(updated July 2022)

Short Bio:

Nathalie Q. Balaban's research interests focus on the development of experimental and theoretical approaches to the study of single-cell heterogeneity, and the determination of its role in disease and evolution. She has pioneered the use microfluidic devices and automated setups to study quantitatively the heterogeneous response of bacteria to antibiotics. Her work revealed the evolution of tolerance to antibiotics and the subsequent evolution of resistance, both in vitro and in patients, leading to new approaches to treat persistent infections.

She has won the Krill prize from the Wolf foundation. She is an elected member of the European Academy of Microbiology, an EMBO member and a Fellow of the American Academy of Microbiology.

Nathalie Q. Balaban has co-founded the Scholar-Teacher program, an initiative for improving science teaching in high schools.

- **PERSONAL INFORMATION**

Place of birth: France
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- **EDUCATION**

1994 - 2000: Ph.D., Physics Department, "*High frequency edge excitations in the Quantum Hall Effect*", Weizmann Institute of Science, Israel.
1991 - 1993: M.Sc., Physics Department, "*Breakdown of the Integer Quantum Hall Effect*", Weizmann Institute of Science, Israel.
1989-1991: B. Sc.: Mathematics and Physics, Hebrew University, Israel. *magna cum laude*

- **CURRENT POSITIONS**

2013 - present Full Professor, Racah Institute of Physics, Hebrew University of Jerusalem, Israel.
2011 - present Joseph & Sadie Danciger Chair in Physics, Hebrew University of Jerusalem, Israel.

- **PREVIOUS POSITIONS**

2014	Visiting Scholar, Department of Systems Biology, Harvard Medical School, USA.
2009 - 2012	Associate Professor, Racah Institute of Physics, Hebrew University of Jerusalem, Israel.
2003 - 2009	Senior Lecturer, Racah Institute of Physics, Hebrew University of Jerusalem, Israel.
2001 - 2003	Fellow, Center for Physics and Biology, Rockefeller University, USA.
2001	Dicke Fellow, Physics Department, Princeton University, USA.
2000	Post-doctoral Fellow, Cell Biology Department, Weizmann Institute of Science, Israel.

- **FELLOWSHIPS AND AWARDS**

2022	European Research Council Advanced Grant (embargoed information until April 28)
2021	Elected EMBO Member.
2018	Elected Fellow of the American Academy of Microbiology.
2016	Klachky Prize for the Advancement of the Frontiers of Science, Hebrew University, Israel.
2016	Elected Member, European Academy of Microbiology.
2015	European Research Council Consolidator Grant

2011 Joseph and Sadie Danciger Chair in Physics, Hebrew University of Jerusalem, Israel.
2010 European Research Council Starting Grant
2010 Breakthrough Scientist award, Ministry of Education, Israel.
2009 Krill Prize for Excellence in Science, Wolf Foundation, Israel.
2003 Fellow, Horowitz Center for Complexity Science, Israel.
2000 Dicke Fellowship, Physics Department, Princeton University, USA.
2000 Fulbright Fellowship, USA (declined).

- **SUPERVISION OF STUDENTS AND POSTDOCTORAL FELLOWS**

Since 2003, I have supervised 5 Post-doctoral Fellows, 9 PhD students and 10 MSc students at the Hebrew University of Jerusalem. All of them are now in academia or industry such as Dr. Jiafeng Liu, Assistant Professor at Tsinghua University (China), Dr. Orit Gefen, Research Associate in the Physics Department, Hebrew University of Jerusalem (Israel) and Dr. Irit Levin-Reismann, Research Associate in the Physics Department, Hebrew University of Jerusalem. The following are currently Post-doctoral Fellows: Dr. Sivan Pearl, MIT (USA), Dr. Amir Goldberg, Weizmann Institute of Science (Israel) and Dr. Noga Mosheiff, University of Pittsburg (USA). Others are now leading researchers in industry such as Dr. Ofer Fridman, Research Group leader, Intel-Mobileye Research Center (Israel), Elyaqim Oster, Data Science Group leader, BrainQ Technologies Ltd. (Israel), and Dr. Eitan Rotem, Researcher at Applied materials Ltd. (Israel).

