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A Scientometric Analysis of Astrophysics Research Output in India: Study Based on Web of Science

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***Abstract* - This study analyzes the Astrophysics research output in India from the year 1989-2014. The data was downloaded from web of science database which was maintained by Thomson Reuters. The findings of the study revealed that The highest number of publications is in the year 2013 with 913 records having a Global Citation score 4342 and Local Citation Score of 324.The study shows that major source of publication in Astrophysics research comes in the form of articles . The study also applied statistical tools such as K-S Test, Price's Square root law and Pareto Principle (80 X 20 Rule).**

***Keywords*: Scientometrices, Histcite, Web of Science, Astrophysics., K-S Test, Price's Square root law and Pareto Principle (80 X 20 Rule)**

I. INTRODUCTION

The Scientometrics is often done using bibliometrics which is a measurement of the impact of scientific publications. The research analysis of scientific publications is an important aspect of research activities in information science in recent years. The effectiveness of scientific and social science research publications, performance can be examined by scientometric analysis. Scientometrics are used to measure scientific activities, mainly by producing statistics on scientific publications indexed in databases. It is flexible tools used to study the scientific communities, to conduct scientific strategic, technical, technological or competitive monitoring, to design and manages research programs and evaluates research. They are extremely valuable methods for evaluating research output, positioning studies and conducting foresight studies in science and technology. Also can be used to measure and compare the scientific activities at various levels of aggregation including institutions/departments, sectors, provinces and countries. They can also be used to measure research collaborations, to map scientific networks and to monitor the evolution of scientific fields. During the last few years, scientometric analysis has been increasingly used and is still being used to examine and evaluate the research performance of scientists and the growth of various disciplines of science. Scientometrics is that branch of Information Science which analyses quantitatively the published information based on bibliographic data elements. It is an academic discipline in much of the research works which are being carried out for a quantitative study of the various aspects of literature output.

Birnholtz, J., Guha, S., Yuan, Y.C., Gay, G., and Heller, C (2013) [1] have described Institutions that are spread across multiple geographic locations face additional challenges. To better understand the nature of cross-campus collaboration within a single institution and the effects of institutional efforts to spark collaboration, they conducted a case study of collaboration at Cornell University using scientometric and network analyses.Nishy, P et.al. (2012) [2] have studied the Indian Journal of Chemistry, Section B during 2005-2009 and have been analysed using various scientometric parameters like geographical distribution, citations received each year, authorship patterns, etc.Builova and Osipov (2011) [3] have briefed information and analytical survey of the papers that were submitted to the Third International Nano technology Forum that was held in Moscow on November 1-3, 2010. Scientometric data on the participants, their origins by region and research center, as well as an analysis of the achievements and problems of Russian research on nano technologies, are given. Raja *et.al.* (2011) [4] have analyzed plasmodium falciparum research publication in India measured from Histcite software and other tools. The results show that the growth of Indian literature in plasmodium falciparum deposition and make the quantitative assessment of the research in terms of year-wise research output, geographical distribution, nature of collaboration, characteristics of highly productive institutions and the channel of communication used by the scientists. Vitzthum ,K *et al.* (2010) [5]analyzed Environmental Tobacco Smoke Research a total of 6580 articles were analyzed during the period 1900 – 2008. The first article was published in the year 1964. Using different scientometric approaches, a continuous increase of both quantitative and qualitative parameters was found. The combination with density-equalizing calculations demonstrated a leading position of the United States (2,959 items published) in terms of quantitative research activities.

Si, Linbo *et.al.* (2010) [6]have carried out the statistical analysis to the published papers, column set, author and citation of Tsinghua Journal of Education (2007-2008) through applying the method of scientometrics, and made

