

University of Groningen

Proximity-induced spin-orbit and exchange coupling in graphene-based heterostructures

Ghiasi, Talieh

DOI:
[10.33612/diss.177745582](https://doi.org/10.33612/diss.177745582)

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
2021

[Link to publication in University of Groningen/UMCG research database](#)

Citation for published version (APA):

Ghiasi, T. (2021). *Proximity-induced spin-orbit and exchange coupling in graphene-based heterostructures*. [Thesis fully internal (DIV), University of Groningen]. University of Groningen. <https://doi.org/10.33612/diss.177745582>

Copyright

Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

The publication may also be distributed here under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license. More information can be found on the University of Groningen website: <https://www.rug.nl/library/open-access/self-archiving-pure/taverne-amendment>.

Take-down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from the University of Groningen/UMCG research database (Pure): <http://www.rug.nl/research/portal>. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.

Acknowledgments

It has been quite a long journey in Groningen since I started with the Top Master program of Nanoscience. During all these years, I learnt a lot from many of those who walked along with me in this journey and here I would like to thank them for their guidance, support and company, even though words may not be enough to express my deep gratitude.

I would like to name a few professors I had the privilege to meet, discuss or work with. **Bart**, six years of working with you has been long enough to realize that you are different and special in your own good way. Among all that I learnt from you and your strategic approaches, a couple of them are highlighted for me; You taught me to think out of the box. In our discussion sessions, you with your train of thoughts (that is hard to catch up with) seek for all the possible paths for explaining our observed results. You pointed out the possible contribution of the spurious effect that seems to be commonly mistaken these days for Rashba-Edelstein signal. I appreciate that you could see this through, right on time! You also taught me how entrustment works wonders. You trust and give freedom to your students to follow a variety of new ideas. You have been usually supportive of our wishful thoughts and allowed us to go to the lab and at least try to see whether they can come true. I am so grateful and proud of what we have accomplished during all these years together. Thank you for all your support, all I learnt from you and all the trust you had in me.

I also would like to express my sincere gratitude to my second supervisor and the former coordinator of the top-master program, **Caspar**. Coming from abroad and trying to cope with the new education system, and managing the rather heavy load of the top-master program became doable because we had you, whom we could surely count on. You are definitely a good listener and a great advisor. Thank you for all your support both during my master's studies and my PhD research. I am grateful that I got the chance to work in your lab, though not for too long. Thank you for all the detailed feedback we received from you on our manuscripts and all the insightful discussions we had.

Jaroslav and **Sergio**, I feel privileged to have met you during my PhD research. The fact that your teams were working side by side with us on spintronics in van der Waals systems was a great advantage as we, together, could push the boundaries of our understandings about these systems. So I am grateful for your contribution as I learnt a lot from your input in this area of the field. Also, thank you for taking the time to evaluate my thesis as the members of the reading committee. **Justin**, I am glad that I was your assistant for the solid-state lectures and got the chance to discuss with you about some of the relevant physics concepts for the tutorials. Teaching solid-state physics was an enjoyable experience for me. You have been evaluating both my master's and PhD theses. Thank you very much for your time and input. **Gerrit**, your company in our group meetings was definitely an added value. Thank you for all your interesting questions and comments. I am also grateful for your extensive and helpful feedback on the anisotropy paper, which improved the manuscript a lot. **Petra**, I appreciate your support, in particular, for women in science. You are a good example for many women who want to continue in this path. **Wesley**, thank you very much for all you taught me about the Raman spectroscopy setup and thanks for allowing me to work in your lab. **Beatriz**, my mentor in the top-master program, I am grateful for your support and generous advice during my studies. **Andreas**, thank you for giving me the chance to learn more about biophysics in your lab for my master's short project. **Bart Kooi**, thank you for your kind and encouraging feedback on my talks in conferences, which gave me more confidence. **Tamalika**, thank you for adding to the friendly vibes in our team. And thanks for the many years of organizing and taking care of our group meetings. **Marcos**, thanks for the interesting discussions we had every now and then. I wish you the best with your new venture in academia.

It has been six years since I joined the group of Physics of Nanodevices (FND) as a master student and it just passed by much faster than I could imagine. That is a good sign I would say, as it is said "time flies when you are having fun!". We had a lot of shared meetings, interesting discussions and memorable group-outings. There were and are many wonderful people in the FND that I am so grateful for getting to know and work with them.

Alexey and **Pep**, I feel deeply privileged for having the chance to work with you two and I am truly grateful for all your support all these years. There are countless joyful memories that we share. We teamed up to work on the Friday-project which became my Full-Week-project! Thank you for your brilliant ideas and your trust in me. I learnt a lot from you both. Also, I would like to thank you for being my paranymphs in my PhD ceremony. And thanks a lot for your valuable feedback on this thesis. **Alexey**, it is not easy for me to thank you for so many years of support. I am not sure I will ever find another work buddy as competent as you. Thank you for your kind patience at work and for all the discussions that we had, related or unrelated to work. They helped me to organize my thoughts or adopt a more moderate perspective. I am also very grateful for having the chance to learn about

your outstanding fabrication skills. Your “Russian” confidence at work, also boosted my level of confidence. Thank you for everything. **Pep**, you also helped me through my master’s project. I had no clue about spintronics when I joined the team and it was you who patiently taught me the principles. I cherish all the moments with you, all those coffee breaks, donuts sessions, conferences and trips we went together. My PhD life, both professional and personal, wouldn’t be as great and enjoyable without you. Thank you!