- **TEACHING ACTIVITIES**

2003 - present Electricity & Magnetism (BSc), Physics Advanced Lab A and B (BSc), Topics in Biological Physics (MSc), Introduction to Biophysics (BSc, MSc &PhD).
2014 Invited instructor, Kavli Institute for Theoretical Physics (KITP), Advanced School on the Evolution of Drug Resistance, UC Santa Barbara, USA.

- **ORGANISATION OF SCIENTIFIC MEETINGS (last 10 years)**

2022 Co-organizer, "Quantitative Biology of Non-growing Microbes", Kavli Institute for Theoretical Physics (KITP), Santa Barbara, USA
2021 Co-organizer of virtual event, "Probabilistic Decision Making: Lessons from Microbes", Minerva Center Minerva Center for Decision Making Strategies in Microorganisms, Weizmann Institute of Science, Israel.
2018 Co-organizer, International Workshop "Optimization and Trade-offs in Cell Growth and Survival", Weizmann Institute of Science, Rehovot, Israel (~150 participants).
2016 Co-organizer, International Workshop "Stochastic Processes in the Cell Cycle", Israel Institute for Advanced Studies, Jerusalem, Israel (~150 participants).
2015 Co-organizer, Minerva Center Meeting on "Stochastic Decision Making in Microorganisms", Weizmann Institute of Science, Rehovot, Israel.

- **INSTITUTIONAL RESPONSIBILITIES (at Hebrew University of Jerusalem)**

2021 – present Member of the University Higher Tenure and Promotion Committee
2018-2021 Head of the Search Committee for New Faculty, Racah Institute of Physics
2010 – 2018 Member, Search Committee for New Faculty, Racah Institute of Physics.
2015 – present Co-Initiator, Scholar-Teacher program. Hybrid program with University academics also teaching part-time high school science curriculum.
2014 - 2017 Chair, "Amirim" program for outstanding undergraduate BSc students.
2013 - 2016 Member, Faculty of Mathematics and Science Committee.
2006 - 2016 Initiator and advisor, Biological Physics Program.

- **INSTITUTIONAL RESPONSIBILITIES (other institutions)**

PhD Thesis Evaluator: University of Copenhagen, Denmark (2021); University of Basel, Switzerland (2020); Katholieke Universiteit Leuven, Belgium (2014); Weizmann Institute of Science, Israel (2004-present).

Tenure Committee Evaluation: Tel-Aviv University, Israel (2020); Bar-Ilan University, Israel (2018).

2021- Review panel member of the NCCR AntiResist Consortium, University of Basel, Switzerland,

2017 International Evaluation Board Member, Institut Pierre-Gilles de Gennes, Paris, France.

2017 High Council for Evaluation of Research and Higher Education (HCERES) Evaluation Committee, Statistical Physics Laboratory, École Normale Supérieure, Paris, France.

- **REVIEWING ACTIVITIES**

2022- present Reviewing Editor, Elife

2022-present Editorial Board, Microlife

2021 - present Associate Editor, BioDesign Research Journal.

2014 - present Editorial Board, Plos Biology.

2016 - 2018 Editorial Board, Biophysical Journal.

Journal reviewer: Biophysical Journal, Cell, Cell Host, Elife, Journal of Bacteriology, mBio, Molecular Cell, Molecular Systems Biology, Nature, Nature Ecology and Evolution, Nature Communications, Nature Genetics, Nature Methods, Nature Microbiology, Nature Methods, Plos Biology, Plos Pathogens, Plos Genetics, PNAS, Physical Review Letters, Physical Review X, Science.

Grant reviewer: Agence Nationale de la Recherche (France), European Research Council, Human Frontier Science Program, Research Foundation – Flanders (Belgium), Israel Science Foundation, US-Israel Binational Science Foundation, Estonian Research Council.