the appraisal of its publication characteristic and academic influence accordingly. A.I. Bonilla-Calero, (2008) [7] has described a "scientometric" analysis of a sample of research output in Physics taken from the institutional repository of the University of Strathclyde ("Strathprints"). The documents in this sample were authored over the period 2000-2005 but were deposited in the repository during the period from publication up to 2007. The paper aims to analyse these data bibliometrically. Yangge Tian et. al. (2008) [8] evaluated global scientific production of geographic information system (GIS) papers from 1997 to 2006 in any journal of all the subject categories of the Science Citation Index. The published output analysis showed that GIS research steadily increased over the past 10 years and the annual paper production in 2006 was about three times of 1997s paper production. Garg *et. al*. (2003) [9] analyzed 1317 papers published in the first fifty volumes of the international journal of Scientometrics during 1978 to 2000. They found that the U.S.A share of papers is constantly declining while that of the Netherlands, India, France and Japan is on the rise. The research output is highly scattered as indicated by the average number of papers per institution. Vinkler *et.al.* (2000) [10] have reviewed the evaluation of real scientometric systems needs compromises among the parties interested and between the practical applicability and the theoretical requirements of scientometrics. In the Chemical Research Center of the Hungarian Academy of Sciences, special scientometric indicators have been used for evaluating publication activity of research teams for about 30 years. Modified Garfield impact factors for journals as well as relative citedness of papers are applied as indicators because of differences among subfields in scientometric features of the publications assessed.

II. OBJECTIVES

1. To analyze the year -wise publication of Astrophysics research output in India.
2. To analyze the degree of collaboration for publications.
3. To analyze the K-S Test
4. To analyze the Price's Square root law
5. To analyze the Pareto Principle (80 X 20 Rule)

III. METHODOLOGY

The data for the study were retrieved from web of science database which is a scientific and indexing service maintained by Thomson Reuters. The Astrophysics research output of India was analyzed. The bibliographic details such as authors, document types, collaboration etc were analyzed using Histcite which is a software package used for bibliometric analysis and information visualization.

IV. ANALYSIS

A total of 12750 astrophysics records were published in India. The research output was analyzed using various scientometric indicators.

TABLE 1 YEAR-WISE DISTRIBUTION OF ASTROPHYSICS RESEARCH OUTPUT

S.No.	Publication Year	RECS	TLCS	TGCS
1	1989	320	572	2361
2	1990	377	758	3434
3	1991	383	702	3616
4	1992	331	554	2804
5	1993	389	963	4904
6	1994	369	985	5997
7	1995	285	878	4245
8	1996	300	977	6688
9	1997	355	884	5200
10	1998	323	904	6647
12	2000	355	1011	6967
13	2001	423	1042	7771
14	2002	422	992	11018
15	2003	400	1113	10796
16	2004	395	1035	9109
17	2005	418	1080	8766
18	2006	554	1543	12066

19	2007	566	1009	8861
20	2008	625	1034	9813
21	2009	647	1133	10575
22	2010	691	865	9049
23	2011	795	657	9055
24	2012	885	483	6902
25	2013	913	324	4342
26	2014	896	88	3287
	Total	12750	22486	179570

Table 1 shows the year- wise distribution of Astrophysics research output in India from the year 1989-2014. A total of 12750 records were published during the given period. The highest number of publications is in the year 2013 with 913 records, having a Global Citation score 4342 and Local Citation Score of 324,followed by 896 papers in the year 2014 with Global Citation score of 3287 and a Local Citation Score of 88. The year 2006 has scored the maximum Global Citation Score of 12066 with 554 publications. The lowest number of publications is in the year 1995 with 285 records, having a Global Citation Score of 878.It is also observed from the table that even minimum numbers of records have scored higher Global Citation Scores.

