PROFESSOR: DIDIER SORNETTE

Didier Sornette joined ETH Zurich in March 2006. Professor Sornette (h-index 49 (ISI) and 67 (scHolar)) graduated from Ecole Normal Supérieure Ulm, Paris, in 1981 and became a Research Director at CNRS France (1981-2006); from 1996, he was jointly Professor at the Institute of Geophysics and Planetary Physics and the Department of Earth and Space Sciences at UCLA (1996-2006). While holding the Chair of Entrepreneurial Risks at ETH Zurich, he is also a Professor of Finance at the Swiss Finance Institute, a Professor of Physics associated with the Department of Physics (D-PHYS) at ETH Zurich, and a Professor of Geophysics associated with the Department of Earth Sciences (D-ERDW) at ETH Zurich. In addition, he is an Honorary Professor at the School of Business and Research Center of Systems Engineering, East China University of Science and Technology (ECUST), Shanghai, China. He is a founding member of the Risk Center, the competence center that plays a central role in ETH Zurich’s Global Risk Initiative. His research focuses on the prediction of crises and extreme events in complex systems, in particular of financial bubbles and crashes, and the diagnosis of systemic instabilities. Other areas of work include earthquake physics and geophysics, financial economics and the theory of complex systems, the dynamics of success on social networks, and the complex systems approach to medicine (immune system, human parturition, epilepsy, etc.). In 2008, he launched the Financial Crisis Observatory to test the hypothesis that financial bubbles can be diagnosed in real time and their termination predicted probabilistically.

MISSION STATEMENT OF GROUP

Our group belongs to the “Systems Design and Risk” research pillar with D-MTEC and is working on a variety of projects related to entrepreneurial risks. Specifically, we view the world as an ensemble of entangled and inherently out-of-equilibrium networks. We strive to push the limits of silo disciplines by developing a combined inter-, multi- and transdisciplinary view of knowledge, using both fundamental research and operational implementation, as well as entrepreneurial initiatives. The multidisciplinary approach is reflected in the multiple academic associations D. Sornette has with different departments.

Our main objectives are to
(i) develop, validate, and transfer into best practice a general theory for the understanding, characterization, prediction, and eventual control of crises to build more resilient societies (recent advances in this direction include the Financial Crisis Observatory and the endo-exo theory of shocks);
(ii) develop a general theory of human preferences and decision making at the individual level and taking account of social interactions (recent progress includes the formulation of a new “Quantum Decision Theory” that solves – consistently and without adjustable parameters – all the paradoxes and fallacies known to plague available decision theories, including Kahneman and Twersky’s Prospect Theory);
(iii) transfer our research and knowledge to industry and society via collaborations, joint ventures, and operational implementation.
GROUP AND RESOURCES

In addition to Didier Sornette (DS), our group is constituted as follows:

(i) Four senior researchers: Dr. Peter Cauwels and Dr. Ryan Woodard are the core members of the Financial Crisis Observatory (FCO); Prof. Alexander Saichev develops, with Didier Sornette, theoretical models of volatility, self-excited cascades and risks; Dr. Monika Gisler co-heads the project on “Social Bubbles” with Didier Sornette;

(ii) Two postdocs: Dr. Vladimir Filimonov co-invented with Didier Sornette the self-excited multifractal process for financial volatility and is co-discoverer of a new method for precisely quantifying in real time the endogeneity level of financial markets, with broad applications to many systems. Dr. Thomas Maillart, who did his PhD under Didier Sornette, is now a part-time postdoc with our group working on a web-based implementation of collective action called Risikopedia;

