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PHYSICS NOBEL LAUREATE WOLFGANG KETTERLE: A SCIENTOMETRIC PORTRAIT

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ABSTRACT

Wolfgang Ketterle was honoured with the Nobel Prize in Physics (2001) at 44 years of biological age and at 20 years of research publishing career. He had 115 publications during 1982 – 2002 in domains: Bose-Einstein Condensation (68), Laser Spectroscopy (30), and Atomic Physics (17) which were analysed for authorship pattern with his 68 collaborators. The most active researchers having number of publications with Ketterle were: S. Inouye (26), A. P. Chikkatur (20), M. R. Andrews (19), D. M. Stampur-Kurn (18), D. S. Durfee (17), H. J. Miesner (17) and D. E. Pritchard (17). His productivity coefficient was 0.78 which clearly indicates that his productivity increased after 50 percentile age. The highest collaboration coefficient (1) for Ketterle was found in 1983-1985, 1988, 1991-1995, and 2001. The publication concentration was 5.21% and publication density was 2.01. The core journals publishing his papers were: Phys. Rev. Lett. (30), Applied Physics-B (7), Journal of Chemical Physics (5), Nature (5), Physics Review-A (5), and Science (5). Most prolific keywords in titles were: Bose-Einstein condensate (38), Bose-Einstein condensation (15), Observation (9), Helium hydride (8), Emission spectrum (6) and Suppression (4). 'Bio-bibliometrics' is a method of retrieving and visualizing biological information that uses co-occurrence of gene naming terms in Medical Sciences to generate semantic links between genes. Therefore it is suggested that 'Scientometric Portrait' is the appropriate phrase for the studies on scientists and 'Informetric Portrait' for the studies pertaining to researchers in other disciplines such as arts, humanities, and social sciences.

Keywords: Scientometric portrait; Scientometrics; Individual scientist; Publication productivity; Research collaboration; Biobibliometrics.

INTRODUCTION

Bio-bibliometrics deals with the biographical study of the individual careers of scientists and researchers and correlating bibliographic analysis of publications or academic and scientific achievements.

Some biographical and bio-bibliometric studies of individuals have been carried out occasionally at the time of retirement or paying homage to an individual after death. For some noted individuals, their contributions are highlighted in the obituary column of professional journals.

Individuals are the source of ideas. The institutions are built by the individuals and grow around individuals. Individuals are the basic foundations of any institution. By studying the individuals who have reached the top positions in academic and research life and by highlighting their works may stimulate the younger generation to emulate them.

'Bio-bibliometrics' is a term that was first coined by Sen and Gan (1990) to mean as the quantitative and analytical method for discovering and establishing functional relationships between bio-data and biblio-data elements. There are many bio-bibliometric studies, but they have hardly used the term 'bio-bibliometrics' in the titles of the papers except for Sen & Gan (1990) and Tiew (1999).

Kalyane and Kalyane (1993) first used the phrase 'Scientometric Portrait' to carry out bio-bibliometric studies on scientists. In some of the papers Kalyane and Devarai (1994), Kalyane and Samanta (1995), and Devarai and Ramesh (1998) used the term 'Informetrics' in the titles of their papers on C. S. Vekata Ram, K. Ramiah, and M. N. Srinivas respectively. However, there was a continuous use of the phrase 'Scientometric Portrait' **(**Kademani et al., 1994; Kademani et al., 1994; Kalyane and Kalyane, 1994; Kalyane and Kademani, 1995; Kalyane, 1995; Kalyane and Munnolli, 1995; Kademani, et al., 1996; Kademani et al., 1996; Kalyane and Sen, 1996; Kademani and Kalyane, 1997; Kademani and Kalyane, 1998; Kalyane and Sen, 1998; Kademani et al., 2000; Kademani, et al., 2001; Kalyane et al., 2001; Kalyane and Sen (website); Kamble, 2002; Kademani et al., 2002; Koganuramath, et al., 2003; Munnolli and Kalyane, 2003; Angadi et al., 2004**)** consistently. 'Information profile' (Sinha and Bhatnagar, 1980; Sinha and Ullah, 1994) and 'citation profile' phrase was used by S. C. Sinha and Ullah (1993). The phrase 'Bibliographics on publication productivity' was used for the similar study (Kamble, 2001). Subir K. Sen (1995), the Chairman of SIG - Informetrics, IASLIC Conference 1994, proposed the term 'Microbibliometrics' for the studies on individual scientists, which were presented by V. L. Kalyane as ongoing projects on individual scientists. The term 'Information Career' was used (Muddiman, 2003).

Recently the term 'Bio-bibliometrics' is being used for method of retrieving and visualizing biological information that uses co-occurrence of gene naming terms in Medical Sciences to generate semantic links between genes (Stapley and Benoit, n.d). Therefore, it is suggested that 'Scientometric portrait' is the appropriate phrase for the studies on scientists, and 'Informetric portrait' for the studies on researchers in other disciplines such as arts, humanities, and social sciences.

The Nobel Prize is regarded as the most honorific recognition of scientific achievement. The prestige of the Nobel prize is so great that it enhances the standing of nations and institutions as well as the reputation of its "laureates" (Zuckerman, 1967; Zuckerman , 1967; Zuckerman , 1977).

