



Contribution ID: 36

Type: **Invited talk**

## Fractal and multifractal organisation of neuroimaging signals

*Thursday, 24 September 2026 12:30 (30 minutes)*

The brain is a complex system whose multiscale organization supports cognitive functioning. In neurodegeneration in particular, alterations in brain structure are accompanied by a broad cognitive decline, motivating the question of whether changes to that in multiscale brain organization track these impairments. Multifractal measures provide a promising description of brain organization that captures its cross-scale heterogeneity.

Presently, we report fractal and multifractal analyses of both temporal and spatial structure of EEG, MRI and functional MRI data. We cover cognitive experiments, as well as neurodegeneration studies of multiple sclerosis and dementia (the latter based on open databases). The techniques presented include multifractal detrended fluctuation analysis (MF DFA) and detrended cross-correlation analysis and how we have adapted them to particular use cases. For instance, DFA methods have been reserved for 1D series, whereas neuroimaging – including MRI and fMRI – produces multidimensional spatially grounded data. Hence, we focus on our recent development of MF DFA to structural brain scans transformed via space-filling curves (SFC).

We selected SFCs that reliably preserve the multi-scale spatial correlations and showed that in theoretically-driven models it allows recovery of linear correlations and nonlinear features, as quantified by the multifractal spectrum. Applied to a cross-sectional MRI dementia dataset, the proposed method reveals a systematic shift from multifractality toward monofractality with increasing age and disease progression. Further statistical and machine-learning analyses identified the brain regions most strongly affected by these processes, highlighting both shared and distinct spatial patterns associated with ageing and dementia.

**Primary author:** Dr OCHAB, Jeremi (Institute of Theoretical Physics, Jagiellonian University, Kraków)

**Co-authors:** CHIALVO, Dante (Center for Complex Systems & Brain Sciences/ Universidad Nacional de San Martin, Argentina.); GUDOWSKA-NOWAK, Ewa (Jagiellonian University in Kraków); CIFRE, Ignacio (Universitat Ramon Llull, Barcelona, Spain); GRELA, Jacek (Jagiellonian University); JANAREK, Jakub (Uniwersytet Jagielloński); NOWAK, Maciej A. (Jagiellonian University); WĄTOREK, Marcin (Jagiellonian University); LOTKA, Marta (Doctoral School of Exact and Natural Sciences, Jagiellonian University in Kraków); Prof. OŚWIĘCIMKA, Paweł (Institute of Nuclear Physics, Polish Academy of Sciences); Dr TOMCZYK, Wojciech (Institute of Theoretical Physics, Jagiellonian University); Dr DROGOSZ, Zbigniew (Jagiellonian University)

**Presenter:** Dr OCHAB, Jeremi (Institute of Theoretical Physics, Jagiellonian University, Kraków)

**Session Classification:** Session 5