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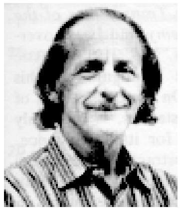

Current Comments®

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The Most-Cited 1984 Physical-Sciences Articles—High-Energy Physics Dominates

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Every year we examine the *Science Citation Index®* (*SCI®*) for papers in the life and physical sciences that became highly cited immediately after publication. We then categorize these papers into the physical and life sciences, based on the *SCI*'s subject designations for the journals in which the articles have been published. If an article's classification is ambiguous, we consult the *Source Index* of the *SCI* for the authors' departmental affiliations. If the classification still remains in doubt, we examine the article closely and, if necessary, seek the advice of experts. In this study, we discuss the 1984 physical-sciences articles that were most cited in 1984 and 1985. Future essays will examine the highly cited 1984 life-sciences and 1983 chemistry articles.

Our most recent report on fast-track physical-sciences papers appeared in 1985.[1] As we remind readers every year, these essays do not necessarily identify all the important papers published in a given year. Many significant papers accumulate citations more gradually, achieving *Citation Classic®* status over time. However, the immediacy of the papers in this study shows that they are putative classics.

The 108 papers listed in the Bibliography at the end of this essay received an average of 49 citations in the two-year study period—8 in 1984 and 41 in 1985. Even the least-cited papers in the Bibliography received 33 citations, the threshold for inclusion in this study. Since each of these papers has been highly cited, the list has been arranged alphabetically by first author.

1984 and 1985 Research Fronts

Another indication of the impact of these papers is that most are already core to numerous new research fronts that have been identified through combined *SCI*/*Social Sciences Citation Index®* (*SSCI®*) data. A research front is formed when pairs of earlier, core documents are cited together frequently by current papers. Thus, the citing authors categorize existing work into subject-related clusters of research. Table 1 lists the titles of the 21 fronts that include at least two of the papers from the Bibliography as core documents.

Superconductivity

The 1985 front entitled "Properties of heavy fermion superconductors and Kondo lattice systems" (#85-0530) has the largest number of papers from the Bibliography in its core—10. The front consists of a total of 37 core papers and 382 citing documents that concern the supercooling of the elementary subatomic particles classified as fermions. Materials cooled to near absolute zero lose virtually all resistance to the flow of electricity—in short, they become "superconductors."[2] (p. 1116) The papers also concern anomalous increases in electrical resistance (as temperature decreases) that are experienced by Kondo lattice systems, which are composed of certain magnetic alloys contained within nonmagnetic material.[2] (p. 525)

One of the core documents in research front #85-0530 was authored by Philip W. Anderson, AT&T Bell Laboratories, Murray Hill, and Princeton University, both in New Jersey. Entitled "Heavy-electron superconductors, spin fluctuations, and triplet pairing," it discusses the interactions of various metals that become superconducting between 1.0 and 0.1 degrees Kelvin. Together with John H. Van Vleck, Harvard University, Cambridge, Massachusetts, and Sir Nevill F. Mott, University of Cambridge, UK, Anderson won the 1977 Nobel Prize in physics for work on computer memory and electronics. Anderson also coauthored a paper on "Models of hierarchically constrained dynamics for glassy relaxation" with R.G. Palmer, Duke University, Durham, North Carolina; D.L. Stein, Princeton; and E. Abrahams, Rutgers University, Piscataway, New Jersey. The authors suggest models for the dynamics of interacting glassy materials. Another paper that is core to front #85-0530 is the second most-cited article in this study, by G.R. Stewart, Z. Fisk, J.O. Willis, and J.L. Smith, Los Alamos National Laboratory, New Mexico. It describes new discoveries about the superconducting properties of specific metals and received a total of 120 citations in 1984 and 1985.

