MEG Signatures of Intrinsic Coupling: New Methods

Organizers: Laura Marzetti

Room: # 105

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Revealing Signatures of Intrinsic Coupling Modes by MEG: Insights from New Methods
In the last 20 years, system neuroscience has seen a paradigm shift in ongoing brain activity, moving away from considering it as an idling state towards its organization in spatiotemporal structures linked to experience. More recently, MEG functional connectivity contributed along this line by designing methods focusing on coupling of slow fluctuations (seconds) of brain activity resembling fMRI. Indeed, MEG functional connectivity studies have also shown that faster intrinsic brain activity is organized with spatio-temporal structures that only partially overlap with that of slow fluctuations, with the notion of Intrinsic-Coupling-Modes (Engel et al., 2013) providing a unifying theoretical framework for the multiple spatial and temporal scales. From a methodological standpoint, two major aspects deserve further discussion: i) approaches able to capture and integrate different aspects of such spatio-temporal structure; ii) issues of the robustness and reliability of such approaches. The aim of this symposium is to bring together experts in analysis methods to discuss these aspects with specific reference to the role of frequency, cross-frequency coupling, and coupling of slow fluctuations. Along with presenting novel methods, pitfalls and methodological issues, the speakers will cover relevance to the ICM model. The symposium will last 60 minutes and host 3 speakers.

Speakers:

- **Laura Marzetti** (Univ. G. d'Annunzio of Chieti-Pescara, Univ. G. d'Annunzio of Chieti-Pescara, Italy)
  "State of the art of methods for the study of intrinsic coupling modes by MEG."

  The notion of Intrinsic-Coupling-Modes (ICM) of brain function provides a powerful theoretical framework for addressing the dynamic coexistence of integration and segregation patterns in the brain observed at multiple spatial and temporal scales.
  Supporting such notion with further empirical evidence from MEG ongoing brain activity requires to design analysis methods able to break the barriers that currently pose a limitation in this framework. This talk will start by discussing the major factors that influence the estimation of functional connectivity from source space MEG data, with reference also to the role of forward and inverse modeling. A review of the state of the art of commonly used MEG functional connectivity methods (Imaginary Coherence, Amplitude Envelope Correlation, etc.) will be then at target with emphasis on the strengths, limitations and functional significance of the different methods. Finally, results from currently available studies will be revisited under the ICM framework.

- **Mark Woolrich** (Univ. of Oxford, United Kingdom)
  "Multi-subject MEG Connectomes"

  Modeling the strength of intrinsic coupling across cortex is a powerful approach for exploring the signatures of healthy and diseased cognition in the human connectome. Here, we assess different MEG functional connectivity metrics largely based on how well they produce consistent results over sessions, subjects and populations. We demonstrate that the performance of different metrics varies, with some struggling to provide robust estimates of connectivity, particularly at the single-subject level. The results also emphasize the importance of correcting for spatial leakage confounds, and we highlight methods for achieving this when computing parcellated connectomes. The strength of coupling in networks covering the whole of cortex can be used to predict dysfunction and behavior, but the effectiveness of these approaches relies on generating accurate network models for each subject. We demonstrate that hierarchical models enable the sharing of information between an entire group of subjects and the individual. This has the potential to provide estimation of the intrinsic coupling within each subject, offering higher sensitivities in subsequent analyses. We illustrate the application of our techniques by analyzing the genetic influence on the amplitude coupling between intrinsic neural oscillations using data from the Human Connectome Project.

- **Guido Nolte** (Universitaetsklinikum Hamburg-Eppendorf, Germany)
  "Bicoherence. The higher harmonics strike back."

  While bicoherence and cross-bicoherence are well-known measures of functional relations across frequencies, their relevance for studying e.g. the alpha rhythm is probably underestimated. This talk will start with general remarks on non-stationarities, which are necessary to understand some technicalities of bicoherence, and which are, hopefully, also of general interest. The main conclusion of this part will be that the non-stationarity of spontaneous brain activity is a myth. Bicoherence itself is a univariate measure, in general reflecting coupling between three frequencies with the constraint for stationary data that the third frequency is the sum of the first two frequencies. In real EEG and MEG data the most prominent signals are couplings between alpha and its higher harmonics. These higher harmonics are barely visible in conventional power analysis. Theoretically, it can be shown that Phase Amplitude Coupling, which attracted much attention lately, is essentially a smeared version of bicoherence, with the advantage of the latter that higher harmonics can easily be recognized as such. Finally, the more general multivariate variants, i.e. cross-bispectrum and cross-bicoherence, are discussed in the context of studying brain connectivity robust to artifacts of volume conduction.