

## DISENTANGLING VISIBILITY AND SELF-PROMOTION BIAS IN THE ARXIV:ASTRO-PH POSITIONAL CITATION EFFECT

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### ABSTRACT

We established in an earlier study that articles listed at or near the top of the daily arXiv:astro-ph mailings receive on average significantly more citations than articles further down the list. In our earlier work we were not able to decide whether this positional citation effect was due to author self-promotion of intrinsically more citable papers or whether papers are cited more often simply because they are at the top of the astro-ph listing. Using new data we can now disentangle both effects. Based on their submission times we separate articles into a self-promoted sample and a sample of articles that achieved a high rank on astro-ph by chance and compare their citation distributions with those of articles in lower astro-ph positions. We find that the positional citation effect is a superposition of self-promotion and visibility bias.

*Subject headings:* sociology of astronomy – astronomical data bases: miscellaneous

### 1. INTRODUCTION

In Dietrich (2008, Paper I) we studied the effect of an e-Print's placement in the daily arXiv:astro-ph listing on the number of citation it gets. We found that e-Prints appearing at or near the top of the astro-ph mailings receive significantly more citation than articles further down the list. We proposed three non-exclusive effects to explain this *positional citation effect* (PCE). These are defined as:

- The Visibility Bias (VB) postulate – Papers appearing at the top of the astro-ph listing are seen by more people and thus cited more often than those further down the list, where the attention of the astro-ph readers might decrease;
- The Self-promotion Bias (SP) postulate – Authors tend to promote their most important works, and thus most citable articles, by placing them at prominent positions;
- The Geography Bias (GB) postulate – The submission deadline preferentially puts those authors at the top of the listing whose working hours coincide with the submission deadline. This group already has higher citation counts for other reasons.

The last postulate pertains to the facts that (1) US American authors have a higher fraction of highly cited papers than their European colleagues (Habing 2007) and (2) the arXiv submission deadline of 16:00 EST/EDT is within the normal working hours of astronomers in the US, while it is not for European astronomers.

We concluded in Paper I that GB is not the cause of the observed PCE because the effect is found independently in the samples of European and US authors. We proposed to disentangle VB and SP by the following method: using the submission times of e-Prints and grouping them into two samples, one that is submitted

so shortly after the deadline that it is statistically expected to be self-promoted, and a second one that is submitted long enough after the deadline to exclude self-promotion, and repeating the citation analysis for both samples, one can distinguish between SP and VB. According to information we received at the time of writing Paper I from arXiv administrators, the initial submission times are not stored. Consequently, we were not able to decide whether the PCE is caused by VB or SP. Meanwhile we were contacted by arXiv staff informing us that, in fact, the original submission times, although indeed not stored as part of an e-Prints record, can be recovered from the server log files. This now enables us to perform the timing analysis proposed in Paper I.

### 2. ANALYSIS

We use the same sample as in Paper I, i.e., astro-ph e-Prints published between the beginning of July 2002 and the end of December 2005. Citation data for these e-Prints were gathered from NASA's ADS Bibliographic Services<sup>1</sup>. We do not correct for the fact that older papers had more time to gather citations than e-Prints published towards the end of the period under investigation here. For every astro-ph e-Print published in one of the core journals of Astronomy (in agreement with Kurtz et al. (2005) we define these as *The Astrophysical Journal (Letters)* and its *Supplement Series, Astronomy & Astrophysics, Monthly Notices of the Royal Astronomical Society, The Astronomical Journal*, and *Publications of the Astronomical Society of the Pacific*) we compute the time  $t_s$  passed from the last submission deadline to the submission time of the article to the arXiv server. We ruled out GB as the sole cause of the PCE in Paper I but we now restrict our analysis to articles whose first author's first affiliation is in North or South America. The reasons for this choice are that European authors must self-promote to achieve the top position on astro-ph, weakening any VB signal if present, and to avoid any residual signal from GB. Restricting our analysis to

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<sup>1</sup> Access this service through <http://adsabs.harvard.edu/index.html>

