Information Processing & Management Vol. 21, No. 3, pp. 177–186, 1985
Printed in Great Britain

0306-4573/85 $3.00 + .00
1985 Pergamon Press Ltd.

IDENTIFICATION OF IMPORTANT AUTHORS IN SCIENCE: A COMPARISON OF TWO METHODS OF IDENTIFICATION

C. D. HURT†
Graduate School of Library Science,
McGill University, 3459 McTavish Street,
Montreal, Quebec H3A 1Y1 Canada

(*Received for publication* 28 *September* 1984)

Abstract—This study examines the problem of identification of important authors in science by examining authors in the area of quantum mechanics. An examination was conducted using two methods of identification. The first method was a bibliometric approach and the second a historical approach. A gamma test of association was employed resulting in a finding of significant association between the ranks of authors. The major conclusion was that, when restricted to the same authors, the two methods of identifying important authors produce a statistically significant number of equivalent names. Discussion of the results and areas for further investigation are included.

INTRODUCTION

The purpose of this study is to examine in greater detail the problem of identification of important literature using two means of identification. In this study, the identification of authors considered to be important in the rise of a particular scientific specialty, quantum mechanics, is examined. The testing involved taking historical treatments of quantum mechanics and matching these against the actual citation records for the specialty. Ranks for the authors cited were determined by frequency of citation. Quantum mechanics literature was examined for the years 1900–1935. Data were collected from a series of histories treating the rise of quantum mechanics as well as from original research papers published during the years 1900–1935.

PREVIOUS RESEARCH

There is a great deal of research that deals with bibliometrics and characteristics of scientific literature. By no means is this literature confined to library and information science, but is also a topic of current concern in the history and sociology of science. The review of the literature by Narin and Moll [1] presents a good historical as well as methodological review of the work in the field. Edge [2] is representative of those who are less than convinced of the utility or even validity of the bibliometric method in modeling the scientific enterprise. Additional work in the area has been done by Bertram [3], Virgo [4] and Frost [5]. Hurt [6] has reviewed the literature dealing with identification of important literature in science, suggesting that the field has some distance yet to go before maturity.

One method, not used here, for identification of important literature uses both citation frequency ranks and the rankings of expert judges. Virgo's [7] work with this methodology suggests that citation frequency and ranking using judges produce sets of important literature that are virtually identical. Mulkay and Edge [8] suggest, however, that the use of expert judges to determine important literature might present methodological problems. Their study, dealing with radio astronomy in Britain, found that the participants in major discoveries recounted those discoveries in different ways. More to the point, they found the same respondents recounted the same events in yet

† Present Address: Graduate School of Library and Information Science, Simmons College, 300 The Fenway, Boston, MA 02115, U.S.A.

another order when tested a second time. Because most experts in a scientific field tend also to be authors in that field, it is unclear if methodologies for judging important literature are any different from the methodologies employed by Mulkay and Edge.

Hurt [9] examined the overall identification of important literature using historical sources and citation records. The results indicated no association between the ranks of items in the historical set and ranks of items in the bibliometric set. Studer and Chubin [10] suggested the same results were valid for the field of endocrinology. Further testing confirmed their hypothesis [11].

The examination of the literature in this area suggests that, while the literature of bibliometrics dealing with scientific specialties is developing, there is a great deal of work yet to be done. The lack of agreement among the studies cited above is also an impetus for this particular study.

DATA COLLECTION

The data used for this study were collected for a previous study [12]. Data were collected using two methods and fell into two data files: Bibliometric or Historical. The Bibliometric File was built using the base year of 1932, the date of Von Neumann's formalism of quantum mechanics [13]. Using a five year time lag to allow 1932 literature to enter the indexing tools, the 1937 volume of *Physics Abstracts* was used to generate the base literature for the Bibliometric File. All references under the heading "Quantum Mechanics" were noted. Using this set of citations as the base literature, all items cited in referenced literature moving backwards in time to 1900 were examined. The actual literature of quantum mechanics was used. *Physics Abstracts* was only used to identify the base literature.

The Historical File was generated by examining historical accounts of the quantum mechanics problem. The references used by historians in their recounting of the rise of the field were noted and collected. Histories were chosen in consultation with an historian of science familiar with the subject and the method. A list of the sources is included as Appendix 1.