The Royal Swedish Academy of Sciences has awarded to Wolfgang Ketterle as one of the three recipients of the Nobel Prize (2001) in Physics for the achievement of Bose-Einstein condensation in dilute gases of alkali atoms, and for early fundamental studies of the properties of the condensates. In addition to being a member of Research Laboratory of Electronics (RLE), Ketterle is an investigator in the MIT-Harvard Centre for Ultracold Atoms (CUA). Ketterle's co-recipients of the Physics Nobel Prize (2001) are Eric A. Cornell of (JILA) and the National Institute of Standards and Technology, and Carl E. Wieman of JILA and the University of Colorado at Boulder.

In 1924, the Indian physicist Satyendranath Bose made important theoretical calculations regarding light particles. He sent his results to Einstein who extended the theory to a certain type of atom. Einstein predicted that if a gas of such atoms were cooled to a very low temperature all of the atoms would suddenly gather in the lowest possible energy state. The process is similar to when drops of liquid are formed from a gas, hence the term condensation. Seventy-two years were to pass in achieving this extreme state of matter in 1995. Cornell and Wieman then produced a pure condensate of about 2000 rubidium atoms at 20 nK (nanokelvin), i.e. 0.000 000 02 degrees above absolute zero. Ketterle performed corresponding experiments with sodium atoms independently of the work of Cornell and Wieman. The condensates he managed to produce contained more atoms and could therefore be used to investigate the phenomenon further. Using two separate Bose-Einstein Condensates

(BEC), which were allowed to expand into one another, he obtained very clear interference patterns, i.e. the type of pattern that forms on the surface of water when two stones are thrown in at the same time. This experiment showed that the condensate contained entirely co-ordinated atoms. Ketterle also produced a stream of small "BEC drops" which fell under the force of gravity. This can be considered as a primitive "laser beam" using matter instead of light.

Bose-Einstein Condensation was first achieved at 10:54 a.m. on June 5, 1995. BEC has been achieved in a variety of chemical elements. One of the latest developments is a BEC on a microelectronics chip. These achievements are a tribute to the ingenuity and perseverance of experimenters and they demonstrate the suitable interplay of many scientific techniques (Pandey, 2003).

OBJECTIVES

Wolfgang Ketterle was taken as a case study for present scientometric analysis. His biographical details and a brief resume can be found at http://cua.mit.edu/ketterle_group/ketterle.htm and are well known.

This study highlights Wolfgang Ketterle's:

- domainwise contributions,
- domainwise authorships,
- prominent collaborators,
- use of channels of communications, and
- documentation of keywords from titles of the papers.

MATERIALS AND METHODS

Scientific publications seem to provide the best available basis for measuring the research output. One of the first writers to suggest scientific papers as a measure of research productivity was Nobel laureate William Shockley (1957) who was interested in measuring the research productivity among individuals within a group by analyzing their publications. A few scientometric studies on Nobel laureates (Cawkell and Garfield, 1980; Gupta, 1983; Kragh, 1990; Kademani et al., 1994; Kademani et al., 1996; Kalyane & Sen, 1996; Kalyane and Kademani, 1997; Kademani et al., 1999; Kademani et al., 2001; Kademani et al., 2002; Kademani et al., 2002; Koganuramath et al., 2003; Angadi et al., 2004) and others (Gupta, 1978; Ruff , 1979; Sinha and Bhatnagar, 1980; Gupta, 1983; Gupta, 1983; Dieks and

Slooten, 1986; Todorov and Winterhager, 1991; Lancaster et al., 1992; Lancaster et al., 1993; Seglen, 1993; Sinha and Ullah, 1993; Kademani et al., 1994; Kalyane and Kalyane, 1994; Kalyane, 1995; Kalyane and Kademani, 1995; Kalyane and Munnolli, 1995; Kademani and Kalyane, 1996; Kademani and Kalyane, 1996; Kademani et al., 1996; Kalyane and Sen, 1998; Kademani and Kalyane, 1998; Brittain, 2000; Kademani et al., 2000; Kalyane et al., 2001; Rusthon, 2001; Sinha & Dhiman, 2001; Kalyane and Sen, 2002; Dave, 2003; Munnolli and Kalyane, 2003; Kalyane and Sen, 2003; Sen and Karanjia, 2003; Kalyane, 2004; Kalyane et al., 2004; Swarna et al., 2004a; Upadhye et al., 2004; Swarna et al., 2004b) have been published.

The present study is limited to the 115 papers by Wolfgang Ketterle (1982-2002). The bibliographic fields were analysed by Normal Count Procedure (Kalyane and Vidyasagar Rao, 1995) for domains, authorships, journals, and keywords in the titles. The ratio of the number of multi-authored publications to the total number of publications in a defined period is called Collaboration Coefficient (Subramanyam , 1983).

RESULTS AND DISCUSSION

Domainwise contributions

Ketterle had research communications in the following domains:

A = Laser Spectroscopy;

B = Atomic Physics ; and

C = Bose-Einstein Condensation.

Ketterle had contributed 68 papers in the domain Bose - Einstein Condensation (1995 – 2002) followed by 30 papers in domain Laser Spectroscopy (1982 – 1999), and 17 papers in Atomic Physics (1983 – 2002). Domainwise profile of the annual growth of publications by Ketterle is presented in Figure 1.

