fact that Werner Heisenberg put forward in 1922 a two-electron atomic model that had electrons moving similarly out of phase and that ascribed a fractional quantum number (½) to the bending mode of the configuration.[1] Although Heisenberg's model predicted the ground-state helium level, which was in excellent agreement with the spectroscopic data, Bohr opposed the model, since a noninteger quantum number was considered sacrilege. For the same reason, Bohr never published his own results. However, the asynchronous two-electron atomic model turned out to be the fertile one, though the corresponding classical configurations can have very complex structure.[2]

References

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■ **Svidzinsky, Scully, and Herschbach reply:** We agree with M. Y. Amusia that a statement we made about the infinite dimension limit is "lacking in rigor." It was intended simply to provide heuristic insight into why, for a wide variety of problems, the large-D limit has proven to be a useful starting approximation to obtain results for $D = 3$.

Amusia's other concerns are answered in a 1975 paper on a D-scaling treatment of helium by David Herrick and Frank Stillinger.[1] They gave a rigorous derivation of the D-dimensional hydrogen atom Hamiltonian, shown as equation 1 in Amusia's letter. That solution applies for $D \geq 2$, as implied in the figure included in box 1 of our article. Herrick and Stillinger also showed that for the correct $D \rightarrow 1$ limit, the Z/r term becomes a δ-function. In D-scaling, contrary to Amusia's assumption, the $D = 3$ form of Coulomb's law can be used for dimensional continuation to the large-D limit. The D-dependent similarity transformation affects the Laplacian, not the potential energy. Both theory and application are amply presented in references given in our article (particularly references 8–11). D-scaling, using just elementary algebra, has attained correlation energies for multielectron atoms with accuracy comparable to or better than conventional electronic calculations.[2]

The papers of Leonard Mlodinow[3] and several other authors, especially the earlier paper by Herrick and Stillinger,[1] fostered the development of D-scaling for electronic structure. Since the kinship of Bohr's model to dimensional scaling was not recognized until 2005, we did not dwell on that history, other than citing the tutorial article by Edward Witten. The treatment of H_2 that Mlodinow cites in the second part of his reference 3 is a deliberately drastic approximation and gives less than 40% of the bond dissociation energy.

As emphasized by Petar Grujic, the bold, perplexing enterprise by Niels Bohr motivated much further work melding classical and quantum mechanics. We note that D-scaling has a distinctive character. It might aptly be termed "semiquantum" rather than semiclassical. Although in the large-D limit the equations become classical, quantum mechanics is hidden in the D-dependent units adopted for distance and energy. At that limit, electrons take fixed positions in the D-scaled space and the first-order correction in $(1/D)$ has them execute harmonic vibrations about those positions. In the prequantum era, such behavior was postulated by Gilbert Lewis and Irving Langmuir,[4] motivated by chemical arguments but disdained by physicists and considered incompatible with the Bohr model.

References

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3. See D. R. Herschbach, *J. Chem. Phys.* **84**, 838 (1986), for analysis of the papers cited in reference 1 of Mlodinow's letter.
4. P. Coffey, *Cathedrals of Science: The Personalities and Rivalries That Made Modern Chemistry*, Oxford U. Press, New York (2008), chap. 5, esp. p. 139.

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Citation counts and indices: Beware of bad data

In recent years, citation counts and associated indices have become increasingly important in a wide range of professional considerations, including hiring, promotions, and grant reviews. Citation counts can make the difference between a cut or an increase in funding for a university department by a national or local government. Also, it is not uncommon to see job applications listing citation counts for every paper on the candidate's CV.

Citation counts are great for bureaucrats and administrators because, by definition, they are quantitative. They can be added, subtracted, normalized, and plotted. Indices based on these counts abound, the ubiquitous Hirsch or *h*-index being the most prominent.

Debate continues to rage as to whether such counts and indices actually mean anything. (See, for example, the Commentary by Orion Penner, Alexander Petersen, Raj Pan, and Santo Fortunato, PHYSICS TODAY, April 2013, page 8.) Do they really measure the importance or impact of a researcher's work on the field? How does one normalize for multiple-author papers, especially those that list hundreds of authors? Should review articles count the same as original research articles? How does one normalize across fields with different citation traditions? Is one paper with a zillion citations better than a lot of papers with modest citations? Do those indices favor experimentalists over theorists? The unanswered questions go on.

One issue that I have not seen debated is the accuracy of the actual citation data. We take for granted that every citation of every paper we have written has been counted. But that is not necessarily so. I offer a case in point:

In 2008 I wrote a paper for *Astrophysical Journal Letters* on the possibility of testing the black hole no-hair theorems using measurements of stars orbiting the galactic-center black hole Sagittarius A*. A year ago I went to INSPIRE—the high-energy physics information system that now combines SPIRES and CERN's Invenio digital library technology—to check on the citations. I was astonished to find that it had been cited only 13 times in five years.

So I checked the NASA Astrophysics Data System (ADS) database and found that my article had been cited 73 times. What happened to the other 60 citations? Most of them were in standard journals like *Physical Review D* and *Astrophysical Journal*. I had assumed that with modern DOI (digital object identifier) designations and search engines, everything would be caught, but apparently not.

To correct the problem, I had to generate a list via NASA/ADS of all the missing citations and send them to INSPIRE. The staff there then entered the information by hand. The list is now accurate—and my own *h*-index went up by one! But I'm not obsessed. Really, I'm not.

My experience does raise a question: What else might be missing?

In all fairness, SPIRES was set up as a database primarily for the high-energy physics community, and the INSPIRE staff members admit that they have difficulty getting all the references from the various astronomy and astrophysics journals. In view of the increasing links between particle physics and astronomy, they told me, they are considering talking to the NASA/ADS staff about ways of better covering both fields.

But I don't mean to pick on INSPIRE. Here's another case. In 1976 I wrote a letter to *Physical Review Letters* with Mark Haugan on weak interactions and Eötvös experiments testing the equivalence principle. A few months ago, I discovered that the citation counts on that paper were wildly divergent: INSPIRE had 35 citations, NASA/ADS had 98, and *Physical Review*'s own website had 202. After some detective work, I discovered the problem. My paper with Haugan was *Phys. Rev. Lett.* **37**, 1 (1976). The late Nobel laureate Pierre-Gilles de Gennes published in a French journal a seminal percolation-theory paper frequently cited as *J. Phys. Lett.* **37**, 1 (1976). In this case, INSPIRE got it more or less right; for the other two counts, the overwhelming majority of excess papers counted as citations of Haugan and Will were actually papers in condensed-matter physics citing de Gennes. The similarity in the journal references obviously confused the citation counters. As much as I'd love to boost my *h*-index, it's probably not fair to ride on de Gennes's coattails.

So caveat emptor: A citation count provided by a system such as INSPIRE or NASA/ADS or even a journal might not be as accurate as you think. Like every good physicist, you should check the quality of the data before worrying too much about the interpretation.

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