Development of a Grating Interferometer for the Measurement of the Neutron Electric Charge

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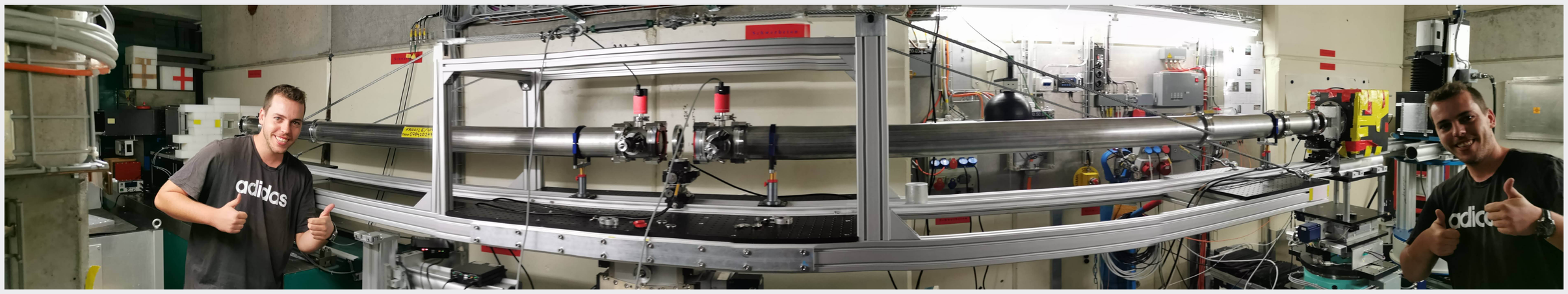
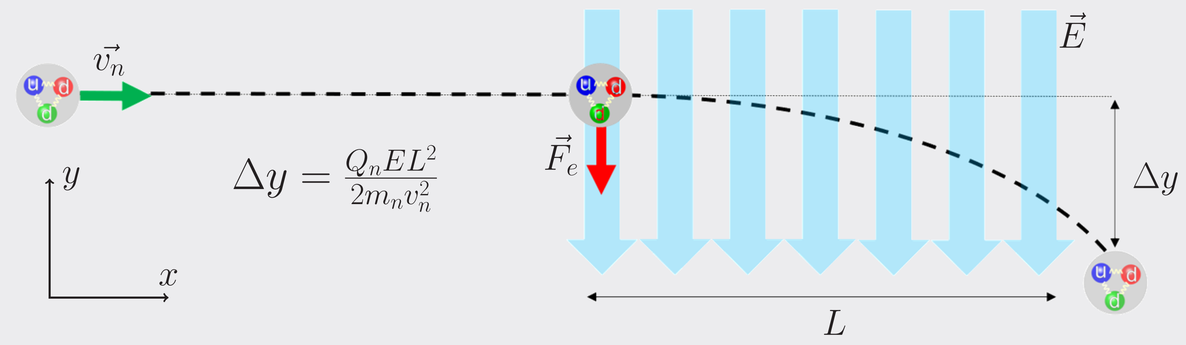
Abstract

Neutron grating interferometers can be employed as powerful tools to perform high-precision measurements of deflection angles and scattering. A novel concept of a symmetric Talbot-Lau interferometer using absorption gratings is under development at the University of Bern. The ultimate goal of this project will be a sensitive measurement of the neutron electric charge. Currently, a proof-of-principle apparatus is being investigated at the cold neutron beamline BOA at the Paul Scherrer Institute. A description of the experiment, alignment procedures and first experimental results concerning the setup are presented.



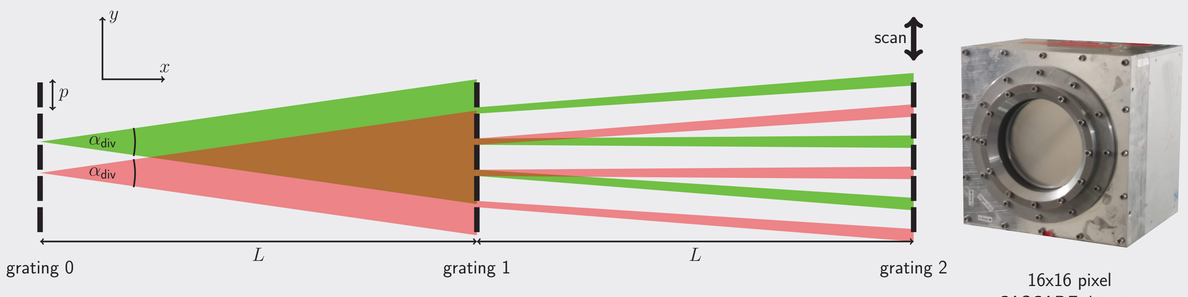
Motivation



- Proof-of-principle apparatus
- Deflections Δy in the picometer-scale
- Improvement of current upper limit[1]: $Q_n < (-0.4 \pm 1.1) \times 10^{-21}\, e$
- Physics beyond standard model