Specific to this study, these data were examined in light of authors and their frequency of citation in the quantum mechanics literature (Fig. 1.). Previous work had examined all authors in both files. This study concentrated on authors common to both files. The criterion for inclusion into the database for this study was a minimum of one citation in both files. A listing of all authors is included as Appendices 2 and 3. Of these authors, only 113 were common to both the Bibliometic and the Historical files. The 113 authors are the focus of this study.

DATA ANALYSIS

The overall test of this investigation was to determine if the rankings determined by frequency in the Historical File were statistically associated with the rankings determined by frequency in the Bibliometric File. Because the possibility of ties in the ranks was a distinct possibility, the Goodman–Kruskal gamma test of association was chosen [14]. The gamma statistic has the same interpretation as the Kendall tau: a probability difference for the same versus different ordering on the underlying variables. The form of the gamma statistic is:

$$\gamma = P - Q/P + Q$$

where P = any cell with non-zero frequency and, ignoring its row and column in a ranked joint-frequency table, summing the number of entries to the right and below that cell; Q = any cell with non-zero frequency and, ignoring its row and column in a ranked joint-frequency table, summing the number of entries to the left and below that cell [15].

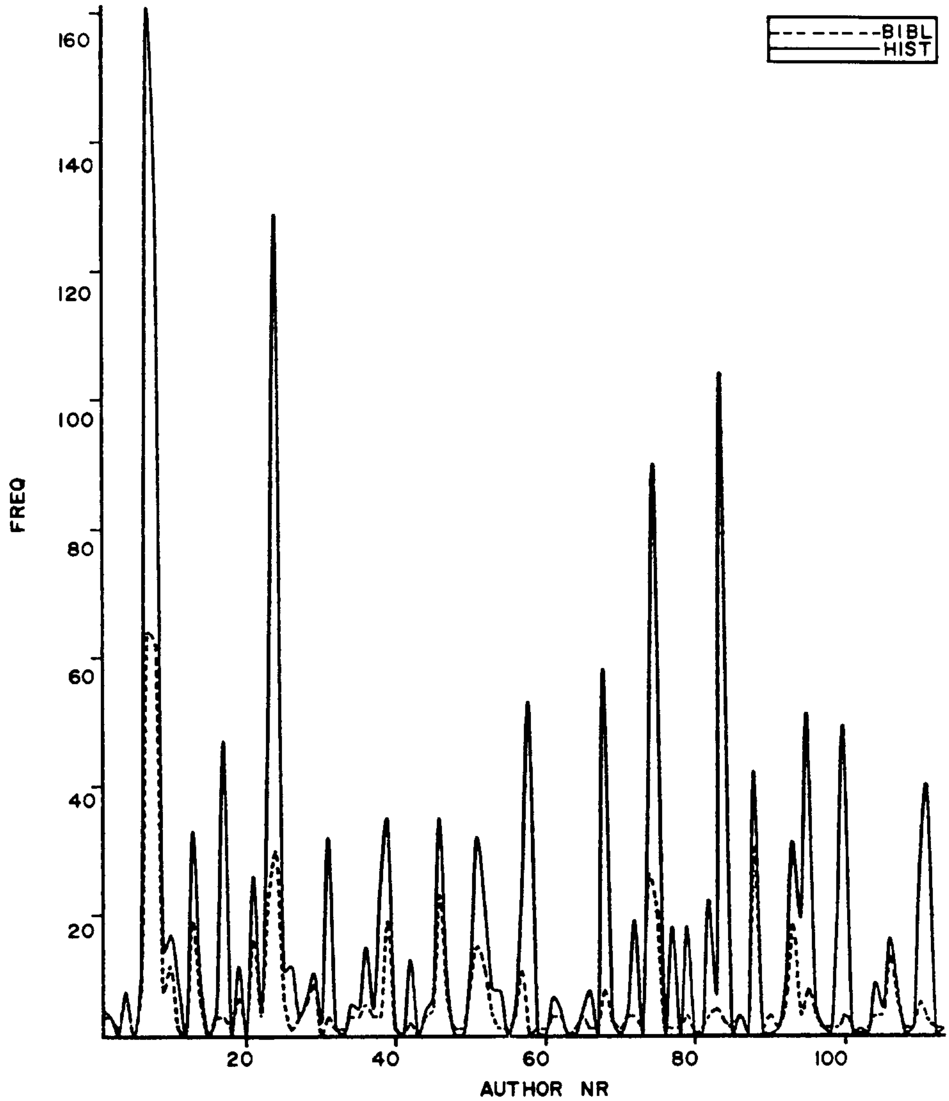

Fig. 1. Author publication frequency.

