CURRICULUM VITAE

- Personal Details

  Christian Bracher
  born March 17, 1969 in Munich (Germany), German national,
  married to Julianna Zdunich (U.S. citizen, Sept. 23, 2000),
  three children (Kilian, born Oct. 11, 2001; Elinor, July 6, 2004; Simon, Jan. 14, 2007).

- Current Position

  08/2006 – today:

  Assistant professor at the Department of Physics & Astronomy,
  California State University Long Beach, 1250 Bellflower Blvd.,
  Long Beach, CA 90840, USA.

- Previous Work Experience

  08/2005 – 06/2006:

  Visiting professor at the Physics Department, Bryn Mawr College,
  101 N. Merion Ave., Bryn Mawr, PA 19010, USA.

  01/2004 – 08/2005:

  Postdoctoral research associate at the Physics Department,
  The College of William & Mary, Williamsburg, Virginia, USA.
  (Supervisor: Prof. John Delos)

  01/2002 – 01/2004:

  Postdoctoral fellow at the Department of Physics and Atmospheric Science,
  Dalhousie University, Halifax, Canada.
  (Supervisor: Prof. Hans-Jürgen Kreuzer)

  01/2001 – 01/2002:

  Continuation of postdoctoral studies at the Institute of Theoretical Physics T30,
  Technische Universität München, Munich, Germany.
  (Supervisor: Prof. Manfred Kleber)

  05/2000 – 12/2000:

  Research fellow at the Max-Planck-Institute for Quantum Optics (MPQ),
  Garching, Germany. (Supervisor: Prof. Herbert Walther)

  09/1999 – 04/2000:

  Postdoctoral studies at the Institute of Theoretical Physics T30,
  Technische Universität München, Munich, Germany.
  (Supervisor: Prof. Manfred Kleber)

- University Education

  08/1999:

  Promotion (PhD degree) in physics.
  [average grade: 1.0 (summa cum laude)]

  PhD thesis: "*A treatise on quantum ballistic motion and its applications from photodetachment to scanning tunneling microscopy*"

  07/1995 – 08/1999:

  Graduate studies at the Institute of Theoretical Physics T30,
  Technische Universität München, Munich, Germany.

  06/1995:

  Diplom (equivalent to master's degree) in physics.
  [average grade: 1.0 (summa cum laude)]

  Diploma thesis: "*Betrachtungen zum Begriff der Verweildauer in der Quantenmechanik*" (in German – English translation: "*Observations concerning the sojourn time problem in quantum mechanics*")

  11/1989 – 06/1995:

  Undergraduate studies in physics at the Technische Universität München,
  Munich, Germany.

- Awards and Scholarships

  06/2007 – 08/2007:

  Scholarly and Creative Activities Committee (SCAC) *Award*,
  California State University Long Beach.

  01/2002 – 01/2004:

  Killam Postdoctoral Fellowship at Dalhousie University, Halifax, Canada.

  01/2002 – 01/2004:

  Feodor Lynen Research Fellowship, awarded by the
  Alexander von Humboldt foundation (Germany).

  03/1992 – 06/1995, 01/1996 – 06/1998:

  Member of the *Studienstiftung des Deutschen Volkes* (German National Merit foundation), scholarships for undergraduate and graduate studies.

  1990/1991:

  Participant in the 3rd (final) round at the Bundeswettbewerb Informatik
  (German national computer science competition).

- Teaching Experience

01/2008 – 05/2008 (level: *graduate*):

— Course PHYS-550B "Quantum Mechanics II,"
Physics Department, California State University Long Beach.

01/2008 – 05/2008 (level: *undergraduate*):

— Instructor, PHYS-100A Introductory Physics Laboratory
Physics Department, California State University Long Beach.

09/2007 – 12/2007 (level: *graduate*):

— Course PHYS-550A "Quantum Mechanics I,"
Physics Department, California State University Long Beach.

09/2007 – 12/2007 (level: *undergraduate*):

— Course PHYS-310 "Classical Mechanics,"
Physics Department, California State University Long Beach.

06/2007 – 07/2007 (level: *undergraduate*):

— Instructor, PHYS-100A Introductory Physics Laboratory
Physics Department, California State University Long Beach.

01/2007 – 06/2007 (level: *undergraduate/general education*):

— Course PHSC-112 "Physical Science,"
Physics Department, California State University Long Beach.

— Instructor, PHSC-112 Laboratory
Physics Department, California State University Long Beach.

08/2006 – 12/2006 (level: *undergraduate*):

— Course PHYS-310 "Classical Mechanics,"
Physics Department, California State University Long Beach.

