Forecast:
See you in
Ann Arbor
www.teachspin.com

The Relaxation Times

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

VOL. III No. 5 *NEWSLETTER OF TEACHSPIN, INC.* *JUNE 2009*

Let Your Students Play, Too!

Quantum Analogs, QA1-A, wins the prize! Without doubt, it has become the most popular instrument for faculty to play with – actually get their hands on – at the physics shows. This is the piece of equipment that physicists seem to enjoy trying out, reconfiguring, asking questions and predicting results. It's our newest crowd pleaser.

Why is this? It might be explained by Barbara's infectious enthusiasm, since she has switched allegiance from her early favorite, Magnetic Torque, to her new pet, Quantum Analogs. (Women are so fickle!) Maybe it's because the idea of an acoustic analog for quantum phenomena is so original and has been so well thought out and executed by Professor Rene Matzdorf. Or it could be that the unit attracts attention because it has so much versatility. That is, one can easily and quickly reconfigure its components to observe new effects. We have never had so many suggestions for things to try with a unit. Maybe, probably, it is all of the above!

In February, 2008, the Relaxation Times devoted three pages to QA1-A, but that only covered some of its capabilities. Let's consider some other aspects of these experiments.

Figure 1 shows a close up photograph of the spherical resonator we call the "Hydrogen Atom", since it is its acoustic analog. To better understand how this operates, we have drawn an inside view, showing the placement of the speaker and microphone as well as a schematic sketch of the acoustic mode for the l = 2, m = 0 resonance that occurs at 8040 Hz. (Figure 2) The quantization axis is set by the speaker, but the two halves of the sphere rotate with respect to each other about the vertical axis. This allows the experimenter to vary the polar angle, θ, by 90° as the angle between the top and bottom hemispheres, α, rotates 180° around the vertical.

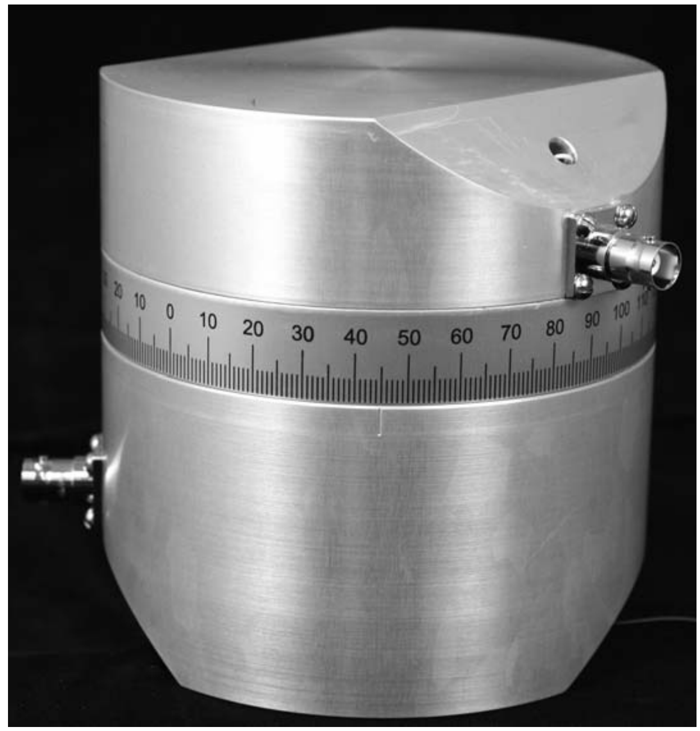


Fig 1: The "Hydrogen Atom"

The students can now directly observe a "slice" of the pressure wave that appears at the boundary walls of the sphere.

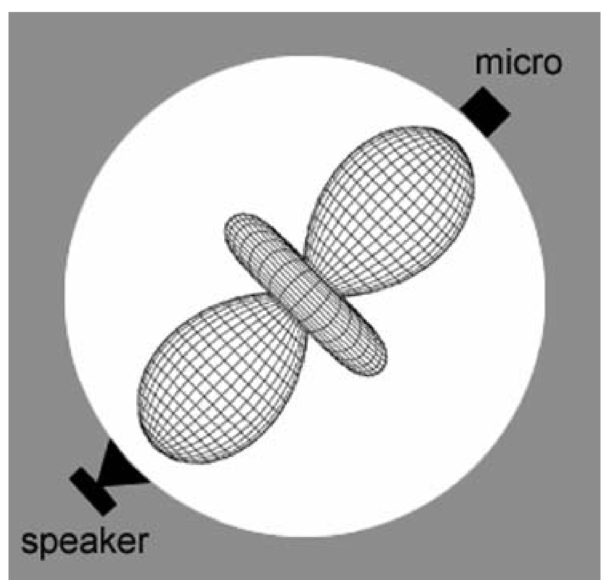


Fig 2: An inside "view" of the pressure wave.