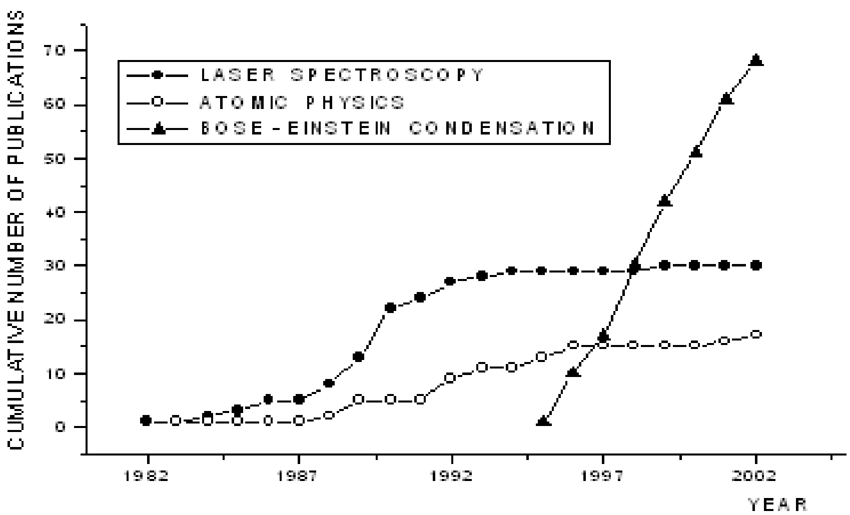

Figure 1: Domainwise Publication Productivity of Wolfgang Ketterle

Collaboratorship

Domainwise authorship pattern and number of publications and authorships in each domain are presented in Table 1. Six authored Bose- Einstein Condensation papers were 20, followed by one paper in Laser Spectroscopy. Two-authored Bose-Einstein Condensation papers were 14, followed by five papers in Atomic Physics and three papers in Laser Spectroscopy. Seven-authored Bose-Einstein Condensation papers were 12, followed by one paper in Laser Spectroscopy. Three-authored Bose-Einstein Condensation papers were 4, followed by four papers in Atomic Physics, and nine papers in Laser Spectroscopy. Five-authored Bose-Einstein Condensation papers were 4, followed by two papers each in Atomic Physics, and Laser Spectroscopy. Eight-authored Bose - Einstein Condensation papers were 2, followed by one paper in Laser Spectroscopy. Fourteen-authored one paper was in Laser Spectroscopy, thirteen-authored one paper was in Bose-Einstein Condensation, eleven authored one paper was in Bose-Einstein Condensation, ten-authored one paper was in Laser Spectroscopy, and nine-authored one paper was in Bose-Einstein Condensation.

Wolfgang Ketterle had 18 single-authored papers in various domains such as Bose-Einstein Condensation (8), Atomic Physics (3), and Laser Spectroscopy (7). The year-wise productivity of Wolfgang Ketterle is shown in Table 2 and Fig. 2. He published his first paper in the year 1982. A total of 84.35 per cent of his papers were collaborative.

Table 1: Domainwise Productivity (1982 – 2002) of Number of Papers and Authorship Pattern of the Nobel laureate Wolfgang Ketterle

No. of Authored papers	Domains			Total No. of papers	Percentage	No. of Authorships	Percentage
	A	B	C				
1-authored	7	3	8	18	15.65	18	03.73
2-authored	3	5	14	22	19.13	44	09.11
3-authored	9	4	4	17	14.78	51	10.56
4-authored	4	3	1	8	06.95	32	06.63
5-authored	2	2	4	8	06.95	40	08.28
6-authored	1		20	21	18.26	126	26.07
7-authored	1		12	13	11.30	91	18.84
8-authored	1		2	3	02.61	24	04.97
9-authored			1	1	00.87	09	01.86
10-authored	1			1	00.87	10	02.07
11-authored			1	1	00.87	11	02.28
13-authored			1	1	00.87	13	02.69
14-authored	1			1	00.87	14	02.09
Total	30	17	68	115	100.00	483	100.00
Percentage	26.09	14.78	59.13	100	A = Laser Spectroscopy; B = Atomic Physics; C = Bose-Einstein Condensation		
Authorships per paper	3.70	2.76	4.72	4.2			

The twentieth century has seen a tremendous collaborative research among scientists working in groups within and across the geographic boundaries of a country, which enhanced the ability of scientists to put in their brain collectively and make significant progress in their respective domains of specialisation. Collaboration is inevitable to make significant advances and breakthroughs in natural sciences and multidisciplinary areas. Whatever the advances have been made today are the results of endeavours of individual scientists as mentors (Marcina, 2000; Sindermann, 1985; Long and McGinnis, 1985).

