Neutron Spin Flipper Automation Using a Red Pitaya STEMlab

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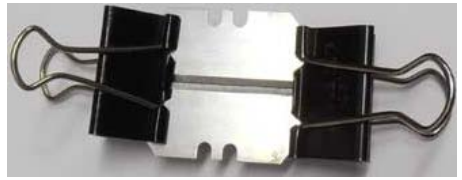
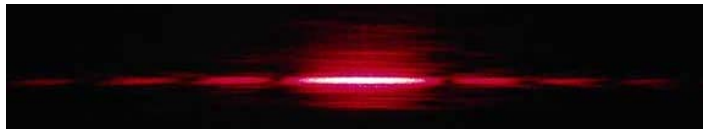
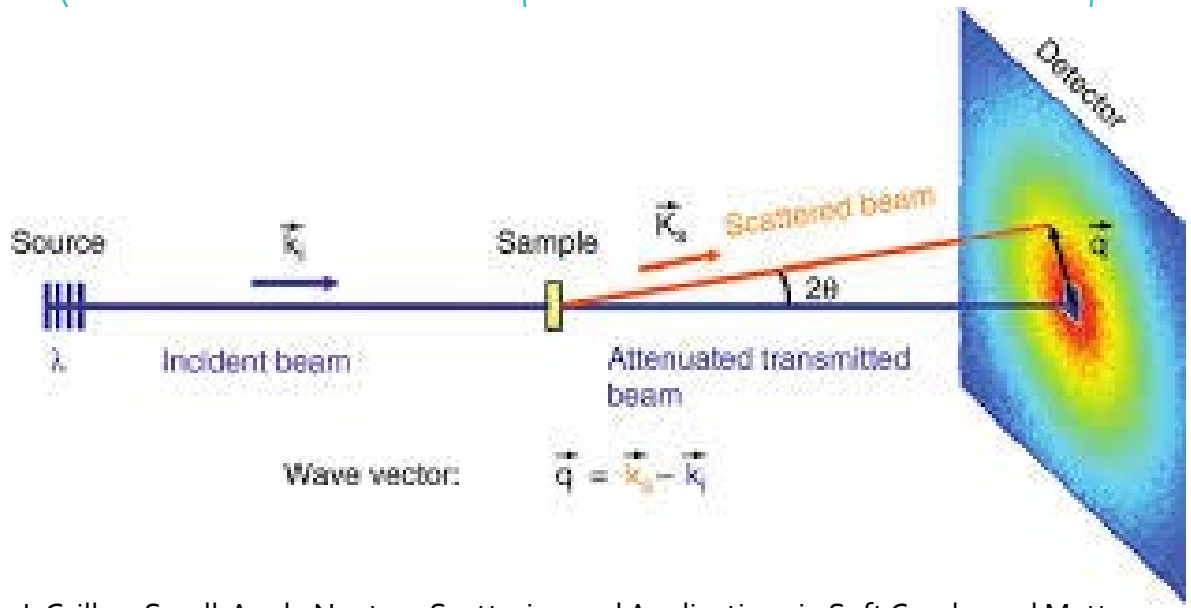
Small Angle Neutron Scattering (SANS)