If there are no tied ranks, then

$$\gamma = \tau$$

HYPOTHESES

The purpose of this study was to investigate whether or not there are statistically significant differences in the identification of important authors in quantum mechanics resulting from two approaches to identification. The hypotheses testing for overall differences were:

*H*0: There is no significant association between the ranks of authors identified by means of historical accounts and ranks of authors identified by means of citation frequency.

*H*1: There is a significant association between the ranks of authors identified by means of historical accounts and ranks of authors identified by means of citation frequency.

The statistical forms of the hypotheses were:

$H0$: $\gamma = 0$
$H1$: $\gamma \neq 0$.

A decision rule for rejection of the hypothesis under test, $H0$, can be written from the gamma statistic under the assumption that gamma ranges from -1.00 to $+1.00$. The sign of the value obtained is an indication of the direction of association. Using a Type I error level or alpha = 0.05 for a two-tailed test of association a critical value can be computed using the absolute value of gamma as a reduction in error measure and examining the gamma value as a proportion in relation to the normal distribution. The form of the significance test is

$$Z = (p_1 - p_0)/((p_0 q_0)/N)^{.5},$$

where p_1 is the observed gamma value, p_0 is the value of no difference or .50, $q_0 = 1 - p_0$, and $N = 113$.

DECISION RULE: Reject $H0$ if the value of Z is greater than or equal to 1.96.

If this test of association is negatively significant, the interpretation of the test is that different ranks are associated (negatively) with the same author in the opposite file. If the test is significant in the positive direction, it is an indication that the same ranks are associated the same author in both files. If the testing shows no association, it suggests there is no association between ranks in one file versus the second file. From nonassociation, statistical independence can be inferred.

The hypothesis under test was formulated under the assumption that there would be no significant association found between ranks in the two files. This assumption is consistent with the findings of previous work. The major difference between this examination and the previous testing is that this study concentrates on authors common to both files. The previous study examined all authors, regardless of inclusion in both files.

RESULTS

The primary test in this study was to determine the level of association between the ranking of authors in two files, Bibliometric and Historical. The obtained value for the gamma statistic was 0.69747. Under the decision rule adopted above, the value of Z, using gamma as p_1, was 4.198. This value is significantly above the critical value necessary for rejection of the hypothesis under test.

The result of the test for overall association was that there is a significant, positive association between the authors cited in the Bibliometric File and the authors cited in the Historical File. The results of this test are not consistent with the findings in previous studies.

CONCLUSIONS

This investigation led to the following conclusions:

(1) There is a strong association between ranks of authors determined by examining historical sources for author frequency and ranks of authors determined by examining the scientific literature for author frequency when the set of authors is restricted to those common to both methods.

(2) Because the gamma measure is symmetric, the reduction in error factor is valid in both directions. Given knowledge of the author's rank in one file, the probability of judging the correct ranking in the second file is 69%.

(3) It is clear that, within limits, citation analysis and historical analysis can agree on important authors in a scientific specialty.

VALIDITY

The data gathering and the data analysis have attempted to avoid biases. This paper examines quantum mechanics only. Further research is necessary to indicate if the same conclusions drawn here might be equally valid in other scientific fields.

A potential point of bias is the use of *Physics Abstracts* and particularly the utilization of the subject heading "Quantum Mechanics." Other subject headings were not utilized because the focus of the research was toward quantum mechanics as it existed in the 1930's. Moving backward through time to 1900 incorporated the aspects of wave mechanics, matrix mechanics, statistics and other contributing areas to quantum mechanics. The conscious decision was made to narrow the term in the 1930's and allow expansion to 1900. This decision was based on the observation that not all matrix mechanics was concerned with quantum mechanics, as one example.

A second point of bias might have been introduced with the use of only one historian of science as a consultant. The argument can be made for two or more historians of science as well as for none. The judgement here was that introduction of an expert counsel reduced the probability of bias rather than confounding the process.

