Designing Quadruple Grating Spatial Heterodyne Spectrometer (QGSHS)

P. G. Bhat[1], A. Gojani[2], I. Gornushkin[2], M. Stano[1], P. Veis[1]

[1] *Dept. of Experimental Physics, FMPI, Comenius Univ., Bratislava, Slovakia.*

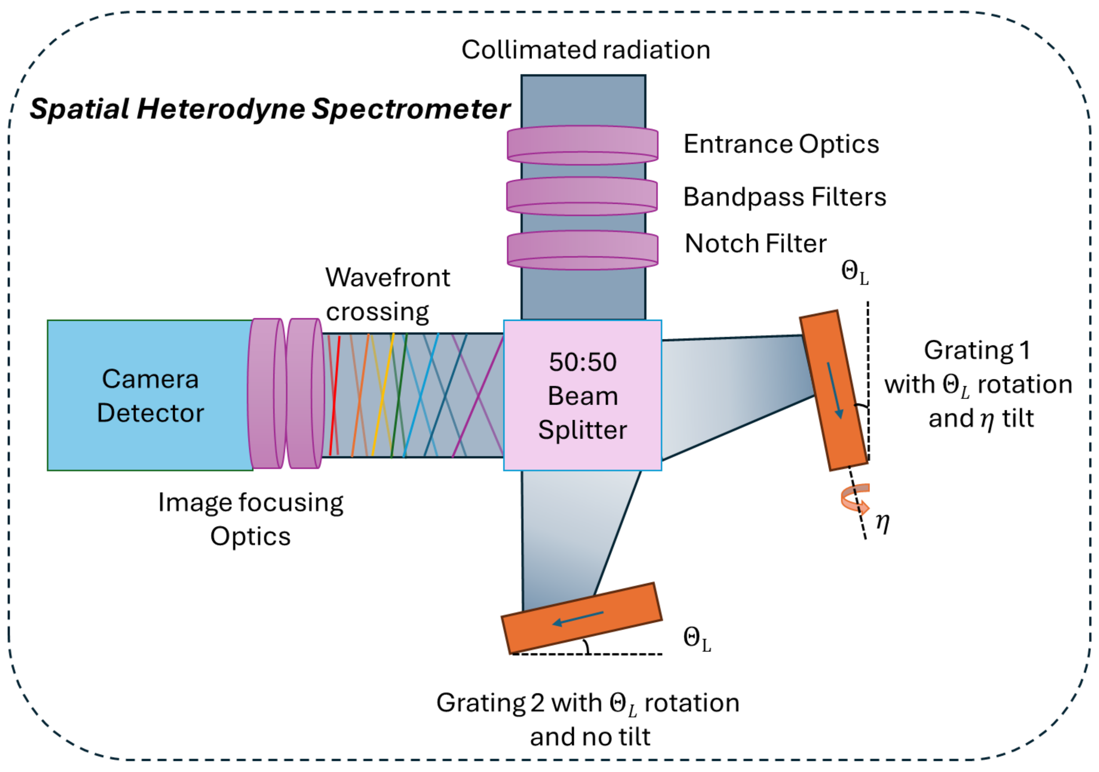
[2] *BAM Federal Institute for Materials Research and Testing, Berlin, Germany.*

