



Universiteit  
Leiden  
The Netherlands

## **Withstanding the cold: energy feedback in simulations of galaxies that include a cold interstellar medium**

Chaikin, E.

### **Citation**

Chaikin, E. (2024, February 27). *Withstanding the cold: energy feedback in simulations of galaxies that include a cold interstellar medium*. Retrieved from <https://hdl.handle.net/1887/3719692>

Version: Publisher's Version

License: [Licence agreement concerning inclusion of doctoral thesis in the Institutional Repository of the University of Leiden](#)

Downloaded from: <https://hdl.handle.net/1887/3719692>

**Note:** To cite this publication please use the final published version (if applicable).

# Publications

## First author

1. *Simulations of  $^{60}\text{Fe}$  entrained in ejecta from a near-Earth supernova: effects of observer motion*  
**Evgenii Chaikin**, Alexander A. Kaurov, Brian D. Fields, and Camila A. Correa  
Published in MNRAS, 2022, 512, 712
2. *The importance of the way in which supernova energy is distributed around young stellar populations in simulations of galaxies*  
**Evgenii Chaikin**, Joop Schaye, Matthieu Schaller, Yannick M. Bahé, Folkert S. J. Nobels, and Sylvia Ploeckinger  
Published in MNRAS, 2022, 514, 249
3. *A thermal-kinetic subgrid model for supernova feedback in simulations of galaxy formation*  
**Evgenii Chaikin**, Joop Schaye, Matthieu Schaller, Alejandro Benítez-Llambay, Folkert S. J. Nobels, and Sylvia Ploeckinger  
Published in MNRAS, 2023, 523, 3709
4. *COLIBRE: calibrating subgrid feedback in cosmological simulations that include a cold gas phase*  
**Evgenii Chaikin** et al.  
In preparation, to be submitted to MNRAS in 2024

## Co-author

1. *The importance of black hole repositioning for galaxy formation simulations*  
Yannick M. Bahé, Joop Schaye, Matthieu Schaller, Richard G. Bower, Josh Borrow, **Evgenii Chaikin**, Roi Kugel, Folkert Nobels, and Sylvia Ploeckinger  
Published in MNRAS, 2022, 516, 167
2. *Swift: A modern highly-parallel gravity and smoothed particle hydrodynamics solver for astrophysical and cosmological applications*

Matthieu Schaller, Josh Borrow, Peter W. Draper, Mladen Ivkovic, Stuart McAlpine, Bert Vandenbroucke, Yannick M. Bahé, **Evgenii Chaikin**, Aidan B. G. Chalk, Tsang Keung Chan, Camila Correa, Marcel van Daalen, Willem Elbers, Pedro Gonnet, Loïc Hausammann, John Helly, Filip Huško, Jacob A. Kegerreis, Folkert S. J. Nobels, Sylvia Ploeckinger, Yves Revaz, William J. Roper, Sergio Ruiz-Bonilla, Thomas D. Sandnes, Yolan Uyttenhove, James S. Willis, and Zhen Xiang  
Submitted to MNRAS, 2023

3. *The interplay between AGN feedback and precipitation of the intracluster medium in simulations of galaxy groups and clusters*  
Folkert S. J. Nobels, Joop Schaye, Matthieu Schaller, Yannick M. Bahé, and **Evgenii Chaikin**  
Published in MNRAS, 2022, 515, 4838
4. *Tests of subgrid models for star formation using simulations of isolated disk galaxies*  
Folkert S. J. Nobels, Joop Schaye, Matthieu Schaller, Sylvia Ploeckinger, **Evgenii Chaikin**, and Alexander J. Richings  
Submitted to MNRAS, 2023
5. *The FLAMINGO project: cosmological hydrodynamical simulations for large-scale structure and galaxy cluster surveys*  
Joop Schaye, Roi Kugel, Matthieu Schaller, John C. Helly, Joey Braspenning, Willem Elbers, Ian G. McCarthy, Marcel P. van Daalen, Bert Vandenbroucke, Carlos S. Frenk, Juliana Kwan, Jaime Salcido, Yannick M. Bahé, Josh Borrow, **Evgenii Chaikin**, Oliver Hahn, Filip Huško, Adrian Jenkins, Cedric G. Lacey, and Folkert S. J. Nobels  
Published in MNRAS, 2023, 526, 4978
6. *FLAMINGO: calibrating large cosmological hydrodynamical simulations with machine learning*  
Roi Kugel, Joop Schaye, Matthieu Schaller, John C. Helly, Joey Braspenning, Willem Elbers, Carlos S. Frenk, Ian G. McCarthy, Juliana Kwan, Jaime Salcido, Marcel P. van Daalen, Bert Vandenbroucke, Yannick M. Bahé, Josh Borrow, **Evgenii Chaikin**, Filip Huško, Adrian Jenkins, Cedric G. Lacey, Folkert S. J. Nobels, and Ian Vernon  
Published in MNRAS, 2023, 526, 6103