http://www.animations.physics.unsw.edu.au/labs/diffraction/diffraction-labs.html

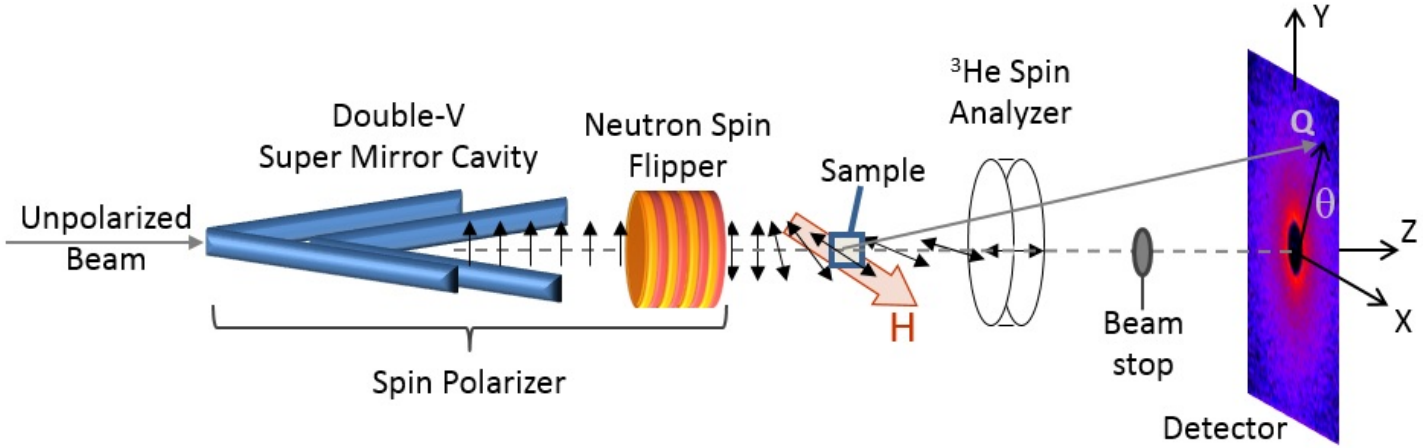






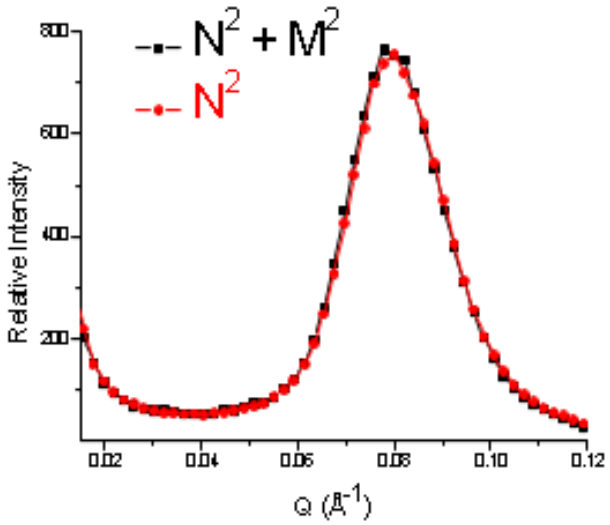
I. Grillo - Small-Angle Neutron Scattering and Applications in Soft Condensed Matter

Neutron Spin Flippers (Polarized SANS)