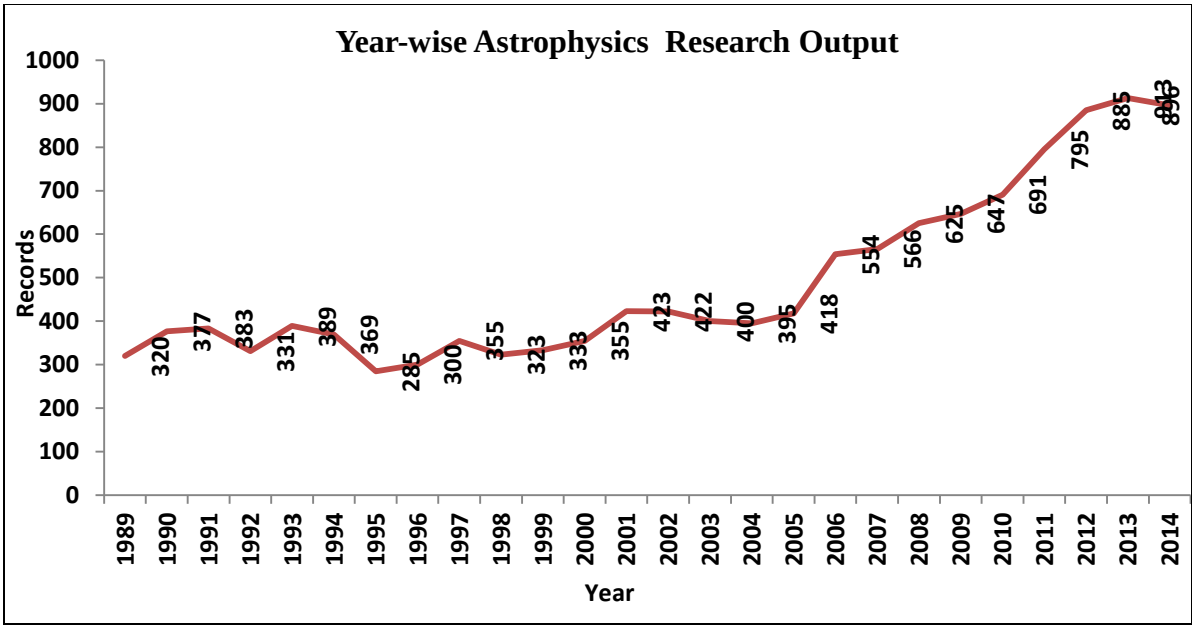

Fig. 1 year-wise distribution of astrophysics research output

TABLE 2 SINGLE VS MULTI-AUTHOR AND DEGREE OF COLLABORATION OF ASTROPHYSICS RESEARCH OUTPUT IN INDIA.

Year	Single Autors		Multi Authored		Total		Degree of Collaboration
	No.of output	%	No.of output	%	No.of output	%	
1989	74	4.07	246	2.25	320	2.51	0.77
1990	103	5.67	274	2.51	377	2.96	0.73
1991	105	5.78	278	2.54	383	3.00	0.73
1992	65	3.58	266	2.43	331	2.60	0.80
1993	69	3.80	320	2.93	389	3.05	0.82
1994	76	4.18	293	2.68	369	2.89	0.79
1995	70	3.85	215	1.97	285	2.24	0.75

1996	72	3.96	228	2.09	300	2.35	0.76
1997	86	4.73	269	2.46	355	2.78	0.76
1998	49	2.70	274	2.51	323	2.53	0.85
1999	75	4.13	258	2.36	333	2.61	0.77
2000	78	4.29	277	2.53	355	2.78	0.78
2001	62	3.41	361	3.30	423	3.32	0.85
2002	73	4.01	349	3.19	422	3.31	0.83
2003	56	3.08	344	3.15	400	3.14	0.86
2004	38	2.09	357	3.27	395	3.10	0.90
2005	49	2.70	369	3.38	418	3.28	0.88
2006	75	4.13	479	4.38	554	4.35	0.86
2007	59	3.25	507	4.64	566	4.44	0.90
2008	79	4.35	546	4.99	625	4.90	0.87
2009	59	3.25	588	5.38	647	5.07	0.91
2010	62	3.41	629	5.75	691	5.42	0.91
2011	84	4.62	711	6.50	795	6.24	0.89
2012	69	3.80	816	7.46	885	6.94	0.92
2013	71	3.91	842	7.70	913	7.16	0.92
2014	59	3.25	837	7.65	896	7.03	0.93
Total	1817	100	10933	100	12750	100	Average 0.86
%	14.25		85.75		100		

