Giant collaboration in astronomy knowledge production at international level

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Abstract

The aim of this article is to investigate giant collaboration in astronomy articles indexed in ScienceDriect database during 2000-2004. The collaboration coefficient (CC) will be calculated and international collaboration will be studied. The collaboration coefficient will be compared with the number of authors per papers to determine the development of collaboration in this article. Some of findings of this study are: 419 astronomy articles with 2761 co-author name occurrences were in ScienceDirect during 2000-2004 indicating a collaboration mean of 6.6 authors per paper.

All 419 articles were published in 37 countries. Bradford's law was confirmed and 10 giant collaborating articles having 59-130 co-authors (average collaborators of 94.4 per article) were identified. 10% of the articles have been produced with large teams including 12 to 130 authors.

The collaboration coefficient was equal to 0.494 in this study, which means the number of multi authored papers could be considerable. The analysis showed that the CC for astronomy papers has grown from 0.385 in 2000 to 0.534 in 2004.

Considering international collaborative occurrences it was shown that USA with 139 (24%) collaborative occurrences ranked first among the 37countries. France, UK, Italy and Japan ranked second to fifth in this study according to the percentages. While, considering Collaboration Coefficient, China, Russia, India and Spain performed much better.

1. Introduction

Collaboration first begun by French chemists in 1800-1830. It grew slowly until World War I, after which it grew at a much more rapid rate (Beaver and Rosen, 1978). In recent years international cooperation is exponentially increasing even faster than that of publication output (Nagpaul, 1999). Presumably, the advantages of collaboration including the fruitful exchange of ideas, the higher quality of collaborative papers, receiving much more citation, in other words, useful science is good science as Tuzi (2003) believes, are some of the reasons for this fast increase. Governmental initiatives in promoting international scientific programs, providing funding for travel, and peripheral countries benefit from international collaboration are some other encouraging matters. In addition, inexpensive communication systems such as electronic mail, remote access to online databases and facilities through the web seam reasonable for such a rapid growth.

The nature of collaborative activity has changed to some extent from that between individual scientists to group mediated by organizations or national and international bodies, during the transition between 'little science' and big science' (Price, 1963).

After World War II, teamwork, or giant collaborations became extensive in some fields such as High Energy physics (HEP) (Beaver, 2001).

In this article the literature of astronomy in ScienceDirect during 2000-2004 will be studied to investigate the giant collaboration if there is any. The collaboration coefficient and international collaboration in this discipline will also be recognized and the Bradford's law will be applied to find out if it confirms the collaborators distribution.

1.1. Objectives

The aim of this study is:

- To investigate the giant collaboration in the area of astronomy in ScienceDirect during 2000-2004.
- The Bradford's law will be applied to find out the core collaborative papers in this study.
- The core (top) collaborative papers will be analyzed to identify the mean collaborative authors, countries…
- The collaboration coefficient and country collaboration in astronomy in ScienceDirect database from 2000 to 2004 will be investigated to find out the development of the collaboration during the studied period in this discipline.

1.2. Research questions

1. Does Bradford's law confirm collaborators distribution in this study?
2. What is the extent of collaboration in astronomy articles indexed in ScienceDirect database from 2000 to 2004?
3. What is the international collaboration extent in this study?
4. In which journals the core astronomy articles (giant collaborative articles) have been published from 2000 to 2004 in ScienceDriect database?
5. What are the mean collaborative countries in this study?
6. Who are the major collaborative authors in this discipline during the studied period?

1.3. Data gathering

ScienceDirect database was searched for astronomy articles limited to years 2000-2004. We found 419 articles. All the 419 articles were downloaded on our pc in a short time (i.e. December, 2004). Following tags including Author(s), Journal(s), Affiliation(s), and publication dates were selected and converted to a database in Excel Spreadsheet for counting, ranking and analyzing.

1.4. Methodology

The Bradford's law was applied to find out the core articles (giant collaborative articles) in astronomy in ScienceDirect database from 2000 to 2004.

The distribution of collaborators according to different periods of time was also calculated.

Collaboration Coefficient was calculated according to the following formula:

$$cc = 1 - \left\{ \sum_{j=1}^{k} (\frac{1}{j}) \times \frac{F_j}{N} \right\}$$

where

j= 1 authored, 2 authored, 3 authored…research papers;

Fj= the number of j authored research papers;

N= total number of research papers published; and

K= the greatest number of authors per paper

The number of authors per paper was compared with the Collaboration Coefficient to find out the growth of collaboration in this area for this study.