Martijn, the hero in my hard times in Groningen, thanks a million for all your support during all these years. Whenever I was in trouble, if there was one person that I could count on his help in Groningen (no matter what), it was you. Thanks for all the great time we spent together and also for being my patient gym trainer.

Julian, our French guy, you were a great addition to our team. So much joy and laughter, so many amazing memories that I can recall. Even though it was short, I enjoyed our team-work on the magnon transport project. Dave (:p), these years in Groningen wouldn’t be as much fun without you. Missing you so much, since you left... and yes, I am still a big fan of your fat contacts.

Jorge-minator, thank you for all the joy you brought to our team. I was lucky to have the opportunity of working with you and learning from you. Your excellent journaling skills and your pragmatism at work are valuable assets for being a practical researcher. Thank you for all our great memories and also for all those amazing pieces that you played for us as our violinist physicist.

Xu, you are the calmest-ever person I have got to know at work (and even across the borders!). I am happy that I had the chance to work with you, even though it was a bit hard for me to adjust my pace ;). We also share a lot of cheerful moments that have made my memories richer. Thank you for all of that.

Dennis, bro, thank you for your kind help every now and then, and also for the great cooking sessions we had together. I am happy that we worked together on the AHE which was a short but rather productive project. Meneer, veel geluk met alles!

Obed, thank you for making our gatherings more enjoyable and musical by playing guitar for us. And thanks for your energetic “Salaam”s and big smiles every time I saw you.

My office-mates, **Tom B., Jan, Frank, Roald** and **Pep**, thank you for being such a great company for work at the office. I really enjoyed our every now and then chats about any random topics! And thank you, my Dutch gozers, who patiently spoke een beetje Nederlands with me. **Jan**, my special thanks to you for your kind help with the Dutch translation of the abstract and summary of this thesis. I really appreciate the time you spent on that.

Lunch-times can be a great chance to take a relaxing break from work if you share it with your lovely friends. **Carmen, Julian, Obed, Xu, Pep, Zahra B., Dennis, Timo, Jorge** and **Alexey**, thank you all for your company during our refreshing lunch breaks.

There are many other members of FND that I am grateful for having the chance to discuss or work side by side with them. There have been many fruitful group meetings that we attended together and I would like to thank you for all your input, interesting comments and questions. **Ludo, Sander K., Nynke, Roald, Sander O., Olger, Gerjan, Saurabh R., Kumar, Anouk, Siddartha, Mallik, Lei, Juan, Jing, Crystal, Ping, Geert, Arijit, Job, Joop, Freddie, Rafael, Sytze T., Azminul, Xiangyang, Anna, Mihai, Vishesh, Amara, Boxuan, Rebecca, Miina, Alida, Arnaud, Atreya, Adam and Rick**, thank you all for making FND such a cool team to be part of. And special thanks to the social managers, **Eric, Xu, Geert, Jan and Frank**, for the time and effort they took to arrange our unforgettable group events. **Geert**, you also helped me with the translation of the article for the Dutch journal of *Nederlands Tijdschrift voor Natuurkunde*. Thank you very much for that!

Special thanks to my master students, with help of whom we could take steps forward in different projects. **Jantje, Feitze and Patrick**, thank you for your contributions and hard work in the past years.

Of course, I have always had the kind support of our technical team. **Johan, Tom S., Martijn, Hans, Herman, Arjun and Feitze**, I appreciate your immediate help with any technical issues in the lab. Without your assistance, the lab wheels wouldn't be turning. Special thanks to **Tom S.** for his great sense of urgency at any time. You set up a good example for efficiency at work. **Johan**, thank you very much for granting permission to work in special situations. There were instances when we managed to proceed with the fabrication on time, just because you kindly backed us up. I would also like to thank our secretaries, **Anna and Marleen** for their kind assistance. **Marleen**, it was fun to play golf with you.

I would like to acknowledge the support of the HQ graphene team. **Niko, Paul, Feitze and Rick S.**, thanks for your quick response and assistance providing us with the transfer stages and the variety of 2D materials.