— Instructor, PHYS-100A Introductory Physics Laboratory
Physics Department, California State University Long Beach.

01/2006 – 05/2006 (level: *undergraduate*):

— Course PHYS-206 "Mathematical Methods and Numerical Techniques I,"
Physics Department, Bryn Mawr College.

— Course PHYS-215 "Electromagnetism, Relativity, and Particle Physics,"
Physics Department, Bryn Mawr College.

— Instructor, Introductory Physics Laboratory
Physics Department, Bryn Mawr College.

09/2005 – 12/2005 (level: *undergraduate*):

— Course PHYS-308 "Advanced Classical Mechanics,"
Physics Department, Bryn Mawr College.

— Course PHYS-101 "Introductory Physics I,"
Physics Department, Bryn Mawr College.

— Instructor, Introductory Physics Laboratory
Physics Department, Bryn Mawr College.

07/2004 – 09/2004 (level: *graduate/postgraduate*):

Set of seven lectures on "Quantum and Semiclassical Dynamics of Electrons in Parallel Electric and Magnetic Fields," Seminar on Algebro-Geometric Methods in Nonlinear Equations (AGNES), Math Department, College of William & Mary.

02/2003 (level: *graduate*):

Set of six lectures on the theory of random walks, as part of the course PHY6602 "Topics in Physics (Theoretical Methods in Physics)", Dalhousie University.

11/1999 – 02/2000 (level: *undergraduate*):

Preparation of assignments and presentation of solutions for the course "Mechanics and Electrodynamics II," read by Prof. M. Kleber, Technische Universität München.

11/1997 – 02/1998 (level: *undergraduate*):

Preparation of a manuscript accompanying the course "Introduction to Mathematical Methods in Physics," read by Prof. M. Kleber, Technische Universität München.

11/1995 – 02/1996 (level: *graduate*):

Preparation of assignments and presentation of solutions for the course "Quantum Mechanics of Many-Body Systems," read by Prof. M. Kleber, Technische Universität München.

- Research activities

  - *Classical, Semiclassical and Quantum Electron Motion in External Fields*

    In the last decade, experimental techniques like photodetachment and photoionization microscopy arrived that allow us to directly observe how photoelectrons coherently spread in external fields. Because the electron wave is made up from charged particles, it is easy to influence and control their motion by applying electric and magnetic fields. Although the potentials involved (uniform electric and magnetic fields, the Coulomb field) are very simple, and permit a largely analytic description of the electron motion, these systems harbor a surprisingly rich set of features that often has only been partially explained theoretically. — Among the examples that I studied, or intend to study, are photodetachment in an electric field, featuring the most striking demonstration of two-path interference using matter waves to date; photodetachment in parallel fields, where the fields may cause complete suppression of the photoeffect, and an interesting structure of caustic surfaces (boundaries of classical motion) is present; and photoionization in parallel fields, a classically chaotic process that should be fairly amenable to experiment. An important technique in analyzing these systems is the multidimensional semiclassical approximation, a method that seeks to explain the features seen in the quantum mechanical cross sections in terms of the classical electron trajectories. Modern mathematical “catastrophe theory” is a closely related subject.

  - *Quantum Sources in External Fields*

    In quantum scattering, it is at times convenient to separate the process that "generates" an electron wave from its subsequent motion under the influence of external and internal forces. To accommodate this, we introduce inhomogeneous "source terms" into the Schrödinger equation, akin to charges and currents in electrodynamics. We have successfully used the versatile source method to describe a variety of scattering processes. The list includes near-threshold photodetachment (see above), but also scanning tunneling microscopy (STM) — here we replace the tip with a pointlike electron source and calculate the conductivity of the tip-surface system; the continuous atom laser, where we studied the coherent motion of a Bose-Einstein condensate (BEC) under the influence of gravity to obtain its beam profile; field emission; and the properties of two-dimensional electron gases (2DEG) in the presence of crossed electric and magnetic fields. In this case, the source formalism directly yields the conductivity quantization seen in the quantum Hall effect.

- *Applications of the Random Walk in Statistical Physics*

  Random walk processes lie at the heart of many important problems in physics. I have studied analytical properties of the continuous persistent random walk in two dimensions (where the directions of adjacent steps are correlated), and self-avoiding walks in two and three dimensions that are based on the rotational isomeric state (RIS) model. These models find application in the statistics of polymer chains and provide an explanation for the elastic properties of single polymer strands. — Diffusion is another process that is microscopically described by a (discrete) random walk. In realistic diffusion models, the hopping rates for a particle depend on the occupation of the neighboring sites due to particle-particle interactions. I developed an analytic model for diffusion on a one-dimensional chain of sites based on the canonical ensemble; starting from a master equation, the probability to find the system in a specific configuration is calculated from the eigenstates and eigenvalues of the evolution operator.

