



# A Year at Perimeter Institute

Perimeter Scholars International (PSI)  
Master's program in theoretical physics



Anna Knörr  
supported through an  
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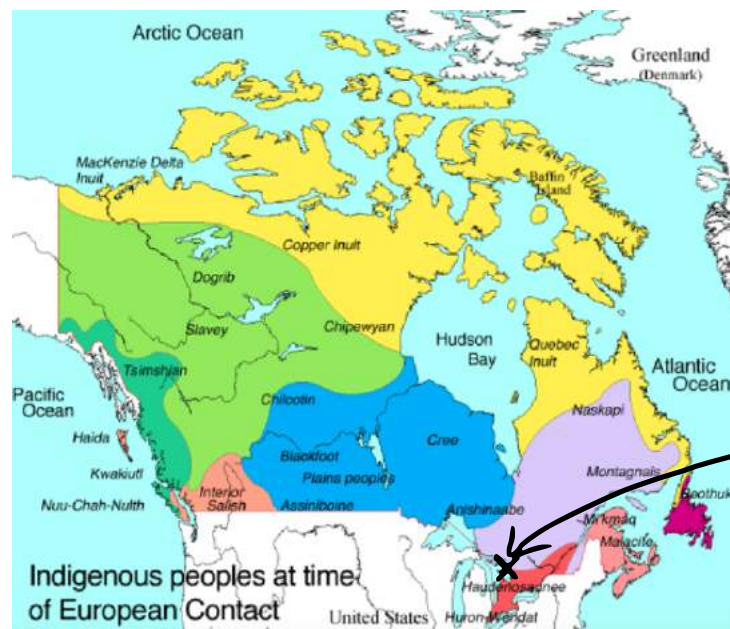
Sept 2021 - June 2022  
Waterloo, Canada

## Territorial Land Acknowledgement<sup>1</sup>

Perimeter Institute acknowledges that it is situated on the traditional territory of the Anishinaabe, Haudenosaunee, and Neutral peoples.

Perimeter Institute is located on the Haldimand Tract. After the American Revolution, the tract was granted by the British to the Six Nations of the Grand River and the Mississaugas of the Credit First Nation as compensation for their role in the war and for the loss of their traditional lands in upstate New York. Of the 950,000 acres granted to the Haudenosaunee, less than 5 percent remains Six Nations land. Only 6,100 acres remain Mississaugas of the Credit land.

We thank the Anishinaabe, Haudenosaunee, and Neutral peoples for hosting us on their land.



Location of Perimeter on a map respecting the indigenous people's view of the land

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<sup>1</sup>In recent years, there has been a huge upsurge in awareness of indigenous peoples' rights and traditional territories. The most prominent topics addressed include the residential school system which approx. 150 000 indigenous children were subjected to up until 1997. The Truth & Reconciliation Commission (TRC), active from 2008-2015, was the Canadian government's first in-depth response to uncover truth behind this system of assimilation and address the induced trauma. A second acute issue is the *Missing and Murdered Indigenous Women and Girls* movement that is calling attention to female homicide. Perimeter acknowledges indigenous peoples' rights by including the above statement at the beginning of many presentations, lecture notes etc. An Anti-Racism group is also part of the institute's Equity, Diversity & Inclusion (EDI) platform.

## What & who is Perimeter?

Before diving into my experience of being at Perimeter, let me introduce you to this place, its mission, its character. Perimeter is a theoretical physics institute on Turtle Island (or more specifically in Canada), founded just over 20 years ago. It was the brain-child of Mike Lazaridis, the founder of BlackBerry, who wanted to do things differently: In 1999, he decided to invest \$100 million to fund a home for talented physicists to think freely about Big Questions<sup>2</sup> and put a young physics PhD graduate in charge of setting the place up.

When you enter the building, you will walk past the slogan “*Today’s theoretical physics is tomorrow’s technology*”. This was the guiding idea that motivated Lazaridis to found the institute and indeed, the Advancement team at PI - responsible for crafting the institute’s public image and securing new funds – plays heavily on the potential power of breakthroughs in theoretical physics in shaping future society in the long-term. “*Perimeter is a 100-year project*”, you will often hear.

Seeing and hearing these words on a daily basis has made me reflect a fair bit on the role of theoretical physics in society. I would affirm that the body of knowledge this research community produces is a valuable resource for more applied communities to draw from<sup>3</sup>. The ensemble of theoretical physicists will have a significant impact on society. On an individual level, however, it is somewhat futile to pinpoint the direct impact of one’s research on society – that is simply not what drives people at place like Perimeter.