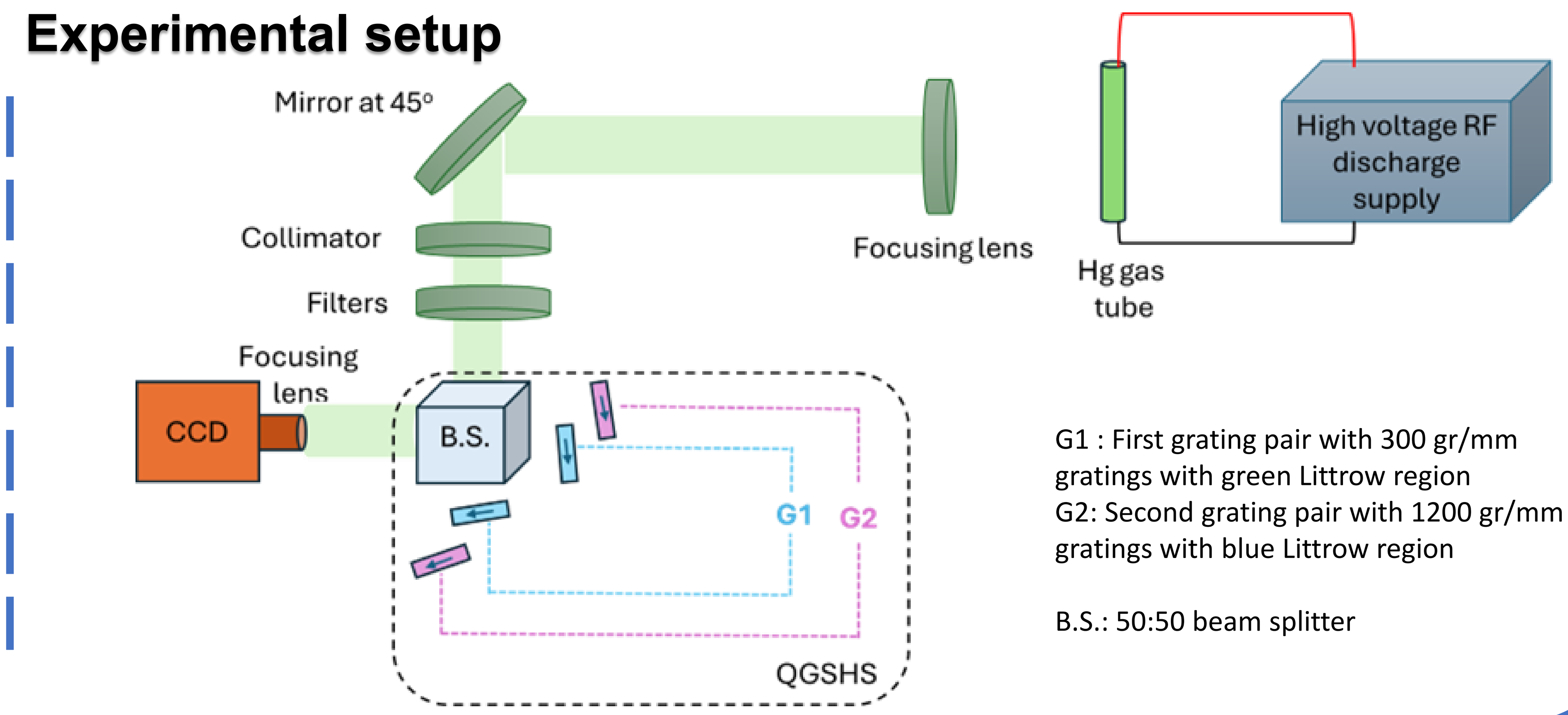
[a)] *Corresponding authors:* ***pavitra.bhat@fmph.uniba.sk***

Introduction

The versatility and design adaptability of the Spatial Heterodyne Spectrometer (SHS) have proven to be beneficial in various disciplines, including analyses in atmospheric, astrophysical, elemental, and others. A hybrid of interferometric and dispersive domains of the spectrometers is implemented in the single SHS spectrometer, providing high throughput and resolutions with design adaptiveness suitable for specific experiments. However, a disadvantage in such spectrometers is the inverse relationship between the wavelength bandwidth and the resolving power of the spectrometer, similar to Czerny-Terner spectrometers. Circumventing this inverse relationship, the current work proposes to partly compensate for the inverse relationship between wavelength bandwidth and the resolving power using a novel SHS design with two gratings in one arm of the SHS interferometer, providing simultaneous detection of two different regions of the spectrum. Additionally, the proposed work has already been realized using a miniature design with dimensions of 110 mm* 100 mm.

Experimental setup



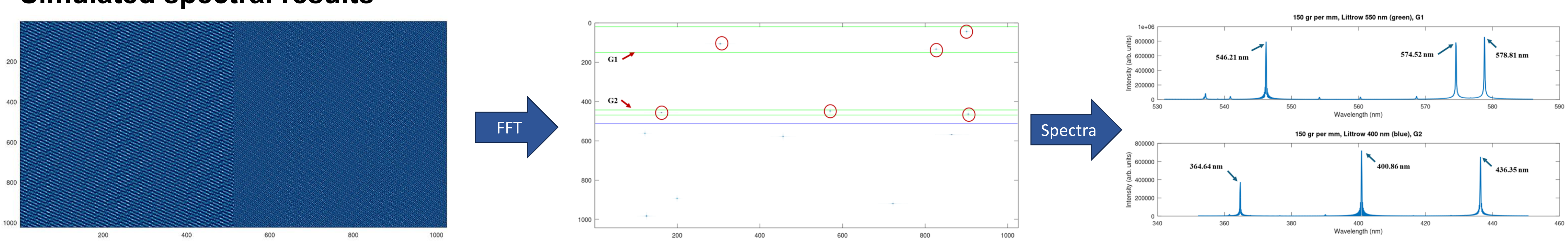


G1 : First grating pair with 300 gr/mm gratings with green Littrow region
G2: Second grating pair with 1200 gr/mm gratings with blue Littrow region