# Curriculum Vitae

I was born on April 25th, 1995, in Kaliningrad, the largest city in the Kaliningrad region of the Russian Federation, an enclave between Poland and Lithuania. Before starting university, my goal was to become a musician, which is a tradition in my family. I started professionally playing piano at the age of four and graduated from a music school when I was 13. During those years, I studied music theory and played the piano on stage numerous times, including participating in international competitions. Despite my promising first steps as a musician, playing the piano was never my own choice; and as I was growing up, I gradually realized that a music career was not something I would want to pursue in the future.

After ceasing to play music, I decided to put all my focus on self-studying graphic design. The ability to create videos with synchronized music devoted to various topics truly fascinated me because this is how I could fully express myself. After a series of successful projects, I was confident that graphic design would become my career, but, like music, this was not meant to happen. The pivotal change happened to me during high school, when I became friends with a group of classmates who were eager to discuss science day and night. I started to regularly join their conversations and, surprisingly, found that talking about 'elementary particles, galaxies, black holes, and the origin of the Universe' makes me unconditionally happy and that I want to learn as much about Astronomy as possible. As I would discover later, I had always had a passion for science, which could manifest itself through me reading popular scientific journals from cover to cover or conducting scientific experiments for kids with great interest. However, it was only one year before the end of high school when it became absolutely clear to me that a career in Astronomy was what I would set out on for my future.

After finishing high school in 2013, I moved from Kaliningrad to Saint Petersburg, where I studied Astronomy as a bachelor's student at Peter the Great St. Petersburg Polytechnic University. I started my first research project in the summer of 2015 with Alexander A. Kaurov who at the time was a PhD student at the University of Chicago in the United States and was offering summer research projects to undergraduate students at my university. My task was to write a code that would solve for the radial temperature profile inside a neutron star as a function of time, including general relativistic effects. While I was working on this project, I collected enough evidence that coding and solving numerical problems

is what I thoroughly enjoy and that I want to continue doing so in the future. Subsequently, Alexander and I decided to make the summer project part of my bachelor's thesis research. My bachelor's thesis topic was 'Simulating thermal evolution of neutron stars with internal heaters', which I wrote under the supervision of Dmitry G. Yakovlev and Alexander D. Kaminker at Peter the Great St. Petersburg Polytechnic University and Alexander A. Kaurov remotely, and which led to the publication of several scientific papers.

Having obtained a Bachelor's degree with distinction in 2017, I relocated from Russia to Germany to follow a Master's program in Astronomy at the University of Bonn. I won an Honours branch scholarship from the Bonn-Cologne Graduate School of Physics and Astronomy, which allowed me to financially support myself during the two years of studying in Germany. At the University of Bonn, I worked in the group of Cristiano Porciani, under whose supervision I wrote my Master's thesis on the optical depth of the intergalactic medium (IGM). Namely, I developed a new method for computing the optical depth of the IGM including the effects of gas bulk motions and thermal broadening, and used cosmological hydrodynamical simulations to test and validate my method.

Following my graduation from the University of Bonn in 2019 with an average grade of 1.1 on my diploma, I moved from Germany to the Netherlands, where I began a four-year PhD project at Leiden University under the supervision of Joop Schaye and Matthieu Schaller. In Leiden, I have been involved in the development of the new model COLIBRE for cosmological simulations of galaxy formation. The development of the COLIBRE simulations, with a focus on modelling energy feedback from supernovae and active galactic nuclei (AGN), has been the primary topic of my PhD research.

After my first year at Leiden University, I became part of the *Big Data applications for Black hole Evolution Studies* (BiD4BEST) Innovative Training Network. As part of BiD4BEST, in the next three years I participated in multiple network-wide training events and received training through three secondments, each of which lasted several months. First, from March to July 2022, I visited the Canary Islands Institute of Astrophysics in Spain where under the supervision of Marc Huertas-Company I applied deep learning methods to simulations of galaxy formation to predict the history of AGN activity in simulated galaxies based on their images. Second, from July to September 2022, I worked as a data scientist at the British company *PreWarp*, which specializes in the fashion industry. Finally, in the first half of 2023, I visited the University of Bologna in Italy for two months where I worked with Marcella Brusa on comparing the properties of AGN-driven winds in the COLIBRE simulations with observational data.