A final point is the power of the two tests utilized. The gamma test of association is a correlation-type test. As such, it can be viewed as a direct probability value disregarding sign. Power is not usually computed for correlation statistics. The second test, the Z test of proportions, can be examined for power. Using a normal approximation approach, a formula for power can be given as:

$$Z_2 = Z_1 - (N^{.5} * \Delta),$$

where Z_2 = Z at the beta level
Z_1 = Z at the 1-alpha level
N = total number of subjects
Δ = level of difference tested in standard deviation units.

Setting Z_1 at 1.96 (for a two-tailed test), $N = 113$, and $\Delta = .25$, Z_2 can be computed. The final value for $Z_2 = -.698$. The examination of this value against a Z table indicates a probability value of .2451 for the beta value. Because power is defined as 1-beta, the power for the Z test is $1 - .2451$ or .7549. An interpretation of this value is that the power is greater than 75% or that the chance of a Type II error is small.

DISCUSSION

The results reported above are interesting in that they do not support previous findings. The findings here should be interpreted in the context of the study, however. Restricted to a particular subject area, a finite number of authors are available for selection. The selection of who is important in a field is somewhat less complicated than the issue of what specific literature is important. Rectification of this study with previous work, however, remains a major issue.

Examination of the previous study finding no association between ranks of items in the two files indicates the Bibliometric File has earlier publication dates as measures of central tendency than does the Historical File [16]. The historians of the quantum mechanics problem are using later literature, in general, than those writing in the field.

Several reasons can be offered for this choice of later material. First, the historian is perhaps being judicious of space. Recognizing, in fact, that the earlier work may be the seminal work, later material by the same author might be more synergistic and therefore a better candidate for inclusion than the earlier work. Second, the historian is usually interested in the outcome of the investigation to a greater extent than the underpinnings of the final result. Third, depending on the theory of historiography to which the historian subscribes, certain prejudices, intentional or not, act on the selection of literature. This suggests that, on one level at least, historians have a different perspective and purpose than to document the rise of important literature. It may well be inappropriate to suggest they should be a party to such identification.

It is necessary to point out that this study has concentrated on only one aspect of citation analysis—the direct relationship between cited and referenced works. Other techniques which might be used are co-citation and tri-citation analysis as suggested by Small. Application of graph theory, epidemic theory and sophisticated statistical techniques have produced a great deal of information concerning citations, their nature and interactions. As mentioned above, work has also been done using direct contact on survey approaches. All this work has one element in common—the inability to *accurately* model the citation phenomenon. Rather than an indictment, this should be a further spur to refine the present models and investigate alternatives.

SUGGESTED FURTHER RESEARCH

This study suggests more questions than it answers. There is a definite need for further work refining the limits of citation analysis. The identification of important literature by other than subjective means is an enterprise requiring further work.

As this study and others have shown, the technique of citation analysis is an approximate measure of the importance of literature. The limitations of the approximation need further exploration.

Finally, this study points to the ability of historical sources, within limits, to identify important authors in a scientific subject field. Not only is replication of this study necessary, but expansion and testing of the thesis that citation frequency is an indication of importance is required.

Acknowledgement—I wish to acknowledge the prodding and encouragement of Derek Price, who, through his persistence and insight, was a valuable stimulus and critic of this work.

REFERENCES

[1] F. NARIN AND J. K. MOLL, Bibliometrics. *Ann. Rev. Inform. Sci. Tech.* 1976, **12**, 35.
[2] D. EDGE, Quantitative measures of communication in science: a critical review. *History of Science* 1979, **17**, 102.
[3] S. J. K. BERTRAM, The Relationship between intra-document citation location and citation level, Ph.D. Dissertation, Univ. of Illinois (1970).
[4] J. VIRGO, A statistical procedure for evaluating the importance of scientific papers, Ph.D. Dissertation, Univ. of Chicago (1974).
[5] C. O. FROST, Use of scholarly materials in German literary research: an analysis of reference citations in publications about literary works written in the German language, Ph.D. Dissertation, Univ. of Chicago (1977).
[6] C. D. HURT, The identification of important literature in science: a critical review of the literature. *Advances in Librarianship,* 1984, **13**, 239.
[7] J. VIRGO, See Ref. [4].
[8] M. J. MULKAY AND D. EDGE, Cognitive, technical and social factors in the growth of radio astronomy. *Soc. Sci. Inform.* 1973, **12**, 25.
[9] C. D. HURT, A comparison of a bibliometric approach and an historical approach to the identification of important literature. *Inform. Proc. Management* 1983, **19**, 151.
[10] K. E. STUDER AND D. CHUBIN, The heroic age of endocrinology. Paper presented at the *1st Annual Meeting of the Society for the Social Studies of Science,* Ithaca, New York, 4–6 Nov. 1976.
[11] C. D. HURT, Important literature in endocrinology: citation analysis and historical methodology. *Library Research* 1982, **4**, 375.
[12] C. D. HURT, See Ref. [9].
[13] J. VON NEUMANN, *Mathematische Grundlager der Quantenmechanik.* Springer-Verlag, Berlin (1932).
[14] L. A. GOODMAN AND W. H. KRUSKAL, Measures of association for cross classifications. *J. Am. Statist. Assoc.* 1954, **49**, 733.
[15] For a more complete description of the gamma statistic, see J. H. Mueller, K. F. Schuessler and H. L. Costner, *Statistical Reasoning in Sociology,* 2nd Edn. Houghton Mifflin, Boston (1970).
[16] C. D. HURT, See Ref. [6].

