

Citation counts and indices: Beware of bad data
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In recent years, citations 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. It is not uncommon to see post-doc applications listing citation counts for every paper on the candidate's CV. I have seen publication lists on CVs and webpages that are simply the output of a SPIRES search on the individual's name. And if a paper should make one of SPIRES' "famous" or "renowned" paper categories, you can be sure that that fact will be indicated prominently somewhere on the 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 (the number n such that in a ranking of papers by citation count, the rank of the $n + 1$ th paper exceeds the number of its citations) being the most prominent among many.

Debate continues to rage as to whether these counts and indices actually mean anything. 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 where the number of authors can reach into the hundreds? 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 these indices favor experimentalists over theorists? And so on.

But 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 this is not necessarily so. 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 SgrA*. I thought it was a pretty good paper which seemed to have had some impact, and so I recently went to INSPIRE (the latest version of SPIRES) to check on the citations. I was astonished to find that it had been cited only 13 times in 5 years. On the other

hand, according to the NASA/ADS database, it had been cited 73 times. What happened to the other 60 citations? Most of them were in standard journals like *Phys. Rev. D* and *Astrophys. J.* I had assumed that, with modern DOI designations and search engines, everything would be caught, but apparently not.

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

But this raises the 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 SPIRES staff 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 that they are considering talking to the NASA/ADS people about ways of doing this better.

But I don't mean to pick on SPIRES.

Here's another case. In 1976, I wrote a *Physical Review Letter* with Mark Haugan on weak interactions and Eötvös experiments. I recently discovered that the citation counts on this paper were wildly divergent: SPIRES said 35 citations, NASA/ADS said 98, while Physical Review's own website said 202 citations! What's going on? 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 a seminal paper on percolation theory in a French journal frequently cited as *J. Phys. Lett.* **37**, 1 (1976). Sometimes "(France)" or "(Paris)" is inserted after Phys., sometimes not. In this case, SPIRES got it more or less right; for the other two counts, the overwhelming majority of papers counted as citations of Haugan-Will were actually papers in soft condensed matter physics, not gravitational physics. As much as I'd love to boost my *h*-index, it's probably not fair to ride on de Gennes' coattails!

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