“*Today’s theoretical physics is tomorrow’s technology*”: PI’s slogan next to the entrance door

I think most researchers at PI would state that they do what they do thanks to curiosity

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<sup>2</sup><http://reviewcanada.ca/magazine/2009/06/creating-another-einstein/>

<sup>3</sup>For an exact description of how an insight from theoretical physics trickled over into technology, I would like to look more closely at specific examples: The case of the steam engine and thermodynamics seems to be quite different than solid state physics and transistors, in terms of whether the invention or the theoretical understanding motivated the other.

and passion for the subject matter itself and the conceptual or analytical tools employed. The combination of an overarching goal within their specific research community – be it quantizing gravity, explaining dark matter etc. – together with honestly finding enjoyment in the day-to-day business of working through lengthy derivations or digging through code is why they are here. Plus the warm-hearted environment that PI is rightly proud of :)



A wintery PI in front of the frozen Silver lake.



A close-up of PI in fall ... credits to fellow PSI on Zheng & his photography skills <3

Perimeter from different angles, in different seasons...

Over the years, Perimeter has moved from being humbly housed in an old post office to its own dedicated, prize-winning building: the Stephen Hawking Center. The building overlooks the affectionately (and superlatively) called Silver Lake and is separated from the nearby University of Waterloo by no more than a 10 minute walk through a park. Moreover, PI has grown significantly since its inception and attracted a long list of renowned thinkers – you will bump into people such as Lee Smolin or Carlo Rovelli in the corridors; the late Stephen Hawking himself was PI's first Visiting Research Chair.

Today, Perimeter is home to roughly 60 resident PhD students, 50 postdocs and 30 faculty members. Hence, it's quite a small place, very different to a university like ETH. Indeed, Perimeter has a strong family feel to it – everyone knows each other, everyone eats lunch and dinner together in the Black Hole Bistro. There are many open spaces for people to sit down with tea or coffee for a casual chat or to discuss some physics at one of the ubiquitous blackboards.

And who are the children in the family? The PSI students. Every year since 2009, the institute welcomes between 20 to 30 master-level students to its premises to experience a 10-month deep dive into theoretical physics, ranging from quantum gravity and quantum foundations via string theory to strong gravity, cosmology, quantum matter, information and more.



Zheng, Astha, Danaan and Cynthi discussing some Feynman diagrams in the Atrium :)

What's special about PSI? For those who are short on time, here's the main message from my report below on the past year: One does not simply study physics, one lives physics. The program is fueled by continuous immersion and discussion with PI's faculty, postdocs and PhD students as well as with your fellow PSIONS. It was an incomparable educational experience and a huge contrast to the exam-based undergrad at ETH Zurich. It really shifted my physics-self-identity from diligent student to budding researcher.

Even more importantly, the year also heavily shaped my world-views as a whole. I lived 24/7 with an incredible mix of youngsters coming from such different walks of life. In terms of nationality, we came from Chile, Brazil, Ecuador, USA, Canada, Spain, Greece, Norway, Germany, Iran, India and China. Socio-economically, our group included many from highly disadvantaged households (fully funded by PSI scholarships). They opened my eyes to the political realities of e.g. Latin-America or Iran. Half of our group identified as bi, gay or lesbian. Each person was a real character; funnily we didn't have a single pure physics nerd.

The year was more socially intense than anything I have experienced before – I learned more about people than physics and that is saying a lot. We formed bonds so deep we call each other second family. Thank you, dear PSI family... I miss you!



Much love to my PSI family!

## Applying for Perimeter

So why did I end up at this place in south-eastern Canada? To be honest, it was by random happenstance. I was in the third year of my physics undergrad at ETH Zurich, not thinking much about choosing a master's degree. I was having a great time – feeling finally settled in to the beautiful city, having accustomed myself to the alternating rhythm of *Semester* and *Lernphase*, having found a community in extracurricular networks like the Student Sustainability Commission (SSC) that gave me a sense of commitment and purpose.

One afternoon in mid-October, I was checking some news on the DPHYS homepage when a link posted by Prof. Renato Renner's group caught my eye: His postdoc Misha Woods was giving a talk at a conference entitled “Quantizing Time”<sup>4</sup>. Hmm, sounds interesting. I clicked on the post and landed on the homepage of Perimeter.

Procrastination mode switched on, I started browsing the site and soon discovered that the institute offers an unusual 10-month master's program called Perimeter Scholars International (PSI). While being explicitly focused on theoretical physics, it promises to introduce students to the full breadth within this discipline.

