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Studies of Longitudinal Dynamics in the Micro-Bunching Instability using Machine Learning

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The operation of synchrotron light sources with short electron bunches increases the emitted coherent synchrotron radiation (CSR) power in the THz frequency range. However, the spatial compression leads to complex longitudinal dynamics, causing the formation of micro-structures in the longitudinal bunch profiles. The fast temporal variation and small scale of these micro-structures put challenging demands on their observation. At the KIT storage ring KARA (KArlsruhe Research Accelerator), diagnostics have been developed allowing direct observation of the dynamics by an electro-optical setup, and indirect observation by measuring the fluctuation of the emitted CSR. Additionally, the longitudinal dynamics can be simulated using the numerical Vlasov-Fokker-Planck solver Inovesa. In this contribution, we present studies of the micro-structure dynamics on simulated data. To deal with generated data sets in the order of terabytes in size, we apply the machine learning technique k-means to identify the dominant micro-structures in the longitudinal bunch profiles. Following this approach, new insights on the correlation of the CSR power fluctuation to the underlying longitudinal dynamics can be gained.

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