The country collaboration was also calculated to identify the most important collaborating countries in this study.

1.5. Analysis of the data

2761 co-author (collaborator) name occurrences happened in the 419 astronomy articles during 2000-2004, which indicates a collaboration mean of 6.6 authors per paper. All 419 articles were published in 37 countries.

Bradford's law was applied to reveal the distribution of collaborators (co-authors) over the articles in astronomy from 2000 to 2004.

Table 1: the distribution of the collaborators in three different zones

Zone	No of Articles	Name occurrences of collaborators	Cumulative Frequency	Multiplier	Adjustment Note	
1	10	944	944	-	10	1*a (a=10)
2	59	915	1859	5.9	60	1*a*k (k=6)
3	350	902	2761	5.9	360	$1*a*K^2$

Dividing the collaborators into three groups, the mean number of collaborators per group was 920.3. Ranking the collaborators by the articles count, 10 articles composed the first zone and 944 authors wrote these 10 articles. The second zone was made up by 915 co-authors publishing 59 articles. The third zone included 350 articles provided by 902 authors. The number of articles in zone 1 was 10. The number of articles in zone 2 was 59, closed to 60, 60=10*6. Using 6 as constant instead of 5.9, and the third zone 350, closed to 360=10*36. Therefore, Bradford's law was confirmed in this study. The 10 articles in the first zone were the core articles (or the giant articles) and are provided by the most important collaborative groups. The average number of collaboration for each of the 10 articles was 94.4 (a high average). The bibliographic information of these 10 articles is displayed in Table 2:

Table 2: the top ten articles (giant collaboration) according to the no. of collaborators

Rank	Article	Collaborators	Journal title	Date of Publication
1	1	130	Astroparticle Physics	2004
2	1	126	Astroparticle Physics	2003
3	1	124	Astroparticle Physics	2004
4	1	120	Nuclear Instruments and Methods in…	2002
5	1	93	Astroparticle Physics	2004
6	1	81	Astroparticle Physics	2000
7	1	74	Nuclear Instruments and Methods in…	2003
8	1	72	Astroparticle Physics	2002
9	1	65	New Astronomy Reviews	2004
10	1	59	Astroparticle Physics	2003

It is interesting that, 7 (70%) titles of the top 10 articles have been published in the "Astroparticle Physics Journal" and the rest of them i.e 30% were published in two different Journals (Nuclear Instruments and Methods in Physics A: Accelerators, Spectrometers, Detectors and Associated Equipment and New Astronomy Reviews). Considering date of publication of the top10 articles, as it is shown in Table2, 4 (40%) of articles have been published in 2004, 30% in 2003, 20% in 2002 and 10% in 2000. In other words, we can say organizing large teams for providing articles is a phenomenon, which has mostly happened in the last two years in this discipline.

For further analysis the authors who have collaborated in providing the top ten papers were considered. These papers were written by 533 authors, only one of these authors had participated in 7 out of the top ten papers, who was Hoffmann, W. from Germany. Table 3 shows the occurrence distribution of author names in papers.

Table 3 the occurrences distribution of authors in papers

Authors	Occurrence in papers	f*x	Cum. f.	
			No.	%
1	7	7	7	0.69
7	5	35	42	4.2
56	4	224	266	26.3
91	3	273	539	53.5
91	2	182	721	71.5
287	1	287	1008	100

The authors' occurrence distribution of different countries in the top 10 papers is also displayed in Figure 1: as can be seen in this Figure, out of 37 countries only 6 countries participated with 852 occurrences and the rest of them i.e. 31 countries had only 92 (10%) occurrences (Figure 1).

