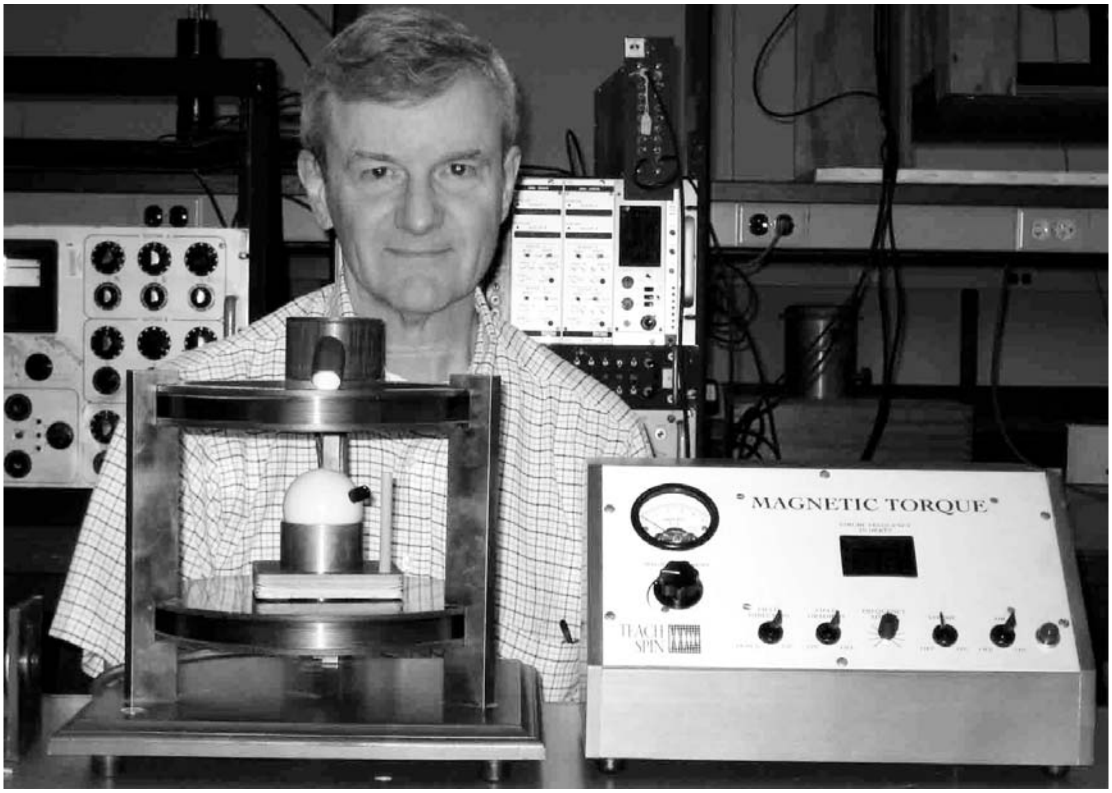
Forecast:
Precise Precessions
www.teachspin.com

The Relaxation Times

2495 Main Street
Buffalo, NY 14214
716-885-4701
fax 716-836-1077

VOL. II No. 6 *NEWSLETTER OF TEACHSPIN, INC.* *FALL 2006*



IMPROVING PRECESSION PRECISION

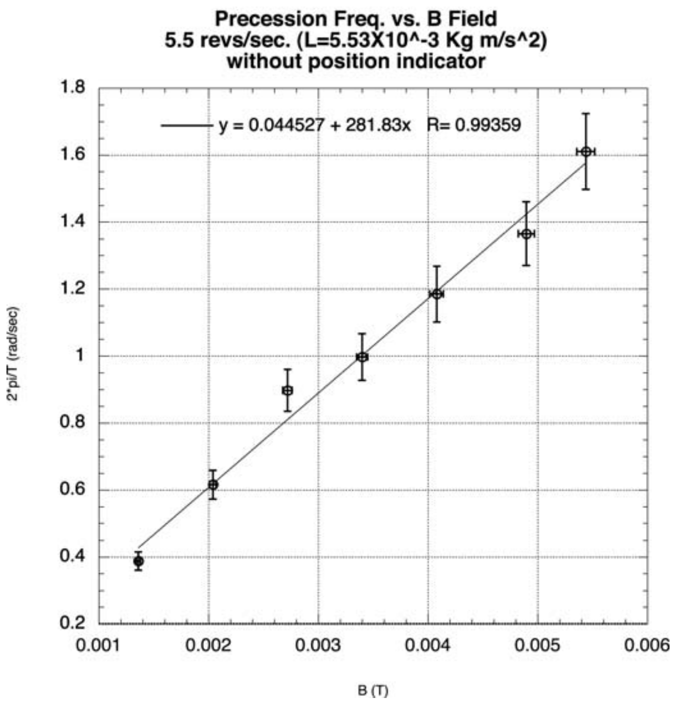
People who own TeachSpin equipment are definitely a special breed. Like us, they can't resist tinkering to keep on improving the performance or expanding the range of their instruments. The precession experiments with Magnetic Torque have always been both the most dramatic and the most frustrating. Spinning the ball is never trivial and, once it is spinning, getting precise results for spin and precession frequency is also a challenge. In this issue, we bring you solutions from the best source – our users.

