Saint-Saëns scores bell-like piano tones

Here's a brief addendum to the Readers' Forum item (PHYSICS TODAY, October 2014, page 10) regarding bell tones from the piano. The unknown piece of music mentioned by Jon Orloff in his exchange with Murray Campbell about such bell tones might well be Piano Concerto no. 5, sometimes called the *Egyptian* Concerto, by Camille Saint-Saëns—specifically the second movement, a small portion of which is shown below. The bell-like quality of the sound that comes from the piano is an artifact of the way Saint-Saëns scored the piano part. The left hand plays a series of notes moderately loud (*mf*), which the listener hears as the melody. Simultaneously, the right hand plays the twelfth above each lower note, and the sixth above that, very softly (*pp*). Those two notes are harmonics (3:1 and 5:1, respectively) of the lower note, and when they are played together with it, they blend with the lower note and give it an exotic, bell-like timbre.

Myron Levitsky
(gipsyfiddle@earthlink.net)
New York City

ago, following up on the work of Paul Ehrenfest,[1] who had studied the hydrogen atom in n spatial dimensions using Bohr orbit theory, I reformulated the problem[2] using Schrödinger's equation extended to n dimensions, in which I had the Coulomb potential for $n \geq 3$. I did not include the Coulomb potential for $n = 1,2$, as discussed by Amusia, as I was only interested in the stability of the higher-dimensional atom for $n > 3$. (For the dimensionality of space I used "n" rather than "D.") In that work I gave the radial equation equivalent to the one above: I wrote, "If we now transform to n-dimensional polar coordinates, introduce n-dimensional spherical harmonics, and factor out the angular dependence,[3] the resulting radial equation takes the form

$$\frac{d^2}{dr^2} + \frac{n-1}{r}\frac{dR}{dr} + \frac{2m}{\hbar^2}\left[E - \frac{\hbar^2}{2m}\frac{l(l+n-2)}{r^2} + \frac{e^2}{(n-2)r^{n-2}}\right]R = 0."$$

In my paper, I did not eliminate the dR/dr term to arrive at a form equivalent to the first equation. However, that is readily done by setting $R = r^{-(n-1)/2}\,\phi$ and generalizing to nuclear charge Z, and setting $n \to D$. The reason I have the D-dependent Coulomb potential for $D > 3$ and the article authors do not is that they have a different goal—to gain new insight into the real, atomic-molecular 3D world using the limiting behavior of the D-dimensional kinetic energy. In contrast, as indicated above, I was only interested in whether the D-dimensional Schrödinger "hydrogen atom" would have stable bound states for $D > 3$.

References

1. P. Ehrenfest, *Proc. Amsterdam Acad.* **20**, 200 (1917); *Ann. Phys. Leipzig* **61**, 440 (1920).
2. F. R. Tangherlini, *Nuovo Cimento* **27**, 636 (1963).
3. See, for example, A. Sommerfeld, *Partial Differential Equations in Physics*, E. G. Straus, trans., Academic Press (1949), app. 4.

Frank R. Tangherlini
(frtan96@gmail.com)
San Diego, California

Modeling Maxwell's Demon

The interesting article "Engineering Maxwell's demon" by Zhiyue Lu, Dibyendu Mandal, and Christopher Jarzynski in the August 2014 issue (page 60) includes a link to a video, created using the three-dimensional animation software Blender, of the device. I've used GlowScript to make an interactive version at http://www.glowscript.org/#/user/Bruce_Sherwood/folder/Pub/program/MaxwellDemon.

The program lets the user zoom and rotate to inspect the device, and it plots the demon's rotational velocity component as a function of time. The plot demonstrates the counterclockwise bias over long times that the authors describe. A user can observe the increased informational entropy in the paddle positions. A modern browser that supports the 3D graphics library WebGL and a graphics card with graphics processing units are required; click "Help" in the upper right corner for details on system requirements. Click "Edit this program" to see the code, which is short for a program of this complexity. I thank the article's authors for helpful advice.

Bruce Sherwood
(bruce_sherwood@ncsu.edu)
Santa Fe, New Mexico

Corrections

February 2015, page 45—The Osirak reactor was in Iraq.

February 2015, page 50—The late heavy bombardment period occurred 4 billion years ago. ■