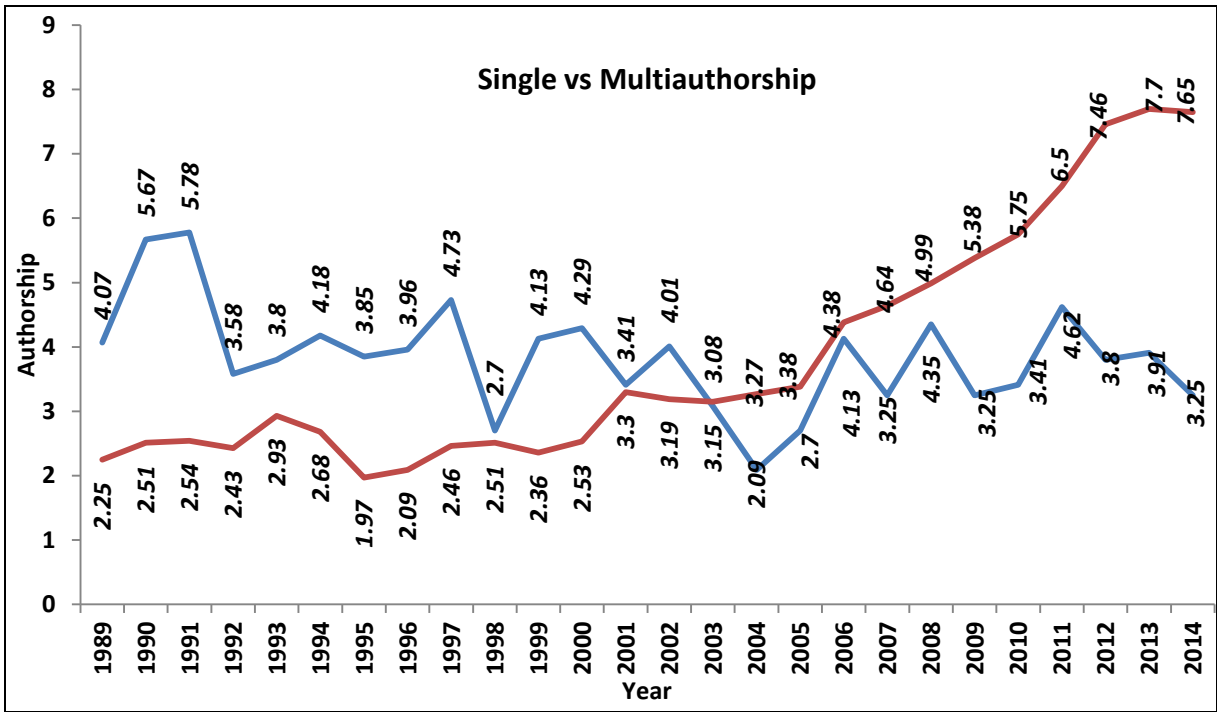

Fig. 2 Single vs multi-author and degree of collaboration of astrophysics research output in india

Degree of Collaboration

To determine degree of collaboration in quantitative terms, the formula given by K. Subramanyam (1983) was used,the formula is

$$C=N_M/N_M+N_S$$

Where C = Degree of collaboration
NM = Number of multi authored papers
NS = Number of single authored papers

In the present study the value of C is

$$C = 0.86$$

A study of the above data indicates the degree of collaboration in the Astrophysics research output in India. The degree of collaboration is 0.86 during the period 1989 to 2014 ie out of the total 12,750 articles published 86 percentage of them are published under united venture. During the year 1989 to 1997 the degree of collaboration was between 0.73 to 0.82 and during 1998 to 2014 has shown the degrees of collaboration values is 0.77 to 0.93. It is seen clearly from the above that the degree of collaboration in Astrophysics research output in India has shown an increasing trend during the study period. Based on this study the result of the degree of collaboration c =0.86 ie 86 percent of collaborative authors articles published during the study periods.

K-S Test

Verify K-S statistic value to see if Lotka's law be capable of hold for Astrophysics research related Publications. For N value is greater than 35, therefore, K-S statistics method can be used to verify if Lotka's law could hold for the sample area publications.

K-S =1.63/√N
K-S=1.63/√30280
K-S =1.63/174.01
K-S= 0.009

Totally30280 authors contributed for astrophysics research output. 1817(14.25%) of authors were contributed at non collaborative for this research product. It emphasizes the fact that the more number of publications by a researcher in any field requires a high degree of inquisitiveness, competency, efficiency, insistence, and exposure to literatures. That is why majority of authors have contributed to more number of papers. Further, the nature of the institutions in which the researchers work the research area of specialization and the availability of infrastructure facilities influence the author's productivity.

Price's Square Root Law

In order to validate whether the distribution status of authors fulfill Price's square root law and the calculation is based on.

