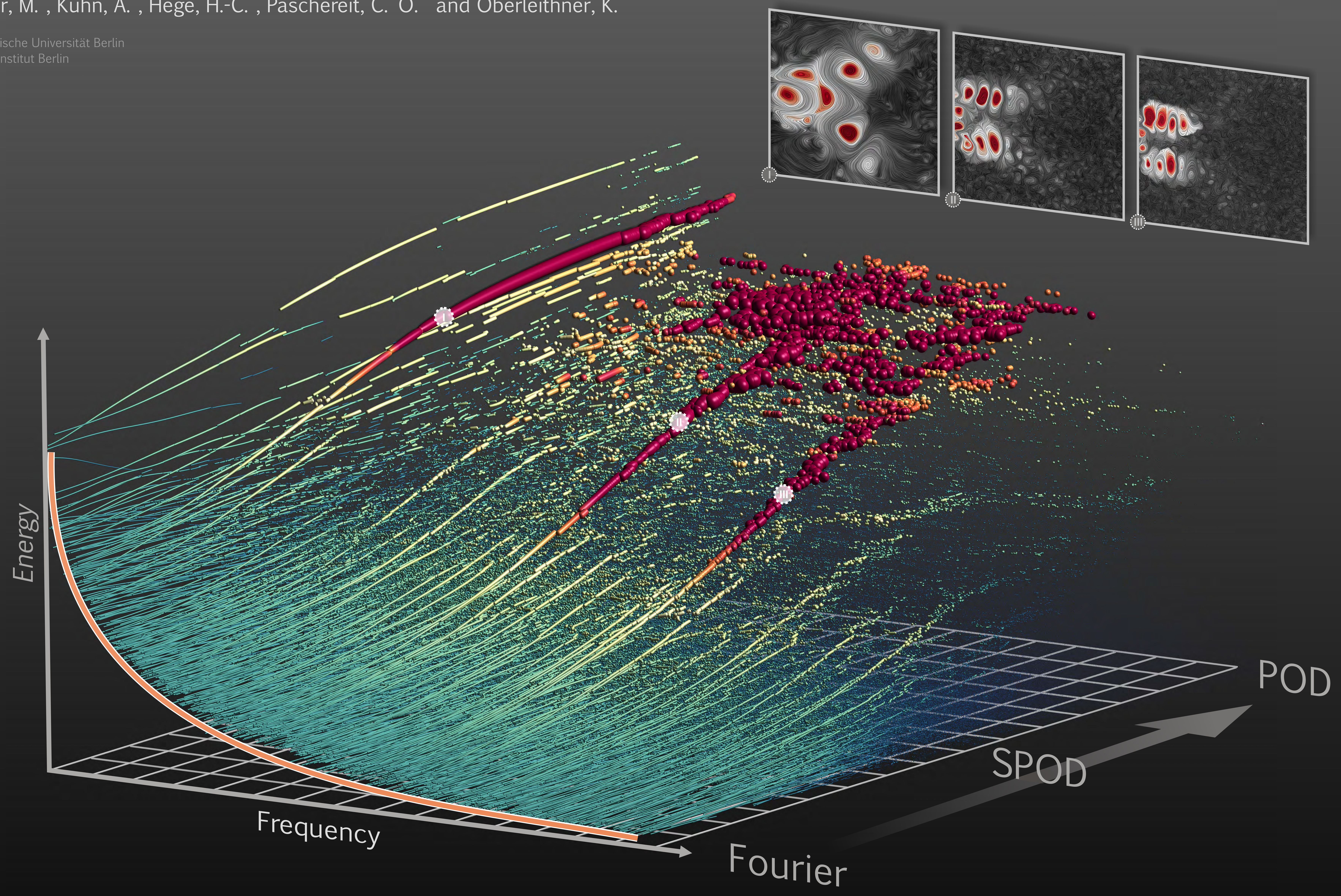
A Graphical Representation of the Spectral Proper Orthogonal Decomposition

Sieber, M.[1], Kuhn, A.[2], Hege, H.-C.[2], Paschereit, C. O.[1] and Oberleithner, K.[1]

1 Technische Universität Berlin
2 Zuse-Institut Berlin



We consider the spectral proper orthogonal decomposition (SPOD) for experimental data of a turbulent swirling jet [1]. This newly introduced method combines the advantages of spectral methods, such as Fourier decomposition or dynamic mode decomposition, with the energy-ranked proper orthogonal decomposition (POD). This poster visualizes how the modal energy spectrum transitions from the spectral purity of Fourier space to the sparsity of POD space. The transition is achieved by changing a single parameter – the width of the SPOD filter. Each dot in the 3D space corresponds to an SPOD mode pair, where the size and color indicates its spectral coherence. What we notice is that neither the Fourier nor the POD spectrum achieves a clear separation of the dynamic phenomena. Scanning through the graph from the front plane (Fourier) to the back plane (POD), we observe how three highly coherent SPOD modes emerge from the dispersed Fourier spectrum and later branch out into numerous POD modes.

The spatial properties of these three individual SPOD modes are displayed in the back of the graph using line integral convolution colored by vorticity. The first two modes correspond to single-helical global instabilities that are well-known for these flows. Their coexistence, however, has not been observed until now. The third mode is of double-helical shape and has not been observed so far. For this considered data set and many others, the SPOD is superior in identification of coherent structures in turbulent flows. Hopefully, it gives access to new fluid dynamic phenomena and enriches the available methods.

[1] Sieber, M., Paschereit, C. O., and Oberleithner, K.
Spectral proper orthogonal decomposition
arXiv preprint arXiv:1508.04642., 2015