

Tokyo, Japan. March 16, 2023
email: math@cidrb.me
Tel. (+81) 080-9401-5547

Nationality: Mexican
HP: www.cidrb.me

Cid Reyes Bustos

Area of specialization

My main areas of study are harmonic analysis, representation theory and combinatorics. Currently, my main research is focused on the mathematical aspects of certain operators used in quantum optics, most notably the quantum Rabi model and its generalizations. In addition, I am currently doing research on spectral graph theory, mostly of Cayley graphs and generalizations to non-regular graphs, focused on the study of the Ihara zeta function with applications to graph expansion.

Education

- 2015 – 2018 • **PhD *Functional Mathematics***.
Graduate School of Mathematics, Kyushu University, Fukuoka, JAPAN.
PhD Thesis: *Study on the spectrum of the asymmetric quantum Rabi model*.
Advisor: Masato Wakayama.
- 2013 – 2015 • **Master of Science *Mathematics***.
Graduate School of Mathematics, Kyushu University, Fukuoka, JAPAN.
Master Thesis: *Cayley-type graphs for group-subgroup pairs*.
Advisor: Masato Wakayama.
- 2005 – 2010 • **Bachelor of Science *Applied Mathematics***.
Graduated with Honoric Mention.
Mexico Autonomous Institute of Technology (ITAM), Mexico City, MEXICO.
Thesis: *Braid group cryptograpy*.
Advisors: Begoña Albizuri, Javier Alfaro and Marcela González
- 2005 – 2010 • **Bachelor of Engineering *Computer Engineering***.
Graduated with Honoric Mention.
Mexico Autonomous Institute of Technology (ITAM), Mexico City, MEXICO.
Thesis: *Braid group cryptograpy*.
Advisors: Begoña Albizuri, Javier Alfaro and Marcela González
- 2002 – 2005 • **High School**
Monterrey Institute of Technology and Higher Education (ITESM), State of Mexico Campus, Atizapán de Zaragoza, MEXICO

Professional Experience

- 2022 - • **Research Associate 2022/04 -**
NTT Institute for Fundamental Mathematics, NTT Corporation. Tokyo, JAPAN.
Research focused on spectral theory of quantum interaction models, graph theory and representation theory.

Professional Experience (continued)

- 2019 – 2022 • **Specially Appointed Assistant Professor** 2019/05 - 2022/03
Department of Mathematical and Computing Science at the School of Computing, Tokyo Institute of Technology. Tokyo, JAPAN
Research focused on the mathematical aspects of quantum interaction systems and applications of representation theory on cryptography. Member of the *Mathematical Modelling for Next-Generation Cryptography (CryptoMath-CREST)* project in the group led by Keisuke Tanaka.
Actively participated on the blockchain and cryptography seminars.
- 2019 – 2019 • **Researcher** 2019/04 – 2019/05
Department of Mathematical and Computing Science at the School of Computing, Tokyo Institute of Technology. Tokyo, JAPAN
- 2018 – 2019 • **Postdoctoral researcher** 2018/10 – 2019/03
Institute of Mathematics for Industry, Kyushu University. Fukuoka, JAPAN
Project: *Mathematical Modelling for Next-Generation Cryptography (CryptoMathCREST)*
Member of the group led by Masato Wakayama. Research focused on the mathematical aspects appearing in post-quantum cryptosystems and quantum interaction systems, particularly the quantum Rabi model and generalizations.
- 2015 – 2018 • **Research Assistant** 2015/10 – 2018/09
Graduate School of Mathematics, Kyushu University. Fukuoka, JAPAN .
Support for research on the spectral analysis of the asymmetric quantum Rabi model, under the supervision of Masato Wakayama.
- 2011 – 2013 • **Statistical Analyst** 2011/01 - 2013/02
Las Quince Letras. Mexico City, MEXICO.
Analysis of survey, sales and industry data using techniques from multivariate statistical analysis, Bayesian statistics, machine learning and data visualization. Experience using the programming languages R, Python and Ruby.
- 2008 – 2010 • **Minor Faculty** 2008/08 - 2010/05
Computer Engineering Department. Mexico Autonomous Institute of Technology (ITAM). Mexico City, MEXICO.
Tutoring students on elementary classes of computer engineering: algorithms and programs, data structures, data bases, among other. Support one faculty member (each semester) on lecture preparation and grading of homeworks.