When Van Bistrow, of The University of Chicago, brought his Magnetic Torque to the Advanced and Intermediate Lab workshop he was co-facilitating at the AAPT summer meeting, he also brought along a neat little accessory he had added to improve the measurement of the precession period. While the rest of us were trying to keep our heads immobile so that we could use one of the brass uprights as a start/stop reference, Van built the marker you see in the picture above. He cut out a base to match the one on the rotating magnetic field and put a vertical marker at one corner. This meant that the reference marker was both close enough to allow for minimum parallax and far enough away to allow the ball to precess freely.

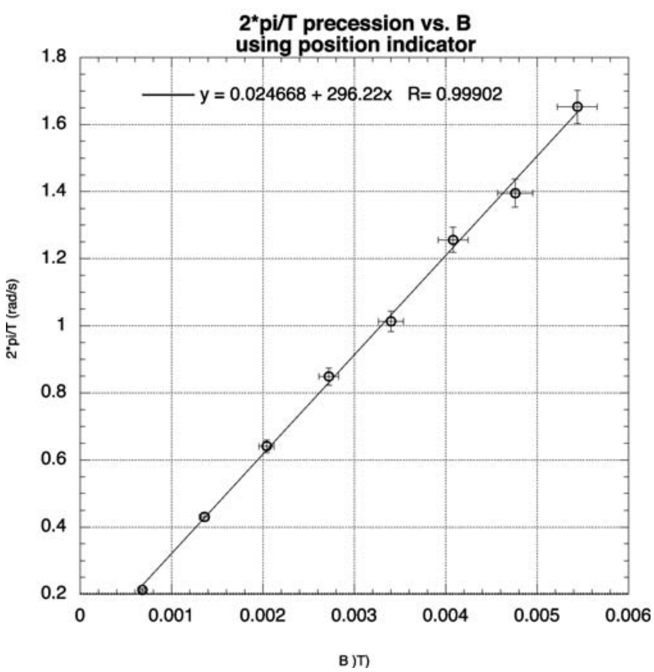
That of, course, still leaves the question of how to find the spin frequency in an efficient manner. We just turned off the current, spun up the ball with the strobe flashing, waited for the ball to spin down to the strobe frequency and then hurriedly set the current to the value we wanted to test. All this meant not only getting in our own way, but also having the ball precessing for more than one revolution. Since the ball slows down, we had increased the error.

Van's solution is one of those things that, in retrospect, is just so perfectly simple. After adjusting the current to his desired value, he set the gradient switch to the ON position. With the currents in the two coils running in opposition, the field at the center of the system is zero and the ball just spins gracefully in place. The marker is moved into place and, stop watch at the ready, the gradient is flipped off, and the precession begins. With this system, the current can be set far more carefully. Because the precession period timing can begin as soon as the desired spin frequency is reached, less spin-down error is created.

The graphs show a comparison of data taken with and without the marker. What the graphs can't show is the decrease in frustration level!



Precession Frequency vs. B Field without Marker

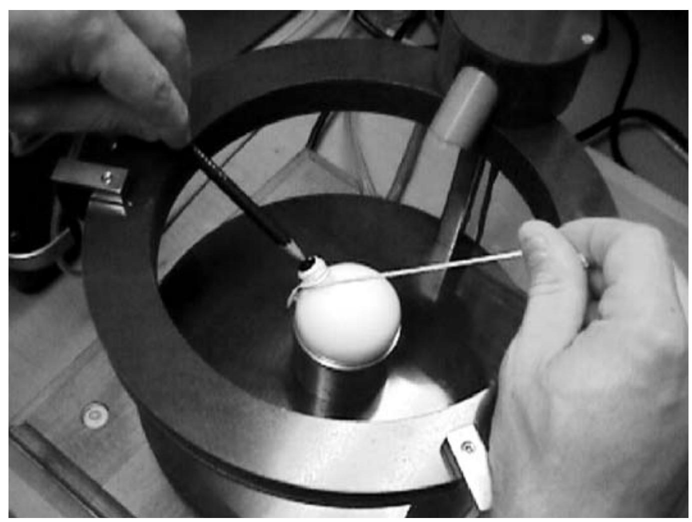


Precession Frequency vs. B Field with Marker

With data like this to prompt us, TeachSpin is working on developing an accessory to improve everyone's precession precision.

