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Observatory Publications and Citations

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Abstract. Observatories have historically tracked the number of publications based on data obtained with their telescope(s). The number of publications, or productivity, is used to measure the progress of an observatory in the early years and then later for comparison with similar observatories. The funding agencies are very interested in understanding how their *investment* is performing. In this paper we use citation counts to measure the *impact* of observatory publications and show some examples of how publication and citation statistics can be used strategically by observatories and other organizations.

1. Introduction

Essentially all observatories track the number of publications based on data obtained with their telescope or telescopes. In the days before the Internet, the list of publications would appear on the back pages of an observatory's annual report. Now, the list of publications is proudly displayed on the observatory's web pages. The papers that appear in refereed journals are usually tracked separately from other types of publications, such as IAU Circulars.

The number of papers published is a direct measure of the scientific productivity of an observatory. The increase in the number of papers in the early years of an observatory can be used to judge the progress being made as the telescope and instruments are commissioned. A mature observatory's publication rate can be used to compare its productivity to other similar observatories. The funding agencies responsible for the observatory are usually interested in seeing how their *investment* is performing relative to other similar observatories.

The publication data can be broken down further. For example, the number of publications based upon data from each instrument can be tracked to judge the productivity of those instruments. This type of information can feed into the strategic planning process for observatories.

While the number of publications is a measure of productivity, the number of citations to these papers is a measure of the impact of the observatory. Citation numbers have traditionally been tracked by the Institute for Scientific

Information (ISI) but citation information is also available from NASA's Astrophysics Data System (ADS). The ISI citation information is available through several commercial services for a fee, while the ADS citation information is available at no charge. Crabtree and Bryson (2000) concluded that while the citation information for specific papers differed slightly between ISI and ADS, the numbers of citations to these papers agreed to approximately 5%.

In this paper we will use publication and citation information to look at a number of different areas. We will compare the productivity and impact of two similar telescopes, the Canada-France-Hawaii Telescope (CFHT) and the United Kingdom Infra-Red Telescope (UKIRT). Then we will use these two metrics to investigate the range of instruments used over the years at the CFHT. Finally, we will look at the relationship between the ranking of a proposal by the Time Allocation Committee and the citations to the papers that result from the observations taken for the project.

2. The Data

We will be presenting publication and citation data for two similar telescopes, CFHT and UKIRT. Both are 4-meter class telescopes located on the summit of Mauna Kea in Hawaii. CFHT and UKIRT are "mature" facilities that began operation around 1980. In our comparison we will look at papers published between 1992 and 1999. Due to the time lag between the acquisition of data and publication, the data for these publications were typically acquired 2–3 years prior to publication.

2.1. Publications

The list of CFHT publications in refereed journals that are based on data obtained with the telescope is maintained by one of us (E.P.B.). The following criteria are used to judge whether a paper is considered a CFHT publication:

A paper must report new results based on significant observational data obtained at CFHT or be based on archival data retrieved from the CFHT archive. If data from multiple telescopes are included, the CFHT data should represent a significant fraction of the total data.

A CFHT staff astronomer examines each paper to judge whether it meets these criteria.

The list of UKIRT papers was retrieved from their web site, and a few papers were removed that we felt did not meet the criteria established for CFHT papers. These were papers that described the performance characteristics of instruments and contained very few if any science results.

2.2. Citations

The publication information is maintained within a Microsoft Access database. Several routines, written in Visual Basic for Applications within the database, query the ADS for information on each publication. These routines utilize an Internet Data Transfer Library (Ashish & Kreft) downloaded from the Internet. The software generates the appropriate query as a URL, sends the URL to the ADS, and parses the returned text to extract the relevant information.

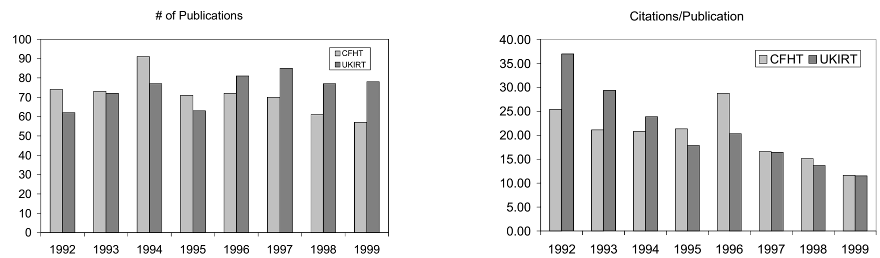

Figure 1. The basic publication statistics for CFHT and UKIRT are shown in Figure 1. On the left is the number of papers published in refereed journals between 1992 and 1999. On the right is the average number of citations per paper for each year. The citation numbers were retrieved from ADS in June 2002.