Symmetry and Supergravity

Eight papers from the Bibliography are core to "Models of supergravity and supersymmetric particle production in colliders" (#85-0698), which has a total of 25 core papers cited by 354 articles published in 1985. According to Steven Weinberg, University of Texas, Austin, supergravity is one of several hypotheses, known collectively as quantum theories of gravity, that try to combine Einstein's theory of general relativity, which describes gravity in terms of the geometric curving of four-dimensional space, with quantum mechanics.[3] Weinberg shared the 1979 Nobel Prize in physics with Sheldon L. Glashow, Harvard, and Abdus Salam, Imperial College, University of London, UK, and the International Centre for Theoretical Physics, Trieste, Italy, for the development of the electroweak theory. This theory unites the description of electromagnetism with the description of the weak atomic force, responsible for the transmutation of subatomic particles.[4] Supergravity is a specific version of quantum gravity that seeks to incorporate gravity into supersymmetry theory, which is a way of classifying particles into families by the rate at which each particle spins. In supergravity, the force of gravity is transmitted by particles called gravitons and their speculated superpartners, called gravitini.[3]

A review article that is core to research front #85-0698 was written by H.P. Nilles of the multinational European Organization for Nuclear Research (CERN), Geneva, and the University of Geneva, Switzerland. Entitled "Supersymmetry, supergravity and particle physics," the paper explores the conditions under which supersymmetry is broken. A paper by John Ellis, CERN, and H. Kowalski, the German Electron-Accelerator (DESY), Hamburg, Federal Republic of Germany (FRG), is also core to this front. Entitled "Gluino signatures at the $p\bar{p}$ collider," it describes the production of pairs of gluino particles at CERN's Proton-Antiproton Supercollider. In addition, Ellis and Kowalski wrote a paper on "Supersymmetric particles at the CERN $p\bar{p}$ collider"; it was cited a total of 52 times, all in 1985, and is also core to research front #85-0698.

Ellis, with six papers in the Bibliography, appears more often than any other author in this study, and, in fact, more than any other author in our studies for the past three years.[1,5,6] This unusually large number of closely related, highly cited articles led me to wonder about the possible effects of self-citation on the number of articles Ellis has in this study. Of the total of 273 citations Ellis's six papers received from 139 unique articles in 1984 and 1985, 40—or approximately 15 percent—were self-citations. This is only slightly more than the typical rate of 13 percent and, at first glance, would seem to have little bearing on the number of Ellis's papers included in the Bibliography. But the self-citations were not evenly distributed. For instance, there were only seven self-citations to the paper on "Gluino signatures at the $p\bar{p}$ collider," coauthored with Kowalski; the paper received a total of 63 references—a self-citation rate of about 11 percent. But an article on "Supersymmetric relics from the big bang" and another entitled "Is supersymmetry found?" had self-cited rates of 20 percent or more.

The research front on "Chiral and soliton models for nucleons and other elementary particles and anomalies" (#85-0243) has 6 of its 52 core papers in the Bibliography.

Table 1: The 1984 and 1985 *SCI®/SSCI®* research fronts that include at least two of the 1984 most-cited physical-sciences papers as core documents. A=research-front number. B=research-front name. C=number of 1984 most-cited physical-sciences papers included in the core of each research front. D=total number of core papers and 1984 or 1985 citing papers for the year designated by the prefix in column A.