PSQ=√N
N=410642
PSQ=√410642
PSQ=640.81

Based on Price's square root law, the just 605 contributors have contributing 8568(67.20 %) publications, the square root value located at just 18.907 percent of publications. The value is surpassing of from 50 % (half of the literature on a subject); so this result is more compliance with Price's Square Root Law. The below table has shown the related result values to highlighted.

Pareto Principle (80 X 20 Rule)

We used for this analysis in same values from the above table to validate Pareto Principle and test whether 80 percent of contributions does come from 20 percent of contributors. Since total authors number is 410642, that mean the 20 percents of total authors number is 82128

Total number of authors is 410642
20 percent of authors value is 82128
Total number of publications is 12750
80 percent of publications value is 10200

Based on analysis, the value of "Accumulated % of A*B" is 22.646 percent of authors were contributed nearly 68 percent of contributions only. In 80/20 rule view, the value should not close to 80 percent. We can conclude that this result is not compliance with Pareto Principles.

TABLE III PARETO PRINCIPLE

No.of Contribution A	No.of Contributors B	%of 30280	A*B	% of A*B	Cumulated value of A*B
349	1	0.003	349	0.085	0.085
245	1	0.003	245	0.060	0.145
221	1	0.003	221	0.054	0.199
213	2	0.007	426	0.104	0.303
204	1	0.003	204	0.050	0.353
197	1	0.003	197	0.048	0.401
187	2	0.007	374	0.091	0.492
185	11	0.036	2035	0.495	0.987

184	11	0.036	2024	0.493	1.480
183	21	0.069	3843	0.936	2.416
181	3	0.010	543	0.132	2.548
178	4	0.013	712	0.173	2.721
176	3	0.009	528	0.129	2.850
175	2	0.007	350	0.085	2.935
174	1	0.003	174	0.042	2.977
171	3	0.010	513	0.125	3.102
170	15	0.049	2550	0.621	3.723
169	5	0.016	820	0.201	3.924
167	3	0.010	501	0.122	4.046
166	4	0.013	664	0.162	4.208
164	12	0.040	1968	0.479	4.687
163	3	0.010	489	0.119	4.806
161	12	0.040	1932	0.471	5.277
160	2	0.007	320	0.078	5.355
157	12	0.040	1884	0.459	5.814
156	11	0.036	1716	0.418	6.232
153	16	0.053	2448	0.596	6.828
150	2	0.007	300	0.073	6.901
144	12	0.040	1728	0.421	7.322
143	11	0.036	1573	0.383	7.705
140	14	0.046	1960	0.477	8.182
139	14	0.046	1946	0.474	8.656
137	31	0.102	4247	1.034	9.690
134	26	0.086	3484	0.848	10.538
133	24	0.079	3192	0.777	11.315
131	14	0.046	524	0.128	11.443
129	17	0.056	903	0.220	11.663
127	13	0.043	381	0.093	11.756
126	4	0.013	504	0.123	11.879
125	14	0.046	500	0.122	12.001
123	11	0.036	123	0.031	12.032
122	13	0.043	366	0.089	12.121
121	32	0.106	1452	0.354	12.475
120	25	0.082	3000	0.730	13.205
117	13	0.043	1521	0.371	13.576
116	25	0.083	2900	0.706	14.282
114	12	0.040	1368	0.333	14.615
113	16	0.053	1808	0.441	15.056
111	16	0.053	1776	0.432	15.488
110	10	0.033	1100	0.268	15.756
109	26	0.086	2834	0.690	16.446
108	12	0.040	1296	0.316	16.762
106	13	0.043	1378	0.335	17.097