(iii) 11 PhD students:
- Maroussia Favre is developing models of human cooperation and gender difference in risk taking;
- Zalan Forro is working on the valuation of social companies (YouTube, Groupon Zynga) in the Financial Crisis Observatory and on GIS-bubble approaches to the real estate market in Switzerland, using Comparis AG’s unique database;
- Georges Harras is finishing his thesis on models of herding behavior and abnormal correlations in financial markets;
- Ryohei Hisano is working on a large database, involving in particular millions of companies in Japan, to test models of growth and competition;
- Andreas Huesler is working on the agency problem in the mutual fund industry, on endogenous economic growth models and their calibration for CO2 production, and on the data analysis of financial bubbles in the laboratory;
- Mohamed Issami is working on coding trading strategies for agent-based models and the problem of reverse-engineering in financial markets;
- Yaver Kamer is developing risk models for earthquakes and testing their predictability;
- Tatyana Kovalenko is studying cognitive limits in decision making to test and extend the quantum decision theory developed by Didier Sornette and Prof. V. Yukalov;
- Susanne von der Becke is working on a general framework for understanding and controlling systemic risks for financial systems, with particular emphasis on the role of the banking sector;
- Yaming Wang is developing methods for fault network reconstruction, based on past seismicity including location uncertainties, in order to better localize the future occurrence of earthquakes;
- Qunzhi Zhang is quantifying the impact of news on financial market moves and is the main architect of the reverse-engineering project using agent-based models.

Our group benefits from collaboration with regular visiting professors (Taisei Kaizoji, Y. Malevergne, V. Yukalov, and E. Yukalova), as well as exchange students, postdocs and professors from China and Russia, in particular.

The group has developed a strong computational infrastructure, which serves the operations of our Financial Crisis Observatory, among others. Our core infrastructure consists of three types of hardware: personal computers and laptops (for quick, interactive analysis), a private rack-mounted cluster of five nodes, each containing four quad-core processors (a total of 80 cores for medium-sized analysis and a considerable amount of post-processing) and the ETH Zurich Brutus cluster. Our ETHZ-FCO is the largest single shareholder of Brutus, having purchased over 12% of the processing power of this shared-resource cluster of 10,000 cores. Brutus is used for the main daily scans and analyses of over two thousand global assets. The private cluster and Brutus have been designed with large memory and disk storage, high speed internal networking and daily RAID data backup.
### Personnel Data

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<th>Position</th>
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<tr>
<td>Professor</td>
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<td>Scientific Staff with Doctoral Degree</td>
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### Financial Data (Expenditures)

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<td><strong>Total</strong></td>
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* Average of full years at ETHZ.

**TABLE 1: PERSONNEL AND FINANCIAL DATA OF THE CHAIR OF PROF. SORNETTE.**
Financial Bubbles and Crashes: Our first priority is to use the Financial Crisis Observatory (http://www.er.ethz.ch/fco/) to test the hypotheses that (i) financial bubbles can be diagnosed in advance before they burst and (ii) their termination time can be predicted probabilistically much better than chance. In 2008, we launched the financial bubble experiment (http://fcofbe.blogspot.com/) and the financial trading experiments to test the existence of predictability and inefficiencies in financial markets empirically. We have also developed a series of mathematical models, agent-based simulations, and a large toolbox of methods to represent and characterize the dynamics of financial prices and, in particular, their most extreme expressions in the form of bubbles and crashes.

The Endo-Exo Dynamics of Success, Fame, and Crises: We found that in many systems, large dynamic changes result from the entanglement of endogenous and exogenous shocks. We have developed a general theory describing the generic dynamic law that characterizes the activity of systems leading to and following a peak, a crisis or a climax. A profound relationship was found between the response to exogenous shocks and the endogenous fluctuations of systems driven by epidemic-like interactions, such as word-of-mouth contacts in social networks and the triggering processes of natural systems. This constitutes a generalized fluctuation-susceptibility theorem for such out-of-equilibrium systems with punctuated dynamics. Applications include the dynamics of commercial sales, YouTube video successes, financial volatility shocks, market crashes, outbursts of cyber-risks, social conflicts and crises, epileptic seizures, earthquakes, landslides, climate dynamics, and so on.