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<sup>4</sup>In case you are curious, listen in to the recording of Misha's talk “Measuring time with stationary clocks” here. Indeed, you can find recordings of all and any lectures or talks given at PI on the PIRSA online video archive.

Two parts of the program's '*PSI is the perfect program for you if...*'-description immediately captivated me:

*"You want to immerse yourself in theoretical physics, push your limits, and experience a once-in-a-lifetime physics "boot camp" among like-minded peers from around the globe."*

*"You value collaboration over competition and are interested in conducting research-driven coursework alongside some of the world's leading theoretical physicists."*

Hands-on learning-by-doing? Where do I sign up?! While I did appreciate the depth of study encouraged by ETH's system, the immersive approach of the PSI curriculum whetted my appetite. After three years of passing exams and being repeatedly nagged by certain other students whether or not I had gotten 0.25 extra points on this or that question, the prospect of replacing exams by daily contact with physics *researchers* appealed to me enormously.

Without much further ado, I wrote up a statement of purpose in time for the mid-November application deadline. Reference letters were also required – I am still very grateful to my professors for writing them on such short notice.

In mid-December, I received an email invitation to a 30-minute online interview. I was asked to prepare a short 5-minute input on a physics topic I found interesting. I opted for setting up a bedside lamp next to my laptop from which I hung a few colorful strings. These I used to explain the concept of braiding anyons in topological quantum computing. The rest of the interview consisted of a few physics questions (nothing too hard, just some basic electromagnetism and a special relativity puzzle). To finish, I was given a few minutes to ask questions about the program. The day after the interview, I received my acceptance letter via email – a real Christmas treat!

For anyone interested in applying for the program, I would emphasize that one should simply show one's personal character and joy for physics both in the statement of purpose as well as the first section of the interview. PSI does not look for pure nerds. Rather, the PSI fellows aim to put together a cohort of dynamical, cooperative, social youngsters that will have a great time exploring physics together and supporting each other. Indeed, the interview as a whole, including the physics questions is just intended as a check that you are a human capable of social interaction and feel comfortable talking through a physics problem – a skill essential to the PSI curriculum. Finally, the focus on social- and open-mindedness is further enhanced by every applicant having to submit a statement about the role of EDI (equity, diversity and inclusion).

## Arriving at Perimeter

Half a year later, I packed up my belongings in *Leonhardstrasse 12*, right next to ETH. I should mention that during the intermittent months, I had been having a few qualms about leaving Zurich. I felt a growing sadness realizing I would be leaving a social network behind. A community that had only just started to reawaken after the worst of the first Covid lockdowns had subsided. I also felt some cognitive dissonance advocating for *staying grounded* in academia, as part of the SSC mobility team, whilst knowing the overseas flight to Canada would emit a tonne<sup>5</sup> of CO<sub>2</sub>.

Yet off I went and soon the melancholy gave way to a burst of adrenaline as I set foot in Toronto on 1st September 2021 and stepped out of the cab that took me and Sotirios – my first PSI acquaintance who had happened to be on the same flight – straight to the campus we would soon start calling home.

For context, PSI students are formally students at the University of Waterloo (UW) since Perimeter Institute itself is not a degree-granting institution. This implies that PSI students are housed in the same area as UW undergraduates. There we have one floor of a dormitory building all to ourselves where we are grouped into apartments of 2-3 people. Without doubt, this 24/7 proximity added to the incredible closeness our cohort developed over the ensuing months.

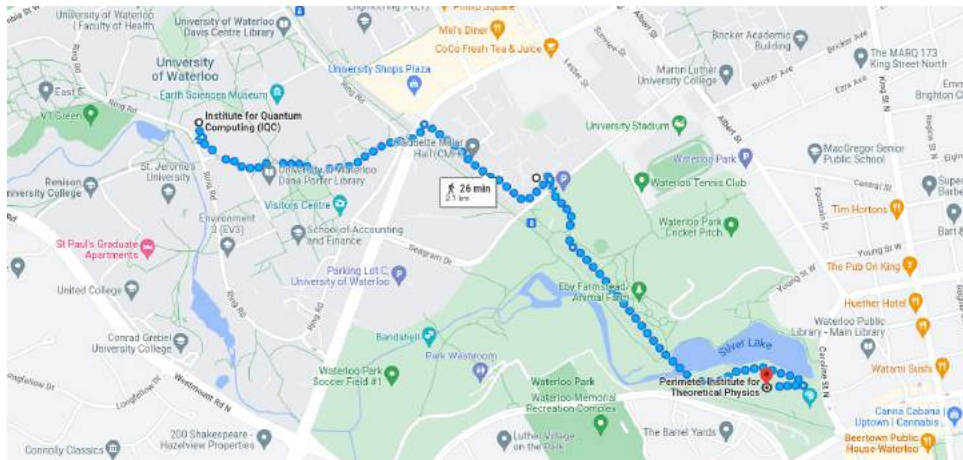
From these dormitories, it is a 15 minute walk to e.g. UW’s Institute for Quantum Computing (IQC) in one direction and a 10 minute walk to Perimeter in the other. As with almost all other matters of practical daily life, the PI support staff takes care of arranging housing in order for PSI students to be able to settle in quickly and make full use of the precious ten months. You literally don’t have to lift a finger.