APPENDIX 1

List of historical sources

HUND, FRIEDRICH. *The History of Quantum Theory*, Harrap, London (1974).
JAMMER, MAX, *The Conceptual Development of Quantum Mechanics*, McGraw-Hill, New York (1966).
TER HAAR D., *The Old Quantum Theory*, Pergamon, New York (1967).
Handbuch Der Physik, Second Edition, Springer, Berlin (1955–).

APPENDIX 2

Authors in history file

	Author	*freq*		*Author*	*freq*
1	Abro, A.	1	63	Fowler, A.	1
2	Aharonov, Y.	4	64	Franck, J.	4
3	Alexander, P.	2	65	Frank, P.	2
4	Allcock, G.	2	66	Franke, H.	2
5	Barkla, C.	1	67	Frankel, H.	2
6	Bedav, H.	2	68	Fues, E.	4
7	Bergstein, T.	4	69	Fujirwara, I.	2
8	Berestetskii, V.	2	70	Gerlach, W.	4
9	Bethe, H.	2	71	Glauber, R.	2
10	Biberman, L.	2	72	Goudsmit, S.	6
11	Blackman, M.	1	73	Gravitt, J.	2
12	Blokhintsen, D.	7	74	Grunbaum, A.	2
13	Boltzmann, L.	1	75	Haar, ter D.	4
14	Bohm, D.	8	76	Haas, A.	4
15	Bohr, N.	64	77	Halpern, O.	2
16	Born, M.	62	78	Hartmann, N.	1
17	Bose, S.	2	79	Haug, A.	1
18	Bothe, W.	8	80	Heisenberg, W.	19
19	Bouten, M.	1	81	Hilbert, D.	2
20	Brillouin, M.	12	82	Hindmarsh, W.	1
21	Brody, N.	2	83	Hittmair, O.	2
22	Broek, A. van den	1	84	Honl, H.	2
23	Broglie, L. de	19	85	Hoyt, F.	2
24	Buchel, W.	1	86	Hubner, K.	2
25	Buneman, O.	2	87	Hund, F.	3
26	Bunge, M.	2	88	Isakson, A.	2
27	Burger, H.	2	89	Ishiwara, J.	1
28	Burgers, J.	2	90	Jammer, M.	4
29	Carruthers, P.	2	91	Janossy, L.	5
30	Chlinski, Z.	2	92	Jaynes, E.	2
31	Cohen, E.	1	93	Jeans, J.	2
32	Colodny, R.	2	94	Jensen, P.	2
33	Compton, A.	6	95	Jordan, P.	23
34	Condon, E.	2	96	Judge, J.	6
35	Conseth, F.	1	97	Kalla, E.	3
36	Conway, A.	1	98	Kaluza, T.	2
37	Coster, D.	4	99	Kayser, H.	2
38	Coulson, C.	2	100	Kelvin, Lord	2
39	Crowther, J.	1	101	Kennarel, E.	2
40	Darwin, C.	4	102	Klein, M.	9
41	Davisson, C.	2	103	Klein, O.	3
42	Davyov	1	104	Komar, A.	2
43	Debye, P.	7	105	Korn, A.	2
44	Demster, A.	2	106	Kossel, W.	15
45	Dirac, P.	16	107	Kouznetsov, B.	2
46	Dorgelo, H.	2	108	Kramers, H.	11
47	Duane, W.	2	109	Kraus, K.	4
48	Eckart, C.	4	110	Kronig, R. de	2
49	Ehrenfest, P.	22	111	Kropp, G.	2
50	Einstein, A.	30	112	Krylov, N.	2
51	Elasser, W.	2	113	Kuhn, W.	2
52	Engleman, F.	2	114	Landau, L.	2
53	Epstein, P.	7	115	Landenburg, R.	4
54	—not coded	0	116	Lanzcos, C.	3
55	Estermann, I.	2	117	—not coded	0
56	Evett, A.	2	118	Lande, A.	11
57	Faget, J.	2	119	Levich, B.	2
58	Fermi, E.	2	120	London, F.	2
59	Feyerabend, P.	2	121	Lorentz, H.	1
60	Feynman, R.	4	122	Louisell, W.	2
61	Fick, E.	6	123	Ludwig, G.	1
62	Fock, V.	9	124	Mackay, D.	2