Dragon-Kings: Extreme fluctuations or events are often associated with power law statistics. Indeed, power law tails are often seen as the epitome of extreme events (the “Black Swan” story). We have introduced a different view of the world of risks, captured by the term “dragon-king.” We claim that extreme events in most natural and social systems may not be due to the same mechanisms that act on other events and may require specific amplifying processes, which are activated intermittently. This gives rise to specific properties and signatures that may be the unique characteristics of dragon-kings, thus leading to possible predictability. We have edited a special volume on dragon-kings soon to appear with Springer, compiling 20 contributions in different scientific fields. Overall, the picture that emerges is that dragon-kings reveal hidden mechanisms, which are only transiently active and which amplify normal fluctuations (often described by the power laws of the normal regime). The dragon-king worldview also provides a general approach for understanding the present world financial crisis as based on two decades of successive financial and economic bubbles, inflating the Mother of All Bubbles, with new monster dragon-kings on the horizon. Our research contributions are broken down into the following topics (see http://www.er.ethz.ch/publications/index):

1. Social Systems/Finance
   1.1 Bubbles and Crashes: Theory
   1.2 Bubbles and Crashes: Theory - Empirical Analyses
   1.3 Social Bubbles
   1.4 Methods and Techniques for Financial Markets
   1.5 Agent-Based Models
   1.6 Asset Pricing, Portfolio Theory, Option Theory, Yield Curve
   1.7 Decision Theory, Behavioral Finance, Social Dilemmas, Cooperation
   1.8 Volatility and Return, Anomalies and Predictions
2. Complex Systems and Self-Organization
   2.1 Predictability and Endo-Exo Dynamics
   2.2 Internet, Open-Source Software, Cyber-Risks, Networks
   2.3 Epileptic Seizures, the Immune System, Biological Systems
   2.4 Concepts and Techniques
   2.5 Self-Organized Criticality, Critical Systems, Power Laws
   2.6 Self-Excited (Hawkes) Branching Processes
3. Discrete Scale Invariance & Complex Dimensions
4. Earthquakes, Landslides, Glacier Collapses and Other Natural Hazards
<table>
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<th>Year</th>
<th>ISI Peer-Reviewed Publications</th>
<th>Other Publications by Group</th>
<th>Talks</th>
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<td>2006</td>
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<td>372*</td>
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<td>2008</td>
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<td>2009</td>
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<tr>
<td>2010</td>
<td>16</td>
<td>16</td>
<td>128</td>
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<tr>
<td>2011</td>
<td>23</td>
<td>23</td>
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<tr>
<td>Total</td>
<td>115</td>
<td>460</td>
<td>505</td>
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* These fields contain the data from the start of the professor’s career until (and including) 2006.

TABLE 2: PUBLICATIONS AND TALKS OF THE CHAIR OF PROF. SORNETTE.

EXAMPLES OF LARGE-SCALE FINANCIAL BUBBLES THAT HAVE BEEN DIAGNOSED EX-ANTE AND PREDICTED BY SORNETTE’S GROUP IN ADVANCED PUBLICATIONS.
TEACHING ACTIVITIES


Financial Management (Master level taught by Prof. J.-P. Chardonnens) ~ 200 students: Financial objectives, financial statement analysis, working capital management, capital budgeting techniques, capital structure, cost of capital.

Financial Market Risks (Master level taught by Prof. D. Sornette) ~ 120 students: Financial risks and management, financial markets, options and derivatives, valuation of bonds, management of international risks.

Entrepreneurial Risks (Master and PhD levels taught by Prof. D. Sornette) ~ 50 students: Risks and entrepreneurship, power law risks, measure of risks, mathematical models, origins of crises, market crashes, predictability, human-made risks.

Equity Derivative Trading in Practice (Master and PhD levels taught by Dr. Mika Kastenholz, Head of Credit Suisse Derivatives Trading Desk) ~ 50 students: Filling in the gaps between textbook quantitative finance and industry practice, emphasis on how theory and quantitative models are used in derivatives trading on a daily basis, single and multifactor vanilla and exotic options with typical models and their limitations described in several case studies.