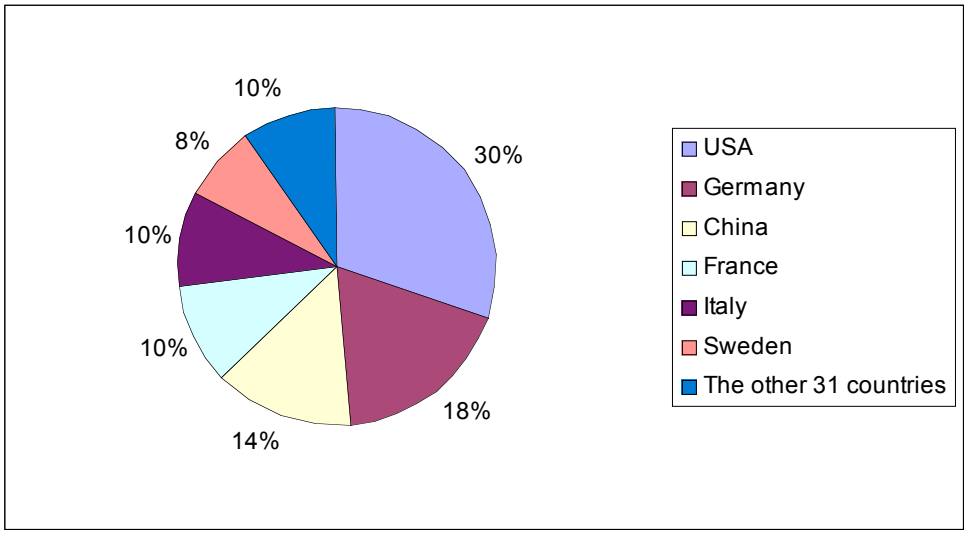

Figure 1: the Authors occurrences distribution of different countries in the top 10 papers

The number and percentage of collaborators in different periods is shown in Table 3.

Table 3: The distribution of collaborators according to different periods of time

Collaborators	2000 (%)	2001 (%)	2002 (%)	2003 (%)	2004 (%)	Totals (%)
1 author	**40** (52.0)	**23** (42.5)	**29** (42.0)	**35** (30.7)	**38** (36.2)	**165** (39.5)
2-6 authors	**25** (32.4)	**23** (42.5)	**28** (40.6)	**47** (41.2)	**33** (31.4)	**156** (37.2)
7-11 authors	**8** (10.4)	**6** (11.2)	**8** (11.6)	**15** (13.1)	**19** (18.1)	**56** (13.3)
12-16 authors	**2** (2.6)	**0** (0)	**1** (1.4)	**8** (7.1)	**5** (4.8)	**16** (3.8)
17-130 authors	**2** (2.6)	**2** (3.8)	**3** (4.4)	**9** (7.9)	**10** (9.5)	**26** (6.2)
Totals	**77 (100)**	**54 (100)**	**69 (100)**	**114 (100)**	**105 (100)**	**419 (100)**
CC	0.385	0.454	0.463	0.569	0.534	0.494

As it is displayed in Table 3, about 77% of articles have written by collaboration of 1-6 authors. While 10% of articles have been produced by large or giant teams including 12 to 130 authors. Although there are various methods to express the degree of collaboration, the Collaboration Coefficient (CC) method has been chosen because it is said to be very precise (Koteswara Rao and Raghavan, 2004).

The Collaboration Coefficient for astronomy research during 2000-2004 has been calculated to find out the extent of collaboration.

Using the above Collaboration Coefficient formula in astronomy articles in ScienceDirect from 2000-2004 we found CC=0.494.

According to Ajiferuke CC tends to zero as single authored papers dominate. This implies that higher the value of CC, higher the probability of multi or mega authored papers. In this study we found CC=0.494 which is far from 0. In other words, in astronomy area the number of multi or mega authored papers could be considerable.

The Collaboration Coefficient was also calculated for each period separately to track the growth of CC, year by year. The analysis shows that the CC for astronomy papers has grown from

