Understanding the complexity of frequency and phase angle fluctuations in power grids

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The Kuramoto model with inertia and noise is a beautiful theoretical model to theoretically study different possible synchronization states of power grids with a given network structure. However, the question remains what type of noise and complex behaviour is actually observed in real power grids. In this talk I will present recent results for measured frequency signals that are based on real-time measurements in power grids in the UK, Europe, and South Africa [1,2,3,4,5]. A spectrum of highly complex non-Gaussian stochastic processes is seen for the tiny deviations of the frequency from the mean 50Hz, as well as for the fluctuations of the phase angle dynamics. The stochastic signal is influenced by trading on the energy markets [1], by fluctuations in the electricity consumption processes [2], by fluctuations of renewable energy generation, control processes and other influences [3]. Major perturbations at a given spatial position propagate as a diffusion process through the power grid network [4]. In the last part of the talk I will talk about new measurements collecting close to 1 Billion data points for frequency deviations and phase angle fluctuations, both for the UK grid and the South African power grid [5]. I will talk about suitable superstatistical modelling approaches to understand this complexity.

References:

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