# Adaptive neuromodulation: a novel approach to electrical brain stimulation

Peter A. Tass[1,2,3,*], Utako B. Barnikol[1,2], Christian Hauptmann[1,2], Oleksandr Popovych[1,2], Milan Majtanik[1,2], Jürgen Voges[2,3], Volker Sturm[2,3], and Hans-Joachim Freund[1,2,3]

[1]Institute of Medicine, Research Center Jülich, Germany
[2]Virtual Institute of Neuromodulation, Research Center Jülich, Germany
[3]Department of Stereotaxy and Functional Neurosurgery, University of Cologne, Germany

In several neurological diseases like Parkinson's disease (PD), essential tremor or multiple sclerosis (MS) brain function is severely impaired by synchronization processes. To overcome limitations and drawbacks of conventional deep brain stimulation (DBS) (Benabid *et al.*1991, McIntyre *et al.* 2004), we develop novel DBS techniques based on nonlinear dynamics and statistical physics. In particular, we propose a novel method which selectively disrupts pathological synchronization and restores desynchronization in a mild but effective manner (Tass 1999, 2003a, 2003b): Effective transient desynchronization is achieved by a multisite coordinated reset (CR) stimulation, where mild resetting stimulus trains are sequentially administered via several sites. After a CR stimulus the target population splits into several sub-populations, quickly runs into a pronounced transient desynchronized state, and then reverts to synchrony if left unperturbed. To maintain a desynchronised firing, CR stimuli have to be administered repetitively, e.g., strictly periodically or on demand. We have successfully tested multisite CR stimulation during stereotaxic electrode implantation in patients with tremor caused by PD and MS. CR stimulation turned out to be superior compared to conventional DBS with respect to tremor suppression and energy consumption (Tass *et al*. 2005). Multisite CR stimulation may also be a promising therapeutic option for other neurological diseases characterized by pathological neuronal synchronization, e.g. epilepsies. As shown theoretically, desyncronizing brain stimulation may even have long-lasting curative effects in terms of therapeutic rewiring (Tass and Majtanik 2005).

[1] Benabid AL *et al.* 1991, The Lancet **337,** 403.
[2] McIntyre CC *et al.* 2004, Clin. Neurophysiol. **115,** 1239.
[3] Tass PA 1999, Phase Resetting in Medicine and Biology. Stochastic Modelling and Data Analysis (Springer, Berlin)
[4] Tass PA 2003a, Biol. Cybern. **89,** 81.
[5] Tass PA 2003b, Phys. Rev. E **67,** 051902.
[6] Tass PA *et al.*, submitted.
[7] Tass PA and Majtanik M, under review.

[*] E-mail: p.tass@fz-juelich.de