Table 2: Collaboration Pattern of Wolfgang Ketterle

Age of Wolfgang Ketterle	Year	Number of papers under various authorships			Collaboration Coefficient	Publishing Career Age
		Single authored	Multi-authored	Total		
25	1982	1	-	1	0	1
26	1983	-	1	1	1	2
27	1984	-	1	1	1	3
28	1985	-	1	1	1	4
29	1986	1	1	2	0.5	5
31	1988	-	4	4	1	7
32	1989	2	6	8	0.75	8
33	1990	4	5	9	0.56	9
34	1991	-	2	2	1	10
35	1992	-	7	7	1	11
36	1993	-	3	3	1	12
37	1994	-	1	1	1	13
38	1995	-	3	3	1	14
39	1996	1	10	11	0.91	15
40	1997	1	6	7	0.86	16
41	1998	1	12	13	0.92	17
42	1999	2	11	13	0.85	18
43	2000	4	5	9	0.56	19
44	2001	-	11	11	1	20
45	2002	1	7	8	0.88	21
	Total	18	97	115		
	%	15.7	84.3	100		

The highest collaboration coefficient (1.00) for Wolfgang Ketterle was found in 1983-1985, 1988, 1991-1995, and 2001.

The Productivity Coefficient (Sen and Gan, 1990) is the Ratio of the productivity age (corresponding to the 50 percentile productivity) to the total productivity life. Productivity Coefficient for Wolfgang Ketterle was 0.78, which is a clear indication that his productivity increased after 50-percentile age. His total productivity age studied here spans 16 years (1982-2002) during which he produced 115 scientific publications. Fifty percent of his total publications were produced within five years (1998-2002). He had the highest number of collaborative papers (12) in 1998 and published the highest (13) number of papers in 1998 and 1999. He published eleven papers in 1996 and 2001 respectively. He did not publish a single paper in the year 1997.

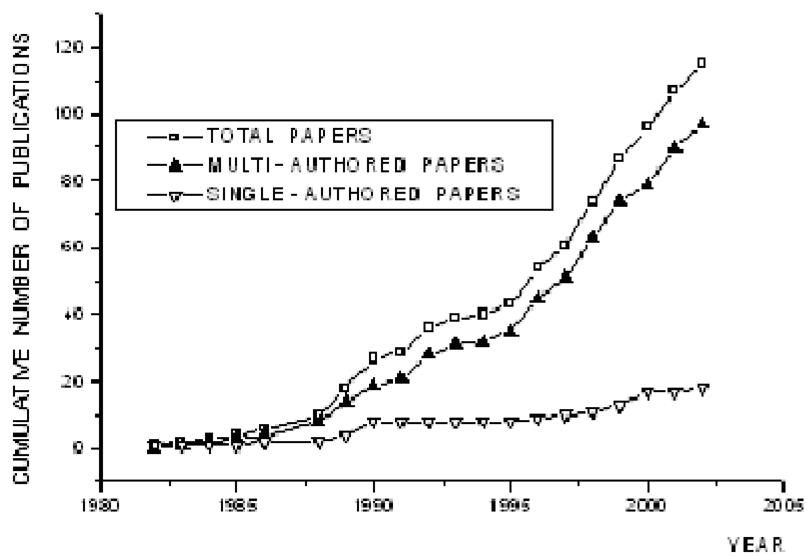

Figure 2: Growth Pattern of Single-Authored and Multi-Authored Paper of Wolfgang Ketterle

The researchers and their authorships in collaboration with Wolfgang Ketterle in the chronological order of their association (starting with the first paper publication year) are documented in Table 3 and depicted in Figure 3.

Collaborator dynamics

In the first quinquennium (QI) there were 6 collaborators, followed by in QII (26), QIII (20) and QIV (28). Overlap or continuity of the collaborators (bold numbers) between two quinquenniums and new collaborators between two quinquenniums (normal figures) are indicated in Table 4. For example, out of 6 collaborators in the QI four continued to collaborate in QII also, while 22 new collaborators joined during QII thus making a cohort of 26 collaborators in QII.

Domainwise authorships

Table 5 shows author productivity and distribution of authors in various domains. The research group of Wolfgang Ketterle had the credits as number of authorships in various domains: Bose-Einstein Condensation (326), Laser Spectroscopy (112), and Atomic Physics (45).

Table 3: Domainwise and Chronological profile (1982 – 2002) of the Nobel laureate Wolfgang Ketterle

Sl. No.	Researcher	Domains			Period of Collaboration FPY-LPY	TY	No. of Author-ships	Quinquennium
		A	B	C				
1.	Ketterle, W.	30	17	68	1982-2002	21	115	QI
2.	Gotze, W.		1		1983-1983	1	1	
3.	Fukuda, Y.	1			1984-1984	1	1	
4.	Figger, H.	5			1984-1989	6	5	
5.	Walther, H.	10	2		1984-1989	6	12	
6.	Dodhy, A.	2	1		1986-1988	3	3	
7.	GraBhoff	1			1988-1988	1	1	QII
8.	Messmer, H.P.	1	2		1988-1989	2	3	
9.	Kollner, M.	2			1989-1990	2	2	
10.	Suntz, R.	2			1989-1990	2	2	
11.	Becker, H.	4			1989-1991	3	4	
12.	Monkhouse, P.	3			1989-1992	4	3	
13.	Arnold, A.	10			1989-1994	6	10	
14.	Wolfrum, J.	11			1989-1994	6	11	
15.	Behrendt, F.	1			1990-1990	1	1	
16.	DieBel, E.	1			1990-1990	1	1	
17.	Dreier, T.	1			1990-1990	1	1	
18.	Hemberger, R.	2			1990-1990	1	2	
19.	Hentschel, W.	1			1990-1990	1	1	
20.	Herden, R.	1			1990-1990	1	1	
21.	Meienburg, W.	1			1990-1990	1	1	
22.	Neckel, H.	1			1990-1990	1	1	
23.	Schindler, K. P.	1			1990-1990	1	1	
24.	Sick, V.	2			1990-1990	1	2	
25.	Thiele, K. U.	1			1990-1990	1	1	
26.	Warnatz, J.	1			1990-1990	1	1	
27.	Lange, B.	2			1990-1992	3	2	
28.	Schafer, M.	6			1990-1992	3	6	
29.	Bouche	1			1992-1992	1	1	
30.	Dinkelacker, F.	1			1992-1992	1	1	
31.	Heitzmann, T.	1			1992-1992	1	1	
32.	Kohler, J.	1			1992-1992	1	1	
33.	Schiff, G.	1			1992-1992	1	1	
34.	Stolz, W.	1			1992-1992	1	1	