Authors in bibliometric file

	Author	*freq*		*Author*	*freq*
125	Madelung, E.	4	165	Ruei, K.	2
126	Mandelstam, L.	4	166	Russell, H.	2
127	Mark, H.	1	167	Rutherford, E.	3
128	Mayer, A.	2	168	—not coded	0
129	McSweeny, R.	2	169	Rydberg, J.	2
130	Meissner, W.	1	170	Schidoff, A.	2
131	Mendelssohn, K.	1	171	Schlipp, P.	4
132	Messiah, A.	4	172	Schlegel, R.	1
133	—not coded	0	173	Schonberg, M.	2
134	Mott, N.	2	174	Schroedinger, E.	30
135	Moore, R.	2	175	Schutsman, L.	2
136	Moseley, H.	8	176	Schwartzchild, K.	4
137	Nagaoka, H.	3	177	Slater, J.	2
138	Naumann, H.	2	178	Smekal, A.	6
139	Von Neumann, J.	4	179	Sommerfeld, A.	18
140	Nicholson, J.	4	180	Stark, B.	4
141	Niessen, K.	1	181	Stark, J.	8
142	O'Leary, A.	2	182	Stern, O.	4
143	Ornstein, L.	2	183	Stoner, E.	2
144	Panofsky, W.	1	184	Susskind, L.	2
145	Paul, H.	2	185	Takabayaski, T.	2
146	Pauli, W.	26	186	Taylor, G.	2
147	Peierls, R.	1	187	Thomas, W.	1
148	Perlman, H.	2	188	Thomson, J.	4
149	Perrin, J.	3	189	Thomson, G.	2
150	Pfleeger, R.	3	190	Thomson, W.	1
151	Planck, M.	21	191	Tomonaga, S.	1
152	Podolsky, B.	2	192	Uhlenbeck, G.	2
153	Poincare, H.	2	193	Van Vleck, J.	4
154	Popper, K.	2	194	Weisskopf, B.	4
155	Rankin, B.	2	195	Von Weizsacker, C.	13
156	Rayleigh, Lord	4	196	Wentzel, G.	6
157	Razavy, M.	1	197	Wheller, J.	2
158	Reichenbach, H.	2	198	Whitt-Hansen, J.	2
159	Ritz, W.	4	199	Whittaker, E.	1
160	Roschdestwensky, D.	2	200	Wein, W.	6
161	Rosenbaum, D.	2	201	Wilson, W.	3
162	Rosenfeld, L.	5	202	Wundt, M.	2
163	Raurk, A.	3	203	Zilsel, E.	2
164	Rubinowicz, A.	1			

