An improved Fourier filtering method for gamma ray spectra

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Introduction

Noise reduction is important in gamma ray spectrometry for further processing of spectra for qualitative and quantitative estimation of radio isotopes. Many methods have been proposed for filtering gamma ray spectra to reduce noise.

However, only a few authors have applied Fourier based methods in gamma ray spectrometry. The aim of this paper is to present a high quality Fourier filtering technique. A filtering criterion is also proposed. The method and the proposed criterion were validated by doing qualitative and quantitative comparison on real and synthetic spectral peaks with a widely used filtering method used in the spectrometry. The Fourier filtering method was found to be superior compared to the widely used filtering method. The results are presented in this paper.

Fourier Domain Filtering

Filtering of gamma spectra is important to improve signal to noise ratio since noise gets amplified while further processing of the spectra like deconvolution.

There are numerous filtering methods proposed for noise reduction. However, only few papers have been found in the literature concerning "application of Fourier-Transform methods to α, β, or γ-ray spectroscopy" [1-5]. One of the authors (VKM) of this paper has developed many techniques to process gamma spectra, including noise reduction, based on Fourier, Walsh-Hadamard, Rader, and Haar transforms [3-5].

In a high quality Fourier filtering method, the Fourier transform of the noisy spectra were computed, and the real and the imaginary parts of the Fourier transformed spectra were separated and then lower order 3rd degree polynomial was fitted in the selected region of each real and each imaginary part to reduce noise while maintaining the fidelity of the spectroscopic information. The inverse Fourier transform gave the filtered spectrum. A criterion was proposed to give superior filtering of the spectra.

By changing the region for polynomial fitting in the Fourier domain spectra, the effect of filtering was observed on the spectra. The observations of the filtered spectra included visual inspection, change in peak shift, and change in peak area. Fig 1 shows the Fourier spectrum of an observed gamma spectrum with FWHM of 19.5 channels. Fig 2 shows the Fourier spectrum after polynomial fitting.

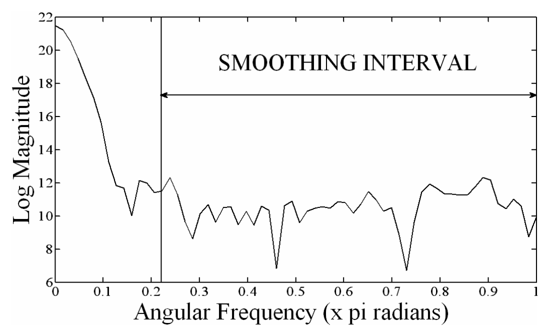

Fig. 1: Fourier spectrum of an observed gamma ray spectrum with FWHM = 19.5

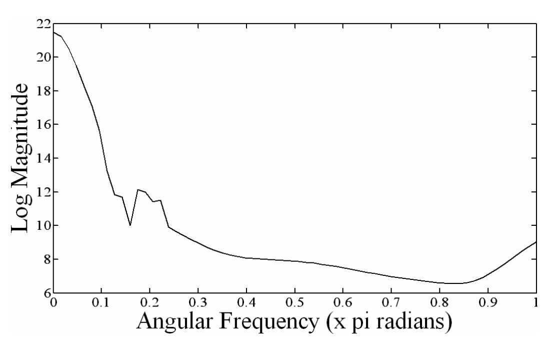

Fig. 2: Fourier spectrum after polynomial fitting

Table 1: Starting point of polynomial fitting for various FWHMs in Fourier Spectra

FWHM	Main lobe width (W) (radians)	Starting point of polynomial fitting (S) (radians)	S/W
10.60	13	17	1.3077
12.90	14	20	1.4286
19.5	10	16	1.6
23.5	9	18	2

Experimental results

A number of spectra, two real and two synthetic, were filtered with the Fourier method and with Savitzky and Golay filter [6]. In the Fourier domain, the starting point of the polynomial fitting interval was varied and its effect on spectral peak area and peak shift after filtering was observed.

The results of change in peak area are shown in the Table 2, both for Savitzky and Golay method, and the Fourier method.

Table 2: Change in area for different FWHM

Gamma Spectrum	FWHM Channels	% change in area with Savitzky and Golay filter	% change in area with Fourier filtering
Synthetic	10.60	0.0437	0.0096
	12.90	0.0813	0.0122
Real	19.5	0.0177	0.0091
	23.5	0.0523	0.00018

It was found that the percentage change in the peak area in case of Fourier domain filtering is an order of magnitude smaller as compared to Savitzky and Golay filtering method. The filtered spectral peak shift in both cases was less than one channel.

Fig. 3 shows an observed gamma spectral peak of FWHM of 19.5 channels before and after Fourier filtering.

It was observed that to preserve both the qualitative and the quantitative spectroscopic information, the starting point (S) of the polynomial fitting should be between 1 to 2 times the main lobe width (W) of the Fourier spectrum as shown in the Table 1. W represents compressed spectroscopic information in the Fourier domain. Thus, the proposed filtering criterion is that the ratio S/W should be 1 to 2.

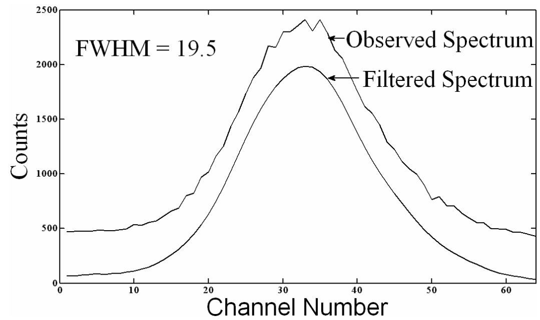

Fig 3: Raw and Fourier filtered spectra (shifted arbitrarily for clarity)

Conclusion

A high quality Fourier filtering method was applied to observed and synthetic gamma spectral peaks. A filtering criterion in the Fourier domain was proposed based on the main lobe width representing compressed spectroscopic information. The Fourier filtering method was found to be superior to a widely used Savitzky and Golay filtering method.

References

[1] A. Adbel-Hafiez, Intl. Journal of pure and applied physics, vol. 3, no. 1 (2007) pp. 132-141.
[2] N. Moriya, Nucl. Instr. Meth. B53 (1991) 208-211.
[3] V.K. Madan, M.C. Abani, B.R. Bairi, Nucl. Instr. Meth. A343 (1994) 616-622.
[4] V.K. Madan, H.B. Kekre, B.R. Bairi, Paritantra v1 (1) (1993) 66-87. [Invited]
[5] V.K. Madan, chapter 23 in: Radiation Detector Systems (ed. S.K. Kataria), Oxford and IBH, New Delhi (1992) 354-379.
[6] A, Savitzky and M.J.E. Golay, Anal. Chem. 36 (1964) pp. 1627-1639.