Scientometric Portrait of Stephen Hawking - the British Physicist and Cosmologist

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Abstract :

The study has been confined to the contributions and the citations received by the famous British physicist and cosmologist Stephen William Hawking reported in the Google scholar database. It investigates the total number of contributions and the most productive years of the great scientist along with the authorship pattern of the contributions made by him and identifying the publishers, who published maximum number of Hawking's works. The study also aims to identify the core journals producing most of his works and finds Physical Review D followed by Physical letters B publishing most of his works, and reveals maximum number of works are contributed in the year 1996; American Physical Society published maximum works; Single authored papers are predominant;Most of Hawking's works are published in English language. Hawking's books received maximum number of citations followed by research articles. MLodinow is found to be the most prolific author working in collaboration with Hawking followed by Penrose.The priority areas in the subject can be identified from the study and the study helps in re-looking into the papers which find utmost importance by studying their citations.

Keywords :

Bibliometric,Citation count, Citation Indexes, Citation ratio, Scientometric portrait, Stephen Hawking

1. Introduction :

Scientometric portraits deal with the biographical study of the individual careers of scientists and researchers, and compares bibliographic analysis of publications or academic and scientific accomplishment. Kademani and Kalyani were the first to use the phrase "Scientometric portrait" to carry out bio-bibliometric studies on eminent scientists, including Nobel laureatessaid by Sedam (2014).

Recently the term "Bio-bibliometrics" is being used for method of regaining and envisioning biological information that uses co-occurrence of gene naming terms in Medical Sciences to generate semantic links between genes. Therefore, it is suggested that "Scientometricportrait" is the suitable phrase for the studies on scientists, andKoganurmath(2014) said "Informetric portrait" for the studies on researchers in other disciplines such as arts, humanities, and social sciences.

The primary concern of this study is to investigate the entire publications of the great scientist Stephen Hawking, one of the pioneers of physics, as well as the citations received by him. This work helps the researchers and knowledge-thrusters to understand the scholarly activities and impactsof Hawking from the viewpoint of Scientometric.

2. Related works :

A number of studies have been carried out in the field of bio-bibliometrics. Most of them are on scientists. Annals of Library and Information Studies (ALIS) top the list among Indian journals in publishing bio-bibliometric studies. The authors found 15 studies related to bio-bibliometrics in ALISby Koley&Sen (2015), Angadi et al., (2006) Hazarika, Sarma&Sen (2010),Mukherjee (2013), Munnolli, Pujar,&Kademani (2011), Kalyane&Sen (2003), Parvathamma&Gobbur (2008), Ray & Sen, (2015), Sinha & Dhiman, (2001).A paper presents an analysis of 422 papers by the Nobel laureate Pierre-Gilles de Gennes, a French physicist, published during 1956 to 1995 in diverse fields of science.The receiving of honours and awards seems to attract more collaborators and hike the productivity rate. The scattering of papers over 146 journals does not follow Bradford's law(Kalyani & Sen, 2017).

Savanur and Sangam(2018)presented a concise sketch of Prof. Peter John Wyllie, pointing on his scientific achievements. His research had a great impact in the fields dealing with terrestrial magmatic phenomena and geology.Munnolli and Kalyane(2003) brilliantly presented the scientometric analysis of the publications of

eminent scientist Ram Gopal Rastogi from 1954-1992. In their paper, they examined 392 scientific papers of Rastogi on different domain of Science.

Mukherjee(2013)presented the bibliometric characteristics including authorshippattern, citations received and relative performance of Prof. Lalji Singh. Another study by Kademani (1998) presented the citations of the publications of Chidambaram, using Citation Index 1958-92. They examined the number of citations per paper and the categories of citing documents and the distribution of citation among them. Rushton(2001) described Eysenck's productivity, his citations,students,departments, journals, personality in relation to his scientific achievement, legacy, and a personal note of appreciation.

3. Objectives of the study :

- To investigate the total number of contributions made by Stephen Hawking;
- To study the most productive years;
- To identify the authorship pattern;
- To identify the core publishers;
- To identify the core journals;
- To find the language wise distribution;
- To identify top cited works;
- To identify the most prolific co-authors;
- To compare and analysis of the citation-based indexes.