Refereed journal papers

- 2022 • **Journal Paper**
Cid Reyes-Bustos and Masato Wakayama,
Heat kernel for the quantum Rabi model.
Adv. Theor. Math. Phys. **26** (5), 2022. In print.

Refereed journal papers (continued)

- 2022/09 • **Journal Paper**
Cid Reyes-Bustos and Masato Wakayama,
Degeneracy and hidden symmetry for the asymmetric quantum Rabi model with integral bias.
Commun. Number Theory Phys. **17** (3) 615-672 [58 pages], 2022.
- 2021/05 • **Journal paper**
Cid Reyes-Bustos, Daniel Braak and Masato Wakayama,
Remarks on the hidden symmetry of the asymmetric quantum Rabi model
J. Phys. A: Math. Theor. **54** 285202 [20 pages], 2021.
- 2021/01 • **Journal paper**
Cid Reyes-Bustos and Masato Wakayama
Heat kernel for the quantum Rabi model II: propagators and spectral determinants.
J. Phys. A: Math. Theor. **54** 115202, [30 pages], 2021.
- 2020/04 • **Journal paper**
Kazufumi Kimoto, Cid Reyes-Bustos and Masato Wakayama,
Determinant expressions of constraint polynomials and the spectrum of the asymmetric quantum Rabi model.
International Mathematics Research Notices, Volume 2021, Issue **12**, 9458–9544
[87 pages], 2021
Published Online April 2020. doi:10.1093/imrn/rnaa034.
- 2016/01 • **Journal paper**
Cid Reyes-Bustos,
Cayley-type graphs for group-subgroup pairs.
Linear algebra and its applications. Vol. **488**, 320-349 [29 pages], 2016.

Other refereed publications

- 2020/10 • **Conference proceeding**
Cid Reyes-Bustos,
Extended divisibility relations for constraint polynomials of the asymmetric quantum Rabi model,
in “International Symposium on Mathematics, Quantum Theory, and Cryptography (MQC 2019)”, eds. T. Takagi et al. Mathematics for Industry **33**, 149-168, Springer Singapore, 2020.
- 2017/03 • **Book Chapter**
Cid Reyes-Bustos and Masato Wakayama,
Spectral degeneracies in the asymmetric quantum Rabi model,
in “Mathematical Modelling for Next- Generation Cryptography” eds. T. Takagi et al., Mathematics for Industry **29**, 117-137, Springer, 2017.

Preprint

- 2022/09 • **Preprint Article**
Cid Reyes-Bustos and Masato Wakayama,
Covering models of the asymmetric quantum Rabi model: η -shifted non-commutative harmonic oscillators.
arXiv:2209.14665 [40 pages], 2022.
- 2020/12 • **Preprint Article**
Cid Reyes-Bustos,
The heat kernel of the asymmetric quantum Rabi model.
arXiv:2012.13595 [14 pages], 2020.
- 2019/09 • **Preprint Article**
Cid Reyes-Bustos,
A simple continued fraction expansion for e^n .
arXiv:1909.13597 [8 pages], 2019.

Research report (non-refereed)

- 2021/09 • **Research Report**
Cid Reyes-Bustos,
The heat kernel of the quantum Rabi model and related models.
RIMS Kokyu-roku **2200**. Spectral and Scattering Theory and Related Topics. 10-23, 2021.
- 2019/08 • **Research Report**
Cid Reyes-Bustos,
Degeneracy structure of the spectrum of the asymmetric quantum Rabi model.
RIMS Kokyu-roku **2123**. Mathematical aspects of quantum fields and related topics. 134-145, 2019.
- 2014/11 • **Research Report**
Cid Reyes-Bustos,
Group-subgroup pair graphs.
RIMS Kokyu-roku **1925**. New Developments of Representation Theory and Harmonic Analysis. 56-63, 2014.

Invited talks

- 2020/12 • **Invited talk 45 minutes**
Title: *The heat kernel of the quantum Rabi model and related models.*
2020 RIMS Workshop, Spectral and Scattering Theory and Related Topic
Research Institute for Mathematical Sciences, Kyoto University
Kyoto, JAPAN (Online).