APPENDIX 3

Authors in bibliometric file

	Author	*freq*		*Author*	*freq*
1	Abro, A.	0	27	Burger, H.	0
2	Aharonov, Y.	5	28	Burgers, J.	0
3	Alexander, P.	0	29	Carruthers, P.	0
4	Allcock, G.	0	30	Chlinski, Z.	0
5	Barkla, C.	0	31	Cohen, E.	0
6	Bedav, H.	0	32	Colodny, R.	0
7	Bergstein, T.	4	33	Compton, A.	9
8	Berestetskii, V.	0	34	Condon, E.	0
9	Bethe, H.	1	35	Conseth, F.	0
10	Biberman, L.	0	36	Conway, A.	1
11	Blackman, M.	0	37	Coster, D.	5
12	Blokhintsen, D.	8	38	Coulson, C.	0
13	Boltzmann, L.	1	39	Crowther, J.	0
14	Bohm, D.	10	40	Darwin, C.	47
15	Bohr, N.	161	41	Davisson, C.	1
16	Born, M.	133	42	Davyov	0
17	Bose, S.	0	43	Debye, P.	12
18	Bothe, W.	14	44	Demster, A.	1
19	Bouten, M.	0	45	Dirac, P.	26
20	Brillouin, M.	17	46	Dorgelo, H.	0
21	Brody, N.	9	47	Duane, W.	0
22	Broek, A. van den	1	48	Eckart, C.	5
23	Broglie, L. de	33	49	Ehrenfest, P.	49
24	Buchel, W.	0	50	Einstein, A.	129
25	Buneman, O.	0	51	Elasser, W.	0
26	Bunge, M.	0	52	Engleman, F.	0

Authors in history file

	Author	freq		Author	freq
53	Epstein, P.	11	125	Madelung, E.	7
54	—not coded	0	126	Mandelstam, L.	5
55	Estermann, I.	0	127	Mark, H.	1
56	Evett, A.	0	128	Mayer, A.	0
57	Faget, J.	0	129	McSweeny, R.	1
58	Fermi, E.	12	130	Meissner, W.	0
59	Feyerabend, P.	0	131	Mendelssohn, K.	0
60	Feynman, R.	4	132	Messiah, A.	5
61	Fick, E.	7	133	—not coded	0
62	Fock, V.	11	134	Mott, N.	8
63	Fowler, A.	3	135	Moore, R.	1
64	Franck, J.	32	136	Moseley, H.	58
65	Frank, P.	2	137	Nagaoka, H.	3
66	Franke, H.	0	138	Naumann, H.	1
67	Frankel, H.	1	139	Von Neumann, J.	5
68	Fues, E.	6	140	Nicholson, J.	19
69	Fujirwara, I.	0	141	Niessen, K.	0
70	Gerlach, W.	5	142	O'Leary, A.	1
71	Glauber, R.	0	143	Ornstein, L.	0
72	Goudsmit, S.	15	144	Panofsky, W.	0
73	Gravitt, J.	0	145	Paul, H.	0
74	Grunbaum, A.	0	146	Pauli, W.	39
75	Haar, ter D.	5	147	Peierls, R.	0
76	Haas, A.	24	148	Perlman, H.	0
77	Halpern, O.	0	149	Perrin, J.	0
78	Hartmann, N.	0	150	Pfleeger, R.	0
79	Haug, N.	0	151	Planck, M.	90
80	Heisenberg, W.	35	152	Podolsky, B.	1
81	Hilbert, D.	2	153	Poincare, H.	18
82	Hindmarsh, W.	1	154	Popper, K.	1
83	Hittmair, O.	0	155	Rankin, B.	0
84	Honl, H.	0	156	Rayleigh, Lord	18
85	Hoyt, F.	0	157	Razavy, M.	1
86	Hubner, K.	0	158	Reichenback, H.	1
87	Hund, F.	13	159	Ritz, W.	22
88	Isakson, A.	0	160	Roschdestwensky, D.	0
89	Ishiwara, J.	1	161	Rosenbaum, D.	0
90	Jammer, M.	5	162	Rosenfeld, L.	7
91	Janossy, L.	7	163	Raurk, A.	0
92	Jaynes, E.	0	164	Rubinowicz, A.	0
93	Jeans, J.	0	165	Ruei, K.	0
94	Jensen, P.	0	166	Russell, H.	0
95	Jordan, P.	35	167	Rutherford, E.	104
96	Judge, J.	8	168	—not coded	0
97	Kalla, E.	0	169	Rydberg, J.	0
98	Kaluza, T.	0	170	Schidoff, A.	1
99	Kayser, H.	0	171	Schlipp, P.	4
100	Kelvin, Lord	1	172	Schlegel, R.	0
101	Kennarel, E.	1	173	Schonberg, M.	1
102	Klein, M.	11	174	Schroedinger, E.	42
103	Klein, O.	0	175	Schutsman, L.	1
104	Komar, A.	0	176	Schwartzchild, K.	1
105	Korn, A.	0	177	Slater, J.	2
106	Kossel, W.	32	178	Smekal, A.	9
107	Kouznetsov, B.	0	179	Sommerfeld, A.	31
108	Kramers, H.	21	180	Stark, B.	19
109	Kraus, K.	8	181	Stark, J.	51
110	Kronig, R. de	8	182	Stern, O.	5
111	Kropp, G.	0	183	Stoner, E.	2
112	Krylov, N.	1	184	Susskind, L.	0
113	Kuhn, W.	0	185	Takabayaski, T.	1
114	Landau, L.	0	186	Taylor, G.	19
115	Landenburg, R.	5	187	Thomas, W.	0
116	Lanzcos, C.	0	188	Thomson, J.	49
117	—not coded	0	189	Thomson, G.	1
118	Lande, A.	24	190	Thomson, W.	2
119	Levich, B.	0	191	Tomonaga, S.	0
120	London, F.	0	192	Uhlenbeck, G.	1
121	Lorentz, H.	53	193	Van Vleck, J.	9
122	Louisell, W.	1	194	Weisskopf, B.	5
123	Ludwig, G.	0	195	Von Weizsacker, C.	16
124	Mackay, D.	1	196	Wentzel, G.	8

