Karen J. Crowther

University of Geneva
Department of Philosophy
Rue de Candolle 2
1211 Geneva, Switzerland

http://karencrowther.space
kcro8477@gmail.com

Employment

Postdoctoral Associate, Department of Philosophy, University of Geneva, 2016–2019
Postdoctoral Associate, Department of Philosophy, University of Pittsburgh, 2014–2015

Specialisation

Philosophy of physics; philosophy of science

Competence

Philosophy of mathematics; metaphysics

Education

PhD in Philosophy, University of Sydney, 2015
BA. (Hons) in Philosophy (Minor: Theology), Monash University, 2009
BSc. (Hons) in Physics (Minor: Mathematics), Monash University, 2008
Exchange Student, Uppsala University, 2006/2007
Visiting Student, University of Cambridge, 2012/2013

Awards

Swiss National Science Foundation Grant for Interdisciplinary Project (in collaboration with Christian Wüthrich (PI) and Niels Linnemann, University of Geneva)	2016
Lucy Firth Publication Prize in Philosophy (Sydney)	2013
Lucy Firth Publication Prize in Philosophy (Sydney)	2012
Andrew Donald Campbell Memorial Prize (Sydney)	2010
Australian Postgraduate Award Scholarship (Sydney)	2010
Camo Jackson Prize for Honours in Philosophy (Monash)	2009
Faculty of Arts Honours Study Assistance Scholarship (Monash)	2009
Faculty of Arts Dean's Recognition Award (Monash)	2009
Golden Key International Honours Society Membership	2005

PhD Thesis

"Appearing out of nowhere: the emergence of spacetime in quantum gravity".
Supervisors: Huw Price and Dean Rickles.
Committee: Jonathan Bain, Eleanor Knox, Christian Wüthrich.

Publications

Crowther, K. and Linnemann, N. (Forthcoming) "Renormalizability, fundamentality and a final theory: The role of UV-completion in the search for quantum gravity", in *The British Journal for the Philosophy of Science*, arXiv:1705.06777

Crowther, K. (2016) *Effective Spacetime: Understanding Emergence in Effective Field Theory and Quantum Gravity*, Springer.

Crowther, K. (2015) "Decoupling emergence and reduction in physics", in *European Journal for Philosophy of Science*, 5(3), 419–445.

Crowther, K. & Rickles, D., eds., (2014) "Special Issue on Principles of Quantum Gravity" in *Studies in History and Philosophy of Modern Physics*, 46, 135–227.

Crowther, K. & Rickles, D. (2014) "Introduction: principles of quantum gravity" in *Studies in History and Philosophy of Modern Physics*, 46, 135–141.

Crowther, K. (2013) "Emergent spacetime according to effective field theory: from

top-down and bottom-up" in *Studies in History and Philosophy of Modern Physics*, 44(3), 321–328.

Selected Presentations

- "On principles of theory construction and justification in quantum gravity" (with Niels Linnemann)
  Reasoning in Physics Workshop (Ludwig-Maximilians University of Munich, December 2016)
- "The role of UV completion in the search for quantum gravity" (with Niels Linnemann)
  Metaphysics and Physics: Methodological Links Conference (University of Lausanne, November 2016)
- "Coming to terms with the breakdown of spacetime"
  International Summer Institute in Philosophy of Physics on the Philosophy of Quantum Gravity (Williams Bay, Wisconsin, June 2016)
- "The Correspondence Principle in Quantum Gravity"
  Beyond Spacetime Seminar (University of Illinois at Chicago, April 2016)
- "Decoupling emergence and reduction in physics"
  Effective Theories, Mixed Scale Modeling and Emergence Conference (University of Pittsburgh, October 2015)
- "Novelty and autonomy as alternatives to, or bases for, a conception of emergence in physics"
  Reduction and Emergence in the Sciences Conference (Munich Centre for Mathematical Philosophy, November 2013);
  Serious Metaphysics Seminar (University of Cambridge, February 2013)
- "Emergent spacetime in (condensed matter approaches to) quantum gravity"
  Philosophy of Science Seminar (Ludwig-Maximilians University of Munich, November 2013);
  HPS Research Presentation Day (University of Sydney, May 2012)
- "Effective spacetime"
  Serious Metaphysics Seminar (University of Cambridge, October 2013)
- "Comments on Oriti's 'Disappearance and emergence of space and time in quantum gravity'"
  Quantum Gravity in Perspective Conference (Munich Centre for Mathematical Philosophy, June 2013)
- "Effective field theory, emergence, and fundamental physics"
  Australasian Association of Philosophy Conference (University of Otago, July 2011)
- "Understanding effective field theory"
  Centre for Time Postgraduate Seminar (University of Sydney, June 2011)
- "Spacetime emergent from a Bose-Einstein Condensate"
  Centre for Time Postgraduate Seminar (University of Sydney, August 2010)