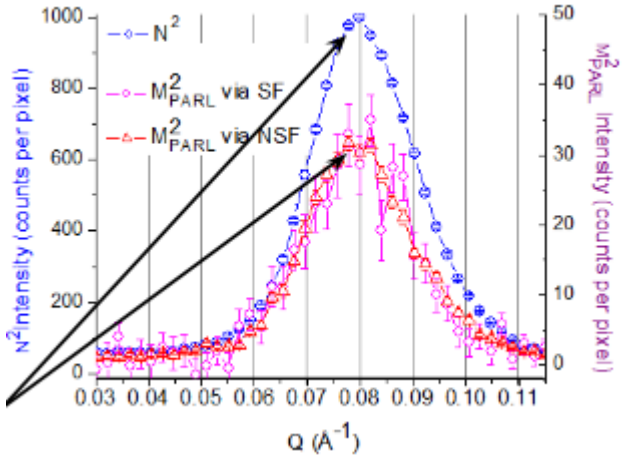


https://www.nist.gov/ncnr/spin-filters/spin-filter-instruments/chrns-sans

Without Spin Flip

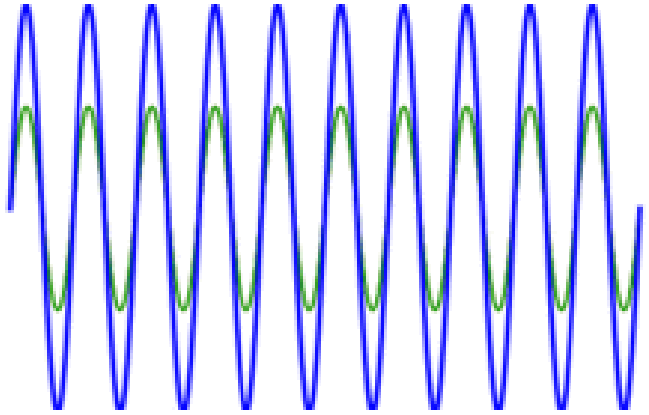


With Spin Flip



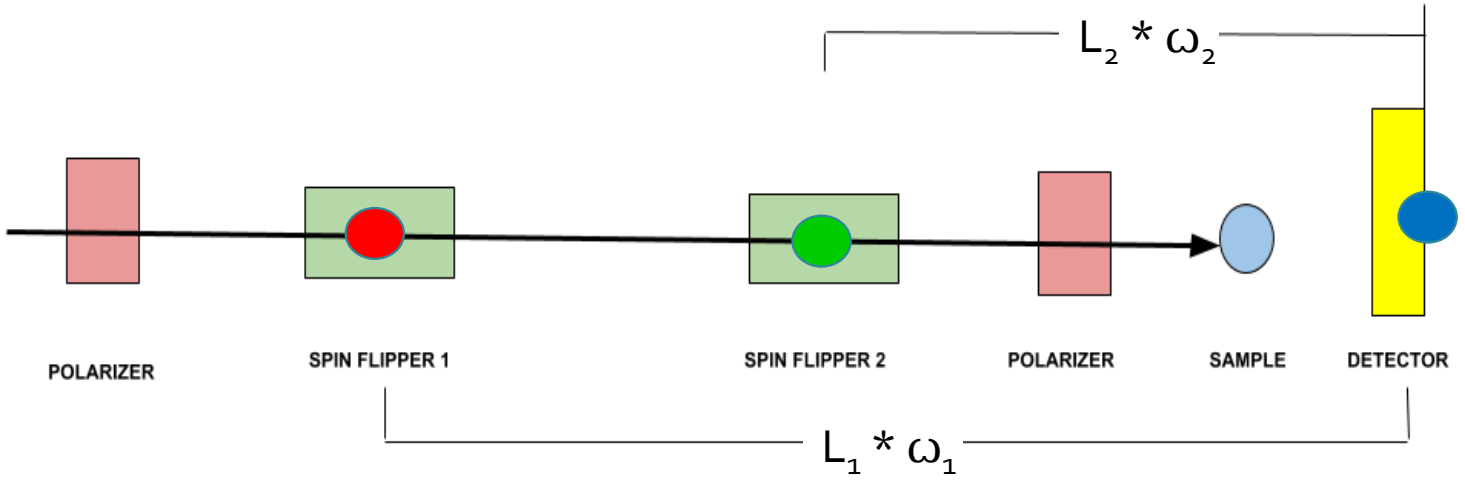
From the NCNR summer school
Kathryn Krycka – Polarization Analysis for SANS

Modulated Intensity SANS (MISANS)



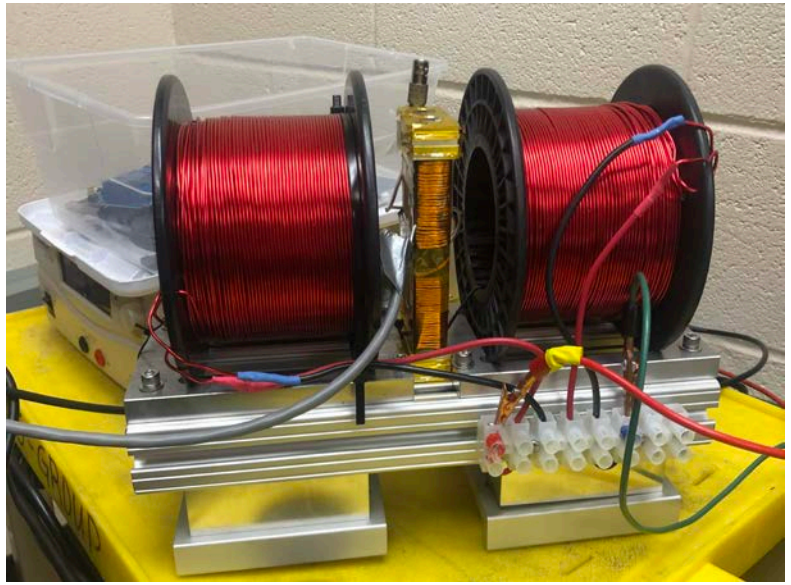
https://en.wikipedia.org/wiki/Beat_(acoustics)

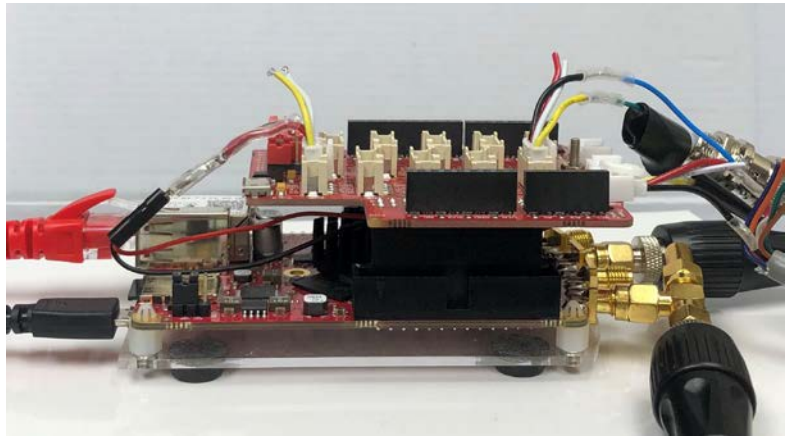
- $L_1 * \omega_1 = L_2 * \omega_2$
- $\Delta\omega = \omega_2 - \omega_1$

