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What Fraction of Papers in Astronomy and Physics Are Not Cited in 40 Years?

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Abstract

Of 4000 papers published in astronomy and in physics in the past 40 years, 40.3%, and 23.4%, respectively, have not been cited (referenced). However, if we limit this to the final research papers (excluding announcements, book reviews, proposals for funding, and observing time, obituaries, etc.), the fractions are 1.4% and 1.5%, respectively. So virtually all the papers in these two sciences are useful. These data also tell us that the productivities of astronomers peak at age 40.4 years. and that 43.0% were published after the age of 50 years. For physicists, the peak occurs at 36.6 years. and only 33.7% were published after the age of 50 years. Therefore physicists peak about four years earlier than astronomers and they produce 9% fewer citations after the age of 50 years.

Key words: astronomical databases: miscellaneous – history and philosophy of astronomy

1. Introduction

We wonder whether the results in our papers are used by others and ourselves in future research. This can be determined by counting citations to our papers in the Astrophysics Data Service (ADS) or Research Gate. Those two services efficiently record all authored papers in hundreds of journals (but not all of them), including ones not intended to be quoted for future research, such as announcements from editors, book reviews, proposals for funding and telescope observing time, etc. In addition, some references are effectively replaced by others: the final research papers replace preprints (e.g., arXiv, astro-ph) and abstracts of papers given at meetings. Authors and referees prefer quoting the final research papers that contain the reasoning and data to quoting abstracts. Below, we will distinguish all papers from final research papers.

Hamilton (1990) published data from Pendlebury at the Institute for Scientific Information saying that 55% of scientific papers are never cited in the first five years after publication. Pendlebury's (1991) initial numbers were shocking: 47.4% for the physical sciences, 74.7% for the social sciences, and 98.0% for the arts and humanities. If that were true, it would mean that more than half of scientific papers do not contribute to our knowledge and were a waste of funds and effort. But that statistic was clarified by Abt (1991), Hargens (1991) and Pendlebury (1991). They pointed out the 55% included all kinds of authored publications including announcements, book reviews, obituaries, preprints, applications for funding, etc., as well as research papers. But if one counts only the final research papers, the fraction uncited in five years is only 5.1% ± 1.0% in astronomy and 8.1% ± 1.2% for physics (Abt 1991). If one eliminates self-citations Abt (2017a), the fractions are 6.4% ± 1.1% and 11.4% ± 1.4%, respectively. Van Noorden (2017) reviewed some of the past articles and adds more frequencies.

Still, a limit of five years is not fair. In astronomy we remember that Zwicky (1933) published evidence that when the virial theorem is applied to galaxy clusters, the masses of clusters were five or more times greater than the masses of the light-emitting objects in them. No one, except for the author, cited that result for 27 years and its implication regarding missing mass was not discussed for 41 years after publication. It has now produced 1030 citations. Therefore, let us count research papers uncited for 40 years. The 40 years. is an arbitrary number; the final results would not be significantly different is we used 30 or 50 years.

These data can also be used to learn more about the ages when astronomers and physicists produced their best work, which has been studied earlier. The first of those papers (Abt 1983) said that the productivities of astronomers peak in their 40s, the second (Abt 2016) said that for outstanding (prize-winning) astronomers the peak occurs in their 30 s, and the third (Abt 2017b) found that for average astronomers the peak occurs in their 40 s.

2. The Data for Astronomy

To select random samples of papers published up to 40 years ago, I selected astronomers and physicists listed in *American Men and Women of Science* (Henderson 2010). I selected the first 25 astronomers and 25 physicists who specified "astronomy" or "astrophysics" and "physics" as the first descriptions of their occupations. The advantage of selecting scientists from that publication is that inclusion in those books is limited to