Corporate Finance (Master level taught by Dr. Markus R. Neuhaus, CEO PwC Switzerland) ~30 students: Investment management, value based management, financial reporting, mergers and acquisitions, internal control, turnaround.

Discovering Management (Bachelor and Master level taught by 11 professors, Didier Sornette contributing a lecture on Risk Management) ~40 students: Discovering Management (formerly known as Discovering Entrepreneurship); a general introduction to the field of entrepreneurship and the practices of professional business management. In his lecture, Prof. D. Sornette introduces the students to fat tail risks, cascade effects and systemic risks through case studies and draws conclusions for best risk management practice. (http://www.entrepreneurship.ethz.ch/education/lectures/dm/)

Interdisciplinary Risk Center Weekly Seminar Series: Complex Socio-Economic Systems and Integrative Risk Management (PhD level co-organized and taught by the 10 members of the ETH Zurich Risk Center): This course consists of presentations and subsequent discussion on modelling complex socio-economic systems and crises.
SERVICES TO THE ACADEMIC COMMUNITY


KNOWLEDGE AND TECHNOLOGY TRANSFER

The group receives a lot of media attention. Didier Sornette and the senior members of the group (Monika Gisler, Peter Cauwels and Ryan Woodard) receive weekly (and often daily) requests for interviews from some of the major journals in Switzerland (Neue Zürcher Zeitung (NZZ), Handelszeitung, Das Magazin, L’Agefi, NZZ am Sonntag), Germany (Der Spiegel, Finanzwelt, Handelsblatt, EURO am Sonntag), France (Les Echos), the UK (Physics World, New Scientist) and the US (Wall Street Journal, Financial Times, The New York Times, Bloomberg Business week, Technology Review MIT, ScienceNews) as well as from radio and TV stations. For a selected list of main media outlets, see http://www.er.ethz.ch/interviews/index.

We are involved in numerous events and conferences to transfer knowledge to the finance and insurance industry. A selected list can be found at http://www.er.ethz.ch/presentations/index.

As a founding member of the ETH Competence Center for “Coping with Crises in Complex Socio-Economic Systems” in 2008 (http://www.ccss.ethz.ch/), which became the Risk Center in 2011 (http://www.riskcenter.ethz.ch), the group contributes to scientific activities, science leadership, and outreach to the private sector. In particular, we give talks to different industries and outlets to promote the Risk Center’s scientific vision.

We have on-going collaborations with numerous institutions and universities worldwide, in particular in the USA, Russia, China, France, and Japan.
In line with the above “Mission Statement,” the group has many projects in development. Perhaps the most ambitious is our contribution as leader of the new Observatory and Exploratory of Economic and Financial Crises within the equally ambitious FuturICT project, which is currently a forerunner in the European Union’s Flagship competition to achieve 1 billion Euros of funding over a decade. Indeed, the Observatory and Exploratory, which will be coordinating and federating the research of dozens of European research groups and institutions, has been inspired by our own FCO. In addition, this model, started in 2008 at ETH Zurich in our group, is now the template for other Observatories and Exploratories planned within FuturICT, from biological risks to crimes.

We are also excited by the prospect of expanding our Financial Crisis Observatory to validate the hypothesis that financial crises are knowable, can be diagnosed in advance, and can be timed probabilistically. We are eager to work with central banks and regulators, in collaboration with our colleagues within D-MTEC, in particular, and at ETH Zurich’s Risk Center, to change the present state of policymaking and regulation into a well-functioning financial system that serves the economy and increases social welfare. We also plan to step up our research efforts on decision making and collective action, integrating the many disciplines involved into a coherent theoretical framework with operational goals, to help break the stalemate in the presently inadequate description of how boundedly rational humans allocate their resources and steer their lives, companies, and societies. We believe that the challenge of the next two decades will create extraordinary tests of our ability to adapt to achieve genuine sustainable development.
Professorships of the Department of Management, Technology, and Economics