	Author	freq
197	Wheller, J.	1
198	Whitt-Hansen, J.	2
199	Whittaker, E.	0
200	Wein, W.	26
201	Wilson, W.	40
202	Wundt, M.	1
203	Zilsel, E.	2
204–210	not coded	0
211	Mayer, J.	22
212	—not coded	0
213	Swirles, B.	6
214	March, A.	2
215–217	not coded	0
218	Iwanenko, D.	2
219–246	not coded	0
247	Wigner, E.	4
248–252	not coded	0
253	Campbell	2
254	Ince	4
255	Watson	1
256	Gonseth	4
257	Frobenius	3
258	Abraham	2
259	Adams	6
260	Ahmeds	3
261	Akesson	4
262	Allen	1
263	Allis	8
264	Aschkinass	1
265	—not coded	0
266	Back	4
267	Bieler	4
268	Black	1
269	Bragg	41
270	Briet	3
271	Bronson	1
272	Brucke	8
273	Campbell	2
274	Carrelli	1
275	Chadwick	15
276	Classen	2
277	Clausius	3
278	Curie	6
279	Cuthbertson	23
280	Drude	24
281	Eddington	4
282	Ehrenhafts	2
283	Ellis	33
284	Elster	3
285	Faxen	10
286	Feenberg	3
287	Frilley	3
288	—not coded	0
289	Gamow	21
290	Gieger	85
291	Geise	3
292	Giesel	3
293	Lenard	80
294	Gudden	1
295	Gurney	18
296	Heaviside	3
297	Heitler	3
298	Hertz	5
299	Houtermans	2
300	Hulme	2
301	Janitzki	1
302	Jewell	2
303	Joos	1
304	Kaufmann	4
305	—not coded	0
306	Koch	3
307	Kollath	3
308	Kovarik	2
309	Kratzer	1
310	Kroo	2
311	Kundar	6
312	Kundt	3
313	Lane	3
314	Leduc	1
315	Loeb	1
316	Majorana	3
317	Marsden	4
318	Massey	4
319	McDougall	2
320	Meitner	5
321	Michaelson	3
322	Mie	15
323	Millikan	2
324	Minkowski	8
325	Moller	6
326	Morse	2
327	Mosengiel	1
328	Normand	1
329	Oppenheimer	3
330	Paschen	20
331	Phillip	3
332	Pohlmeyer	4
333	Precht	3
334	Ramsauer	35
335	Ramsey	3
336	Ruark	3
337	Regener	8
338	Reiche	3
339	Rieff	1
340	Reiman	4
341	Righi	3
342	—not coded	0
343	Rubens	2
344	Rusche	6
345	Sachur	2
346	Sargent	3
347	Schuster	4
348	Searle	3
349	Shenstone	3
350	Simon	2
351	Skobelzyn	3
352	Strutt	2
353	Thiband	4
354	Thorson	1
355	Tolman	3
356	Townsend	6
357	Urey	2
358	Van den Braek	4
359	Walker	4
360	Watson	4
361	—not coded	0
362	Whiddington	3
363	—not coded	0
364	Wood	3
365	Wooster	3
366	Zwicky	1