The information for each publication in the ADS is accessed by a publication bibliography code, bibcode, which is generated from the year, journal, volume, and page information for a publication. One of the many services ADS provides is a verification utility that returns a yes/no as to whether a particular bibcode is valid. For each entry in our database, the ADS bibcode is generated from the publication information and verified with the ADS. The information for those entries with invalid bibcodes is checked and updated; then a new bibcode is generated and verified. This verification of each paper's bibcode ensures that we have the correct publication information for each entry. Once each publication has a valid bibcode, the ADS is queried for the full title, list of authors and the number of citations. Finally, the bibcodes of each citing paper, and the number of citations by year, of the citing paper are recorded for each publication.

3. CFHT-UKIRT Comparison

The basic measures of productivity and impact are the number of papers published and the average number of citations per paper. These two metrics are plotted in Figure 1 for CFHT and UKIRT for each year between 1992 and 1999. While CFHT had more publications between 1992 and 1995, and UKIRT had more for the last half of the period, the average productivity of the two telescopes is remarkably similar. UKIRT papers published between 1992 and 1994 were cited more than CFHT papers, on average, while CFHT papers published 1995 and 1996 were cited more than UKIRT papers.

The decline in CFHT productivity in the last few years of this period is likely linked to the introduction of a new wide-field camera, UK8K. This instrument was scheduled for many nights each semester but produced fewer papers than earlier CCD imagers on CFHT. This is likely due to the fact that the data from this camera were difficult to reduce, and there was no data reduction pipeline. Conversely, the higher level of UKIRT publications between 1992 and 1994 may be due to the fact that the popular CGS4 instrument had an efficient

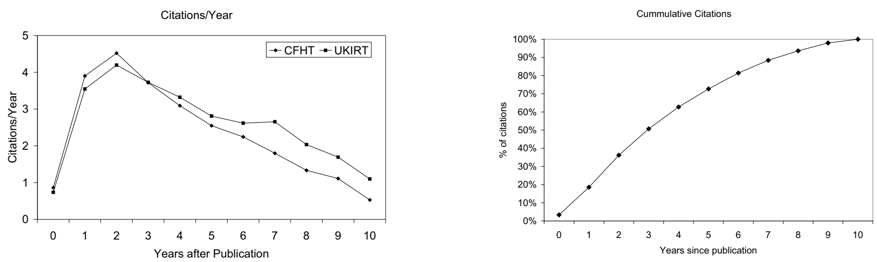

Figure 2. The average cites per paper for both CFHT and UKIRT as a function of time since publication is shown on the left. On the right is a cumulative citation curve for CFHT papers.

data reduction pipeline that helped astronomers reduce the data quicker. The productivity of both CFHT and UKIRT during this period, ten to twenty years after first light, is fairly steady. Crabtree & Bryson showed that it took CFHT ten years to reach a more or less steady state of paper production.

The left side of Figure 2 shows the number of citations per paper per year as a function of the time since publication for both CFHT and UKIRT. The citation rate peaks two years after publication and falls more or less exponentially after that. The citation rate for CFHT papers peaks slightly higher but the rate for UKIRT papers falls more slowly. Fitting a simple exponential to these gives indicates a citation "half-life" of 3.5 years for CFHT papers and 5.7 years for UKIRT papers. This difference is significant but difficult to interpret. One interpretation is that on average CFHT papers are in subject areas that are very active so that results are supplanted more readily by new ones. This would be consistent with a higher peak and faster fall off. Alternatively, UKIRT papers based on results from CGSS4, a very efficient and successful instrument, might remain relevant for a longer period and produce the slower drop off in citations.

The citation rate curve can be used to construct a citation growth curve. The cumulative citation count for CFHT papers as a percentage of the citation count after ten years is shown on the right side of Figure 2. (A similar curve can be generated for UKIRT papers.) This curve can be used to estimate the number of citations any given paper will have after ten years. For example, the growth curve shows that three years after publication a paper will have approximately 50 per cent of the citations it will have after ten years. We can now normalize the citation counts for papers of different ages to the number of citations ten years after publication.

