Oscillating graphite as a light ion polarimeter?

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Vibrating arm of a graphite cantilever with a short spike in the beam

Rotating graphite paddle on a multi-walled carbon nano-tube support

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VERTICAL CARBON CANTILEVER WITH SPIKE IN BEAM

Graphite of rectangular cross section is clamped at one end (in pipe)

- A 2 mm spike at other end moves a little into a p$\uparrow$ or ^{3}He$\uparrow$ beam

- A particular ion bunch taking 13 μs to go round the EIC resonates with the 5th mode of a cantilever of Young's modulus 194 GPa and density 2.2 g/cm^3 if its height is 0.7 mm & its length in mm is

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  (5 - 1/2) [ 13 (194/2.2)^0.5 * 0.7 (pi/48^0.5) ]^0.5 = 28
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  where $k \approx 5\,\pi - \pi/2$ is the 5th solution of eqn: $\cos k\, \cosh k = -1$

- Time of flight good for a trailing bunch as target leaves the beam

- Several successive bunches will hit target scattering carbon L & R

- Sublimation may be reduced as target oscillates away from bunches

- Vibrations of cantilevers and above factor $\pi/48^{\,0.5}$ appear in §7 of

  https://ocw.mit.edu/courses/mechanical-engineering/2-002-mechanics-and-materials-ii-spring-2004/labs/labU1Us04.pdf

- Difference between left and right scatters may help drive vibration

- For a target of circular cross-section, replace $48^{\,0.5}$ by 8 so that in

  https://www.nature.com/articles/srep22600

  a MWCNT cantilever of modulus 200 GPa, density 2.27 g $/$cm^3, diameter 0.0001 mm, vibrating at frequency 1.518 MHz, has length

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  1.875 [ (200/2.27)^0.5 * 0.0001/1.518/ 8pi ]^0.5 = 0.0093 mm
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  WolframAlpha says first solution of $\cos k \cosh k = -1$ is $k \approx 1.875$

- Choose the diameter of the MWCNT to adjust rate of interaction
- An appendage of diameter 400 nm would be equivalent to a ribbon
- There may be electromagnetic ways of inducing an oscillation also
- Some MWCNTs conduct heat well and may help with sublimation
- Excess target charge may be conducted away by an (n, n) MWCNT
- Shedding flakes may fall through beam allowing an estimate of p$\uparrow$

Rotation is another way of arranging intermittent target interaction.

CARBON BLADE ROTATING ON A MWCNT WIRE AXLE

The horizontal MWCNT wire is suspended from one or two supports

- A rotating paddle target can be lowered into a polarized ion beam
- Beam bunches passing through blade of target may cause rotation
- A disk rotating on a MWNT is shown in Figure 3-1 on page 61 of

  `dspace.mit.edu/bitstream/handle/1721.1/46796/429047845-MIT.pdf`

- A 120 ns gap between target interactions enables ToF measurement
- The blade or blades are oriented at about 45 degrees either by suspending at that angle, or, by shaping each paddle appropriately

- Toothed nanometer gear wheels on MWCNT have been discussed
- Outer tubes of MWCNTs rotate with little friction on inner tubes

A carbon paddle blade can hopefully be attached to the outer tubes

- Carbon nanobuds on either side of the paddles will prevent sliding
- A nanobud is a stable fullerene attached to a MWCNT's outer wall
- Several paddles could be distributed along the axle for redundancy

SUMMARY

Mode 5 of a 3 cm cantilever will resonate at 77 kHz if its height is 0.7 mm. Mode 34 will resonate at 54*77 kHz (240 ns), if achievable.

An ion beam may rotate the blade of a paddle on a long Multi-Walled Carbon Nano-Tube ($<$ 50 cm) axle, suspended from one or two supports, to provide intermittent carbon recoils for polarimetry.