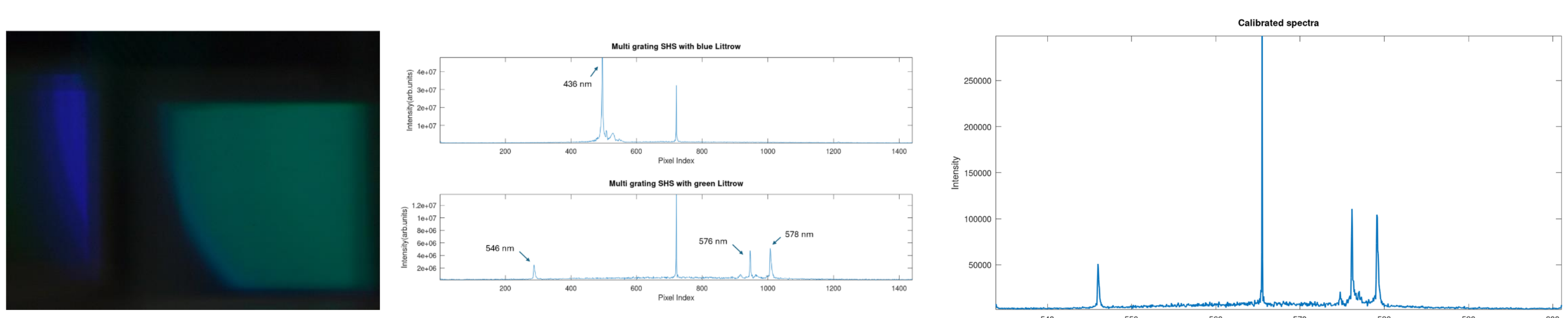
B.S.: 50:50 beam splitter

Results

Simulated spectral results



Experimental spectral results from miniature setup



Number of averages per spectrum	546.0735 nm		576.9598 nm		579.0663 nm	
	Fwhm (nm)	Resolving power	Fwhm (nm)	Resolving power	Fwhm (nm)	Resolving power
10	0.25365	2152.862	0.15018	3841.789	0.25881	2237.419
25	0.25211	2166.013	0.14827	3891.278	0.24388	2374.39
50	0.24202	2256.316	0.15002	3845.886	0.25279	2290.701
75	0.23223	2351.434	0.15064	3830.057	0.25558	2265.695
100	0.23005	2373.717	0.15275	3777.151	0.25499	2270.937

Conclusion

- The design of the miniature QGSHS was reported for the first time experimentally with the spectrometer design of around 11 cm x 10 cm; however, this design could be further improved by considering the appropriate grating pair, each of which would give at least three spectral features, required for calibration.
- The present work reported on the detection of Hg emission peaks in two wavelength regions, the blue region with a 435.8328 nm emission peak, and the green region with three Hg emission peaks, i.e., 546.0735 nm, 576.9598 nm, and 579.0663 nm. The FWHM analysis of the latter region suggests the resolving power to be around 3890, easily achieved with the 300 gr/mm grating in the miniature design.
- The theoretical resolution for the same configuration was about 7200. The differences in the resolving power could be further improved by illuminating the entire grating; however, such differences in the theoretical and experimental resolving powers are not uncommon.

References

[1] D. W. Hahn and N. Omenetto, "Laser-induced breakdown spectroscopy (LIBS), part II: Review of instrumental and methodological approaches to material analysis and applications to different fields," *Applied Spectroscopy*, vol. 66, no. 4. pp. 347–419, Apr. 2012.

[2] J. M. Harlander, "Spatial Heterodyne Spectroscopy: Interferometric Performance at any Wavelength Without Scanning," Graduate School of the University of Wisconsin-Madison, 1991.

[3] W. Li Zhang et al., "Research status of spatial Heterodyne spectroscopy – A review," Microchemical Journal, vol. 166, Jul. 2021, doi: 10.1016/j.microc.2021.106228.

Acknowledgment

The authors would like to thank the financial support provided by the Scientific Grant Agency of the Slovak Republic (VEGA-1/0815/25, VEGA-2/0120/25), by the Slovak Research and Development Agency (APVV-22-0548, APVV-23-0281), by the Comenius University (UK/1259/2025, UK/3040/2024) and by the EU NextGenerationEU through the Recovery and Resilience Plan for Slovakia (project No. 09I01-03-V04-00066).

UNIVERZITA KOMENSKÉHO V BRATISLAVE

FAKULTA MATEMATIKY, FYZIKY A INFORMATIKY
Univerzita Komenského v Bratislave