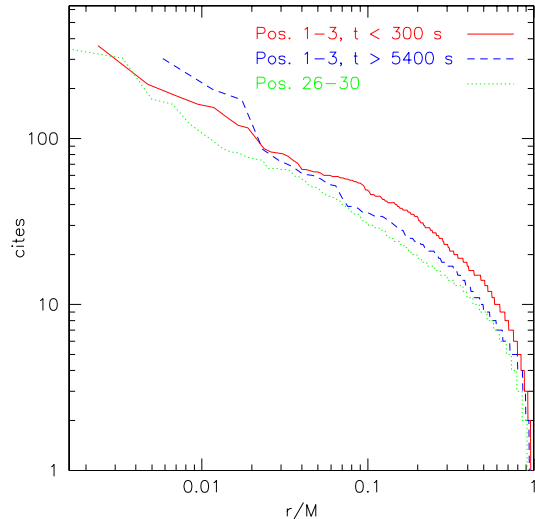


FIG. 1.— Zipf plots for the timing analysis. The  $x$ -axis show the normalized rank of astro-ph postings in their respective samples after sorting them by citations. The  $y$ -axis gives the number of citations. The different color/line-styles represent the different samples under investigation. The solid red line represents e-Prints in the first three astro-ph positions posted within the first 5 minutes after starting a new list. The dashed blue line is the Zipf law for articles in the same positions but posted more than 1.5 h after the deadline. The dotted green line gives all articles of American authors in positions 26–30 for comparison.

American (North and South) authors we avoid a correlation of different citation distributions with submission behavior while at the same time maximizing the sample size.

We perform an analysis of the citation counts similar to the one in Paper I. The citation distribution is a power law (Redner 1998), which is best analyzed using a Zipf plot. A Zipf plot shows the citations on the  $r^{\text{th}}$  most cited paper out of an ensemble of size  $M$  versus its rank  $r$  or, if several samples of different sizes are to be compared, its normalized rank  $r/M$ . Figure 1 shows Zipf plots for three different samples of core journal articles; two samples of articles in the first three astro-ph positions, one submitted very shortly after the deadline ( $t_s < 300$  s) very likely aimed at self-promotion and one submitted obviously without the intent to achieve the “pole position” ( $t_s > 5400$  s). We bin the first three positions because the PCE is much for stronger for them than for lower positions at which it is still significant and to average out the noise that would dominate in studying individual positions. The third sample contains articles that appeared at astro-ph positions 26–30 at any submission time.

We clearly see that the three curves, while their slopes are roughly equal, are at different loci, corresponding to different normalizations of the citation distribution power law. The highest curve, i.e. the highest normalization of the citation power law is the sample of articles submitted shortly after the deadline. Articles listed at the top positions but submitted later are cited less often, with the exception of the three most cited articles in this sample, but still considerably more often than articles further down the list.

To quantify the impact of VB and SP we compute the average citations a paper gets in the range  $-3.0 <$

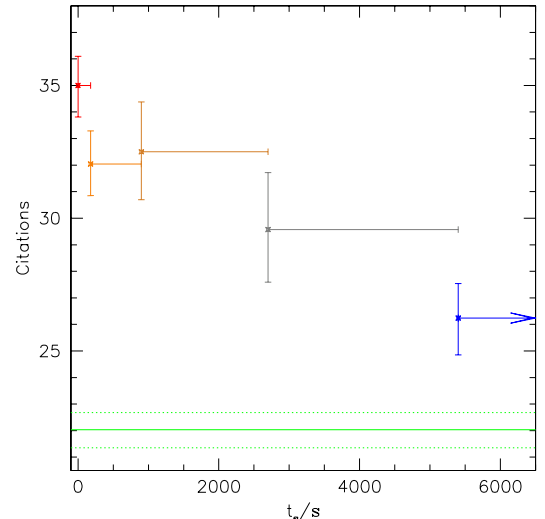


FIG. 2.— Average citation numbers for articles in the first three positions of astro-ph depending on their submission time. The horizontal error bars denote the width of the sample bins. The green horizontal line corresponds to the average citations (with dotted error bars) of e-Prints at positions 26–30.

$\ln(r/M) < -1.0$ . We choose this range to avoid the bulk of mostly ignored papers and especially to avoid being dominated by a few highly cited papers. We find that articles in the early sample are on average cited  $34.4 \pm 1.1$  times, while articles from the later sample are cited  $26.2^{+1.3}_{-1.4}$  times. The comparison sample from astro-ph positions 26–28 has a mean citation number of  $22.0 \pm 0.7$ . The quoted errors are the 68% confidence intervals estimated from bootstrap resampling the citation counts in the selected interval.