Professional Service

Assistant/Committee:

- Effective Theories, Mixed Scale Modeling and Emergence Conference, University of Pittsburgh, October 2015
- Free Will and Retrocausality in a Quantum World Conference, Trinity College, University of Cambridge, July 2014

Referee/Expert:

- *British Journal for Philosophy of Science*
- *European Journal for Philosophy of Science*
- *Studies in History and Philosophy of Modern Physics*
- The Fund for Scientific Research-FNRS (F.R.S.-FNRS) Brussels, Belgium
- Beyond Spacetime essay contest

Convener: Sydney Foundations of Physics Seminar Series, University of Sydney, 2011

Teaching Experience

Practical Class Tutor/Laboratory Demonstrator:

- "Physics Simulations Using Microsoft Excel" for the Sutton Trust Summer School (Physics), University of Cambridge, July 2014
- "Mechanical Resonance" for the Sutton Trust Summer School (Physics), University of Cambridge, July 2014
- "Mechanical Resonance" for Experience Cambridge (Physics and Engineering), University of Cambridge, July 2014

Guest lectures:

- "Newton's Absolute Space" for Philosophy of Physics Masters Seminar, University of Geneva, November 2016
- "Time Travel for Beginners" for the Sutton Trust Summer School (Philosophy and Theology), University of Cambridge, July 2013
- "The Emergence of Spacetime in Quantum Theories of Gravity" for HPSC4101 *Philosophy of Physics*, University of Sydney, May 2011

Laboratory Demonstrator/Tutor
IA Physics
Cavendish Laboratory, University of Cambridge 2013

Class Tutor
PHIL1013 *Society, Knowledge and Self*
University of Sydney 2012; 2011

Laboratory Demonstrator
PHYS1011/PHYS1902/PHYS1003 *Junior Physics Laboratory*
University of Sydney 2012; 2011; 2010

Workshop Tutor
PHYS1003 *Physics 1 (Technological)*
University of Sydney 2010

Laboratory Demonstrator/Tutor
PHYS1011/PHYS1022 *Physics*
Monash University 2009; 2008

Thesis Abstract **Appearing out of nowhere: the emergence of spacetime in quantum gravity**

Quantum gravity is a long-standing problem at the forefront of contemporary research in theoretical physics. Minimally, it represents the attempt to find a theory (quantum gravity) that, in some sense, unifies general relativity (GR, the classical field theory that describes gravity) and quantum theory (the framework whose theories describe all other fundamental forces). The two pillars are notoriously hard to reconcile—owing, largely, to their disparate treatments of space and time. Quantum gravity is supposed to be necessary for describing the world at an extremely small distance scale (corresponding to an extremely high energy scale), and is thus expected to "replace" GR in this domain. Various predictions made by many of the existing (incomplete) approaches to quantum gravity have been interpreted by physicists as suggesting that our familiar notions of space and time cease to be applicable at this scale. I examine the reasons for thinking that spacetime might "break down", as well as explore the meaning of such a claim.

The main focus of my work concerns the question of *emergence*. If spacetime does not exist at the fundamental level, then how is it so remarkably successful as a concept at familiar scales—in other words, if GR is replaced by quantum gravity at some scale, then how do we "recover" GR (with its description of spacetime) in the domain where we know it applies? In order to answer this question, I consider more accessible cases of emergence in physics—those that describe phenomena or mechanisms thought to have analogues in quantum gravity, as well as those whose study utilises techniques that promise also to be useful in quantum gravity research. By exploring these different examples of theories and techniques (including condensed matter physics, quantum field theory, hydrodynamics, effective field theory [EFT] and the renormalisation group, [RG]), I develop a novel account of emergence in physics. The conception of emergence that I propose differs from previous accounts in the philosophy of science literature, in that—rather than involving the notion of reduction—it emphasises the novelty and autonomy of the emergent theory from the small-scale theory (to which it is related by EFT and the RG). The autonomy, essentially, arises because the small-scale theory is underdetermined by the large-scale physics (i.e. there are many different small-scale theories that could give rise to our current, accessible, physics).

This new conception of emergence, I argue, is important because it properly does justice to physics as actually practised. It is useful not only for application to other areas of philosophy of physics, but impacts upon philosophy of science itself; it helps us understand how theories may be related to one another. I explore several different approaches to quantum gravity (including condensed matter approaches, causal set theory, causal dynamical triangulations, quantum graphity and loop quantum gravity) in order to determine how such a notion of emergence might apply in these cases (if at all), and to see what they could teach us about the fundamental nature of spacetime. I discover that the large-scale structure of spacetime leaves quantum gravity largely underdetermined, and that the very features of the emergence-relation that are responsible for its great utility across different fields of physics also serve to restrict how much we can legitimately draw from it.