4. Importance of the study :

Stephen Hawking is one of the doyens of physics. To get a clear picture of the entire contributions of the renowned scholar, in the field of science, this type of bibliometric analysis is very essential.We can also get an idea about the subject fields in which Stephen Hawking has laid much emphasis and can also identify the untouched areas of research and thereby work on them.

5. Methodology adopted :

To conduct this study, the following steps have been followed :

- The entire contributions of Stephen Hawking with their corresponding citations are collected from the Google scholar database during March 2019.
- Then these are arranged individually accordingly to the parameters mentioned in the objectives into the excel sheet.
- The data collected is analyzed to find the total contributions, most productive years and several citation-basedindexes.
- Finally, from this study, interpretations are made and conclusions are drawn, with some suggestions and scope for further work.

6. Data analysis and interpretation :

6.1.Top ten contributing year :

The following table show the most productive year of the scientist and also represents either the productivity is continuing for a long timeor not. The following table depicts that the excellencies of Stephen Hawking did not stop at a point, but was ever continuous.

Table 1: Number of Publications Year-wise (From Maximum to Minimum)

Publication Year	Total No. of Publication	Percentage
1996	25	5.28
2002	24	5.07
2010	21	4.44
2015	21	4.44
1999	18	3.81
1995	17	3.59
2011	17	3.59
2005	15	3.17
2000	13	2.75
2003	13	2.75

The above table shows that the maximum number of publications were contributed in the year 1996,followed by the years 2002, 2010 and 2015 i.e. each have above20 publications (5.28 4.43%). It also reveals that he was too much productive till his death.

6.2. Authorship Pattern of Stephen Hawking's Contributions :

Authorship pattern provides worthy information concerning characteristics of authors, their collaboration, measuring and monitoring research activities among others (Keadzo and Grace, 2008). Teamwork among scientists shows that they are working together and pursuing a target (Kundra, 1996).Authorship pattern represents the number of authors per paper.

Table 2 : Author vs. works

No. of Author	No. of Works	Percentage
One	281	59.40
Two	123	26.00
Three	33	6.97
Four	25	5.28
Five	9	1.90
Six	2	0.42
TOTAL	473	100

The table 2 shows that 281 papers i.e.(59.41%) were made by single author (i.e. Hawking himself), followed by 123 contributions (i.e.26.004%) by 2 authors and 33, 25, 9 and2 contributions were made by 3,4,5 and 6 authors respectively. So, it can be interpreted that Hawking preferred working alone or maximum with any one co-author during his entire lifetime.

6.2.1 Single Authorship Vs Multiple Authorship

Table 2.1: Year-wise authorship-pattern

Pub. Year	No. of Authors						Total No. of Publication
	One	Two	Three	Four	Five	Six	
1965	2						2
1966	3	1					4
1967	1						1
1968	1	1					2
1969	2						2
1970	1	1					2
1971	2	1					3
1972	1	2					3
1973	1	2	1		1		5
1974	3	1					4
1975	2						2
1976	2	1	1				4
1977	2	3					5
1978	2	2	1				5
1979	2	1					3
1980	1						1
1981	4		1				5
1982	4	1	1				6
1983	2	3		1			6
1984	4	2					6

1985	5	3	1				9
1986	1	1	2				4
1987	7	1					8
1988	8	2	1				11
1989	6	1					7
1990	5	2		1			8
1991	5	1					6
1992	5	4					9
1993	6	3	2				11
1994	9	3					12
1995	5	6	1	5			17
1996	10	9	3	3			25
1997	3	6					9
1998	3	7	1		1		12
1999	6	6	4	1	1		18
2000	8	2	2	1			13
2001	7	1	3				11
2002	16	7				1	24
2003	8	1			3	1	13
2004	9	1		1			11
2005	14			1			15
2006	6	2	1				9
2007	3	2	1		2		8
2008	7	1	1	1	1		11
2009	7	1					8
2010	11	9	1				21

2011	8	9					17
2012	4	1					5
2013	6						6
2014	7	2		3			12
2015	16	2	1	2			21
2016	7	1	1				9
2017	3	1	1	1			6
2018	3	1		2			6
Not Retrieved	5	2	1	2			10
TOTAL	281	123	33	25	9	2	473

Table 2.1 shows the detailed break-up of single authorship and multiple-authorship over the years. From the years 1965 to 2018 single authored papers are predominant over multi-authored papers in almost forty years. In rest of the fourteen years two-authored papers are more or mostly same as single authored papers. Only in the year 1995 number of four-authored papers are same as the single authored papers.