Upon arrival, Sotiris and I got straight into the mood of North-American campus life. Regardless of the frankly very bland architecture of the dormitories, the friendly “*We’re so happy you’re here!*” posters hanging at every corner, together with the many volunteers swarming around the parking lots made for a very welcoming atmosphere.

This feeling was only deepened by an encounter I would now deem prototypical of Canadian helpfulness towards strangers. As you can imagine, Sotirios and I were somewhat immobile with our big bulky suitcases. Enter Wilson. Wilson is a beaming student with a big heart from IQC. That day he was just strolling around the dorms hoping to meet some new arrivals. By the end of day he had not just helped us move our luggage up into our apartments, but also walked us over to Perimeter, taken us on a tour of “uptown Waterloo” and invited us to one of his upcoming parties. Needless to say, we’ve made many memories

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<sup>5</sup>Estimated using the myclimate Flight Emissions Calculator.



The short walk from e.g. UW's Institute for Quantum Computing (IQC) via the docks through the park over to Perimeter



Feeling welcomed to the UW campus, together with fellow PSIon Sotirios from Greece!

since then :)

## Settling in to Perimeter

Over the next few days, the dorms started to fill up: My own roommates: book-worm Shawn from the province of Manitoba (Canada) and my Forró-dancing 'big sister' Carol from Brazil. Next door: goofy Sofia from Spain - the most authoritative source for cringy physics & sex jokes for miles around - and Boba-loving, piano-playing Anna B. from Québec (Canada) with a Swiss-Chinese heritage. Further down the corridor our cosmology duo: fiery Javi from Chile, always ready to defend the rights of her country's poor, paired up with our group-mom (& pony-champion) Jordan from BC (Canada). Next, the trio of

cheekily elegant Merengue-master Cynthi from Ecuador, untameable street-dancing Astha from Rajasthan (India) and cheerily cynical, communist-affine Danaan from BC (Canada).

On the boys' corridor: flamboyant fashionista Jaime from Madrid together with our bass-playing baking chef Gabriel from Brazil, proudly raised-by-the-Internet. Dearly huggable Amirezza from Iran, my soon-to-be-boyfriend Eivind from Norway and chuckling Mathew B. from nearby Toronto with his witty political commentary. Zheng from China – full of surprises and a master of calligraphy, cooking and photography; Matthew F. from Colorado (US) – usually to be found hanging from a boulder or asking his app which Everettian branch of the wave-function he is on; Marcelo with the most soothing Brazilian voice. Finally, the comical trio of proudly Mediterranean Sotirios from Greece - often spending too-long-nights at PI battling his perfectionist instincts, wise Manu from Madhya Pradesh (India) with a deep love for the philosophy of his home country, and chill Charlie from Tennessee (US) whose patience in explaining the Hayden-Preskill protocol and more I am still grateful for  $\odot$ .

Simultaneously, we started to settle in to the institute on the other side of the park: I remember the exhilaration of entering Perimeter for the first time! Cracking open the door to the Time Room – the lecture hall with  $270^\circ$  of blackboards. Enjoying the morning sun shining through the big windows of our very own PSI study room. Being spoiled with good food by the staff of the Black Hole Bistro. Discovering the Space Room, the Gravity room, the Feynman lounge, the Alice and Bob rooms... Wandering up and down the skew stair cases, through the beautiful glass-walled corridors you can write on... Relishing the intentional architecture that takes you on smart paths through the entire building to let people bump into each other and thus invite everyone to talk with everyone.

## Diving into courses

Courses also kicked in from day one. 'Twas still Covid so we started off with a flipped-classroom style: Watching snippets from lectures recorded in previous years, mixed together with short quizzes into weekly modules. I quickly learnt to look forward to the tutorials which we could do in person – very active, very intense. In groups, you work through conceptual questions and calculations that activate the knowledge you (hopefully :p) listened to the very same morning.