35.	Martin, A.		3		1992-1993	2	3	QIII
36.	Joffe, M. A.		4		1992-1995	4	4	
37.	Pritchard, D. E.	2	5	10	1992-2002	11	17	
38.	Davis, K. B.		3	2	1993-1996	4	5	
39.	Druten, N.J van		1	9	1995-1997	2	10	
40.	Mewes, M. O.		2	10	1995-1997	3	12	
41.	Kurn, D. M.			12	1995-1998	4	12	
42.	Andrews, M. R.		1	18	1995-1999	5	19	
43.	Durfee, D. S.			17	1995-2000	6	17	
44.	Townsend, C.G			7	1996-1997	2	7	
45.	Stringari, S.			1	1997-1997	1	1	QIV
46.	Miesner, H. J.			17	1997-1999	3	17	
47.	Inouye, S.			26	1997-2001	5	26	
48.	Stenger, J.			12	1998-2000	3	12	
49.	StamperKurn,D			18	1998-2001	4	18	
50.	Chikkatur, A. P.		1	19	1998-2002	5	20	
51.	Kohl, M.			2	1999-2000	2	2	
52.	Kuklewicz,C.E			2	1999-2000	2	2	
53.	Pfau, T.			2	1999-2000	2	2	
54.	Onofrio, R.			4	1999-2001	3	4	
55.	Gorlitz, A.		1	9	1999-2002	4	10	
56.	Gupta, S.			10	1999-2002	4	10	
57.	Hadzibabic, Z.			2	1999-2002	4	2	
58.	Raman, C.			12	1999-2002	4	12	
59.	Low, R.			1	2000-2000	1	1	
60.	Abo-Shaeer, JR			8	2000-2002	3	8	
61.	Gustavson,T.L.			5	2000-2002	3	5	
62.	Vogels, J. M.		1	7	2000-2002	3	8	
63.	Rosenband, T.			3	2001-2001	1	3	
64.	Leanhardt, A.E.			4	2001-2002	2	4	
65.	Xu, K.			4	2001-2002	2	4	
66.	Anglin, J. R.			2	2002-2002	1	2	QV
67.	Dieckmann, K.			1	2002-2002	1	1	
68.	Stan, C. A.			1	2002-2002	1	1	
69.	Zwierlein,M.W.			1	2002-2002	1	1	
1-69	Total	112	45	326	1982-2002	21	483	

(A = Laser Spectroscopy; B = Atomic Physics ; C = Bose-Einstein Condensation; FPY = First Publication Year; LPY = Last Publication Year; TY = Total years)

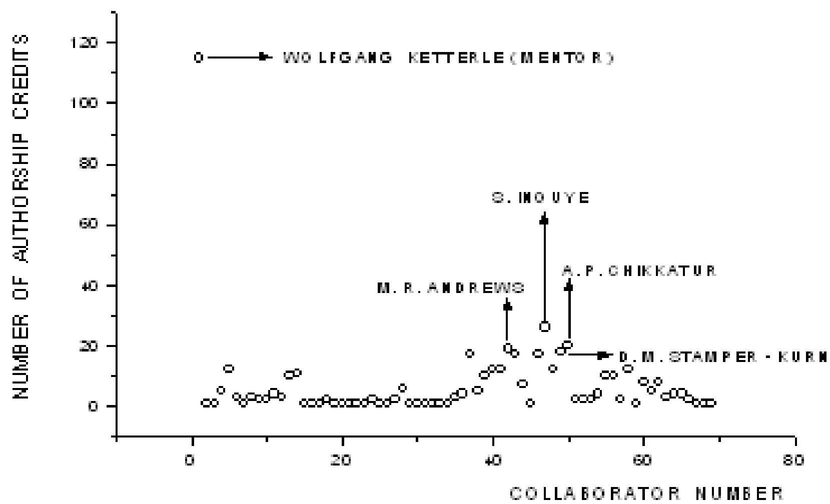

Figure 3: Authorship Credits to Collaborators with Wolfgang Ketterle

Table 4: Cohort of Collaborators in the Quinquennium, Number of Common Collaborators and New collaborators between the Respective Quinquenniums