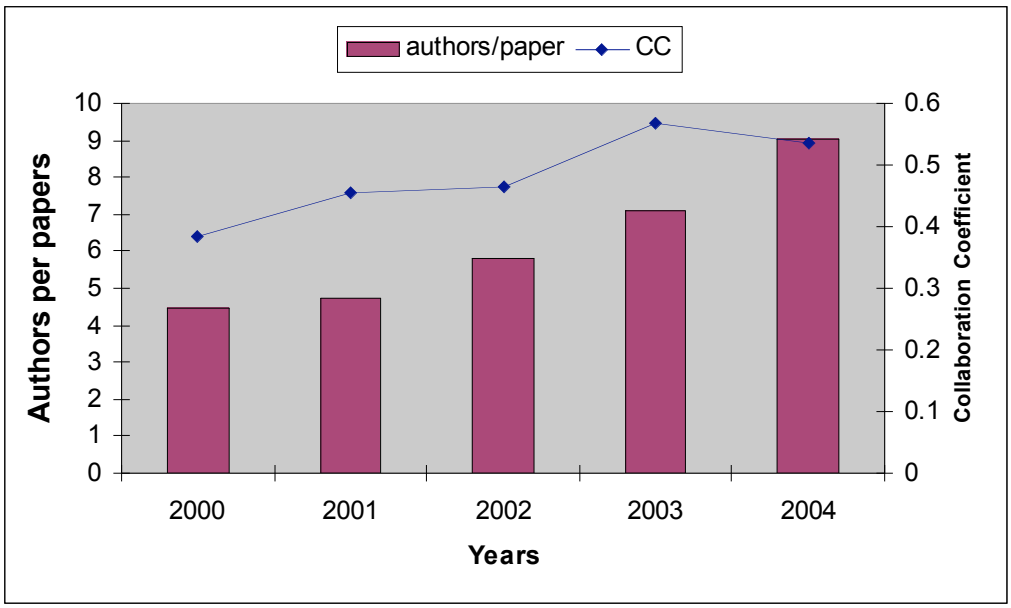

Figure 2 Collaboration Coefficient

0.385 in 2000 to 0.534 in 2004 (Figure 2). This clearly indicates the growing importance of Collaboration in astronomy research in ScienceDirect database papers.

The distribution of country collaboration was also studied. Countries with at least 10 collaborators were selected for this step of the study. There were only 11 countries with minimum 10 to maximum 139 articles. As it is displayed in Table 4, USA with 139 (24%) collaborative occurrences ranked first among the 37countries. France, UK, Italy and Japan ranked second to sixth in this study.

The distribution of country collaboration with at least 10 collaborators is displayed in Table4. As this table shows the multilateral collaboration dominated the single and bilateral collaboration in this study.

Table 4: the distribution of country collaboration with at least 10 collaborators

Rank	Countries	Articles			Totals	CC
		one author	multilateral	bilateral		
1	USA	53	71	15	139	0.41
2	Germany	23	45	6	74	0.45
3	France	19	29	7	55	0.42
4	UK	19	25	8	52	0.42
5	Italy	7	29	6	42	0.55
6	Japan	6	18	4	28	0.51
7	Netherlands	7	16	2	25	0.47
8	Spain	5	12	3	20	0.49
9	India	2	13	1	16	0.59
10	Russia	0	9	2	11	0.64
11	China	0	8	2	10	0.64
Other 26 countries		24	78	6	108	0.70
Totals		165	353	62	580	

1.6. Discussion and Conclusion

The analysis of 419 astronomy papers in ScienceDirect during 2000-2004, indicates that all papers were published with 37 countries with a collaboration mean of 6.6 authors per paper. Similarly, Newman (2004) found that the number of papers per authors across three subject areas: biology, physics and mathematics is similar and it is between 5-7.

Bradford's law was confirmed in this study and 10 core collaborative papers were identified. The collaboration mean for these 10 papers was 94.4. The collaboration occurrences of the top 10 papers were 59-130.

7 (70%) titles of the top ten papers have been published in the "Astroparticle physics Journal" and the rest of them i.e. 30% were published in two different journal (Nuclear Instruments and Methods in Physics A: Accelerators, Spectrometers, Detectors and Associated Equipment, and New Astronomy Reviews). This article found that team working mostly has happened in this discipline during last two years.

USA as the main partner with 30% links to other countries was identified in this study. Basu and Kumar (2000) Similarly found USA as the main partner with India with 30% links from 1990-1994.

In this study the number of multi authored papers could be considerable since CC is equal to 0.494. To track the growth of CC, year by year, the collaboration coefficient was also calculated for each period. We found CC from 0.385 in 2000 to 0.534 in 2004 which indicates the growing collaboration in astronomy research in ScienceDirect database. According to Ajiferuke et al. (1988) CC tends to zero as single authored papers dominate. Similarly, Bharvi's et al. (2003) found that the scientometric output is dominated by single authored papers, while in the present study the multi authored papers are dominated.

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