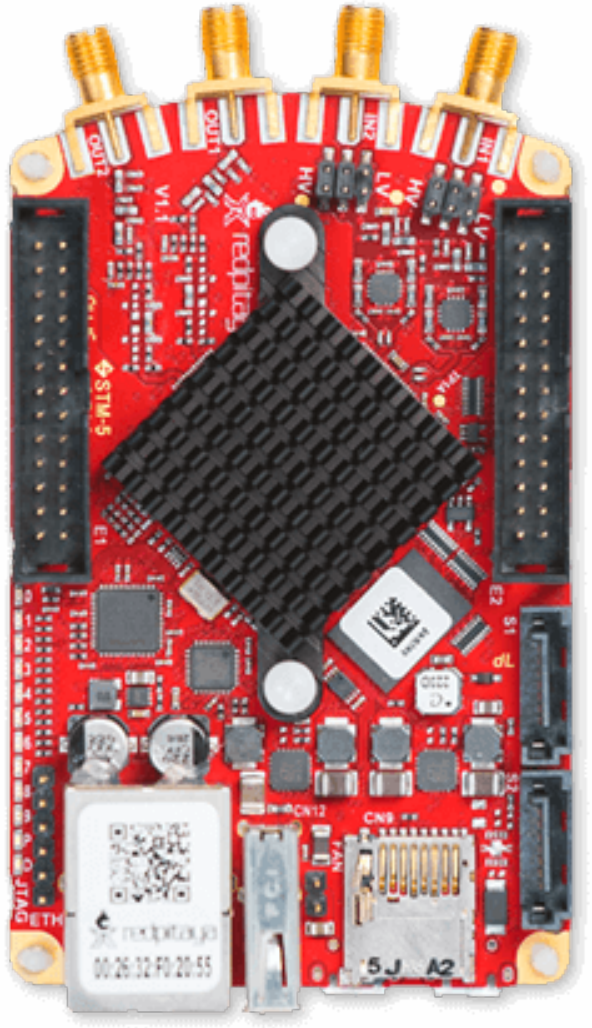


Hardware

- Prototype of RF neutron spin flipper
  - Longitudinal DC fields
  - Orthogonal AC field
- Red Pitaya STEMlab
  - Measurement device
  - Centerpiece of project







https://www.redpitaya.com/

Software/ Languages

- Active control of flipper
  - *SCPI // HPIB*
- Interactive window for application
  - *Python Anaconda in Jupyter*
- Fast Live Data Acquisition
  - *Holoviews & Bokeh*
- Appropriate documentation
  - *GitHub*

jupyter Bokeh ANACONDA HoloViews

Software Example

Magnetic Sensor Demonstration

The program tracks data over 10 seconds then displays it using Holoviews with Bokeh.

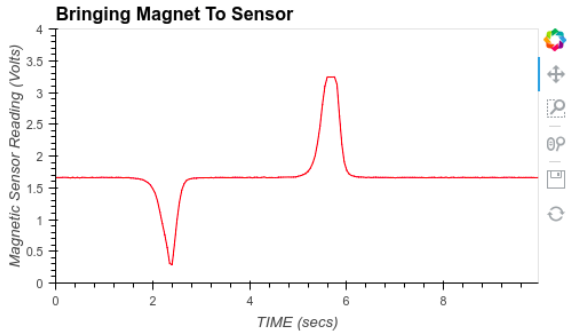
In [45]:
```
x = []
y = []

#set curve options
%opts Curve (color='red' line_width=1) [width=500]

#collect the data and add it to two arrays
for i in range(200):
    x.append(i*.05)
    y.append(float(RP.query('ANALOG:PIN? AIN0')))
    time.sleep(.05)


#display the data that was collected
curve = hv.Curve((x, y), kdims=['TIME (secs)'], vdims=['READING'], group='Bringing Magnet To Sensor').redim.range(RE
curve.redim.label(READING = 'Magnetic Sensor Reading (Volts)')
```

Out[45]:



GitHub: https://github.com/kznam/redpitaya-python-data-aquisition

Future Projects

- use machine learning for optimization of flipping conditions for various frequencies (up to six orders of magnitude)
- I2C connection (slow serial bus)
  - Switching capacitors in RF coil to change frequency
  - More Sensors
- Unit Standardization
- 3 triggers
  - 2 frequency generation
  - 1 detector
- Water Cooling for coils

Project Overview

- Interactive near real-time overview of the flipper status using Red Pitaya STEMlab to:
  - Control and display of static magnetic field
    - live feedback loop to correct for field changes
  - Display the RF waveform and extract relevant parameters
    - frequency, amplitude, and phase through fitting algorithm
- Software approach was effective and successful

Acknowledgements

- Special thanks to
  - Markus Bleuel, mentor
  - SHIP coordinators (Julie Borchers, Joe Dura, Yamali Hernandez)
  - Przemek Klosowski, Juscelino Leao, Thuan Thai, Jacob Tosado
  - Fellow SHIP students
  - NIST, NCNR
  - CHRNS