Invited talks (continued)

- 2019/09 • **Invited talk** 45 minutes
Title: *Extended divisibility relations for constraint polynomials of the asymmetric quantum Rabi model.*
International Symposium on Mathematics, Quantum Theory, and Cryptography (MQC 2019)
IMI Auditorium, Kyushu University.
Fukuoka, JAPAN.
- 2019/01 • **Invited talk** 45 minutes
Title: *On the number of exceptional solutions of the asymmetric quantum Rabi model.*
Mathematical developments related to the quantum Rabi model
Mathematical Sciences Institute, Australian National University
Canberra, AUSTRALIA.
- 2018/07 • **Invited talk** 45 minutes
Title: *Degeneracies in the spectrum of the asymmetric quantum Rabi model.*
Strongly Coupled Light-Matter interactions: Models and Applications
Lanzhou University, Lanzhou, CHINA.
- 2018/07 • **Invited talk** 45 minutes
Title: *Spectral degeneracies in the asymmetric quantum Rabi model.*
Mathematical aspects of quantum fields and related topics
Research Institute for Mathematical Science (RIMS). Kyoto University, Kyoto, JAPAN.
- 2014/06 • **Invited talk** 50 minutes
Title: *Group-subgroup pair graphs.*
New developments of Representation Theory and Harmonic Analysis
Research Institute for Mathematical Science (RIMS). Kyoto University, Kyoto, JAPAN.

Other presentations

- 2023/01 • **Research presentation**
Title: *The symmetry and degeneracy picture of the asymmetric quantum Rabi model*
Rabi and Spin Boson Models,
Kyushu University, Fukuoka, Japan.
- 2022/12 • **Research presentation**
Title: *Structure and eigenvalues of Group-subgroup pair graphs.*
Zeta functions in Okinawa 2022
Okinawa Convention Center, Okinawa, Japan.
- 2022/11 • **Research presentation**
Title: *Cayley-type graphs for group-subgroup pairs.*
Seminar of Prof. Tsuyoshi Mieozaki,
Waseda University, Tokyo, Japan.

Other presentations (continued)

- 2022/09 • **Research presentation**
Title: *Spectra and Ihara zeta function of group-subgroup pair graphs.*
MSJ Autumn Meeting 2022.
Hokkaido University, Hokkaido, Japan.
- 2022/09 • **Research presentation**
Title: *Shifted non-commutative harmonic oscillators.*
MSJ Autumn Meeting 2022.
Hokkaido University, Hokkaido, Japan.
- 2022/09 • **Workshop presentation**
Title: *Quantum walks and zeta functions.*
Crypto-Math CREST mini-workshop: “Quantum computation and cryptography”
Presented with Shingo Sugiyama,
Dwango Office, Tokyo, Japan.
- 2021/10 • **Research presentation**
Title: *Simetría y degeneración espectral en el modelo cuántico de Rabi asimétrico.*
Congreso Nacional SMM 54.
Benemérita Universidad Autónoma de Puebla. Puebla, Mexico.
Online Meeting (in Spanish).
- 2021/09 • **Research presentation**
Title: *Degeneracy and hidden symmetry of the asymmetric quantum Rabi model.*
Mathematical Society of Japan 2021 Autumn Meeting at Chiba University
Online Meeting.
- 2021/09 • **Research presentation**
Title: *Heat kernel for the asymmetric quantum Rabi model.*
Mathematical Society of Japan 2021 Autumn Meeting at Chiba University
Online Meeting.
- 2021/03 • **Research presentation**
Title: *A potential relation between quantum optics models and quantum error-correcting codes.*
CryptoMathCREST Workshop
Online Meeting. Organized by Kosuke Sakata (Tokyo University).
- 2019/09 • **Research presentation**
Title: *Heat kernel and spectral zeta function of the quantum Rabi model.*
Mathematical Society of Japan 2019 Autumn Meeting
Kanazawa University
Kanazawa, JAPAN.
- 2019/09 • **Research presentation**
Title: *Spectral determinant and G-function of the asymmetric quantum Rabi model.*
Mathematical Society of Japan 2019 Autumn Meeting
Kanazawa University
Kanazawa, JAPAN.