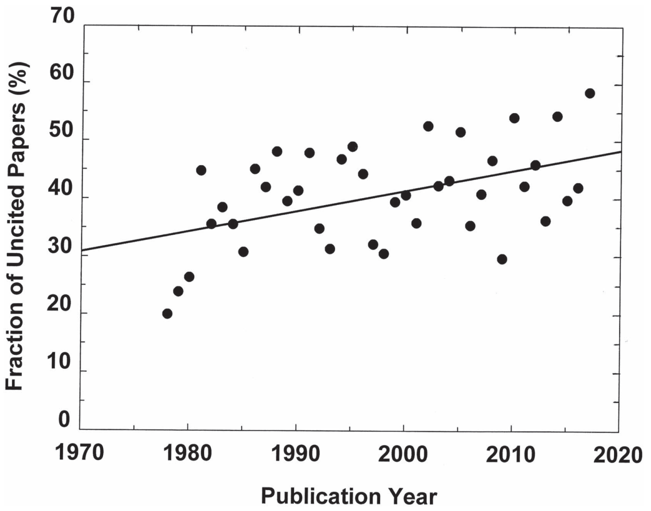

Figure 1. Fractions of uncited astronomical publications of all kinds are shown for various years. The mean linear relation is $F = 30.85 + 0.35089$(Y-1970), which gives a mean of 40.3%.

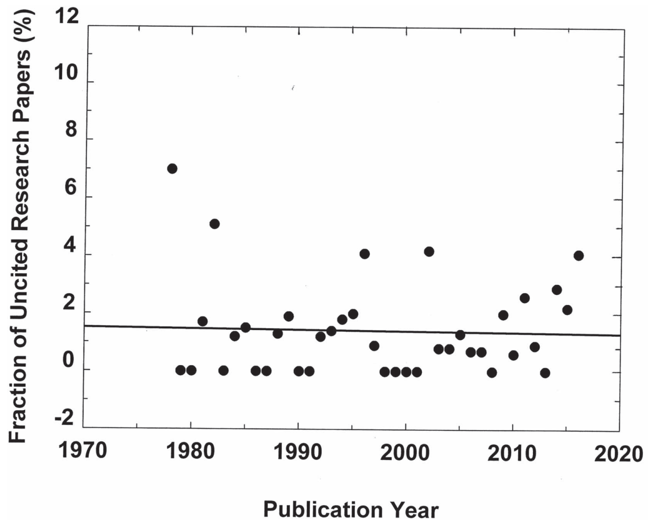

Figure 2. Fractions of final astronomical research papers that are uncited are shown. The high point (17.1%) for 2017 is not included because too little time has passed for citations in 2017 for papers published in 2017. The fitted linear relation is $F = 1.51 - 0.003785$(Y-1970). The mean is 1.4% ± 1.7%.

scientists who have careers longer than 40 years. I eliminated some who published too few papers (<100) to give useful information and a few with names so common that their papers were hopelessly confused with those of others with the same names. Also I eliminated a few who did not publish their birth years.

Kurtz & Henneken (2017) explored the results of using only older astronomers (careers longer than 40 years) with what they did earlier and found similar results.

The ADS gives the number of citations for all the authored papers by the physical scientists. I recorded those by publication year. This counting was done in January 2018 for the papers published in 1978–2017. The numbers increase slowly with time, although papers in 2017 have not had enough time to collect many citations while those from the 1970s have had about 40 years. The average number of papers counted per year was 100 for all 25 astronomers. Figure 1 shows that the fraction of uncited astronomical papers of all kinds increased from an average of 33.7% in 1978 to 47.4% in 2017. The average with no citations is 40.3%.

However, as noted in the previous section, many of these have no lasting research value, so I then counted only final research papers. By research papers I mean ones that give full research data and were published in the standard astronomical journals. The percentages may differ for different journals. If I and others loaded up the PASP with papers like this one that are widely read but rarely cited, the percentage of uncited papers in the PASP might increase.

The results are shown in Figure 2. There is little dependence upon year. The average is 1.4% ± 1.7%, which shows that very few research papers are not cited in 40 years.

One can inquire about the nature of papers uncited in 40 years. For instance, this author has published 77 papers of this kind loosely called "publication studies." They are widely read but rarely cited; 16 have never been cited. Research Gate tabulates the numbers of times each paper is downloaded to be read, but not necessarily cited in later publications. To date, this author has had 1875 of his papers "read" and 8212 papers "cited." So even uncited papers can produce an impact on the thinking of scientists, even if they are not cited later.