The solutions of the Helmholtz equation for these boundary conditions are the same spherical harmonics that the students are introduced to in the quantum mechanical description of atomic hydrogen. Polar plots of these mathematical solutions appear in almost every quantum mechanics text. But now the students have the opportunity to actually acquire real data and create their own polar plots of these functions.

This can be accomplished with a voltmeter and a piece of graph paper – but the paper might frighten today's students, so Professor Matzdorf has provided some easy-to-use software which enhances the acquisition of these polar plots. As a representative sample of such date, we have chosen $Y_0^2\,(\vartheta, \varphi)$ which is shown in Figure 3. Here we plotted both the theoretical and experimental curves. The data was acquired at a fixed drive frequency, with only the vertical axis angle, α, as the independent variable. The fit to the theory is remarkable.

Other frequencies can also easily be measured and the appropriate spherical harmonics easily recognized. In Figure 4, we have both the theoretical and experiment plots for the resonance that occurs at 7460 Hz, which is identified as $l = 5$, $m = 0$.

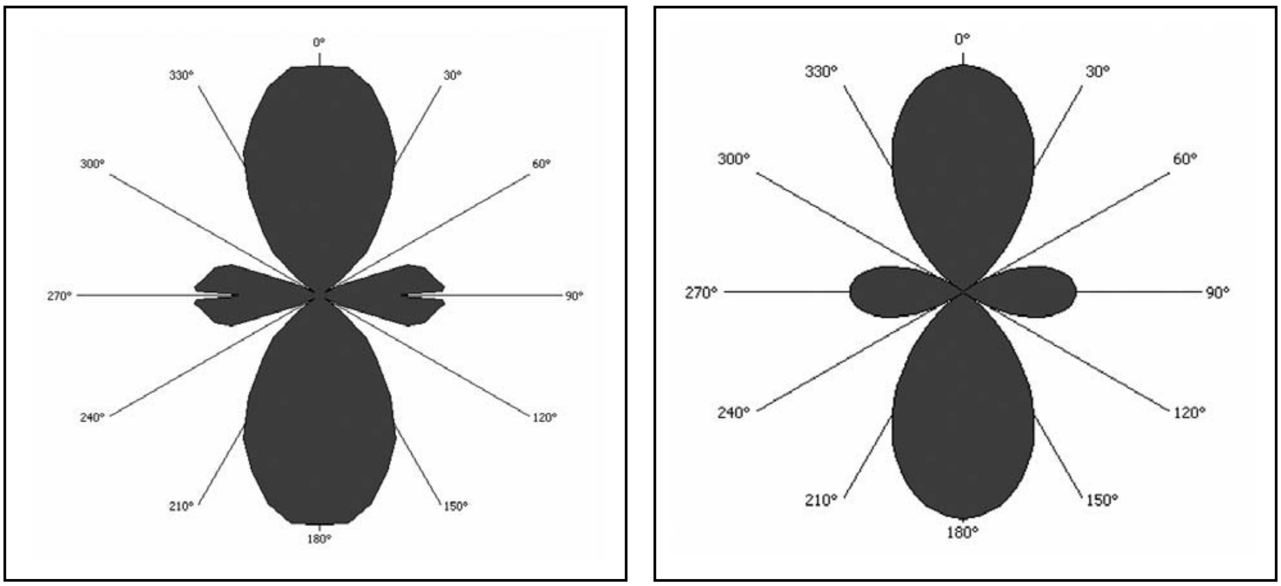


Fig 3: Wavefunction of the peak at about 8040Hz that belongs to the radial quantum number n' = 1 (left) and calculated spherical harmonics for *l* = 2, *m* = 0 (right).