The average number of citations per paper, normalized to ten years after publication, is shown in Figure 3. The impact of CFHT papers has remained fairly constant during this period except for papers published in 1996 when the average citations per paper was approximately 40 per cent higher than the 8-year average. UKIRT's average impact over this period is approximately 10 per cent higher than CFHT's with 1992 and 1993 being the highest impact years.

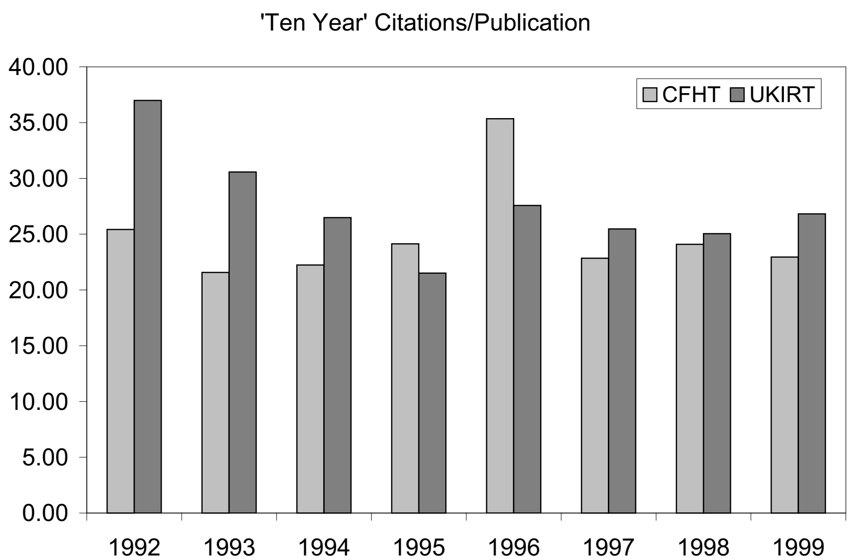

Figure 3. CFHT and UKIRT average citations per paper normalized to a 10-year citation rate using the method described in the text.

4. CFHT Instrumentation: Productivity and Impact

Observatories provide a range of instrumentation capabilities that allow investigation of various scientific problems. An observatory will usually have a small number of "workhorse" instruments as well as other more specialized instruments that are not used as frequently. The scheduling of instruments is determined by the demand for them as requested in the proposals submitted by the astronomers. CFHT has had a large number of instruments available during the 20-year history of the telescope, and here we will investigate the productivity and impact of the various instruments.

Each CFHT paper was looked at to determine which instrument was used to acquire the data used in the paper. This was done electronically using the scanned papers available from the ADS. If a paper used more than one instrument then the instrument used for the majority of the data was the one assigned. All of the direct imaging cameras, using either photographic plates, CCDs, or other detectors, are included in the category 'Direct'. Specialized cameras such as HRCam, which incorporated a fast tip-tilt guide mirror, are listed separately.

Publication and citation information for the top eleven CFHT instruments are shown in Table I. We actually identified 39 unique instruments that were used at CFHT between 1980 and 1999. The number of nights each instrument was scheduled on the telescope was determined by reviewing all of the CFHT schedules from 1982 onward. Over 70 per cent of CFHT papers were produced by only five instruments, counting several different direct imagers as a single instrument. CFHT is known for its exceptional image quality, and it is no surprise that direct imaging has produced the largest number of publications. Direct imaging is also the most efficient, by a large degree, at turning observing time in papers or citations. This is due in part to the simpler data reduction procedures for this type of data and the availability of software such as DAOPHOT (Stetson 1994).

Is there a lesson to be learned from this brief examination of the productivity and impact of various CFHT instruments? It is clear that not all instruments are equally efficient at turning observing time on the telescope into papers and/or citations. If the observatory's goal is to produce scientific papers with a high impact then they may want to start thinking strategically about the instruments built and offered to their communities. Not only do low productivity instruments not produce papers, they also take observing time away from more productive instruments. However, one must also think about the instrumentation development process. The very successful MOS at CFHT was not the first instrument of that type on the telescope, and it owes its success to earlier versions that were not so efficient at producing papers and citations.