- **INVITED TALKS AT INTERNATIONAL CONFERENCES (selected from a total of ~50)**

2022 Gordon Conference, Molecular Evolution, USA.
2022 EMBO Workshop on Antibiotic Resistance, Switzerland (Keynote Lecture)
2021 World Microbe Event (FEMS2021&ASM2021), Virtual, (Plenary Lecture).
2021 Physical Biology Circle meeting, Dresden, Germany. (Keynote Lecture),
2020 International BioDesign Research Conference, Stanford University 2020 (virtual).
2020 Evolutionary Systems Biology; Wellcome Genome Campus, Cambridge, UK.
2019 Quantitative Biology International Conference, San Francisco, USA (Opening Banquet Lecture).
2019 Federation of European Microbiological Societies Meeting, UK (Session Chair and Speaker).
2019 American Physical Society March Meeting, Boston, USA (Session Chair and Speaker).
2018 International Conference in Systems Biology (ICSB), Lyon, France (Plenary Talk).
2018 EMBO Meeting on Bacterial Persistence, Switzerland (Invited Speaker and Panel Leader).
2018 European Infection Diseases meeting (ECCMID), Madrid, Spain (Keynote Lecture).
2017 Microbiology and Infection, Wurzburg, Germany (Plenary Lecture).
2017 New Approaches and Concepts in Microbiology, EMBO meeting, Heidelberg, Germany.
2016 Gordon Conference on Microbial Stress Response, Mount Holyoke, USA.
2015 Royal Society Workshop, Buckinghamshire, UK.
2015 Gordon Conference on Signal Transduction, Newport, USA.
2015 Gordon Conference on Stochastic Physics in Biology, Ventura, USA.
2014 Kalvi Institute for Theoretical Physics, Santa Barbara, USA (Invited Speaker and Instructor).
2014 Biophysical Society 58th Annual Meeting, San Francisco, USA (Session Chair and Speaker).
2014 SysBio, Lyon, France (Keynote lecture), November 2014

- **PATENT**

2016 "Kit and discs for use in disc diffusion antibiotic sensitivity testing". Patent number Pct/Il2016/051126 (USA) N.Q. Balaban and O. Gefen.

- **OUTREACH**

- 2012 – present Scholar-Teacher program: Co-organizer of a hybrid academic research position program at the Hebrew University of Jerusalem, funded in part by the Jerusalem Municipality. The scholars hold a joint part-time senior academic position at the University and part-time high school teacher appointment as a way to boost the level of creative science teaching in high schools.
- 2015 – Development of scientific courses for high school children at the Hebrew University
- Public lectures for popular science dissemination on radio, TV and printed press interviews in Israel and abroad, as well as public science lectures for minority groups to promote STEM education. Popular science article on our work reviewed by high school children in Frontiers for Young Minds (2019).
- 2019 – present: Member of the committee for Physics High School Education – Ministry of Education.

Book Chapters:

- Balaban, N.Q., U.S. Schwarz, and B. Geiger, *Measurement of cellular contractile forces using patterned elastomer.* in Cell Biology: A Laboratory Handbook 3ED Ed. Julio Celis, 2005.

- Balaban N. Q. *Bacterial Persistence* in Bacterial Stress Responses 2ED Ed. G.Storz&R. Hengge (2010) ASM press, USA

- Levin Reisman I. and Balaban N.Q. *Quantitative measurements of the lag phase* Methods in Molecular Biology Ed. Michiels J. (2016) Humana Press, USA

- Balaban N.Q and Jiafeng Liu. *Evolution under antibiotic treatments: interplay between antibiotic persistence, tolerance and resistance* (in Persister cells and Infectious Disease Springer Nature, Ed. Kim Lewis, (2020))

Publications - *Total citations (Scholar): 15,000*

1. Liu, J., Gefen, O., Zhang ZY., Liu MM., Bar-Meir, M., and Balaban, N.Q. (2022). Interaction Tolerance Detection test for understanding the killing efficacy of directional antibiotic combinations. **mBio** *(in press).*
2. Hagai Rappeport, I.L.R., Naftali Tishby, Nathalie Q. Balaban (2022). Detecting chaos in lineage-trees: A deep learning approach. **PRR** *(in press).*
3. Kaplan, Y., Reich, S., Oster, E., Maoz, S., Levin-Reisman, I., Ronin, I., Gefen, O., Agam, O., and Balaban, N.Q. (2021). Observation of universal ageing dynamics in antibiotic persistence. **Nature**.
   (**Recommended F1000**; *Flagged for News and Views article in Nature Reviews Microbiology 2021)*
4. Brauner, A., and Balaban, N.Q. (2021). Quantitative biology of survival under antibiotic treatments. **Current Opinion in Microbiology** *64*, 139-145.