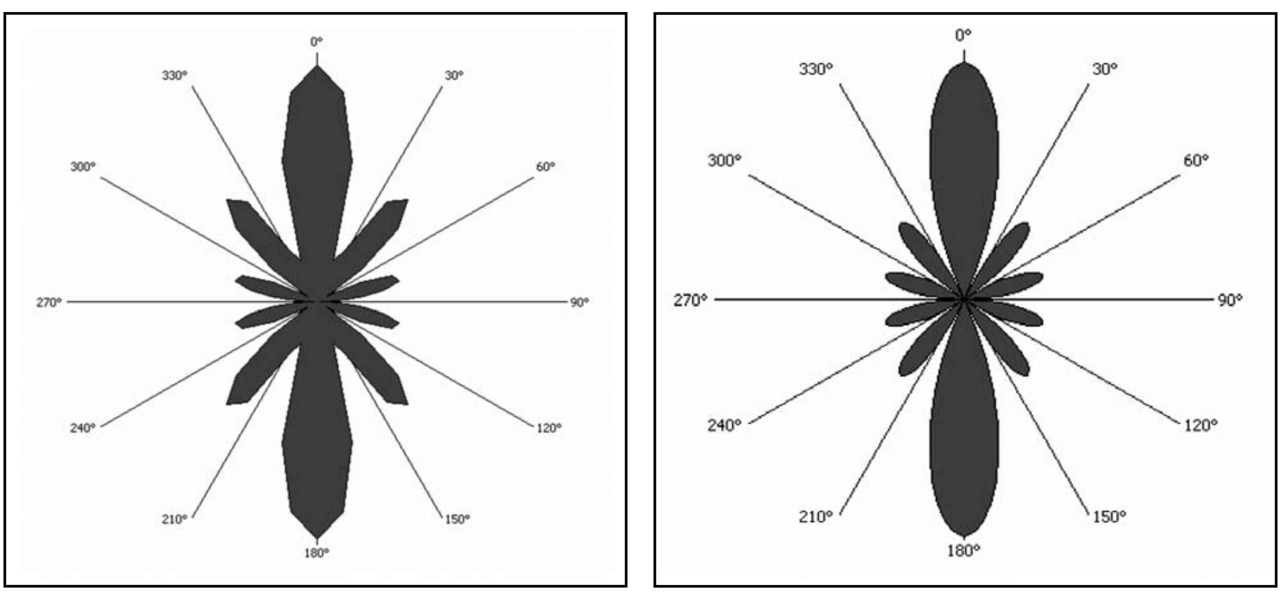


Fig 4: Wavefunction of the peak at about 7460Hz (left) and calculated spherical harmonics for *l* = 5, *m* = 0 (right).

The amplitude of the signal detected by the microphone for a given resonant frequency depends strongly on the angle between the microphone and the speaker, due to the different symmetry of the wave functions. This we have clearly seen in both Figures 3 and 4. However, students can easily conclude ***incorrectly*** that the resonant frequency itself also depends on this angle. In Figures 5 and 6, we show that, although the amplitude of the resonant peaks ***does*** depend on α, the location in frequency space of all of the resonances are the same. The resonances with high l values are most intense when $\alpha = 180°$.

Fig 5: Spectrum $\alpha = 0°$, giving $\theta = 90°$ between speaker and microphone

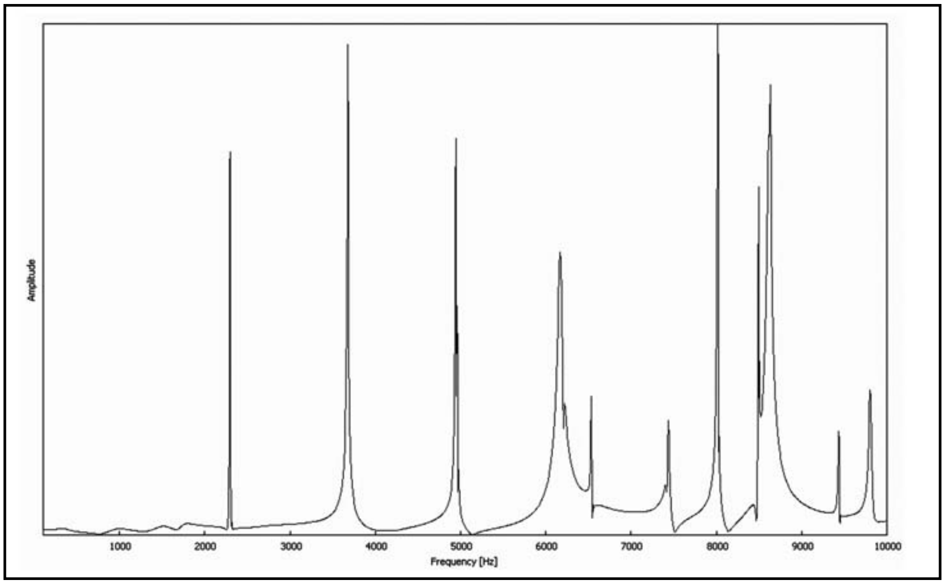
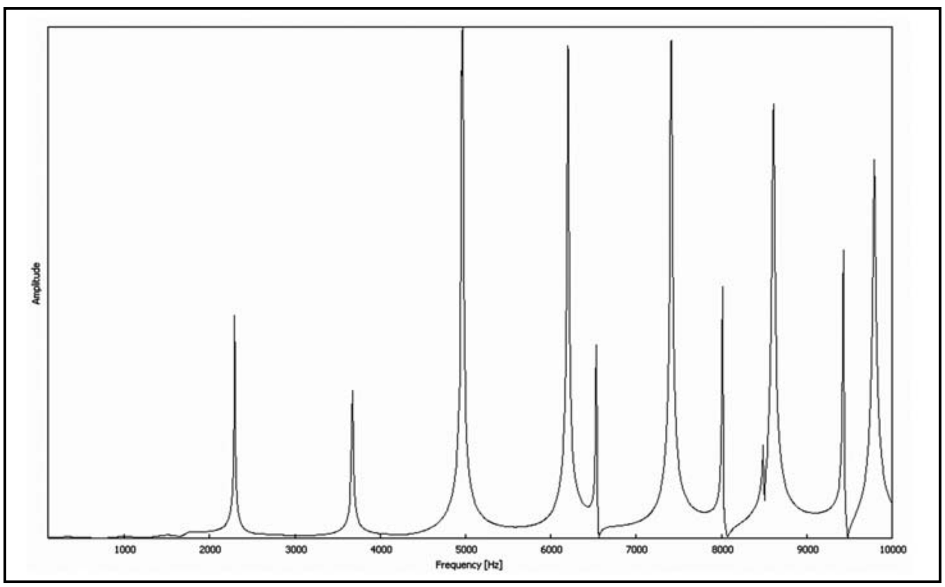