Following the completion of my PhD, I will start a two-year postdoctoral contract at Leiden University, during which I will continue working with Joop Schaye on galaxy simulations with the COLIBRE galaxy formation model and their application to the upcoming Athena mission.

# Acknowledgements

The full meaning put into the acknowledgements from this section can only be understood if one knows the circumstances I have faced over the past four and a half years. Shortly after the start of my PhD, my father unexpectedly passed away. A few months later, there was an outbreak of Covid-19. And just when I thought I had finally recovered psychologically from those events – at least to some degree – February 2022 came knocking on the door, by the end of which my life was forever split into ‘before’ and ‘after’.

The fact that this section is being written implies that I have approached the finish of my PhD research. Reaching this milestone would never be possible without the numerous contributions of many amazing people whom I met before and during my PhD journey. I cannot express how grateful I am therefor, as those contributions – besides all the warm and exciting moments – enabled me to maintain my mental health at a sufficient level, allowing me to keep doing research, live, and move forward.

I first wholeheartedly thank my family for their full, unconditional support before and during my PhD, especially knowing how tough the past years have been for all of us.

Folkert, Lúdia, and Anna (de Graaff), you were the first people who showed me around Leiden Observatory. You helped me get accustomed to this new place and start to feel comfortable! Thank you very much!

Dario, our weekly music rehearsals and conversations during the peak of Covid-19 in 2020 and 2021 gave me that much-needed feeling of hope for the future and helped me stay afloat. Thank you very much for those invaluable moments!

Roi en Joey, de afgelopen drie jaar hebben we samen heel veel onderzoek gedaan en lesgegeven als TAs. Telkens als ik om hulp vroeg, stonden jullie altijd klaar om me te voorzien van nuttig advies en gedetailleerde feedback, zowel op mijn onderzoek als op zaken buiten het werk! Hartelijk bedankt!

I thank my dear colleagues from Leiden Observatory who made me feel welcome at the institute and with whom I shared some memorable moments within and/or outside the institute: Andrés, Andrew, Anniek, Bianca, Christiaan, Christian, Dilovan, Elia, Erik, Fraser, Frits, Jeger, Jurjen, Kirsty, Lammim, Maite, Mantas, Margot, Marina, Marta, Nastasha, Orestis, Peter, Roland, Shun-Sheng, Stijn,

Thijs, Timo, Turgay, Will, Yanling, Zhenlin, Zorry. Thank you very much guys! And I am sorry that I couldn't go into more detail due to the word limit.

Being part of the BiD4BESt innovative training network was a fantastic, unforgettable experience! Thank you, Alba, Alex, Blessing, Brivael, Carolina, Giovanna, Hao, Ivan (Lopez), Ivan (Munoz Rodriguez), Luca, Mathilda, and Nischal for all the amazing times and heartwarming memories! Your charisma, character, and positive attitude to life are unmatched! Together with you, I learned that high performance at work and occasional fun outside work don't have to be mutually exclusive! I hope our connection remains strong long after the end of the BiD4BESt project!

I thank my dear colleagues from the COLIBRE team with whom I have worked in the past four years! The weekly COLIBRE telecons have been an indispensable source of motivation for me and a foundation of stability in my work-related environment, especially during difficult times.

I am very grateful to Joop Schaye, Matthieu Schaller, Huub Röttgering, Alexander Kaurov, Cristiano Porciani, Francesco Shankar, Helen Taylor, Marjan Balkestein, Evelijn Gerstel, and Natalya Matyushina for offering their support in December 2019 and February-March 2022, the times when I confronted the biggest difficulties in my life. I don't know words that could fully convey how important and impactful those conversations with you were for me!

My dear friends Jiwoong Jang, Luis Aizpuru, Katya Leonova, Khasan Harfush, Yvonne Fichtner, Ben Hastings, Rongvoram Nivesvivat, Vika Kulakova, Iveth Adaena Gaspar, Vlad Borisov, and Damir Shagaev, it was a pleasure to be your roommate, classmate, and/or colleague in the past 10 years! Thank you for all the support, advice, and positive emotions during my PhD! I am delighted that we periodically talk and meet, even though most of us are now scattered all over the world!

This thesis would not be possible without my very good friends whom I met (long) before starting a bachelor's program in Astronomy: Lesha, Danil, Viktor, Kostya, Varya, Dasha, Masha, Igor', Misha, Ilian, Tolik, Roma, Rinat, Vitalik, and Petya. You guys contributed to the buildup of my personality, my objectives in life, and my values. Without you, I would unlikely be able to write this paragraph in English, start a career as an astronomer, and I would just no longer be myself!

晋弋, 你给我的生活增添了很多欢乐和温暖! 谢谢你对我的鼓励和支持! 何其有幸我能与你相遇!