Table 1. CFHT Papers and Citations by Instrument

Instrument	Papers	Papers/night	Cites/Paper	Cites/Night
Direct Imaging	358	0.36	35.47	12.86
Coude Spectrograph	169	0.25	28.37	6.97
MOS	75	0.19	48.38	9.92
FTS	64	0.16	17.28	2.70
HRCam	49	0.24	27.60	6.61
Herzberg Spectrograph	34	0.24	29.11	6.86
Fabry-Perot	24	0.16	19.84	3.11
Adaptive Optics	21	0.21	20.76	4.45
SIS	18	0.12	26.82	3.24

5. What do Citations Measure?

Observing time on large telescopes is typically oversubscribed by a factor of three or four. A Time Allocation Committee (TAC), composed of astronomers, reviews the proposals, sometimes with the input of outside referees, and ranks the proposals. The top third or so of the proposals are the ones that are scheduled on the telescope. All of the proposals that make it to the telescope are likely to produce a publication if the telescope and instrumentation work properly and if the weather cooperates. If one believes that the TAC ranks the proposals in

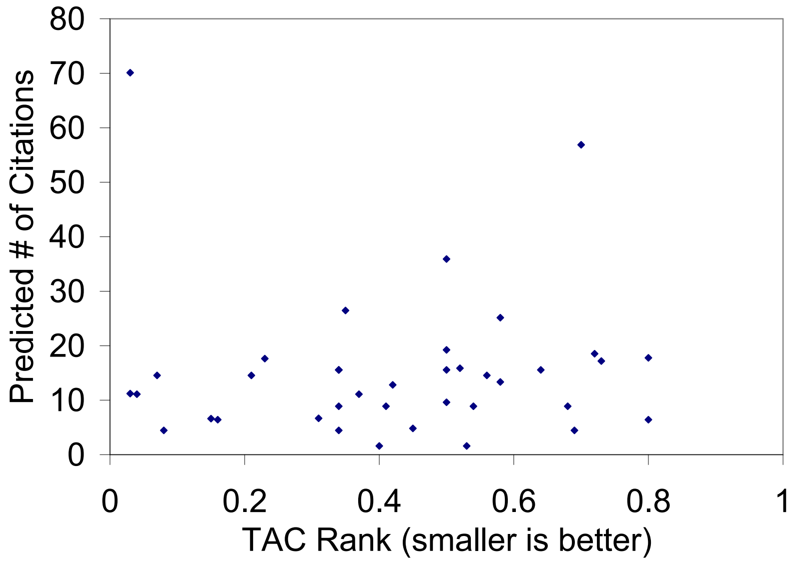

Figure 4. The predicted number of citations versus the TAC rank for 39 CFHT proposals that were scheduled on the telescope between 1996 and 1999.

order of their scientific merit, then one would expect this ranking to be more or less reflected in the citation count for the published paper for that proposal. No one has compared the scientific ranking of proposals by a TAC with the citation count for papers resulting from the research.

One of us (D.C.) has access to the TAC ranking for CFHT proposals scheduled between 1996 and 1999. We identified published papers that could be tracked back to a proposal in the appropriate period using the date of the observations and published CFHT schedules. We selected those papers that were based on CFHT data only, and that were the result of a proposal in only one semester (no long term programs). We have identified 39 papers in our database that meet these criteria and for which we have the TAC ranking. Figure 4 shows the predicted number of citations for these papers, using the method described earlier, versus the TAC ranking (a small number is better).

There is no correlation at all between the TAC ranking and the predicted number of citations. If one believes that the TAC is able to judge the scientific merit of the proposals, then this Figure suggests that citations do not measure it. On the other hand, if one believes that the citations are a measure of scientific merit, then the TAC is not ranking proposals this way. Figure 4 shows that the citation count for higher ranked proposals has lower scatter than for lower ranked proposals. Perhaps is ranking less risky proposals, ones more certain to achieve a result, higher than riskier proposals less certain to produce results.

6. Conclusions

CFHT and UKIRT, two telescopes with much in common, achieved similar levels of productivity and impact in the 1990s. There are some detailed differences that we have attributed to particular instruments and the availability of pipeline reduction software.

A large fraction of CFHT's productivity and impact during the period from 1980 to 1999 was due to only five instruments. A large number of instruments were built for CFHT that produced very few papers. Strategically, it may be more effective for observatories to offer a smaller number of instruments rather than trying to cover a broad range of capabilities.

Observatories and funding agencies can learn a lot from tracking the productivity and impact of publications. This information is important input into any strategic planning exercise involving future instrumentation, the decommissioning of instrumentation, or the direction for new facilities.

References

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