Fig 6: Spectrum at $\alpha = 180°$, giving $\theta = 90°$ between speaker and microphone



We have greatly expanded the manuals, both the instructors and student versions. The instructor's manual is now 72 pages and the student version covers 54 pages. There is much more detailed information and data on the "molecule" and a considerably enhanced section on "Modeling a One Dimensional Solid". Rene Matzdorf can't seem to stop playing with his unit and keeps discovering new experiments, with new theoretical explanations, for the students to experience. Of course, TeachSpin will provide all of its customers with any and all updates of the manual as new experiments come to light. We would like to encourage everyone who already has Quantum Analogs to come up with new experiments that can be shared with students all over the world. Prof. Matzdorf has created a website for Quantum Analogs which he will be keeping up-to-date with all of these new ideas. **www.physik.uni-kassel.de/quantum-analogs** Take a look!

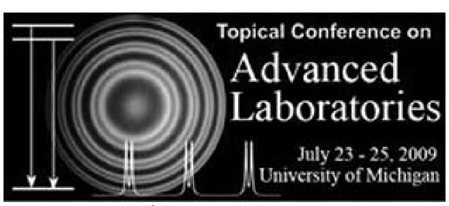
TEACH SPIN

Tri-Main Center, Suite 409
2495 Main Street
Buffalo, NY 14214-2153

Topical Conference on Advanced Labs
July 23 – 25
University of Michigan, Ann Arbor

For those of you who remember South Pacific, the song goes "If you don't have a dream, how you gonna have a dream come true?". Well, our dream is doing just that. We dreamed of an organization that would connect the advanced lab practitioners into a community that could lobby for increased attention and resources. And now there is ALPhA! We wished for a conference where people from a wide variety of institutions could share expertise and ideas, frustrations and successes. We hoped there would be time for people to present their "best stuff" and explore new options. We even hoped for a collection of vendors who would bring apparatus geared to upper division labs and allowed enough time for people to not just get hands-on but hands dirty playing with them.

Now, all we need is you - you presenting a paper or poster about a favorite lab, or the way you organize your course, or, or, or. . .



AAPT NSF APS physics ALPhA

Follow the Link www.advlab.org

Come to LEARN, Come to SHARE.

Either or both, JUST BE THERE

Our Stimulus Package

TeachSpin is doing its part to help you in this difficult economic environment. We realize that academic budgets have been cut and that laboratory budgets may be even more drastically reduced. In light of that reality, we have frozen our prices at their 2008 level. We will keep our prices at this level for the entire 2009 calendar year. This is a firm commitment and should help you plan your purchases for the academic year beginning September 2009.

Of course, the real stimulus to the economy will come from the students you graduate who are well equipped to begin either graduate studies or industrial research, after experiencing a wide range of intellectually challenging, hands-on, modern advanced laboratory experiments. It is this kind of laboratory education that is needed to create experimental physicists – the backbone of our modern high-tech industries. Do your part to really stimulate the economy, not just for the next year, but also for many, many years to come. Build a superb advanced lab program. TeachSpin can be of help by supplying you with some of our instruments.