I would also like to express my gratitude to some other incredible people at the faculty of Science and Engineering. **Raanan Tobey, Maxim Mostovoy, Shirin Faraji, Jeannette de Boer, Jan Peter, Jacob Baas and Gert ten Brink**, thank you all for your support and guidance. **Rene Fransen**, I am very grateful for all the interesting press releases you wrote for our publications. **Karin de Jonge**, thank you for all the kind words, beautiful smiles and the good vibes I received from you whenever we met. You were a great support for the top-master students. **Pavlo and Andrii**, I am grateful for having met you. I hope zhyttya keeps being dobre for both of you. **Pavlo**, you have been a great daily supervisor during my short top-master project. Thanks for all I learnt from you. **Sasha**, thanks for the discussions we had. Your consistent hard work makes you a right example of a dedicated researcher. Keep up the good work! **Sytze d. and Majid**, thanks for our interesting discussions and the small collaborations we had. **Mehdi S., Xukai, Xiaotian, Daniel Y., Jamo, Razieh, Tenzin, Mostafa, Wytse, Dima, Natasha, Artem, Marten K., Minpeng, Puhua, Tashfeen, Aisha, Diego, Yingfen, Nahid, Machteld, Mart, Arunesh, Mehrdad**,

Marjan, Hamoon, Kiana, Armin, Koorosh and Hamidreza J., I always enjoyed our interesting discussions or short chit-chats in different occasions. Thanks for sharing your thoughts and experiences with me. **Jordi, Maikel, Maarten, Crystal, Megan, Silang, Misha, Lianjia, Ievgenii and Fangfang**, we went through the ups and downs of the top-master program all together. Thanks for your company in our group work and also in our amazing trip to Schiermonnikoog.

Having so many professional Persians in one group makes the group quite special. **Taraneh, Ali C., Zahra A., Soheil S., Masoud and Emad**, when you moved to building 13, you made the department feel like home ;). Thanks for all the energy I received from you in our quick Persian chats in the corridors. I wish you all the best in your career and your life journey.

Saeedeh F., you are such a dedicated researcher that sets up a great example for many of your fellows. Despite being serious at work, thanks for being such a fun and easy person to spent time with.

Zahra B., the twin buddy;), you definitely made my PhD time in Groningen more enjoyable. All those coffee breaks and planting sessions, were so much fun with you. We share a lot of unforgettable memories. Mersi poorjabbar joon!

Shaghayegh, Nima, Saide J., Mohammad Reza, Pooya, Neda, Pooriya, Ali K., Soheil, Azadeh, Laaya, Samaneh, Somayeh, Atie, Sara R., Solmaz and the whole **Shadzian team**, you guys are unlimitedly fun to be with! It was so refreshing and relaxing for me to spend time with you. The fun we had over all those games, including Kalame dar sabad, is not easy to forget. Thank you for all the time, joy and laughter we had together. I never felt lonely in Groningen, as I got to know you soon after I arrived in Groningen. **Shaghayegh** joon, special thanks to you for helping me out with the fluorescence microscopy in my master's studies. I really appreciate the time you spent, carefully checking my samples. **Samaneh**, the kind and caring buddy, thanks for all the energy I received from you. **Laaya**, your company was always great, my calm and supportive friend.

Solmaz, thank you for our amazing memories. You were such a cool host, inviting us over and over again at your place. Those unforgettable/unforgivable dubsmaashes we made together! **Soli and Bart**, I wish you a lifetime of love and happiness together.

Azadeh and Soheil, the artist couple, I can hardly express my deep feelings for you through words. Sooo many incredible joyful moments we had together. Thank you for pushing me to take a break every now and then from my measurements :)! **Azola**, there is so much history behind us, even across the borders. I have always had your support, just like a kind sister. You introduced Groningen to me and helped me find my way in the hard times of entering a foreign country. Your strength in facing life difficulties, while making time for your friends and for music, painting, radio Orcid and coaching, makes you a great role model for me. I am deeply grateful for having you in my life. **Soheile aziz**, thank you for the more than delicious Asghar-

polos you cooked for us, usually accompanied by your beautiful piano-playing and singing. I deeply cherish the time we spent together.

Dorsaye nazaninam, my bestie, I feel blessed for having you in my life. We went through a lot of ups and downs together for many years and still our bond is strong enough to keep us together, even though we are living apart. You have such a kind-hearted soul and beautiful personality that I deeply value and I learnt a lot from. Thank you for everything!

I also would like to thank those who supported me from my former lab in Iran. **Dr. Ajeian**, thanks for your encouraging phone calls and thank you for welcoming us so warmly, each time we visited you. **Zahra S., Moosa, Saeed, Maryam, Mohsen, Hossein, Sara, Fatemeh, Mohammad T., Mehdi D., Mohammad** and **Bahador** (Laye-nazoki-ha team) thank you for your kind company whenever I came to Iran. I really enjoyed our exciting get-togethers.

Last but foremost, I would like to express my deep gratitude to my family. **Man Pari, Mom, Dad, Efaf** and **Amir**, I am so grateful and blessed for having you in my life. You are so supportive, kind and caring. Thanks for the unconditional love I have always received from you. **Efafe** azizam, I feel so proud and lucky for having you as my sister. You helped me a lot along this path. You have always been there for me, as a good listener and a great advisor, motivating me to go beyond limiting thoughts. **Amir** jan, thanks for your support. I wish you a life full of great adventures. **Mom** and **Dad**, all these years of living far from you, even though hard, passed so fast because I always had your love and support. What I feel for you two is beyond words to describe. Your calmness, patience and inspiring guidance walked me through the life challenges and encouraged me to do and be my best, no matter what. I am so deeply grateful for all the dedication and sacrifice you made in life for our family. I eternally love you!

Talieh Ghiasi
Groningen
July, 2021