### Outline of PSI curriculum

Due to its unusual curriculum, I thought it might be helpful to briefly summarize the PSI curriculum: During the first three months (Sept-Dec) one learns the advanced basics of theoretical physics in three sets of one-month-long **core courses**, with two courses running in parallel during each set. The exact



Astha proving her strength on Marcelo...



Nap time!

Important use cases of the PSI study room...

combination of classes varies but will contain a review of classical physics and quantum theory to bring everyone onto the same page and then proceed to cover the basics of general relativity, quantum field theory and statistical physics.

To pass each course one must attend tutorials, hand in homework assignments and have a conversation about the material with the lecturer at the end of the month (also called the "interview" but it's honestly very casual). There is no prep phase for these interviews in contrast to the *Lernphase* that preceds most exams at ETH. Instead, PSI follows the mentality of learning through immersion where your mind directly starts processing the concepts as they are being presented in lectures. You spend so much time discussing the material in the PSI room and writing down notes and assignments that you will simply be "in the GR mindset" etc. by the end of the month<sup>a</sup>.

These core courses are taught by a dedicated staff of **PSI** fellows. These are a team of researchers who have shifted their focus from pure research to education. Not only do they do their very best to create engaging tutorials full of cringy physics jokes, lend you quantum-field-theory-versions of Memory to play over

the winter holiday and offer daily office hours for questions. In addition, every student is assigned a mentor to regularly check in how things are going in general<sup>b</sup> :)

After the winter break, it is time for three sets of **elective courses** (Jan-April). These are specialized courses taught by various members of PI's faculty on their own areas of research (see Table 1 below for a overview of topics on offer in 2022/23). You are free to take as many of these courses as you wish, with a minimum of six courses in total. These courses do not culminate in an interview and you are not expected to come away with a solid understanding of the respective field. Rather they are intended to *expose* you to a broad range of current hot topics – if a particular idea excites you, then feel free to explore it in as much depth as you please. The only requirement is tutorial attendance and handing in homework assignments in which you will carry out typical derivations, simulations or arguments that will help you start researching in this field.

Furthermore, the electives' period is interspersed with the PSI winter school: For two weeks in February, you get to work intensely in groups of 2-4 students with a PI faculty member on a short research project. The aim is to offer you the opportunity of get research experience in a field beyond your PSI essay. In case this isn't enough, you are also more than welcome to attend any of the daily seminars and lunches or meet for a 1-on1 chat with PI's faculty.

Finally, the month of May is dedicated to writing up your PSI essay, essentially a short master thesis<sup>c</sup> (max. 30 pages). Students typically find a supervisor towards the end of the core course phase and conduct their research in parallel to the elective courses. The program ends with the defense of the essay (20 minutes + 40 minutes of questions) in mid June.

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<sup>a</sup>If you do feel you need more time, however, the PSI fellows are happy to accommodate. At the end of the day, your well-being is their top priority, so they emphasize we shouldn't build up unnecessary pressure on ourselves. We should learn out of curiosity.

<sup>b</sup>Similarly, one also gets assigned a PhD buddy to further strengthen the community and give student-perspective advice on PhD applications.

<sup>c</sup>An example very worth reading: Matt's thesis "Quantum-Classical Gaps and Quantum Shallow Circuits" - a mix of quantum foundations and quantum computing, supervised by Rob Spekkens.

I must say, discussing at a blackboard is such a different feeling to working on paper. For me, the sensory fusion of talking and writing, gesticulating and pacing around makes this mode of learning very stimulating - I dearly hope VMP and ETH as a whole will invest in populating study areas with more blackboards! Further, the process of being exposed to ideas in live lectures and online videos, then grappling with these concepts in Q&As plus blackboard tutorials and finally writing up detailed homework assignments on paper<sup>6</sup>

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<sup>6</sup>I should mention that several of us invested our study stipend in a Remarkable tablet. Even though it



Walls = blackboards



Tables = blackboards

Tutorial time = blackboard time!

proved to be a great combination that helped us quickly absorb and consolidate a lot of material.

Another important aspect to highlight is the fact that students have quite different backgrounds. Some will have completed double-degrees in math and physics or obtained minors in computer science. People from Canada or India, for example, will probably have done a four (instead of the European-style three) year undergraduate program; some might already have a master's degree or spent a year as a student researcher at a different physics institute. Curricula in different countries will have laid emphasis on different topics. In any case, there will certainly be people who already have in-depth knowledge on general relativity and/or quantum field theory thanks to having written a thesis in those areas as well as people who have never even had an introductory course to such matters (e.g. me!).