3. The Data in Physics

Similarly, I counted papers by the first 25 physicists listed in *American Men and Women of Science*, eliminating some with too few papers and some with similar names as other physicists. The results for all publications are shown in Figure 3. The mean of 23.4% is smaller than for astronomical papers (40.3%). However, I noticed that the astronomical papers included more announcements, book reviews and proposals for funding and telescope observing time than the physics papers. That explains part or all of the difference in the fractions.

There is another difference between astronomy and physics. Among the astronomers in *American Men and Women of Science* with last names starting with "Aa" through "Ba," only five out of 32 (16%) were eliminated because they published too few (<100) papers to be useful. However, among the physicists with last names starting with "Aa" through "Ak," 19 out of 50 (38%) were eliminated because they published too few (<100) papers. That means that either astronomers tend to publish more papers than physicists or that the standards for

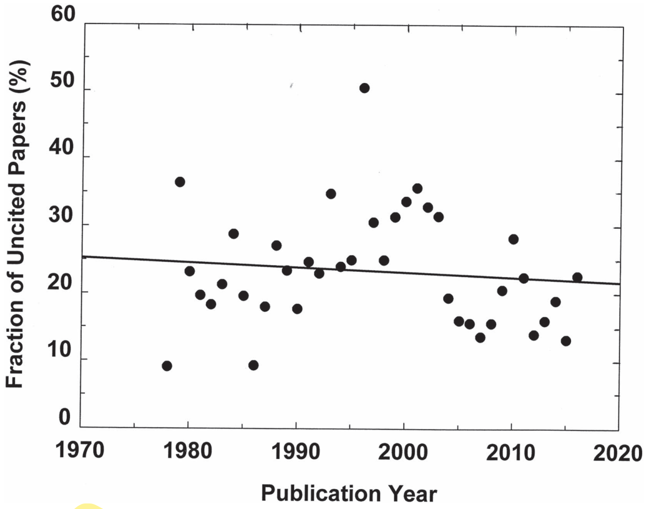

Figure 3. Fractions of uncited physical publications of all kinds are shown for various years. The mean relation is $F = 25.26 - 0.070283$(Y-1070), which gives a mean of 23.4%.

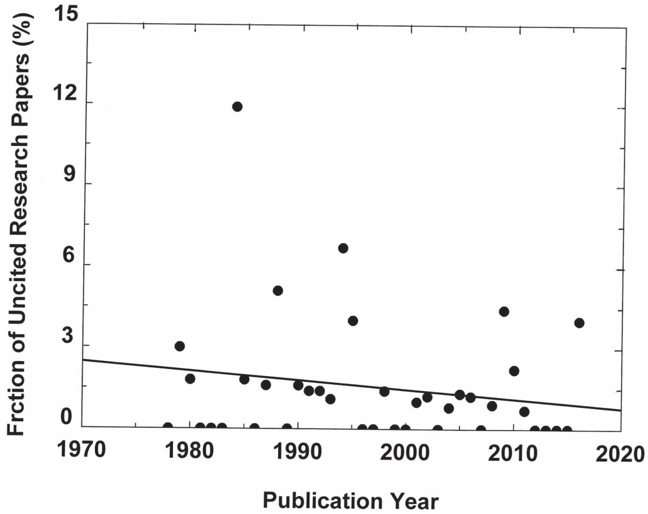

Figure 4. Fractions of physics research papers that are uncited. The linear relation is F = 2.46 − 0.033725 (Y-1970) and the mean value is 1.55%.

inclusion in those volumes are more lax for physicists than for astronomers.

If I counted only final research papers in physics, the results are shown in Figure 4. The mean is 1.5% ± 2.4%, so there is no significant difference between papers in astronomy and physics in the fractions of uncited research papers. Both are acceptably low.

One could explore which papers or which fields of research produced few citations in 40 years. I noticed that in many cases, the papers published early in scientists' careers tended to receive fewer citations because they were superseded by more thorough later papers. Egghe et al. (2011) claimed few citations were not limited to secondary authors and that of the papers by Nobel laureates, 10% remain uncited. But Heneberg (2013) found that that statistic was faulty and was really 1.6%. Then he searched in journals not included in the Web of Science and reduced the fraction to 0.3%.

