifications to the typical faculty-hiring paradigm in Isreal to mitigate elements that discourage women. Of principal concern is the "requirement" that promising faculty candidates must go abroad for extensive periods of time before they can be considered for faculty positions. While establishing a worldwide reputation should remain a key criterion for appointment, we believe that there may be other ways of achieving that reputation without causing undue hardship for women with families.
- Examine the effects of over-representation of women in lower status academic roles. Given the difficulties for women in obtaining faculty positions in Israel via the usual route, they are not surprisingly over-represented in lower status physics jobs. This has a pernicious effect, not only on their morale in these jobs, but also through the message it conveys to female students interested in purusing a physics career. This should be examined at the institutional level, to see what potential mitigations might be invoked to improve the situation.
- Provide increased counseling to foreign postdocs. Foreign postdocs often face particular challenges in adapting to Israeli customs and culture. Many universities do provide counseling for them through their internation centers, but the practice is not universal. Rarely do postdocs receive advice, however, in planning for their future after their postdoctoral appointments terminate. While the departments should take primary responsibility for this concern, additional help at the institutional level is also warranted.

Physics Departments

- Improve coordination with the other departments for joint degree programs with physics. Students need assurance that the demands of the joint program are understood by both relevant departments. Particular attention should be paid to the sequencing of courses from semester to semester to even out the workload.
- Consider more modern approaches to classroom teaching. There have been many studies showing that students develop a better command of physics when their classes are taught in an active learning environment. Israel is behind other countries in implementing such techniques.
- Improve student mentoring, with particular attention to advising them on post-graduate career opportunities. Students receive little advice on what opportunities their physics degree might offer for post-graduate employment, especially for non-academic careers. Departments should engage outside speakers, including their own alumni, to advise students on these topics.
- Develop real plans for increased interactions with alumni. The alumni represent an untapped resource for the department. They generally appreciate contact from their alma mater institutions, and they can be helpful in a variety of ways.

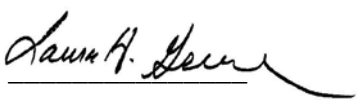
- Work with alumni and industry leaders to better educate the public on the value of a physics education. Physics teaches its student how to think in interesting, problem-solving sorts of ways. Such training is enormously valuable for many professions and applications. We believe that the physics degree is under-appreciated in Israel in comparison to other advanced countries. The departments can take a more proactive role in helping to alter the public perception in this arena.

Signed by:

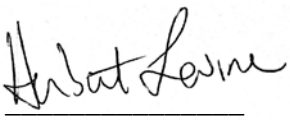


Prof. Steven Kahn

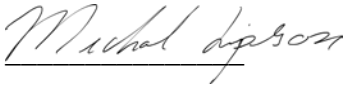
Committee Chair



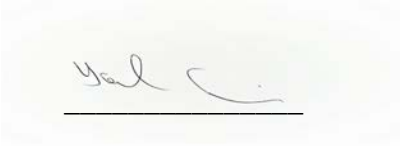
Prof. Laura Greene



Prof. Herbert Levine



Prof. Michal Lipson



Prof. Yael Shadmi

Appendix 1: Letter of Appointment

December 2018

Prof. Steven Kahn
Department of Physics
Stanford University
USA

Dear Professor,

The Israeli Council for Higher Education (CHE) strives to ensure the continuing excellence and quality of Israeli higher education through a systematic evaluation process. By engaging upon this mission, the CHE seeks: to enhance and ensure the quality of academic studies, to provide the public with information regarding the quality of study programs in institutions of higher education throughout Israel, and to ensure the continued integration of the Israeli system of higher education in the international academic arena.

As part of this important endeavor we reach out to world renowned academicians to help us meet the challenges that confront the Israeli higher education by accepting our invitation to participate in our international evaluation committees. This process establishes a structure for an ongoing consultative process around the globe on common academic dilemmas and prospects.

I therefore deeply appreciate your willingness to join us in this crucial enterprise.

It is with great pleasure that I hereby appoint you to serve as chair of the Council for Higher Education's Committee for the Evaluation of **Physics** departments. In addition to yourself, the composition of the Committee will be as follows: Prof. Laura Greene, prof. Herbert Levine, prof. Michal Lipson and prof. Yael Shadmi.

Ms. Maria Levinson-Or will be the coordinator of the Committee.

Details regarding the operation of the committee and its mandate are provided in the enclosed appendix.

I wish you much success in your role as a member of this most important committee.

Sincerely,

Prof. Ido Perlman
Vice Chair,
The Council for Higher Education (CHE)

Enclosures: Appendix to the Appointment Letter of Evaluation Committees

cc: Dr. Varda Ben-Shaul, Deputy Director-General for QA, CHE
Ms. Maria Levinson-Or, Committee Coordinator