	QI (1982 – 1986)	QII (1987 – 1991)	QIII (1992 – 1996)	QIV (1997 – 2001)
QI	(***6***)	**4** (***26***) 22	**K** (***20***) 19	**K** (***28***) 27
QII		(***26***)	**4** (***20***) 16	**K** (***29***) 28
QIII			(***20***)	**7** (***27***) 20
QIV				(***28***)

(Tuple: Collaborators during the quinquennial period in (italics bold) parenthesis; bold atop corner for number of common collaborators ; normal bottom corner for number of new collaborators ; and K for Ketterle alone common between the quinquenniums)

Table 5: Publication Productivity (1982-2002) of Wolfgang Ketterle and his Collaborators

No. of Papers (p)	Domains			No. of Authors (n)	Total Authorships (nxp)	Prominent Collaborators
	A	B	C			
1	18	1	5	24	24	
2	10		10	10	20	
3	6	6	3	5	15	
4	4	4	12	5	20	
5	5	3	7	3	15	
6	6			1	6	Schafer, M.
7			7	1	7	Townsend, C.G.
8		1	15	2	16	Abo-Shaeer, J.R. and Vogels, J. M.
10	10	2	28	4	40	Arnold, A; Druten, N.J; Gorlitz, A. and Gupta, S.
11	11			1	11	Wolfrum, J.
12	10	4	46	5	60	Walther, H. ; Mewes, M.O. ; Kurn, D.M. ; Stenger, J. and Raman, C.
17	2	5	44	3	51	Pritchard , D.E. ; Durfee, D.S. and Miesner, H.J.
18			18	1	18	Stampur-Kurn, D.M.
19		1	18	1	19	Andrews, M.R.
20		1	19	1	20	Chikkatur, A.P.
26			26	1	26	Inouye, S.
115	30	17	68	1	115	Ketterle, W.
Total	112	45	326	69	483	

(A = Laser Spectroscopy; B = Atomic Physics ; C = Bose-Einstein Condensation)

Prominent Collaborators

Most active researchers with number of publications with Wolfgang Ketterle (Table 5) were : S. Inouye (26), A. P. Chikkatur (20), M. R. Andrews (19), D. M. Stampur-kurn (18), D. S. Durfee (17), H. J. Miesner (17), D. E. Pritchard (17), H. Walther (12), M. O. Mewes (12), D. M. Kurn (12), C. Raman (12), J. Stenger (12), J. Wolfrum (11), A. Arnold (10), N. J. Druten (10), A. Gorlitz (10), and S. Gupta (10). Five scientists had collaboration in three papers each. Ten scientists had collaboration in two papers each. Twenty-four scientists could only collaborate in one paper each. The total number of authors in the research group was 69 and total number of authorships was 483.

Use of channels of communications

Distribution of Wolfgang Ketterle's 115 publications were spread over 24 journals, 19 conference proceedings, books, etc. Channelwise scattering of publications of Wolfgang Ketterle is provided in Table 6 and Fig. 4 He has published 30 papers in *Phys. Rev. Lett.* (1985-2002), 7 papers in *Applied Physics-B* (1990-1995), 5 papers each in *Journal of Chemical Physics* (1988-1990), *Nature* (1998-2002), Physical Review-A (1989-2001), and *Science* (1996-2001). Figure 5 indicates the growth of publications by Wolfgang Ketterle in the 6 core journals. The publication concentration was 5.21 % and the publication density was 2.01

Table 6: Dissemination Channels of Publications used by Wolfgang Ketterle

Sl. No.	*Channel of Communication*	No. of Papers	Cumu-lative	FPY - LPY	TY	IF
1.	Phys. Rev. Lett.	30	30	1985 - 2002	18	6.462
2.	Appl. Phys. B	7	37	1990 - 1999	10	1.913
3.	J. Chem. Phys.	5	42	1988 - 1990	3	3.301
4.	Nature	5	47	1998 - 2002	5	25.814
5.	Phys. Rev. A	5	52	1989 - 2001	12	2.831
6.	Science	5	57	1996 - 2001	6	23.871
7.	Chem. Phys. Lett.	4	61	1986 - 1989	4	2.364
8.	Z. Phys. D	3	64	1988 - 1989	2	-
9.	J. Low Temp. Phys.	2	66	1998 - 2001	4	1.058
10.	Optics & Photonics News	2	68	1998 - 1999	2	-
11.	Phys. Bull.	2	70	1996 - 1997	2	-
12.	Appl. Opt.	1	71	1990 - 1990	1	1.913
13.	Ber. Bunsenges. Phys. Chem.	1	72	1992 - 1992	1	1.531
14.	Can. J. Phys.	1	73	1984 - 1984	1	0.551
15.	Europhys. Lett.	1	74	1989 - 1989	1	2.228
16.	Experiments in Fluids	1	75	1992 - 1992	1	0.702
17.	J. Opt. Soc. Am. B	1	76	1993 - 1993	1	1.943
18.	Physics Today Japanese (Parity)	1	77	2000 - 2000	1	-
19.	*LEOS Newsletter*	1	78	1996 - 1996	1	-
20.	*Optics Express*	1	79	1998 - 1998	1	1.811
21.	*Physica*	1	80	2000 - 2000	1	-
22.	*Physics World*	1	81	1997 - 1997	1	1.281
23.	*Physique Astrophysique*	1	82	2001 - 2001	1	-
24.	*Z. Phys. B*	1	83	1983 - 1983	1	-
25-57.	Others in Books, Conf. etc.	32	115			