5. Liu, J., Gefen, O., Ronin, I., Bar-Meir, M., and Balaban, N.Q. (2020). Effect of tolerance on the evolution of antibiotic resistance under drug combinations. **Science** *367*, 200-204. *(Flagged for News and Views article in Science 2020;* ***Highly Cited Paper - Web of Science)***
6. Javid, B., and Balaban, N.Q. (2020). Impact of Population Mask Wearing on Covid-19 Post Lockdown. **Infectious Microbes & Diseases**, 10.1097/IM1099.0000000000000029.
7. Andersson, D.I., Balaban, N.Q., Baquero, F., Courvalin, P., Glaser, P., Gophna, U., Kishony, R., Molin, S., and Tonjum, T. (2020). Antibiotic resistance: turning evolutionary principles into clinical reality. **FEMS Microbiol Rev** *44*, 171-188.
8. Levin-Reisman, I., Brauner, A., Ronin, I., and Balaban, N.Q. (2019). Epistasis between antibiotic tolerance, persistence, and resistance mutations. **Proc Natl Acad Sci U S A** *116*, 14734-14739.
9. Balaban, N.Q., Helaine, S., Lewis, K., Ackermann, M., Aldridge, B., Andersson, D.I., Brynildsen, M.P., Bumann, D., Camilli, A., Collins, J.J., et al. (2019). Definitions and guidelines for research on antibiotic persistence. **Nature Reviews Microbiology** *17*, 441-448.
10. Mosheiff, N., Martins, B.M.C., Pearl-Mizrahi, S., Grunberger, A., Helfrich, S., Mihalcescu, I., Kohlheyer, D., Locke, J.C.W., Glass, L., and Balaban, N.Q. (2018). Inheritance of Cell-Cycle Duration in the Presence of Periodic Forcing. **Physical Review X** *8*, 021035.
11. Amir, A., and Balaban, N.Q. (2018). Learning from Noise: How Observing Stochasticity May Aid Microbiology. **Trends in Microbiology** *26*, 376-385.
12. Ronin, I., Katsowich, N., Rosenshine, I., and Balaban, N.Q. (2017). A long-term epigenetic memory switch controls bacterial virulence bimodality. **Elife** *6*.
13. Liu, J., Gefen, O., and Balaban, N.Q. (2017). Tackling Antibiotic Resistance with Systems-Level Perspective. **Cell Syst** *5*, 546-548.
14. Levin-Reisman, I., Ronin, I., Gefen, O., Braniss, I., Shoresh, N., and Balaban, N.Q. (2017). Antibiotic tolerance facilitates the evolution of resistance. **Science** *355*, 826-830. **(Recommended F1000;** ***Highly Cited Paper - Web of Science****.)*

15. Gefen, O., Chekol, B., Strahilevitz, J., and Balaban, N.Q. (2017). TDtest: easy detection of bacterial tolerance and persistence in clinical isolates by a modified disk-diffusion assay. **Sci Rep** *7*, 41284.
16. Brauner, A., Shoresh, N., Fridman, O., and Balaban, N.Q. (2017). An Experimental Framework for Quantifying Bacterial Tolerance. **Biophysical Journal** *112*, 2664-2671.
17. Pearl Mizrahi, S., Gefen, O., Simon, I., and Balaban, N.Q. (2016). Persistence to anti-cancer treatments in the stationary to proliferating transition. **Cell Cycle** *15*, 3442-3453.
18. Mizrahi, S.P., Sandler, O., Lande-Diner, L., Balaban, N.Q., and Simon, I. (2016). Distinguishing between stochasticity and determinism: Examples from cell cycle duration variability. **Bioessays** *38*, 8-13.
19. Levin-Reisman, I., and Balaban, N.Q. (2016). Quantitative Measurements of Type I and Type II Persisters Using ScanLag. **Methods Mol Biol** *1333*, 75-81.
20. Brauner, A., Fridman, O., Gefen, O., and Balaban, N.Q. (2016). Distinguishing between resistance, tolerance and persistence to antibiotic treatment. **Nature Reviews Microbiology** *14*, 320-330.
21. Sandler, O., Mizrahi, S.P., Weiss, N., Agam, O., Simon, I., and Balaban, N.Q. (2015). Lineage correlations of single cell division time as a probe of cell-cycle dynamics. **Nature** *519*, 468-471. **(** *Flagged for News and Views in Nature 2015)*