Other presentations (continued)

- 2018/11 • **Research presentation**
Title: *Orthogonal polynomials related to the asymmetric quantum Rabi model.*
Symposium on Representation Theory 2018
Suimeso, Tottori, JAPAN.
- 2017/09 • **Research presentation**
Title: *Degeneracies of the spectrum of the asymmetric quantum Rabi model.*
CryptoMathCREST Workshop "Unsolved Problems in Mathematical Cryptography"
Shonan Village, Kanagawa, JAPAN.
- 2017/09 • **Research presentation**
Title: *Spectral degeneracies in the asymmetric quantum Rabi model.*
Mathematical Society of Japan, Autumn meeting 2017.
Yamagata University, Yamagata, JAPAN.
- 2016/03 • **Research presentation**
Title: *Group-subgroup pair graphs and applications to coding theory.*
CryptoMathCREST Workshop "L-Function and Cryptography"
Institute of Mathematics for Industry (IMI), Kyushu University, Fukuoka, JAPAN.
- 2015/03 • **Research presentation**
Title: *Deep Riemann Hypothesis and DRH expanders.*
CryptoMathCREST Workshop "Ramanujan graphs and Cryptography"
Institute of Mathematics for Industry (IMI), Kyushu University, Fukuoka, JAPAN.
- 2014/10 • **Research presentation**
Title: *An extension of Cayley graphs to group subgroup pairs and its Ihara zeta function.*
Zeta functions in Okinawa 2014
Okinawa Convention Center, Okinawa, JAPAN

Internship

- 2016/06 • **Mitsubishi Electric Corporation**
Information Security Section. Kamakura, JAPAN.
Instructor: Katsuyuki Takashima
Research Subject: *Riemann hypothesis and information security*
The objective was to study the improvements in computational complexity for certain attacks on cryptosystems under the assumption of the Deep Riemann Hypothesis or the Montgomery conjecture.

Service to Profession

- 2023 • **Minisymposium organizer**
I am one of the organizers of the minisymposium "The mathematics of quantum interaction models" for ICIAM 2023 to be held during August 2023 in Tokyo.

Service to Profession (continued)

- 2022 – • **zbMATH Open reviewer**
Active reviewer for zbMATH Open (Zentralblatt MATH).
- 2018 – • **MathSciNet reviewer**
Active reviewer for Mathematical Reviews (MathSciNet) of the American Mathematical Society.
- 2021 - • **Journal manuscript referee**
I have refereed manuscript for publication in the journals:
- Journal of Physics A: Mathematical and Theoretical,
 - Journal of Physics Communications.
 - St. Petesburg Math. Journal

Awards and Honors

- 2022 • **AIP Challenge Program**
Research grant awarded by AIP Network Laboratory of JST for the support of individual research during the period 2022-2023.
www.jst.go.jp/kisoken/aip/program/wakate/challenge/list2022.html
- 2017 • **Excellent Poster Award**
Awarded in the Forum Math-for-Industry 2017.
University of Hawaii at Manoa, Hawaii, USA.
- 2012 • **Ex-ITAM Research Prize**
Prize awarded to recently graduated students of the Mexico Autonomous Institute of Technology (ITAM) for the research work on the thesis. Awarded for both Computer Engineering and Applied Mathematics.
Mexico City, MEXICO.
- 2013 – 2018 • **MEXT Scholarship**
Scholarship granted by Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan to fully cover the expenses of Master and Doctor studies in Kyushu University.
- 2012 • **Honoric Mention**
MIXBAAL prize to the best undergraduate thesis in applied mathematics in Mexico.
XXII National School in Optimization and Numerical Analysis, (ENOAN 2012)
Tabasco, MEXICO.
- 2011 • **Prize to Academic Excellence**
Awarded to the year best graduates in faculties and schools of engineering in Mexico.
National Association of Engineering Faculties and Schools (ANFEI)
Mexico City, MEXICO.

Affiliations

- 2019 – • **Sociedad Matemática Mexicana (SMM) (Mexican Mathematical Society)**
- 2017 – • **Mathematical Society of Japan (MSJ)**
- 2017 – • **Asia Pacific Consortium of Mathematics for Industry (APCMfi)**

Language Skills

- **Spanish** *Native.*
- **English** *Fluent.*
- **Japanese** *Intermediate.* JLPT Level N2. Certificate Number *N2A095944J*