- *Interaction of Atoms and Photons in the Micromaser*

  The micromaser setup consists of a beam of excited atoms traversing a superconducting microwave cavity that is exactly tuned to one of the atomic transition frequencies, together with detectors for atoms leaving the cavity in either state. This device allows us to examine cavity quantum electrodynamics, i.e., the interaction of electromagnetic waves and atoms, under nearly ideal conditions. I performed an inquiry into the statistics of atomic pattern probabilities in a simple operation mode of the micromaser, and also discussed the possible usage of this device as a "quantum clock" that yields the traversal time of a quantum particle in a potential barrier (see below).

- *The Tunneling Time Problem in Quantum Mechanics*

  The tunneling time problem concerns the amount of time spent by a quantum particle in a given sector of space, in particular the duration of tunneling events. Unlike a classical particle that is either reflected off a potential barrier, or transmitted over it, there are finite probabilities that a quantum particle is reflected and transmitted, and it seems natural that both processes should be associated with a certain duration, the reflection and transmission time scales. Despite decades of study, the nature of these tunneling times is still controversial, and while some conceptual framework emerged, consensus on quantum time scales of motion has not been achieved. My work tries to identify sensible definitions, and practical methods to extract the tunneling times, and seeks to establish relationships between the various proposals that have been put forward.

- Publications

[1] C. Bracher, M. Kleber, and T. Kramer:
New mathematical tools for quantum technology
in: *Mathematics of Quantum Computation and Technology*
(eds. G. Chen, L. Kauffman, S. Lomonaco)
Chapman and Hall/CRC (Boca Raton, Florida) 2007, 115-147.
(Preprint: arXiv:quant-ph/0703009)

[2] J.-S. McEwen, S. H. Payne, H. J. Kreuzer, and C. Bracher:
Hopping kinetics on a finite 1-D chain: An exact analysis
Int. J. Quant. Chem. **106** (2006), 2889-2903.

[3] C. Bracher and J. B. Delos:
Motion of an electron from a point source in parallel electric and magnetic fields
Phys. Rev. Lett. **96** (2006), 100404.

[4] C. Bracher, T. Kramer, and J. B. Delos:
Electron dynamics in parallel electric and magnetic fields
Phys. Rev. A **73** (2006), 062114.

[5] C. Bracher, J. B. Delos, V. Kanellopoulos, M. Kleber, and T. Kramer:
The photoeffect in external fields
Phys. Lett. A **373** (2005), 62-66.

[6] B. Donner, C. Bracher, M. Kleber, and H. J. Kreuzer:
A simple method for simulating scanning tunneling images
Am. J. Phys. **73** (2005), 690-700.

[7] T. Kramer and C. Bracher:
Propagation in crossed electric and magnetic fields: The quantum source approach
in: *Symmetries in Science XI*, (eds. B. Gruber et al.)
Kluwer (Dordrecht) 2004, 317-353.
(Preprint: arXiv:cond-mat/0309424)

[8] T. Kramer, C. Bracher, and M. Kleber:
Electron propagation in crossed electric and magnetic fields
J. Opt. B: Quantum Semiclass. Opt. **6** (2004), 21-27.

[9] C. Bracher:
Eigenfunction approach to the persistent random walk in two dimensions
Physica A **331** (2004), 448-466.

[10] J. N. Yukich, T. Kramer, and C. Bracher:
Observed photodetachment in parallel electric and magnetic fields
Phys. Rev. A **68** (2003), 033412.

[11] C. Bracher, T. Kramer, and M. Kleber:
Ballistic matter waves with angular momentum: Exact solutions and applications
Phys. Rev. A **67** (2003), 043601.

[12] T. Kramer, C. Bracher, and M. Kleber:
Matter waves from quantum sources in a force field
J. Phys. A: Math. Gen. **35** (2002), 8361-8372.

[13] T. Kramer, C. Bracher, and M. Kleber:
Four-path interference and uncertainty principle in photodetachment microscopy
Europhys. Lett. **56** (2001), 471-477.

[14] C. Bracher, M. Kleber, and M. Riza:
Variational approach to the tunneling-time problem
Phys. Rev. A **60** (1999), 1864-1873.

[15] C. Bracher, and M. Kleber:
Minimum tunneling time in quantum motion
Ann. Phys. (Leipzig) **7** (1998), 687-694.

[16] C. Bracher, M. Riza, and M. Kleber:
A simple adsorbate model in STM
(Proceedings of the STM'97 conference, Hamburg 1997)
Appl. Phys. A **66** (1998), S901-S905.