We repeat this calculation for three additional time intervals and plot the result in Fig. 2. We find that after the initial rush of self-promoted papers the citation rates slowly drop for e-Prints submitted later after the deadline. This confirms a contribution of SP to the PCE. We also find that papers submitted more than 1.5 h after the deadline, i.e., those e-Prints that achieved a high position in the astro-ph listing almost certainly by chance and not by the submitter’s intent, are still cited significantly more often ( $3\sigma$ ) than papers further down the list. This proves that also VB contributes to the PCE. We note that these results are independent of the exact binning that is employed. Choosing different bins close to and far away from the submission deadline moves the points in Fig. 2 somewhat up and down. The overall result that papers submitted shortly after the deadline have higher citation rates than e-Prints submitted later remains, as does the difference in citation numbers between late articles at the top and articles down the astro-ph listing. The presence of both SP and VB thus does not depend on the exact binning employed.

### 3. SUMMARY AND DISCUSSION

We studied the factors contributing to the increased number of citations e-Prints at the top of the daily astro-ph listing receive compared to e-Prints listed further down the astro-ph mailing. By making a timing argument we constructed samples of e-Prints appearing at the three first positions of astro-ph that are either (1) almost certainly submitted with the intent of getting the top

spot; or (2) achieved a high position of astro-ph purely by chance; or (3) fall somewhere in between and have a mixture of categories.

We found that the sample of self-promoted papers indeed has the highest citation rates. This shows that self-promotion as a mechanism that preferentially puts intrinsically more citable papers to the top of the astro-ph listings in fact works. This is not surprising, considering that Kurtz et al. (2005) found evidence for a self-selection bias in which papers authors post on astro-ph. We, in turn, find a similar effect within the e-Prints on astro-ph.

Arguably, the more important finding of this work is the difference in citation rates between the not self-promoted sample of e-Prints and articles appearing much lower in the astro-ph mailing. The citation rates for the late sample are lower than for the self-promoted sample but still significantly higher than for articles lower in the astro-ph mailing. This provides strong evidence for the visibility bias theory that articles are cited more often, not due to some inherent quality they have, but simply because they are at the top of the astro-ph listing.

Citation counts are often used to evaluate the scientific quality of individuals or institutions and hiring or funding decisions are partly based on them. Our finding that a visibility bias exists at the top of arXiv:astro-ph should provide a strong cautionary note concerning the use of such statistics. We also note that the fraction of astro-ph e-Prints submitted very shortly after the deadline increased during the interval under study here. In the second half of 2002 1.5% (2.9%) of all e-Prints were submitted within the first 60 s (300 s). In the second half of 2005 these numbers rose to 2.3% (4.6%). The chance that this is a statistical fluctuation is smaller than 0.01%. This change in submission behavior appears to be indicative of a growing feeling in the astronomical community that VB plays a role and that citations are not awarded purely on merit of the work presented in a paper.

One could simply get rid of VB by randomizing the order of the astro-ph listing for every reader. In this way the VB would average out over the readership of astro-ph. However, by doing so one would ignore the underlying problem that leads to VB in the first place.

Everyday astronomers are confronted with an enormous amount of new information, which they have to sort, classify, and ultimately decide what is of relevance for their own research.

Publications are never cited without a reason, i.e., VB does not lead to unjustified additional citations of a paper. Thus, we must draw the conclusion that papers down the astro-ph list are overlooked and not cited when they should be. Any randomization would mitigate the VB problem by changing the set of papers that does not get the attention it deserves but it would not fix the real problem, i.e., the information overload which astronomers face every day. It is important to realize that the VB effect on citations is only a secondary effect. The primary effect, from which the citation inequality follows, is that researchers are not aware of relevant publications and results in their own field. This is potentially an impediment for science and the real problem that needs fixing. Since we cannot expect the number of publications to decrease, the solution has to be in the way information is presented.

Only a relatively small subset of e-Prints is relevant to any individual researcher and the daily challenge is to identify these in the much larger astro-ph listing. A possible first step in this direction is the arxivsorter (Magué & Ménard 2007), which we already mentioned in Paper I. Arxivsorter aims to sort daily, recent, or monthly astro-ph listings by relevance to an individual reader. The underlying idea is that scientists through co-authorship form an interconnected network of authors. By specifying a few authors relevant to a reader's fields of interest, the "proximity" of a new e-print in the author network can be calculated. This proximity seems to be a good proxy for relevance to a reader's interests.

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