6.3. Publisher Wise Distribution of Publications : (Core Publishers Who Published > = 5 works):

Publisher wise distribution of publications shows the authors flair to publish in a specific publication house. Additionally, it also shows which publisher preferred which type of publications. The table below depicts the publisher-wise distribution of publications.

Table 3: Publisher Wise Distribution of Publications

Publishers	No. of Publications	Percentage
American Physical Society (APS)	51	10.78
Elsevier	25	5.29

Springer	17	3.59
Cern	15	3.17
Harvard University	14	2.96
Arxiv	8	1.69
Amfora	7	1.48
Iopscience	6	1.27
Royal Society Publishing	6	1.27

The table 3 shows top ranking publishers publishing Hawking's works in maximum. Out of the total 473 publications, APS published maximum no. of Hawking's works i.e. 51 in number (10.78%) followed by Elsevier who published 25 number of works(5.28%), Springer published 17 works(3.59%) and so on.

6.4. Top ten journals publishing Hawking's articles

Every famous author is found to have certain preferable journals where he or she publishes his or her intellectual thought content. The table 4 shows the renowned journals where maximum numbers of Hawking's works are published.

Table 4 : Top ten journals publishing Hawking's articles

Sources	No. of Publications	Percentage
Physical Review D	44	9.30
Physics Letters B	13	2.75
Communications in mathematical Physics	11	2.33
Nuclear Physics B	11	2.33
Physical review letters	7	1.48
Proceedings of the Royal Society of London	5	1.06
Quadernsd'arquitectura i urbanisme	4	0.85
Monthly Notices of the Royal Astronomical Society	3	0.63
Journal of High Energy Physics	3	0.63
Classical and Quantum Gravity	3	0.63

This table 4 shows the 10 journals where most of the works of Stephen Hawking has been published. Among these journals, in Physical Review D maximum no. of works have been published i.e. 44 in number, followed by Physics Letters B i.e. 13 in number. Journals like Nuclear Physics B, Communications in Mathematical Physics, Physical review letters published 11,11 and 7 articles respectively. Hawking's works are all published in top class Journals of Physics with high impact factor.

6.5.Language wise distribution of the collections

English is found to be the most preferred language for expressing the thought content by most of the famous scientists and Hawking is no exception. The table below shows the language wise distribution of collections.

Table 5: Language wise distribution of collections

Sl. No.	Language	No. of Contributions	Percentage (%)
1	English	367	77.58985
2	Others	106	22.41015
TOTAL		473	100

This table 5 portrays that out of 473 publications, 367 (i.e. 77.59%) are published in English language and 106 only (i.e.22.41%) are published in other languages. This interprets that Hawking preferred English language over other languages as it is internationally accepted.

6.6. Document types of Hawking's works

Hawking was equally promising in authoring books and research articles for reputed publication houses.

Table 6: Document types of Hawking's works

Sl. No.	Document Types		No. Of Works
1	Printed Material	Book(Original and translated works)	202

		Research Paper(Both in print & Online)	136
		Article(Newspaper and Magazine)	19
		Proceeding	8
		Symposium	3
		Book chapter	2
		Book review	2
		Essays	2
		Lecture	9
		Speech	2
		Popular Saying	1
2	Sound Recording	Interview	3
		Speech	1
3	Video Recording	TV series	1
		Video Episode	1
		Speech	2
4	Electronic Resources	PDF	23
		Web page	21
		Blog post	1
5	Not retrieved		34
	Total		473

*Classified according to AACR IIR 2004 edition

The table 6 depicts that the original and translated books of Hawking are the most common document type with 202 works followed by research paper, both printed and online publications, 136 in number. Apart from Printed materials, the other document types of Hawking's works include printed material, Sound recording, Video recording and Electronic resources. The document types of thirty-four works could not be clear due to insufficient data in Google scholar.