(FPY = First Paper Year, LPY = Last Paper Year, and TY = Total Years, IF = Impact Factor taken from *Journal Citation Reports - 2001*)

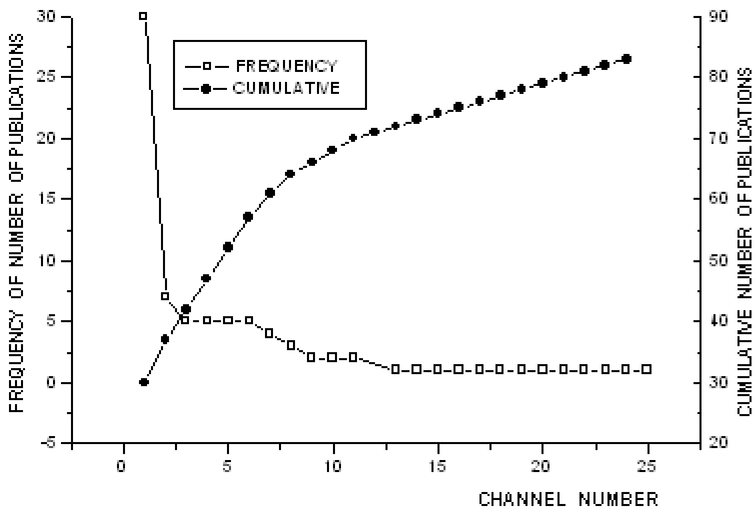

Figure 4: Bradford – Zipf Bibliograph for Wolfgang Ketterle

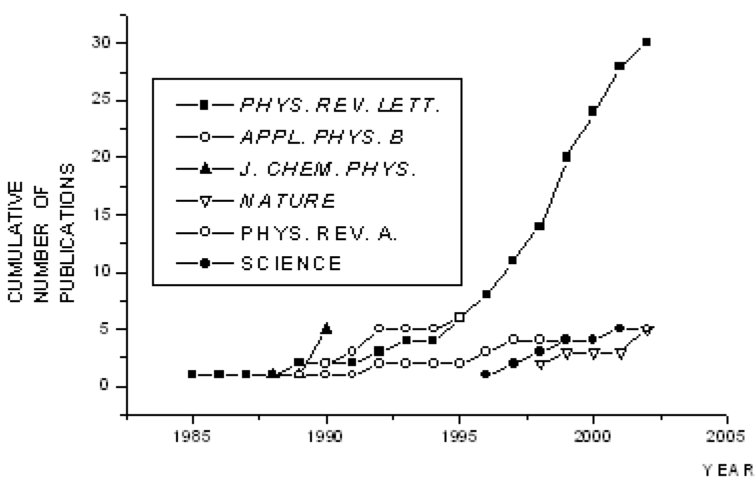

Figure 5: Growth of the Publications by Wolfgang Ketterle Preferentially Contribute to Six Journals

Distribution of Wolfgang Ketterle's publications in different types of communication channels

It is clearly evident from Table 7 that his 72.15 percentage of publications were published in scientific journals followed by (16.5%) publications in conference proceedings.

Table 7: Distribution of Wolfgang Ketterle's Publications in Different Types of Communication Channels

Sl.No.	Document Type	No of Papers
1.	Journal Articles	83
2.	Conf/Sem. Papers	19
3.	Edited books	4
4.	Pre-Print	3
5.	Dissertation	2
6.	Books	1
7.	Encyclopaedia	1
8.	Patent	1
9.	Year Book	1
	Total	115

Keyword Tomography

The recent study on Database Tomography (Kostoff and Eberhart, 1997) for Research Impact Assessment is interesting. Titles of publications convey precisely the thought contents of the papers. The potency of information concentrated on the titles of the papers is more than the rest of the sections of the papers. Therefore if a word occurs more frequently than expected it to occur, then it reflects the emphasis given by the author about the domain of his research. These important words called 'keywords' are one of the best indicators to understand and to grasp instantaneously the thought content of the papers, methodologies used and areas of research addressed to. The keyword frequencies appeared in the titles of the papers is provided in Tables 8 – 9. High frequency keywords were Bose-Einstein condensate, Bose-Einstein condensation, Observation, Helium hydride, Emission spectrum, Suppression.