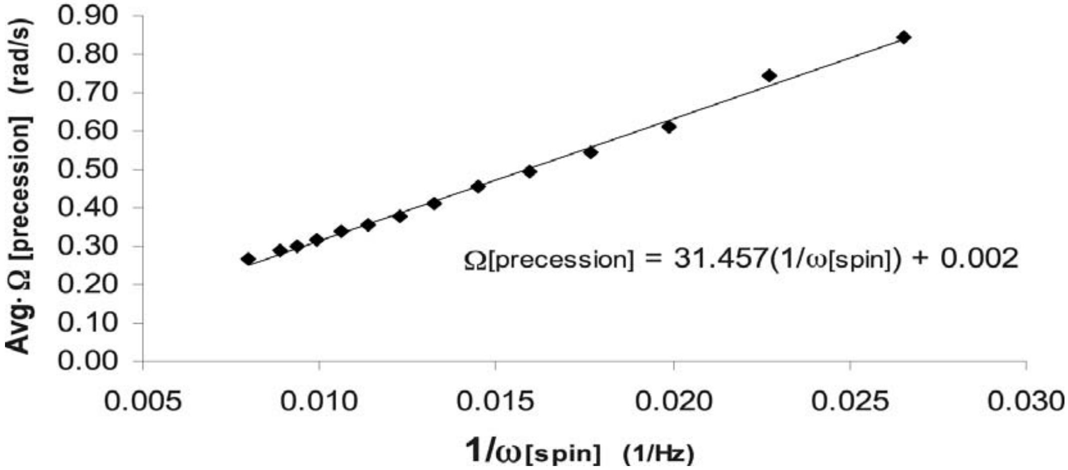
In Van's experiment, students first use static torque to find the magnetic moment of the dipole imbedded in the ball. Then, from the slope of the precession frequency vs. magnetic field line, they can verify "quantitatively that the gyromagnetic ratio of the ball is given by the ratio of its magnetic dipole moment to its angular momentum." Chicago's second year majors do the Magnetic Torque experiment in a four hour laboratory session before a lab on ESR. We, of course, think it a perfect segue to Earth's Field NMR or even Pulsed NMR.

All of these measurements, however, depend on getting the ball spinning in the first place, and, for many people, the finger snap just does not work. Jake Fontana and Jamie Romnes, students of Professor Richard Frankel at the California Polytechnic State University, San Luis Obispo, sent us a description of their system for getting the ball spinning, which, as they say, is "reminiscent of old-fashioned tops." (Definitely a "classic" item!)



Setting Up for the Pull String Method

As shown in the picture, they wrapped some masking tape around the ball handle to keep the string from slipping, and then used a pencil point to stabilize the ball while the string was pulled. Once the string was fully off the post, they just removed the pencil. Among other things, they discovered that they could pretty closely control the spin rate of the ball by the length of string they wound.



$$\Omega = \frac{\mu}{L} B$$

$$L = I\omega$$

$$\Omega = \frac{\mu B}{I}\left(\frac{1}{\omega}\right)$$

Average Precession Frequency, Ω (rad/s) vs. Inverse Spin Frequency of the Ball (1/Hz)

In the Cal Poly experiment, the current, and thus the magnetic field, was kept constant. The graph of precession frequency vs. the inverse spin frequency of the ball gave the beautiful straight line shown. Since the slope of the line is μB/I, the magnetic moment, μ, is easily found. PDF versions of both experiments are posted on the Magnetic Torque Experiments page of the TeachSpin website, www.teachspin.com.

WE ARE SHIPPING

Yes, we are actually shipping the first units of our newest instrument, Modern Interferometry. We do, sincerely, apologize for the delay, since we had expected to have it ready by the beginning of the semester. There are many reasons for the delay, some of which were beyond our control, but what is important is that we are building and sending the units to those who took advantage of our low introductory price of $12,000.00. There are still a few units left to be sold at this special price, and then the regular price of $13,612.00 will go into effect.

TeachSpin has long had a policy of selling the first few units of an instrument at a low introductory price, so that we can offer our customers a significant savings and TeachSpin can quickly improve its cash-flow caused by the development costs of the instrument. We see it as a win-win for everyone.

