Complex current fluctuations in Ni-H electrochemical experiments: Characterization using non-linear signal analysis

#Felix Scholkmann[1], Emma Gutzmann[2], David J. Nagel[2]
[1] Research Office for Complex Physical and Biological Systems, Zurich, Switzerland
[2] The George Washington University, Washington, USA
Email: Felix.Scholkmann@gmail.com

The sophistication of the analysis of data from low-energy nuclear reactions (LENR) experiments has varied widely. While Fleischmann and his colleagues, for example, did diverse and thorough analyses of data from the calibration and performance of their calorimeters [1], overall, there has been relatively little analysis of the temporal histories of the temperatures or electrical currents within LENR electrochemical cells. Here, we report on detailed analyses of the current fluctuations within electrochemical cells with Ni cathodes and light water electrolytes. These analyses are part a three-prong research program aimed at understanding Ni-H electrochemical approaches to the production and control of LENR. Two papers describe the experiments [2] and their simulations [3].

We analysed time-series from electrochemical LENR experiments with electrolytes of K_2CO_3 or Na_2CO_3, and electrode potentials of 3 to 5 V. In particular, we determined (i) how the fluctuation magnitude and the fractal dimension (D_F) of the time series depend on the electrode potential, and (ii) if the complexity of the signals can be captured by analysing the multiscale time irreversibility (MTI) [4]. The analyses revealed that (i) the fluctuation magnitude depends non-linearly on the electrode potential (power-law), (ii) that D_F increases with electrode potential, (iii) the MTI is able to quantify the scale-dependent complexity of the electrochemical signals (see Fig. 1), and (iv) that characteristics of large fluctuations in the data follow lognormal distributions. The MTI generally increases with the electrode potential applied in the cell. As shown in Figure 1, the signals show sawtooth-shaped fluctuations on multiple scales, with a sudden increase and a slower decay. The complexity and the sawtooth pattern indicate the presence of one or more dynamic mechanisms at the electrode-electrolyte interface. Departures of gas bubbles from the cathode surface probably contribute to the observed behaviour, giving a background against which we hope to detect the effects of LENR.

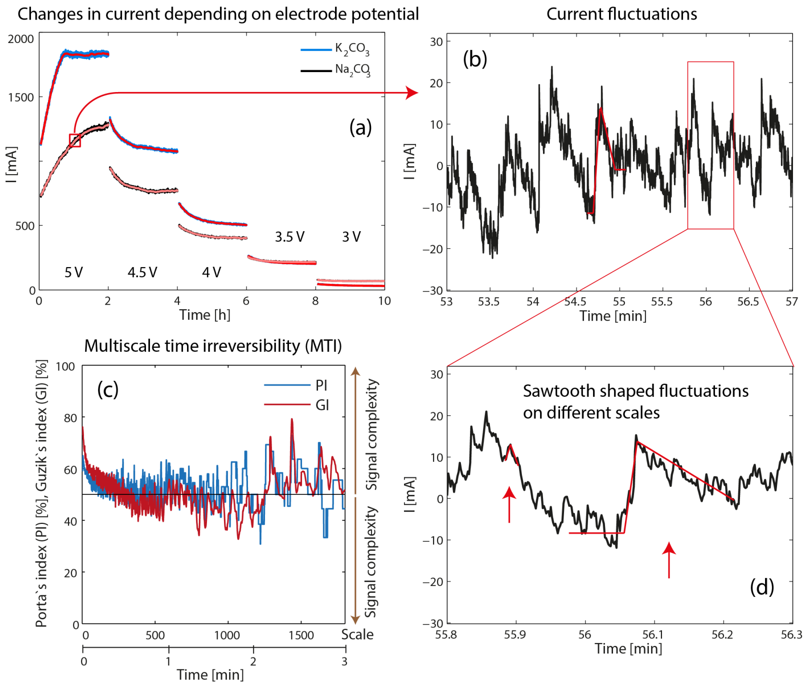

Figure 1 Visualization of one data set: raw data (a), enlarged sections of the current fluctuations (b, d), and the result of the multiscale time irreversibility analysis (c). A deviation from the horizontal line in (c) from 50 % indicates complexity of the time-series, i.e. asymmetric shapes of the fluctuations.

[1] M. Fleischmann and S. Pons, "Calorimetry of the Pd-D_2O system: from simplicity via complications to simplicity", Physics Letters A, 176 (1-2), 118-129, 1993
[2] E. Gutzmann, J. E. Thompson and D. J. Nagel, "Parametric experimental studies of Ni-H electrochemical cells", Abstract submitted to this conference (ICCF-21, Fort Collins, CO USA)
[3] G. Papadatos, Z. Awtry, D. J. Nagel, "Electrical and thermal simulations of Ni-H electrochemical cells", Abstract submitted to this conference (ICCF-21, Fort Collins, CO USA)
[4] L. Chladekova *et al.*, "Multiscale time irreversibility of heart rate and blood pressure variability during orthostasis", Physiological Measurement, 33, 1747-1756, 2012