High-Impact Astronomical Observatories

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We present a ranking of the top ten high-impact astronomical observatories derived through the analysis of the 200 most cited papers published in 2004. We provide a description of our methodology and a discussion of the final ranking led by the SDSS, ESO, HST and WMAP.

1. INTRODUCTION

Every year Forbes publishes the list of the 500 biggest companies, and the US News and World Report ranks colleges and universities in what constitutes an important measure of status in higher education. The Shanghai Jiao Tong University also compiles the popular Academic Ranking of World Universities.

In astronomy, as in business and academia, different methods to measure the research output and scientific productivity of large observatories are published every year. For instance, major facilities publish their annual report with their productivity represented not by income, like corporations ranked by Forbes, but by their number of published papers. Another example is the Science News Metrics compiled by Greg Davidson, from Northrop Grumman. This provides an independent evaluation of the share that projects from NASA's Office of Space Science have in the most important discoveries made in science (Christian & Davidson 2006).

How should we measure what is the contribution of observatories worldwide to the most active subjects in astronomy? Which are the observatories with the highest impact in astronomy? How do leading observatories evolve with time? We present a method to identify the facilities that contribute scientific results to the hot topics of astronomy by analyzing the most cited papers in the recent past. We used this technique during the process of developing a series of statistical tools to measure the scientific output of the Hubble Space Telescope (Meylan et al. 2004). Our method was inspired by the work of Benn & Sánchez (2001) on the scientific impact of large telescopes. This particular result appears to be of interest to many individuals and organizations and a brief description of the method we use and a presentation of the most recent results seems to be appropriate at this time.

2. METHODOLOGY

The NASA Astrophysical Data System (ADS) has the capacity to sort papers by citation counts. We use this tool to obtain the number of citations for the most cited papers published in a given year. Figure 1 shows the number of citations plotted against the rank of the 1000 most cited papers in astronomy published in 2004. One can clearly see from Figure 1 that the number of citations declines rapidly, and that the 200 most cited papers stand out from the rest. Given their weight, a sample constituted by these 200 most cited papers is sufficient to provide a snapshot of high-impact astronomy on a given year. The 200 most cited papers make up only 0.4% of all the references indexed by the ADS in 2004 but they amount to 16.3% of all citations.

The number of citations quoted through this article correspond to the values obtained from the ADS during the writing of the manuscript, i.e. the summer of 2006.

The paper "Type Ia Supernova Discoveries at $z > 1$" from the Hubble Space Telescope, by Riess et al. and the "Cosmological parameters from SDSS and WMAP" by Tegmark et al. are respectively the first and second most cited papers published in 2004 and also the most cited papers of our sample. Both of these papers have more than 600 citations each and are far above the rest on the upper left side of Figure 1.

To obtain the ranking of the facilities providing data to high impact studies we retrieved and analyzed the 200 most cited papers published in 2004. These papers have been cited during the past year and a half, i.e. the year 2005 and the first semester of 2006. Obviously, a paper only becomes a high-impact paper after it has been cited, and naturally it takes time to build citations; that is why there is a considerable time gap between the publication year and the time when the list of papers with high impact is compiled. We collect citation numbers close to the peak of the citation rate i.e. two years after publication (Crabtree and Bryson 2001).

We downloaded the full text of each paper belonging to the above list using the ADS links. Each paper was analyzed and classified as either observational or theoretical. According to this classification, theoretical papers do not include any direct data obtained with an observatory and therefore