This means learning in PSI is a collective process. You quickly figure out who has expertise in which area. No time for egos – time is better spent learning from each other. This set-up in PSI is intentional: You are supposed to realize that in research no one ever knows everything and you need to learn to share and build off of each other's expertise. Plus, you only really know you understand something if you can explain it... thus, everyone benefits!

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is very pricy, I would thoroughly recommend this tablet for academic purposes. It is so useful for quickly downloading and organizing papers and comfortably reading them on a beanbag without straining your eyes :) Don't be fooled by people calling it an inferior iPad - it is simply not intended for browsing purposes or as an all-rounder device. It's great for what's its designed for, namely focused reading & writing.

PSI Timetable - 2022/2023			
August 17, 2022 - 9:00-10:00 or 4:00-5:00 August 24, 2022 - 9:00-10:00 or 4:00-5:00		Online ice-breaking event Online ice-breaking event	
Courses		Courses	
Classical Physics - Core PHYS 776 Sept 6 - Oct 5, 2022 - 9:00 am Kubiznak		Quantum Theory - Core PHYS 605 Sept 6 - Oct 5, 2022 - 10:45 am Wohns	
Oct 6 - 7, 2022: Classical Physics Interviews		Oct 6 - 7, 2022: Quantum Theory Interviews	
Relativity - Core PHYS 604 Oct 11 - Nov 9, 2022 - 9:00 am Lehner		Quantum Field Theory I - Core PHYS 601 Oct 11 - Nov 9, 2022 - 10:45 am Xu	
Nov 10-11, 2022: Relativity Interviews		Nov 10-11, 2022: QFT I Interviews	
Statistical Physics - Core PHYS 602 Nov 15 - Dec 14, 2022 - 9:00 am Redner		Quantum Field Theory II - Core PHYS 603 Nov 15 - Dec 14, 2022 - 10:45 am Kubiznak	
Dec 15-16, 2022: Statistical Physics Interviews		Dec 15-16, 2022: QFT II Interviews	
Dec 19, 2022 - Jan 2, 2023: Winter Break		Dec 19, 2022 - Jan 2, 2023: Winter Break	
Numerical Methods - Core PHYS 777 Jan 5 - Feb 8, 2023 Schnetter		Mathematical Physics - Core PHYS 777 Jan 5 - Feb 8, 2023 Costello	
Feb 9-10, 2023: Q&A and Interview		Feb 9-10, 2023: Q&A and Interview	
Standard Model - Elective PHYS 622 Jan 9 - Feb 8, 2023 Boyle		Gravitational Physics - Elective PHYS 636 Jan 9 - Feb 8, 2023 Gregory	
Winter School - Feb 13-17, 2023		Winter School - Feb 13-17, 2023	
Particle Physics - Elective PHYS 646 Feb 28 - Mar 31, 2023 Arvanitaki/Huang		Quantum Fields & Strings - Elective PHYS 777 Feb 28 - Mar 31, 2023 Gornis, Gaiotto, Wohns	
Quantum Information - Elective PHYS 635 Feb 28 - Mar 31, 2023 Martin-Martinez		Machine Learning - Elective PHYS 777 Feb 28 - Mar 31, 2023 Hayward	
Quantum Matter - Elective PHYS 777 Apr 3 - May 5, 2023 TBD		Quantum Gravity - Elective PHYS 650 Apr 3 - May 5, 2023 Riello	
Mathematical Physics - Elective PHYS 777 Apr 3 - May 5, 2023 Costello		Cosmology - Elective PHYS 621 Apr 3 - May 5, 2023 Dalal	
		Quantum Foundations - Elective PHYS 639 Jan 9 - Feb 8, 2023 Hardy	
		Winter School - Feb 13-17, 2023	
		Strong Gravity - Elective PHYS 777 Feb 28 - Mar 31, 2023 East and Lehner	
		AdS/CFT - Elective PHYS 777 Apr 3 - May 5, 2023 Kubiznak	

Table 1: Sample course overview of the 2022/23 PSI cohort

## Carving out one's physics interests

After a day at the institute, discussions would often continue at the dorms in the evening. (Yes, the TVs in our apartments had been switched for whiteboards prior to our arrival.) Yet what we discussed was, thank goodness, not just sparked by what the current homework assignment was on; instead it was often sparked by some random question someone was curious about. For example, Sotirios just wouldn't stop trying to see what happens if one doesn't set the torsion to zero in GR :p

Furthermore, a natural broader question to ask each other was *"So, what physics are you interested in?"*. Sounds like a simple question. But I actually found it not so easy to answer with conviction. Quantum info and perhaps cosmology was usually my response, delivered with a shaky smile and scratch of the head. Sure, I thought these areas of physics were kind of cool. But how should I know whether I actually liked a *research* field? I hadn't really done much research yet!

