

# Synchronization and Multiscale Complex Dynamics in the Brain - BSYNC09

## *Scientific Report*

**Dates and duration:** November 2-6, 2009

**Coordinators:** Jordi Garcia-Ojalvo (Universitat Politècnica de Catalunya, Terrassa, Spain), Claudio Mirasso (Instituto de Física Interdisciplinar y Sistemas Complejos, Palma de Mallorca, Spain), Gordon Pipa (Max-Planck-Institut für Hirnforschung, Frankfurt/Main, Germany)

The purpose of BSYNC09 was to bring together experimental neuroscientists working with different levels of description of brain activity, and physicists experienced in the study of multiscale processes, in order to bridge the gap currently existing between the theoretical and experimental approaches to the understanding of brain function. The result was a conference with an unusually diverse combination of invited speakers and participants, including highly recognized and well known scientists in clinical neurophysiology (Cornelis Stam, Jose Luis Cantero), experimental neural dynamics (Gilles Laurent, Wolf Singer, María V. Sánchez-Vives), psychiatry (Michael Breakspear), neuroimaging (Rainer Goebel, Fernando Maestú), complex network theory (Stefano Boccaletti, Mario Chavez, Víctor Eguíluz), computational and theoretical neuroscience (Alessandro Villa, Klaus Obermeyer, Gordon Pipa, Fritz Sommer), nonlinear and stochastic physics (Lutz Schimansky-Geier, Benjamin Lindner, Arkady Pikovsky), neuronal modeling (Hans Braun, Dmitry Postnov), and biomedical time series analysis (German Gómez-Herrero, Ernesto Pereda).

Among the specific topics covered, some of the talks dealt with the application of complex-network approaches to characterize and understand the structural basis of brain dynamics and the resulting functional connectivity profiles (M. Chávez, C. Stam, M. Valencia, A. Díaz-Guilera, V. Eguíluz, A. Arenas, S. Boccaletti). Another group of talks emphasized criticality and percolation as crucial characteristics of brain activity (M. Breakspear, W. Shew, J. Soriano). The existence of synchronization-based correlates of neurological disease was discussed by W. Singer, F. Maestú, O. Rosso, A. J. Pons, and F. Amor. The computational capabilities of the brain were analyzed from different perspectives in the talks of A. Villa, G. Pipa, F. Sommer, K. Obermeyer, J. Cabessa, and R. Vicente. The relevance of oscillatory activity in time and/or space for the correct operation of the brain was discussed by G. Laurent, T. Siapas, E. Niebur, M. Sánchez-Vives, and K. Takahashi. Theoretical studies of different aspects of synchronization in neuronal models were reported by L. Schimansky-Geier, H. Braun, A. Pikovsky, D. Postnov, and E. Ullner. The talks by G. Gómez-Herrero and E. Pereda provided an overview of techniques that allow us to determine correlation and causality in the functional activity of the brain. The importance of neuroimaging in monitoring the brain at the appropriate temporal and spatial scales was discussed by R. Goebel. The potential of anesthesia as a brain state adequate for the study of global brain activity was described by B. Scheller, while I. Fischer proposed a cross fertilization study between laser dynamics and neurons that would allow us to understand new mechanisms leading to particular synchronization mechanisms.

A very stimulating collection of posters was also presented in the conference, and discussed during three dedicated sessions in the conference program. A wide variety of topics following the main themes described in the previous paragraph were presented in the posters. Additionally, a round table discussion was devoted to exchange opinions on the factors that most likely determine the collective activity of a healthy brain, the role of theoretical modeling in linking these factors with experimental data, and the importance of nonlinearity and noise in brain activity.

In summary, the workshop BSYNC09 provided a setting in which experimentalists and theoreticians, and researchers at the neuronal and macroscopic scales of the brain, exchanged ideas, compared views and shared goals on what mechanisms underlie the normal coordinated function of the brain. Informal feedback from participants showed that they were very satisfied with the meeting, and were interested in repeating the experience again. Clearly MPIPKS is an excellent setting for the exchange of interdisciplinary ideas, and we are very thankful for the support received from the institute.