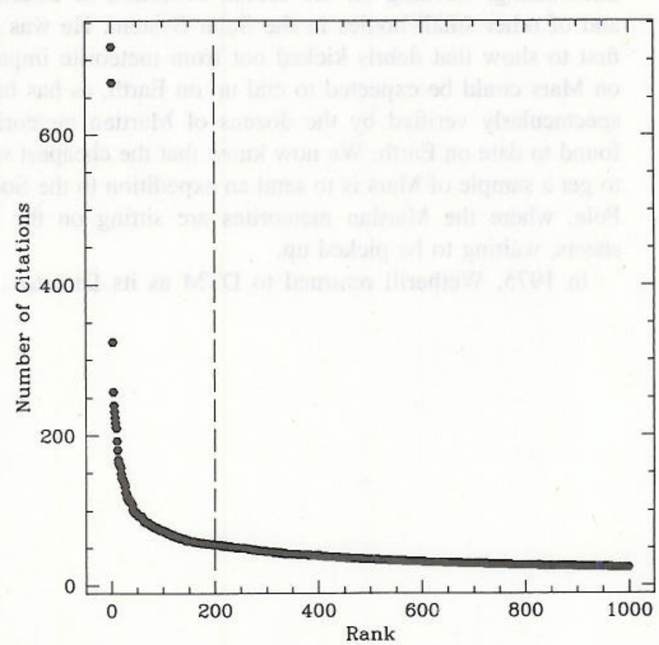

FIG. 1. Number of citations vs. rank of the 1000 most cited papers published in 2004.

TABLE 1. HIGH-IMPACT OBSERVATORIES

Rank	Facility	Citations	Participation
1	SDSS	1843	17.4%
2	ESO	1365	12.9%
3	HST	1124	10.6%
4	WMAP	1121	10.6%
5	Keck	642	6.0%
6	Kamiokande	372	3.5%
7	Chandra	365	3.4%
8	ACBAR	207	2.0%
9	NOAO	202	1.9%
10	Las Campanas	176	1.7%

we did not include them in this study. For those papers that included observational data we determined the facility or facilities used by the authors examining the observation section of each paper and the different figures with images and spectra. The facility providing the data for a given paper is credited with the citations that paper receives. A prorated number of citations per facility is credited if the paper is based on observations made by different telescopes.

The following are two examples among the most cited papers published in 2004. The paper entitled "The Second Data Release of the Sloan Digital Sky Survey" by Abazajian et al. received 258 citations. In this case all the citations are credited to the Sloan Digital Sky Survey since they only use data from the SDSS.

The second example is "The Great Observatories Origins Deep Survey: Initial Results from Optical and Near-Infrared Imaging" by Giavalisco et al. This paper is the first paper of the GOODS project, an initiative to observe the same area of the sky at different wavelengths with different facilities. It received 227 citations and it is based on observations obtained with the Hubble Space Telescope (HST), Chandra X-ray Observatory, the European Southern Observatory (ESO), and Kitt Peak National Observatory (KPN0). HST is credited 68 citations or 30% of the total reflecting the amount of data used, Chandra receives the same amount, 68 citations, or 30% of the total; ESO receives 45 citations, or 20%, and KPNO receives 45 citations as well. The large sample of papers we study averages out any inaccuracy in the percentage of participation we assign to each facility on a given paper.

After slicing and dicing all the 200 most cited papers we added up the citations credited to each facility and created the ranking of high impact observatories presented in Table 1 and discussed in the next section.

3. RESULTS

The first column of Table 1 gives the rank by decreasing order, the second column gives the name of the facility, the third column the total number of citations credited to that facility, and the fourth column gives the percentage the number in column 3 represents of the total number of citations of the 200 most cited papers.

Similar rankings of the high-impact observatories have been published before, corresponding to papers published in 1998, 1999, 2000, 2001 (Meylan et al. 2004), and papers published in 2002 and 2003 (Madrid et al. 2006). This allows us to see the evolution with time of the different high-impact facilities.

The SDSS ranks as the facility with the highest impact in astronomy for the second year in a row. This astronomical survey is made with a dedicated 2.5-meter telescope on Apache Point Observatory in New Mexico. ESO, that ranks second this year, was ranked 10^{th} in 1998 and has climbed its way to be among the five observatories of highest impact every year since 2001.

HST and the Wilkinson Microwave Anisotropy Probe rank closely third and fourth respectively. HST is a permanent member of this list of high-impact observatories ranking year after year among the top five. WMAP ranked first on a previous ranking based on the analysis of papers published in 2003 (Madrid et al. 2006).

Keck takes place number five. Keck as well as Chandra (ranked seventh) are also permanent members of the high-impact club, ranking among the top ten observatories every year since 1998 for Keck and since 2000 for Chandra.

The results presented in this section should not come as a surprise for those who keep up with the literature in astronomy. This ranking provides an objective measure of the share a facility has in "what's hot" in a particular year. Results of studies like this one, based on citation counts, should be combined with other metrics such as productivity (Grothkopf et al. 2005) and public impact (Christian 2004) when determining the overall scientific output of an observatory.

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