6.7. Top Co-authors of Hawking

The study reveals that Hawking preferred to work alone rather than in collaboration probably because of his locomotive hindrances. But still some co-authors who worked with Hawking for maximum time are depicted in the table below.

Table 7: Core Co-authors of Hawking

Sl. No.	Name of Authors	No. of Contributions
1	L Mlodinow	21
2	R Penrose	13
3	GW Gibbons	11
4	R Bousso	9
5	L Hawking	8
6	T Hertog	7
7	E Lillestøl	6
8	I Sellevåg	6
9	GM Fraser	6
10	DN Page	5

This table shows the core co-authors of Stephen Hawking. L. Mlodinow collaborated maximum i.e.21 works with Hawking, followed by R. Penrose, G. W. Gibbons, R. Bousso and so on. Hawking actually was more comfortable to work alone than that in collaborationand it has already been seen from table 2 and table 2.1.

6.8. Top citation receiving works :

The following table shows which works of the scientist are regarded as the burning topic of research. Day by day these works gained more popularity among the fellow scientists.

Table 8 : Citation wise distribution of works

Title	Cites	Percentage
The large-scale structure of space-time	12073	12.69
Particle creation by black holes	10918	11.47
A brief history of time: from big bang to black holes	6981	7.34
Black hole explosions?	4725	4.97
Wave function of the universe	3415	3.59
Action integrals and partition functions in quantum gravity	3057	3.21
The four laws of black hole mechanics	2794	2.94
Cosmological event horizons, thermodynamics, and particle creation	2780	2.92
The development of irregularities in a single bubble inflationary universe	2153	2.26
Breakdown of predictability in gravitational collapse	1979	2.08

Table 8 shows to ten cited works of Hawking. Total seventeen publications received more than 1000 citations. Out of these the four most highly cited works are The Large-Scale Structure of Space-Time (12073) followed by Particle Creation by Black Holes(10918), followed by A Brief History of Time: From big bang to black holes and Black Hole Explosions which received 6981 and 4725 citations in number respectively. This clearly proves how inspiring and pioneering were the works of Hawking which received acknowledgement throughout the world.

6.9. Citation Indexes

Table 9 : Different citation indexes

Citation Indexes	Values
Total Citation	95155
Total Paper	473
No. of Cited Paper	405
No. of Uncited Paper	68
Cited-Uncited Ratio	5.96 : 1
No. of Low-Cited paper (=5)	141
No. of High-Cited Paper (=25)	164
High-Low Cited Ratio	1.16 : 1
h-index	103
h-core citation	10609
h-core Excess citation	79647
Tail citation	4899
g-index	308
i10 index	219
e-index	290.7679
R index	308.472
a index	923.835
g/h Ratio	2.99 : 1

High value of total citation shows the tremendous influence of his research works and the value of h-index and i-10 index also shows the high productivity of the scientist. The h-core excess citation shows the received citations are not uniformed, from e-index and R-index it is also reestablished that the citations and highly skewed in nature.

7. Major findings :

The Large-Scale Structure of Space-Time(12073) is the highest cited work, L. Mlodinow is the top co-author and favored language in most cases is English.

The maximum number of publications were contributed in the year 1996, followed by the years 2002, 2010 and 2015.

Physical Review D (44) and American Physical Society (51) are the core journal and publisher.From the years 1965 to 2018 single authored papers are predominant.

High value of total citation shows the tremendous influence of his research works and the value of h-index and i-10 index also shows the high productivity of the scientist.

8. Conclusion and future direction :

Stephen Hawking was a real gem in the field of physics and cosmology. He was highly acknowledged by his peers and that can be revealed from the citations he received throughout the period. The citation pattern, high value of h-index (103) and total citation count (95155) shows the excellence, acceptance, productivity and uniqueness of the scientist. The continuous publications indicate his meritorious services and dedication to work and passion towards research. He can be a role model and an inspiration for the research scholars and students in the field of natural science.

This work ends with the expectation that it may help the researchers and information professionals a lot. One may extend this study to find out the co-citation coupling, bibliographic coupling and institutional linkage etc. In spite of his locomotive hindrances he was a successful scientist and an inspiration to many others who could take his example and say 'where there is a will there is a way'.

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