Indeed, perhaps the biggest shock for me upon arrival was the realization of the amount of research experience others had already gained during their undergraduate degrees. An

academic cultural shock of sorts. In particular, many students came from school systems with 4-year undergraduate degree. In these systems, students can often spend every summer with different research groups at their university (or in industry), figuring out their interests. By the end of the four years, they are thus already in the mindset of a budding researcher and (a bit more) ready to apply to 'grad school'.

In this context, the PSI year can rather be seen as an additional “in-between-year” to further refine your interests and as a springboard to help you build academic contacts in North America. (Which, it must be said, do provide a huge boost to any grad application to US universities. Indeed, these applications are quite a gamble otherwise. Some PSIs who had already begun publishing papers during their 4-year undergrads had applied to PhDs in the US in the previous year and were rejected. A few months at PI and writing emails from a Perimeter address helped them get in touch with academic circles here, giving their application the crucial cherry amidst the masses of students hoping to start their PhD at places like MIT.)

For my part, I had spent my summers mostly studying for exams and having not even written a proper Bachelor thesis (ETH physics undergraduates simply spend 3-4 weeks tagging along in a group). I felt it was only now I was properly starting to ask myself that question of *"What physics am I interested in?"*.

This sentiment of having only just exited an exam-focused undergrad was the reason I personally felt overwhelmed by the prospect of a PhD at that time. Hence, I decided to stay out of the application frenzy that kicked in during late fall. I was happy to first settle in to this new place, enjoy exploring, answer that crucial question of what physics I enjoy properly and worry later about what would come the year after<sup>7</sup> :)

## What's next?

Indeed, I ended up being very lucky: Together with Sofia, I am allowed to stay at Perimeter for a second year of master studies with very few requirements - basically a year to focus on research. Actually, I started my second year with an internship at QuEra Computing Inc. in Boston, a full-stack quantum computing startup that is pioneering the use of *neutral atoms* as qubits. I was further lucky to witness the launch of their first finished computer Aquila (256 qubits) just two months after I joined!

I was part of the scientific software team and helped integrate a Quantum Monte Carlo

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<sup>7</sup>For potential PSI applicants, I would, however, recommend thinking a little beforehand about how PSI might fit into your more long-term plans. At least in terms of a plan A, to be modified as you gain new input during the PSI year.



Cuddle-time  $\heartsuit$  during the PhD application frenzy

(QMC) algorithm into QuEra's open source platform Bloqade. Further, I promoted the company's technology in my first public physics talk. Stay tuned for more details in an upcoming article on Perimeter's homepage :)

For the rest of the year (Jan-July 2023), I will be continuing work with QuEra as an external collaborator but will be based back in Waterloo working on research projects with my supervisor Roger Melko and the rest of the *pickle* (more officially called PIQuIL - Perimeter Institute Quantum Intelligence Lab). Roger's background is numerical methods (especially QMC) for condensed matter systems but has moved more and more towards machine learning techniques such as RBMs (Restricted Boltzmann Machines) and RNNs (Recurrent Neural Networks) as well as the interface of quantum computers with artificial intelligence. For example, for my PSI essay I will be using QMC and QuEra's quantum computer to investigate the (2+1)D Ising quantum phase transition first observed in Ebadi et al (2020).

It's only January at time of writing and it has already been an exciting start to the new year - the Canadian Minister of Science, Innovation and Industry François-Philippe Champagne visited PI to announce the inaugural Canadian National Quantum Strategy. Together with other PI research involved in quantum, I was honored to meet the minister prior to the announcement and share thoughts on the future of quantum in Canada.

If you're thinking of coming to Perimeter, are interested in ML and open-source code and just want a group with good social vibes, I highly recommend the pickle. See below a



Honored to discuss quantum with Canada's Minister of Science, Industry & Innovation

summer barbeque party in Roger's backyard. (He himself was off hiking, so he's not in the photo - further evidence of his trust in us :) ).



The beloved *pickle* - such a fun research group with such a cool supervisor Roger Melko!

