Application of the Savitzky-Golay-Filter to analyze the energy-loss of a heavy ion beam in an X-ray-heated CHO-foam

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Measurements of the ion beam energy loss in low density CHO-foams in solid and plasma states have been carried out at the Z6-experimental area using a combination of the UNILAC ion beam and PHELIX laser pulses.
The Savitzky-Golay-Filter was applied to increase the accuracy of the measured data.
The Ti^{+12} ions, accelerated up to 4.77MeV/u energy, pass the low density 1 mm thick CHO foam layer a Triacetate-Cellulose with the chemical structure $C_{12}H_{16}O_{8.}$ The energy loss in cold foam layer was measured by means of a time-of-flight method. Interaction of a 100-180J PHELIX nanosecond laser pulse with a gold-layered hohlraum, placed above the foam target, gave rise to soft X-ray emission with close to Planckian spectral distribution. Supersonic X-ray waves heat the foam and transfer it from a solid into a hydrodynamically stable plasma layer with homogeneous distributions of density, temperature and ionization degree.
The energy loss in the cold and converted to plasma target was registered by means of the diamond stop-detector, placed 12,126m far away from the interaction region, and evaluated using the data-analysis program Origin9. [1]
The received data is influenced by a low signal-to-noise-ratio, which disturbs the data-sets and reduces the data accuracy. In order to remove these errors and improve the accuracy of the measured data, the Savitzky-Golay-Filter-Method (SGF-Method) was applied.

The Savitzky-Golay-Filter is a digital filter, used to smooth digital data-sets, thus increasing their signal-to-noise ratio without distortion of the data. It is based on the standard method of least squares. Therefore a convolution process, combining the method of least squares with a k-degree polynomial, is used. This process fits every data-point x_i of the data-set I, in an area of k successive adjacent data points. Thus a sum of 2k+1 data points is included in the process. [2]

$$f(x_i) = \sum_{j=-k}^{k} c_n x_{i+j}$$

Variation of the filter-coefficient c_n provides the smoothed data points $f(x_i)$. The efficiency of the smoothing process can be seen in the following graphic, presented in fig.1.

The smoothed data-sets are evaluated and the energy-loss ΔEi of Ti-Ions in solid- and plasma-foams is recorded.

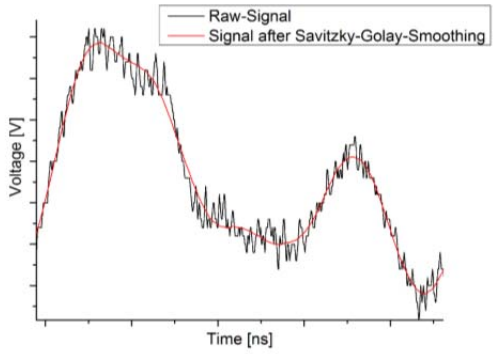

Figure 1: Raw and smoothed data-signals.

The average energy-loss in TAC-foams with 2mg/cc density is compared to theoretical expectation-values and results of former experiments: [3]

	ΔE_S [MeV/mm]	ΔE_P [MeV/mm]
Smoothed data	5,94 ± 1,19	9,01 ± 1,80
Theoretical values	5,61	7,48
Former data	5,56 ± 1,11	9,30 ± 1,19

The application of the Savitzky-Golay-Filter-Method was successful and delivered reliable results. Through increase of the signal-to-noise-ratio, the amount of data, which can be used for analysis, is raised. Additionally the boundaries of the SGF-Method could be established for a signal-to-noise ratio of the magnitude 1.

References

[1] T. Rienecker, R. Maeder, O. Rosmej, et al., "Measurements of the Heavy Ion Stopping in X-ray heated low-density nanostructured targets." GSI-Report 2013.
[2] D.S.Gilliam, "Mathematical systems theory in biology, communications, computation and finance." Springer (2003), p.301.
[3] R. Maeder, "Messung des Energieverlustes von Titan-Ionen in CHO-Schaum im Fest- und Plasmazustand" Bsc.-Thesis, Goethe-University, Frankfurt a.M. (2013).

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