[17] C. Bracher, W. Becker, S. A. Gurvitz, M. Kleber, and M. S. Marinov:
Three-dimensional tunneling in quantum ballistic motion
Am. J. Phys. **66** (1998), 38-48.

[18] C. Bracher, M. Riza, and M. Kleber:
Propagator theory of scanning tunneling microscopy
Phys. Rev. B **56** (1997), 7704-7715.

[19] C. Bracher:
The micromaser as a quantum clock
J. Phys. B: At. Mol. Opt. Phys. **30** (1997) 2717-2734.

[20] C. Bracher, M. Kleber, and W. Becker:
Three-dimensional tunneling
in: *Tunneling and Its Implications*
(Proceedings of the Adriatico Research Conference)
(eds. D. Mugnai, A. Ranfagni, L. S. Schulman)
World Scientific (Singapore) 1997, 191-205.

[21] C. Bracher and M. Kleber:
Reflection time as an eigenvalue problem
Ann. Phys. (Leipzig) **4** (1995), 696-717.

— *Reports*

[1] M. Drexler, I. J. Sobey, and C. Bracher:
Fractal characteristics of Newton's method on polynomials
Report No. 96/14, Numerical Analysis Group,
Computing Laboratory, Oxford University, 1996.

[2] M. Drexler, I. J. Sobey, and C. Bracher:
On the fractal characteristics of a stabilised Newton method
Report No. 95/26, Numerical Analysis Group,
Computing Laboratory, Oxford University, 1995.

— *Book Reviews*

[1] W. C. Mih: *The Fascinating Life and Theory of Albert Einstein*
Contemporary Physics **43** (2002), 323.

[2] P. A. Tipler, R. A. Llewellyn: *Modern Physics* (3rd edition)
Contemporary Physics **41** (2000), 343-344.

[3] L. S. Schulman: *Time's Arrows and Quantum Measurement*
Contemporary Physics **39** (1998), 504-505.

[4] S. C. Bloch: *Classical and Quantum Harmonic Oscillators*
Contemporary Physics **39** (1998), 490.

[5] S. F. Savitt (ed.): *Time's Arrows Today: Recent Physical and Philosophical Work on the Direction of Time*
Contemporary Physics **38** (1997), 443.

- Review and Referee Activities

2007 – today:

Referee for the Canadian Journal of Physics.

2004 – today:

Referee for the Journal of Computational and Applied Mathematics (Elsevier).

2001 – today:

Referee for APS journals Physical Review A, Physical Review E, and Physical Review Letters.

1997 – 2001:

Book reviews for the Taylor & Francis journal Contemporary Physics.

1996 – today:

Referee for IOP journals Journal of Physics A, Journal of Physics B, Journal of Physics: Condensed Matter, and Inverse Problems.

- Conferences and Talks (Selection)

  09/2006:

  Quantum Ballistic Motion: The Strange and Fascinating Ways of Electrons in Electric and Magnetic Fields, talk presented at the Department of Physics and Astronomy seminar, California State University Long Beach.

  05/2006:

  Quantum theory of atom lasers, and *Dynamics of photoelectrons in a magnetic field*, talks presented at the DAMOP 2006 Conference, Knoxville, Tennessee, USA.

  07/2005:

  Hopping, desorption and adsorption kinetics in a finite 1D chain, presentation at the 5th Congress of the International Society for Theoretical Chemical Physics, New Orleans, Louisiana, USA.

  05/2005:

  Electron dynamics in parallel electric and magnetic fields, talk presented at the DAMOP 2005 Conference, Lincoln, Nebraska, USA.

  06/2003:

  The persistent random walk in two dimensions, talk presented at the Canadian Association of Physicists (CAP) Congress 2003, Charlottetown, PEI, Canada.

  05/2003:

  Quantum mechanics with sources, talk presented at the theoretical physics seminar series, Physik-Department, Technische Universität München, Germany.

  07/2002:

  Beam profile of a continuous atom laser, poster presented at the Eighteenth International Conference on Atomic Physics (ICAP) 2002, Cambridge, Mass., USA.

  04/2002:

  An introduction to quantum ballistic motion, talk presented at the Department of Physics and Atmospheric Science seminar, Dalhousie University, Halifax, Canada.

  04/2001:

  Photodetachment in parallel electric and magnetic fields, talk presented at the 7th European Conference on Atomic and Molecular Physics, Berlin, Germany.

  06/2000:

  Quantum ballistic motion in uniform electromagnetic fields, talk presented at the Laboratoire Aime-Cotton, Orsay, France.