22. Pearl, S., Sandler, O., Agam, O., Simon, I., and Balaban, N.Q. (2014). Deterministic Versus Stochastic Variability in the Mammalian Cell Cycle. **Biophysical Journal** *106*, 232a-232a.
23. Levin-Reisman, I., Fridman, O., and Balaban, N.Q. (2014). ScanLag: high-throughput quantification of colony growth and lag time. **J Vis Exp**.
24. Goldberg, A., Fridman, O., Ronin, I., and Balaban, N.Q. (2014). Systematic identification and quantification of phase variation in commensal and pathogenic Escherichia coli. **Genome Medicine** *6*.
25. Gefen, O., Fridman, O., Ronin, I., and Balaban, N.Q. (2014). Direct observation of single stationary-phase bacteria reveals a surprisingly long period of constant protein production activity. **Proceedings of the National Academy of Sciences of the United States of America** *111*, 556-561.
26. Fridman, O., Goldberg, A., Ronin, I., Shoresh, N., and Balaban, N.Q. (2014). Optimization of lag time underlies antibiotic tolerance in evolved bacterial populations. **Nature** *513*, 418-421. **(Recommended F1000; *Highly Cited Paper - Web of Science*.)**
27. Sorek, M., Balaban, N.Q., and Loewenstein, Y. (2013). Stochasticity, Bistability and the Wisdom of Crowds: A Model for Associative Learning in Genetic Regulatory Networks. **PLoS Comput Biol** *9*.
28. Kaspy, I., Rotem, E., Weiss, N., Ronin, I., Balaban, N.Q., and Glaser, G. (2013). HipA-mediated antibiotic persistence via phosphorylation of the glutamyl-tRNA-synthetase. **Nat Commun** *4*.
29. Balaban, N.Q., Gerdes, K., Lewis, K., and McKinney, J.D. (2013). A problem of persistence: still more questions than answers? **Nature Reviews Microbiology** *11*, 587-591.
30. Sorek, M., Balaban, N.Q., and Loewenstein, Y. (2012). Associative learning for multiple patterns in genetic networks. **Journal of Molecular Neuroscience** *48*, S112-S112.
31. Fridman, O., Goldberg, A., and Balaban, N.Q. (2012). Whack-an-E.coli with the morbidostat. **Genome Biology** *13*.
32. Storz, G., and Hengge, R. (2011). Bacterial Stress Responses (ASM).
33. Balaban, N.Q. (2011). Persistence: mechanisms for triggering and enhancing phenotypic variability. **Current Opinion in Genetics & Development** *21*, 768-775.
34. Balaban, N.Q. (2011). Persister Bacteria. In Bacterial Stress Responses, 2nd edition, 2 Edition, G. Storz and R. Hengge, eds. (Washington, DC: ASM Press), pp. 375-382.
35. Rotem, E., Loinger, A., Ronin, I., Levin-Reisman, I., Gabay, C., Shoresh, N., Biham, O., and Balaban, N.Q. (2010). Regulation of phenotypic variability by a threshold-based mechanism underlies bacterial persistence. **Proceedings of the National Academy of Sciences of the United States of America** *107*, 12541-12546.
(Recommended F1000)
36. Levin-Reisman, I., Gefen, O., Fridman, O., Ronin, I., Shwa, D., Sheftel, H., and Balaban, N.Q. (2010). Automated imaging with ScanLag reveals previously undetectable bacterial growth phenotypes. **Nature Methods** *7*, 737-U100.
37. Gefen, O., and Balaban, N.Q. (2009). The importance of being persistent: heterogeneity of bacterial populations under antibiotic stress. **Fems Microbiology Reviews** *33*, 704-717.
38. Pearl, S., Gabay, C., Kishony, R., Oppenheim, A., and Balaban, N.Q. (2008). Nongenetic individuality in the host-phage interaction. **Plos Biology** *6*, 957-964.
39. Gefen, O., Gabay, C., Mumcuoglu, M., Engel, G., and Balaban, N.Q. (2008). Single-cell protein induction dynamics reveals a period of vulnerability to antibiotics in persister

bacteria. **Proceedings of the National Academy of Sciences of the United States of America** *105*, 6145-6149.