## Miscellaneous

### Winter School

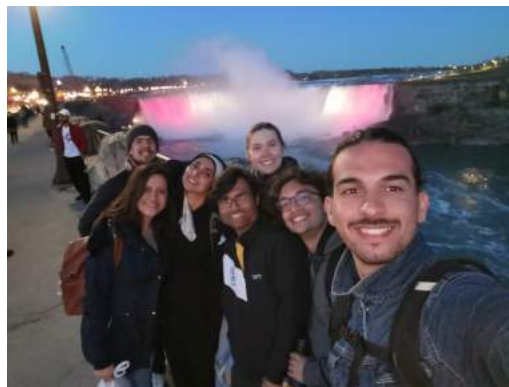
In the new year, I'm also hoping to continue some work on quantum magic that originated in last year's PSI Winter School. I was lucky to be part of the "magic girls" group with fellow PSIONS Anna B, Carol and Astha under the supervision of Prof. David Gosset and Dr. Ziwen Liu. You can browse our presentation at the end of the winter school [here](#).

### Trips

Big highlights and central bonding moments were long-weekend-trips between courses. (After playing the game *hot seat*, i.e. asking each other rather controversial and/or personal questions, for 10 hours on the long drive to Quebec City, for example, does mean one gets to know each other quite well :p). Destinations included Toronto, Quebec City, Montreal and the Niagara Falls.



Manu, Cynthi and Soti in front of Toronto's skyline



Niagara Falls!

Long-weekend trips!

### Christmas abroad

For any potential future PSIONS - don't worry about being lonely if you stay in Waterloo for Christmas. About half of us did and it was one of the most heart-warming evenings of the year as well one of the most cheerful Xmas I have ever spent! One long table full of dishes around the world, dancing on the tables as the evening grew old and with many PSIONS from non-Christian cultures celebrating Xmas for the first time!



A very special Xmas together in Waterloo ☺

### PSI Cult :)

A further testament to the, well, slightly cult-like feelings we developed... half of us got a group wave-function-PSI tattoo!



Ami, Cynthi and I posing with our wavefunction tattoo on a group-trip to Montreal :p

### Equity, Diversity, Inclusion (EDI) Platform

In recent years, Perimeter has put an increasing emphasis on establishing equity, diversity and inclusion (EDI) as part of the institute's values. A centerpiece in PI's strategy is the

EDI platform, home to several groups such as LGBTQ, Anti-Racism, Parental Policies etc. run by motivated PI residents (both on the research and admin side). Recently, PI also employed a full-time senior manager (Ana-Sofia Barrows) to support these groups.

After arriving at PI, I soon realized I missed being engaged in ETH's SSC (Student Sustainability Commission) and hence co-founded PI's Climate Action Group, together with Rob Spekkens. Together, we are working on emission reduction targets for the institution.

Many thanks to our facilities manager Brian Lasher for relentlessly pushing for renewable sources to heat the building with - hopefully we can soon cut approx. 75% of emissions to due heating by switching to air source heat pumps. (Geothermal energy is not possible due to PI's geographical location on top of a water reservoir combined with Waterloo's Clean Water Act). Many thanks also to Dave Fish, part of PI's educational outreach team, in putting together fantastic teaching resources on the physical basis of climate change, adaptation & mitigation as well as climate disinformation. Looking forward to seeing the course soon being rolled out across Canada as part of PI's teacher training program. We are also collaborating with the FlyingLess project to address the culture of flying in academia.

Personally, I am also looking forward to collaborating with PI's Anti-Racism Group in the new year after having been strongly inspired by e.g. the book *Braiding Sweetgrass*. Can we take inspiration from indigenous communities to develop frameworks for sustainable progress and innovation?

## Living in Waterloo

I thought I'd throw in a brief note on living in Waterloo. One of my ETH professors had warned me that I was headed to the "*Ödnis Ontarios*". And indeed, Waterloo is in some sense a weird place. Home to over 100,000 people, you'd think it has a decent amount of cultural and night life. Instead, you'll rather get the feeling of a large spread-out village with one main street (King Street). This is mostly due to the fact that a) a fair amount of people in Waterloo actually work in Toronto where the housing prices are even more ridiculous than in Waterloo. And b) that Canada, like the US, is a car country. Hence, more exciting places are often a drive away.

However, I honestly have to say that right now I love being here. Not only is PI simply a beautiful place (the most beautiful in town). I think that once you have a strong group of friends, you're all set up. Together with work and regular bjj (Brazilian Jiu Jitsu) training - there are many martial arts gyms as well as a great latin dance studio in town! - just hanging out with friends to talk about what's going on in their country (many friends from Iran or Latin America, for example), watch movies, cook, dance etc. is more than enough to keep one happy :)

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For any questions regarding the PSI master's program or the Perimeter Institute, Canadian and East Coast universities in general, feel free to contact me by email ([an.kn@protonmail.ch](mailto:an.kn@protonmail.ch)).