Table 8: Keyword Frequency from the Title of Publications (1982 – 2002) by Wolfgang Ketterle

Keywords	Frequency
Bose-Einstein condensate	38
Bose-Einstein condensation	15
Observation	9
Helium hydride	8
Emission spectrum	6
Suppression	4
Light scattering	3
Spectroscopy	3
Bose-Einstein condensed gas	3
Dilute atomic gases	3
Atom lasers	3
Atomic gases	2
Bragg spectroscopy	2
Collective enhancement	2
Combustion diagnostics	2
Cooling atoms	2
Enhancement	2
Evaporative cooling	2
Experimental studies	2
Optical confinement	2
Probing	2
Quantum matter	2
Rayleigh scattering	2
Realization	2
Spin domains	2
Spinor	2
Studies	2
Superradiant	2
Tunable excimer lasers	2

Table 9: Keywords Appeared Only Once in the Titles of the Papers (1982 – 2002) by Wolfgang Ketterle

2D determination; 2D single-shot imaging;2D-LIF of OH; Absolute temperature fields; Absoluten nullpunkt; Amplification; Analytical model; Atmospheric pressure flames; Atom cooling; Atom traps; Atomic beam; Atomic matter waves;Atomic physics; Atoms; Atoms optics; Autoionizing rydberg states of H3; Bending vibration; Boes-Einstein condensate; Boes-Einstein condensates; Bogoliubov transformation; Bose and Fermi gases; Bose condensate;Bose-Einstein condensed atoms; Bose-einstein kondensation; Bose-Einstein-kondensate; Bose-Einstein-kondensation; Bosonic stimulation; Bound helium hydride; Bound-free emission ; CARS spectroscopy; CH3OH/O2-mixtures; Coherence properties ; Cold atoms; Collective excitations; Collisionless ; Collisions at nanokelvin temperatures; Combustion processes; Condensed matter physics; Confining dc magnetic trap; Correlated atomic beams; Counterflow diffusion flames; Critical velocity; Dark light traps; Dark spontaneous-force; Deflection; Degenerate; Determination; Discrete spectrum; Disordered conductors; Dissipationless flow; Effective collisional lifetimes; Electronic structure; Evaporative; Evidence; Excimer lasers; Excitation; Fehbach resonances; Fermions; Feshbach resonances; Finite number; Finite temperatures; Flames; Focusing ground state atoms; Formation; Formation and decay; Four-wave mixing condensates; Gas of sodium atoms; Gas von natrium-atomen; Gaseous; Gravitational limitations; Ground state; Helium hydride molecule; High densities; High rydberg states; Higher densities of cold atoms; Highly anisotropic traps; Hydrodynamic excitations; I bands near 5600, 5800 and 6025 A; I bands near 8000 A; Ideal bose gas; Ignition processes; II bands near 4500 and 7100 A; II bands near 5500 and 6400 A; III bands near 5200; 5300 and 6000 A; Impurity scattering; Inelastic collisions; Intense slow atom beams; Intensity graded light sheet; Interference; Isotropic laser light; IV bands near 4100 and 4600 A; Laser in-situ monitoring; Laser stimulation; Lifetimes of triatomic hydrogen molecules; Light; Low-lying Rydberg states(n = 2 - 5); Lower dimensions; Magnetic trap; Making; Matter; Metastable state; Mgnetically trapped nanokelvin atoms; Modeling; N=3 states of H3; ND4 schuler band; Neon hydride; Neue form von quantenmaterie; Neutralized ion beam experiment; New form; Non-destructive imaging; Nuclear spin relaxation; OH radicals; One or three dimensions; Optical bragg scattering; Optical tweezers; Optically confined; Output coupler; Particales trapped; Phase-coherent amplification; Phonons; Potical trap; Promising technique; Propagation of sound; PTA; Quantum degeneracy; Quantenmechanik; Quantum; Quantum tunneling; Reversible formation; Saturated 2D-LIF of OH; Simultaneous; Single-shot imaging of OH and O2; Slowing; Sodium; Sodium atoms; Spectra; Spinor condensates; Spontaneous emission; Static field; Stirred; Strongly; enhanced; Superfluid flow; Superfluidity; Surface excitations; Third velocity component; Time-dependent potentials; Traiatomic hydrogen; Transport; Transverse cooling; Trapping; Tratomic hydrogen; Triatomic hydrogen; Tunable KrF excimer laser; Two bose condensates; Two species mixture; Two-diamensinal laser induced fluorescence; Two-dimensional laser diagnostics; Two-step condensation; Two-wavelength excimer laser ;Two-wavelength operation; Ultracold atomic gases ;Understanding; V characterization; V1 vibration of H3+; Vortex excitations; Vortex lattices; Vortex nucleation; Vortex phase singularities; Wave amplification; Weakly interacting gas; Zeeman slower; Zero Kelvin Rydberg spectrum of H3

CONCLUSION

Wolfgang Ketterle's publication productivity under study for 21 years (1982 – 2002) during which he has published 115 papers indicated that his productivity increased after his 50 percentile age i.e. from 1998 onwards. The percentage of collaborative work of the scientist was found to be very high as he had as many as 68 collaborators whom he guided as mentor. The scientist worked in highly specialsed fields. His papers have been scattered in 24 scientific journals. He received many awards and honours including the Nobel Prize in physics in 2001. This kind of quantitative studies with graphic presentations facilitate one to study and grasp with clear perceptions about the work of a scientist. It will be an interesting study if one attempts to study the analysis of citations, socio-cultural backgrounds of Nobel laureates and incorporate their personal views on various aspects which would enhance the quality of the study. The biobibliometrics term is used for a method of retrieving and visualizing biological information that uses co-occurrence of gene naming terms in Medical Sciences to generate semantic links between genes (Stapley and Benoit, n.d). Therefore it is suggested that 'Scientometric Portrait' is the appropriate phrase for the studies on scientists and 'Informetric Portrait' for the researchers in other disciplines such as arts, humanities, and social sciences.

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