40. Gefen, O., and Balaban, N.Q. (2008). The Moore's Law of microbiology - towards bacterial culture miniaturization with the micro-Petri chip. **Trends in Biotechnology** *26*, 345-347.
41. Loinger, A., Lipshtat, A., Balaban, N.Q., and Biham, O. (2007). Stochastic simulations of genetic switch systems. **Physical Review E** *75*.
42. Lipshtat, A., Loinger, A., Balaban, N.Q., and Biham, O. (2006). Genetic toggle switch without cooperative binding. **Physical Review Letters** *96*.
43. Lipshtat, A., Perets, H.B., Balaban, N.Q., and Biham, O. (2005). Modeling of negative autoregulated genetic networks in single cells. **Gene** *347*, 265-271.
44. Kussell, E., Kishony, R., Balaban, N.Q., and Leibler, S. (2005). Bacterial persistence: A model of survival in changing environments. **Genetics** *169*, 1807-1814. (**Recommended F1000)**

45. Balaban, N.Q., Schwarz, U.S., and Geiger, B. (2005). Measurement of cellular contractile forces using patterned elastomer. In Cell Biology: A Laboratory Handbook 3ED Ed. Julio Celis.
46. Balaban, N.Q. (2005). Szilard's dream. **Nature Methods** *2*, 648-649.
47. Balaban, N.Q., Merrin, J., Chait, R., Kowalik, L., and Leibler, S. (2004). Bacterial persistence as a phenotypic switch. **Science** *305*, 1622-1625. **(Recommended F1000;** *Flagged for News and Views in Science 2014***)**

48. Schwarz, U.S., Balaban, N.Q., Riveline, D., Addadi, L., Bershadsky, A., Safran, S.A., and Geiger, B. (2003). Measurement of cellular forces at focal adhesions using elastic micro-patterned substrates. **Materials Science & Engineering C-Biomimetic and Supramolecular Systems** *23*, 387-394.
49. Bershadsky, A.D., Balaban, N.Q., and Geiger, B. (2003). Adhesion-dependent cell mechanosensitivity. **Annual Review of Cell and Developmental Biology** *19*, 677-695.
50. Schwarz, U.S., Balaban, N.Q., Riveline, D., Bershadsky, A., Geiger, B., and Safran, S.A. (2002). Calculation of forces at focal adhesions from elastic substrate data: The effect of localized force and the need for regularization. **Biophysical Journal** *83*, 1380-1394.
51. Riveline, D., Zamir, E., Balaban, N.Q., Schwarz, U.S., Ishizaki, T., Narumiya, S., Kam, Z., Geiger, B., and Bershadsky, A.D. (2001). Focal contacts as mechanosensors: Externally applied local mechanical force induces growth of focal contacts by an mDia1-dependent and ROCK-independent mechanism. **Journal of Cell Biology** *153*, 1175-1185. (**Recommended F1000)**
52. Balaban, N.Q., Schwarz, U.S., Riveline, D., Goichberg, P., Tzur, G., Sabanay, I., Mahalu, D., Safran, S., Bershadsky, A., Addadi, L., et al. (2001). Force and focal adhesion assembly: a close relationship studied using elastic micropatterned substrates. **Nature Cell Biology** *3*, 466-472. (**Recommended F1000)**

53. Riveline, D., Zamir, E., Balaban, N.Q., Kam, Z., Geiger, B., and Bershadsky, A.D. (1999). Focal contact as mechanosensor: Directional growth in response to local strain. **Molecular Biology of the Cell** *10*, 341a-341a.
54. Balaban, N.Q., Meirav, U., Shtrikman, H., and Umansky, V. (1998). High frequency edge excitations in the quantum Hall regime. **Physica B** *251*, 435-439.

55. Balaban, N.Q., Meirav, U., and Bar-Joseph, I. (1998). Absence of scaling in the integer quantum hall effect. **Physical Review Letters** *81*, 4967-4970.
56. Balaban, N.Q., Meirav, U., Shtrikman, H., and Umansky, V. (1997). Observation of the logarithmic dispersion of high-frequency edge excitations. **Physical Review B** *55*, 13397-13400.
57. Balaban, N.Q., Meirav, U., and Shtrikman, H. (1995). Crossover between different regimes of current distribution in the quantum Hall effect. **Phys Rev B Condens Matter** *52*, R5503-R5506.
58. Balaban, N.Q., Meirav, U., and Shtrikman, H. (1994). The breakdown of the quantum Hall Effect as a probe of current distribution. **World Scientific, Singapour**.