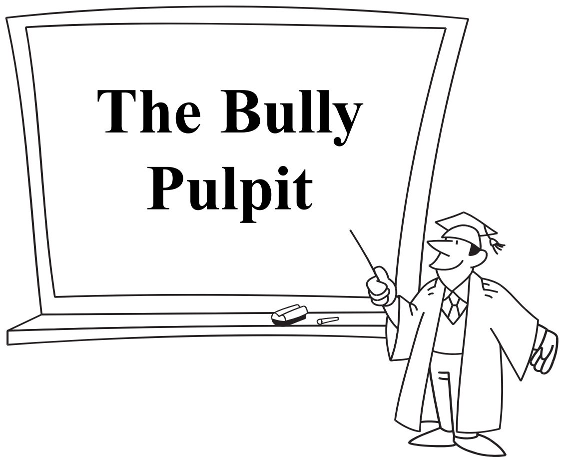
Check our website for a complete list of parts and a description of the experiments your students can perform with these components. It's impressive!

CREDIT WHERE CREDIT'S DUE

The initial idea, which now has been transformed into our Modern Interferometry "Kit," came from the Science Research Laboratory, Inc., in Somerville, MA. While they were developing a Sagnac interferometer for industrial research applications, their physicists realized that it also had pedagogical applications. They received an NSF-SBIR grant to develop the educational component of their Sagnac interferometer and Jonah Jacobs, of SRL, contacted TeachSpin to partner in bringing this apparatus to the college and university teaching community.

We would like to thank the National Science Foundation for supporting this work. Through CalTech, the NSF has also supported the development of both Diode Laser Spectroscopy as well as its new Fabry-Perot interferometer accessory. We hope the NSF will continue to support our efforts to bring modern hands-on apparatus for teaching into the advanced lab.

We would like to encourage other entities, such as government laboratories or industry groups, to contact us about projects they are working on that they believe can be developed into apparatus that will enhance experimental education in physics.



I can clearly recall standing in front of a large class (several hundred) of engineering students and presenting them with a cursory overview of the freshman mechanics course I was about to teach. I was always curious as to why these students had decided to study engineering and which engineering programs they had chosen. Had any of them considered physics?

I had a tradition of asking my students to raise their hands as I named the various programs – chemical, electrical, mechanics, civil... etc.. In the early years, that is the 1970's, when I asked a mechanical engineer why he or she chose this area, I was likely to hear: "I love working on my jalopy; I fix power lawn mowers to make extra cash; I repair bicycles for fun," or similar reasons. The electrical engineers would tell me about building a radio controlled airplane or they were ham radio operators, or they built custom hi-fi systems. Most of them were electronic junkies. But over the years the answers changed.

Try asking your introductory physics class for engineers the same questions. It's been a few years since I tried this, but the results I got the last few times I inquired, troubled me. The major reasons for choosing an engineering discipline were jobs, money, security, not love, passion, experience, excitement. As often as not, these students really did not have any idea of what that profession did and what it required. Mechanical engineering students were angry that they had to study Newtonian mechanics, electrical engineering students were ticked off because we required them to learn Gauss's Law, Ampere's Law, Faraday's Law! "Let's get to the good stuff – we're engineers."

It's not that these kids aren't bright, even hard working, but hands-on experience, taking things apart, constructing stuff in the basement, designing your own scooter, these experiences are **not** typical today. Ken Libbrecht told us a story about a Caltech junior physics major who was so excited to discover the ratchet socket wrench when he was asked to take apart and clean a vacuum system in the advanced lab. He thought it was the best invention since sliced bread! Our modern day mass production – throw away society makes it very difficult – sometimes impossible, to open up and examine how something works, or to imagine actually repairing it. Of course, my mom patiently watched as I took things apart, but rarely put them back together. That's what moms are for.

Physics is all about how things work. For the experimentalist, that means instruments, computers, devices of all kinds. We need to give our kids, our students, the opportunity to really understand how the instrument – the experiment works. They all need hands-on experiments where they can do it wrong and, without blowing up the lab or the budget, learn from their mistakes. They need to have their own hands on real knobs, not to be watching someone else or clicking on a computer simulation.

At TeachSpin, we believe we are helping to facilitate this hands-on experience. No, they are not creating the apparatus from scratch, but we work hard to build instruments that students can "mess with" – instruments that **uncover**, not cover, the basic principles of physics. Physics must never abandon its heritage – "**How does it work? I need to know**".

Jonathan

TEACHSPIN
Tri-Main Center 409
2495 Main Street
Buffalo, NY 14214