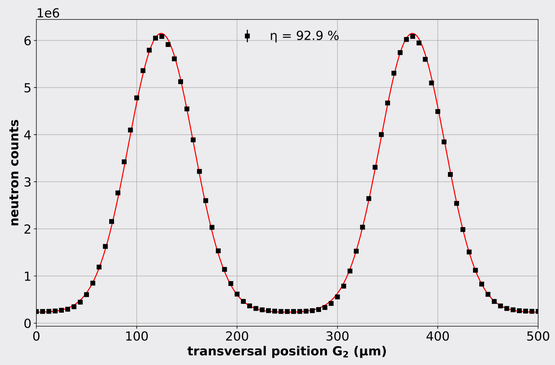
[1] J. Baumann, R. Gähler, J. Kalus, and W. Mampe, Experimental limit for the charge of the free neutron, Phys. Rev. D 37, 3107 (1988)

Working Principle



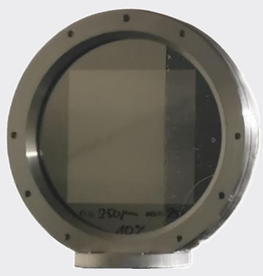
16x16 pixel *CASCADE* detector

- Transverse scan of grating 2
- Oscillating intensity pattern
- Visibility: $\eta = \frac{N_{max} - N_{min}}{N_{max} + N_{min}}$

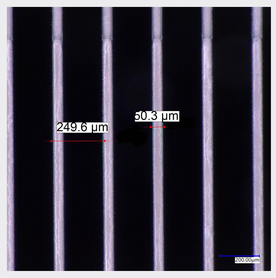


Neutron Absorption Gratings

- Gd coated Sapphire window
- $250\,\mu m$ grating constant
- $20\,\%$ duty cycle
- $30\,\mu m$ Gd layer
- $\leq 0.1\,\%$ transmission at $3\,Å$

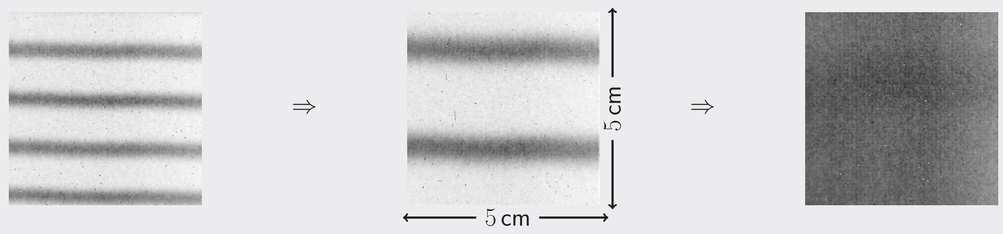


$\varnothing = 10\,cm$



micro view

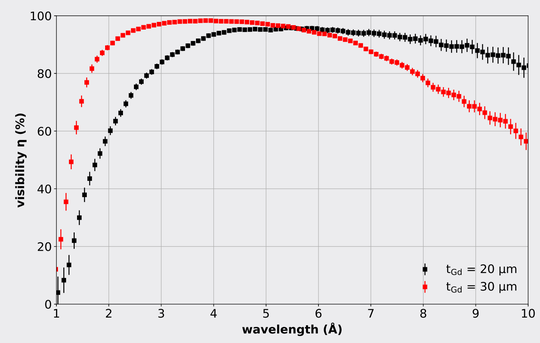
Alignment (Moiré Pattern)



- Alignment procedure visualized with a CCD camera.
- The gratings are well aligned if no moiré pattern is visible.

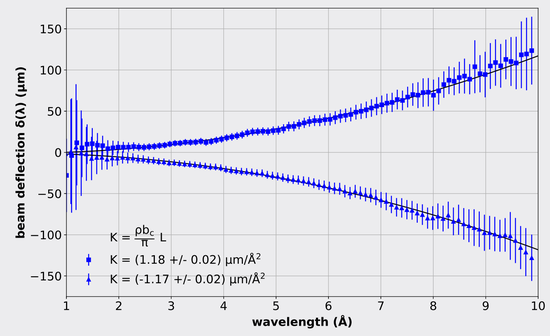
Time-of-Flight Analysis

- $25\,Hz$ chopped beam
- $20\,\mu s$ time bins
- Wavelength dependencies
  - Visibility
  - Offset
  - Amplitude
- Compare Gd thickness



Deflection Measurement

- Aluminum prism in beam
- Deflection $= K \cdot \lambda^2$
- $K_{lit} = 1.19\,\mu m/Å^2$



Status

- Considering diffraction using smaller grating constants
- Temperature stabilization and drift compensation of the setup
- Testing new types of gratings (period, diameter, hybrid)
- Implementation of HV electrodes

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