4. The Most Productive Years

These same data can be used to determine the most productive years of scientists. The advantage of using these data over previous ones is because we have information for similar samples in astronomy and physics. For the same 25 astronomers the numbers of normalized citations in bins of five years are shown in Figure 5. I used normalized citations because in multi-author papers it would not be fair to credit each author with all of the citations for the paper. Also, there is no way of knowing which authors contributed the most to each paper. Some astronomers died after age 55 or later, so the counting for older years included only those who survived. The best fourth-order polynomial gives a peak productivity at 40.4 years and 43.0% of the astronomer's productivity occurred after age 50.

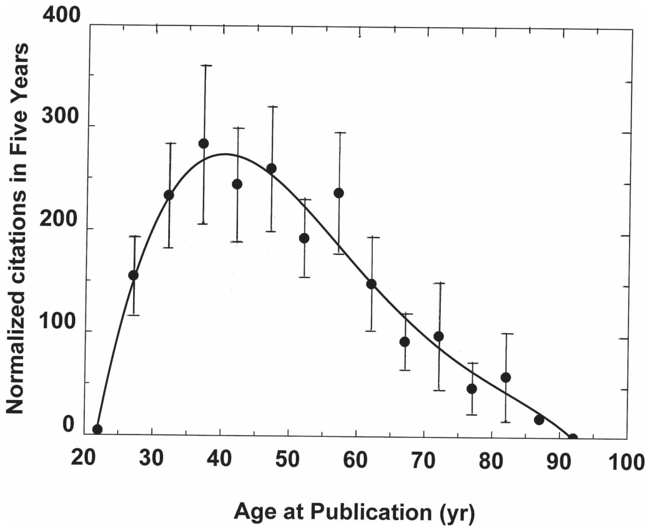

Figure 5. Productivities of astronomers measured in terms of normalized citations in five-year bins. The data for older astronomers are only for those who lived to those ages. The error bars (s.e. in the means) are large because of the wide ranges (e.g., 8.00 and 1004.25) in the citation counts for different astronomers during any one bin. The best-fit curve is a fourth-order polynomial with a peak age at 40.4 years.

In the case of physicists as shown in Figure 6, the peak productivity age is at 36.6 years and only 33.7% of their citations occurred after the age of 50 years. Therefore, physicists peak about 4 years earlier than astronomers, and after the age of 50 years, they produce 9% fewer citations.

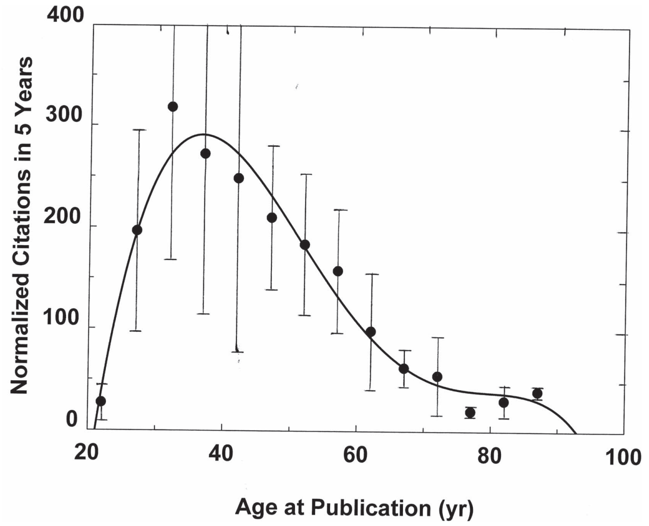

Figure 6. Productivities of physicists measured in terms of normalized citations in five-year bins. The best-fit curve is a fourth-order polynomial with a peak at 36.6 years.

One can speculate on the reasons for these differences. Perhaps they are because physics is a more developed science. I think of astronomers who had to collect observations and data for many years before they could formulate and explain their conclusions. Also, although experience has shown that the ADS collection of papers by astronomers is surprisingly complete except for some obscure journals, perhaps we should heed the ADS warning that, in physics, it may be less complete.

This research has made use of NASA's Astrophysical Data System.

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