105	19	0.063	1995	0.486	17.583
104	16	0.053	1664	0.405	17.988
102(8568)	**377(605)**	**0.122**	**3774(77627**	**0.919**	**18.907**
101(8669)	**152(757)**	**0.502**	**15352(9297**	**3.739**	**22.646**
100	38	0.125	3800	0.925	23.571
99	45	0.149	4455	1.085	24.656
98	43	0.142	4214	1.026	25.682
97	16	0.053	1552	0.378	26.060
95	20	0.067	1900	0.463	26.523
94	26	0.086	2444	0.595	27.118
93	27	0.089	2511	0.611	27.729
91	13	0.043	1183	0.288	28.017
90	15	0.050	1350	0.329	28.346
89	15	0.050	1335	0.325	28.671
88	24	0.079	2112	0.514	29.185
87	19	0.063	1653	0.403	29.588
86	14	0.046	1204	0.293	29.881
84	15	0.050	1260	0.307	30.188
82	19	0.063	1558	0.379	30.567
81	29	0.096	2349	0.572	31.139
80	19	0.063	1520	0.370	31.509
79	18	0.059	1422	0.346	31.855
78	43	0.142	3354	0.817	32.672
77	80	0.264	6160	1.500	34.172
75	22	0.073	1650	0.402	34.574
74	40	0.0132	2960	0.721	35.295
72	24	0.079	1728	0.421	35.716
71	30	0.099	2130	0.519	36.235
70	22	0.073	1540	0.375	36.610
69	33	0.109	2277	0.554	37.164
67	22	0.073	1474	0.359	37.523
66	18	0.059	1188	0.289	37.812
65	27	0.089	1755	0.427	38.239
63	32	0.106	2016	0.491	38.730
62	22	0.073	1364	0.332	39.062
61	25	0.083	1525	0.371	39.433
60	33	0.109	1980	0.482	39.915
58	21	0.069	1218	0.297	40.212
57	26	0.086	1482	0.361	40.573
56	30	0.099	1680	0.409	40.982
55	25	0.083	1375	0.335	41.317
54	27	0.089	1458	0.355	41.672
52	34	0.112	1768	0.431	42.103
51	28	0.092	1428	0.348	42.451
48	47	0.155	2256	0.549	43.000

47	78	0.258	3666	0.893	43.893
46	65	0.215	2990	0.728	44.621
44	48	0.159	2112	0.514	45.135
43	43	0.142	1849	0.450	45.585
42	48	0.159	2016	0.491	46.076
40	57	0.188	2280	0.555	46.631
39	51	0.168	1989	0.484	47.115
38	110	0.363	4180	1.018	48.133
37	71	0.234	2627	0.640	48.773
36	136	0.449	4896	1.192	49.965
34	125	0.413	4250	1.035	51.000
33	175	0.578	5775	1.406	52.406
32	1031	3.405	32992	8.034	60.440
31	216	0.713	6696	1.631	62.071
30	104	0.343	3120	0.760	62.831
29	105	0.347	3045	0.741	63.572
28	110	0.363	3080	0.750	64.322
27	116	0.383	3132	0.763	65.085
26	172	0.568	4472	1.089	66.174
25	163	0.538	4075	0.992	67.166
24	132	0.436	3168	0.771	67.937
23	108	0.357	2484	0.605	68.542
22	272	0.898	5984	1.457	69.999
21	111	0.367	2331	0.568	70.567
20	211	0.697	4220	1.028	71.595
19	1791	5.915	34029	8.287	79.882
18	304	1.004	5472	1.332	81.214
17	195	0.644	3315	0.807	82.021
16	191	0.631	3056	0.744	82.765
15	272	0.898	4080	0.994	83.759
14	201	0.664	2814	0.685	84.444
13	306	1.011	3978	0.969	85.413
12	222	0.733	2664	0.649	86.062
11	400	1.321	4400	1.071	87.133
10	421	1.390	4210	1.025	88.158
9	345	1.139	3105	0.756	88.914
8	442	1.460	3536	0.861	89.775
7	536	1.770	3752	0.914	90.689
6	649	2.143	3894	0.948	91.637
5	855	2.824	4275	1.041	92.678
4	1744	5.760	6976	1.699	94.377
3	1923	6.351	5769	1.405	95.782
2	3507	11.582	7014	1.708	97.490
1	10307	34.039	10307	2.510	100.000
Total :12750	30280		410642	100	

V. CONCLUSION

The Astrophysics research output in India as evidenced from the study has the highest publication of 913 papers in 2013 with 4342 Global Citation Scores followed by 896 papers in 2014 with 3287 Global Citation Score and 885 papers in 2012 with 6902 Global Citation Scores. The study shows that the degree of collaboration in Astrophysics research output in India has shown an increasing trend during the study period. The calculated K-STest value is 0.009.Here the calculated price's square root law value is surpassing of from 50 % (half of the literature on a subject); so this result is more compliance with Price's Square Root Law. As per 80/20 rule view, the value should not close to 80 percent. So this result is not compliance with Pareto Principles.

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