A	B	C	D
84-0022	Weak boson production, electroweak interactions, and Higgs masses	2	23/468
84-1199	Production of jets and large transverse energy events at $p\bar{p}$ colliders, their interpretation, and vector bosons	2	2/30
84-3850	Magnetic properties of amorphous $Nd_2Fe_{14}B$ and other rare-earth transition-metal borides and hydrides	3	10/60
85-0089	Optical bistability and nonlinear optical properties of semiconductor quantum wells	2	41/328
85-0102	Electron localization and quantum transport phenomena in disordered electronic systems	2	54/653
85-0212	Energy bands in quantum well heterostructures and heterojunctions in semiconductors	3	36/485
85-0243	Chiral and soliton models for nucleons and other elementary particles and anomalies	6	52/735
85-0301	Dynamical effects and critical behavior in various random field models	4	33/301
85-0505	Properties of percolation networks of different dimensions and fractal models	3	37/337
85-0507	Icosahedral order and symmetry properties of quasicrystals and crystals	2	22/164
85-0530	Properties of heavy fermion superconductors and Kondo lattice systems	10	37/382
85-0691	Kaluza-Klein cosmology and models of higher-dimensional supergravity	3	26/367
85-0698	Models of supergravity and supersymmetric particle production in colliders	8	25/354
85-0716	Dissipative quantum tunneling and emission of particles in heavy ion collisions	3	52/514
85-0742	Monte Carlo method for the study of surface-critical phenomena of the Ising model	4	27/295
85-0769	Quark clusters and EMC effects in deep-inelastic lepton scattering	2	23/274
85-1165	Production of Higgs bosons and models of weak CP-violation	5	28/466
85-2079	Theoretical and experimental studies of Ising and other spin-glasses	3	42/430
85-2347	Compactification, supersymmetry, and anomalies in the superstring model for the theory of supergravity	2	10/183
85-2982	Diffusion-limited aggregates, fractal structures, and disorderly growth models	2	26/299
85-4447	Magnetic properties of rare-earth-based permanent magnet compounds	4	12/107

Solitons are isolated, single waves (as opposed to a crest or a trough in a wavefront),[2] (p. 1053) and "chiral" refers to the direction of a particle's spin; in chiral symmetry, the number of particles spinning in one direction is balanced by the number of particles spinning in the opposite direction.[2] (p. 1139)

One of the core articles for this front is by Luis Alvarez-Gaumé, Harvard, and Edward Witten, Princeton. It discusses the theoretical implications of the breakdown of chiral symmetry on various theories of gravity. The article is the third most-cited paper in this study, receiving 23 citations in 1984 and 86 in 1985. Incidentally, Witten coauthored four papers in the Bibliography, second only to Ellis.

Cosmology and String Theory

Cosmology is a field that encompasses supergravity, supersymmetry, Kaluza-Klein theories, and grand unified theories (GUTs) in an attempt to describe the formation and evolution of the universe. In our study of the 1983 physical-sciences papers, we listed six fronts that specifically mentioned these elements of cosmology in their titles.[1] In this study, only three research-front titles in Table 1 include these terms. One of these is the front on models of supergravity and supersymmetric particle production (#85-0698), mentioned earlier; the other two are "Kaluza-Klein cosmology and models of higher-dimensional supergravity" (#85-0691) and "Compactification, supersymmetry, and anomalies in the superstring model for the theory of supergravity" (#85-2347).

Three of the 26 core papers in #85-0691 are included in the Bibliography. Among them is an article by Philip Candelas, University of Texas, Austin, and Weinberg that refines and extends the work of German theoretical mathematician Theodor F.E. Kaluza (1885-1954) and Swedish physicist Oscar Klein (1895-1977). Their theories, first published about 60 years ago, were an attempt to add electromagnetism to Einstein's geometrical description of gravity by propos-

Table 2: The number of authors per paper for the 1984 physical-sciences articles most cited in the *SCI®*, 1984-1985.

Number of Authors per Paper	Number of Papers	Number of Authors per Paper	Number of Papers
139	1	12	1
137	1	10	2
135	1	7	3
74	1	6	2
59	1	5	10
35	1	4	16
28	1	3	18
23	1	2	25
16	1	1	21
15	1		

ing an extra, unseen fifth dimension (in addition to the familiar four of length, width, depth, and time).[7] (p. 150-1) Indeed, such attempts continue to this day, as evidenced by a paper in the Bibliography by Deshdeep Sahdev, University of Pennsylvania, Philadelphia, that solves a class of Einstein's equations in terms of Kaluza-Klein theory.

Modern adaptations of the theories of Kaluza and Klein propose an additional six or seven dimensions that are "rolled up" into exceedingly small (10^{-20} the size of an atomic nucleus), looped "strings."[7] (p. 159-61) These extradimensional strings manifest themselves as the variety of particles currently populating the subatomic universe.[8] They form the basis of superstring theory, which unites the electroweak theory with quantum chromodynamics, the description of the strong force that holds atomic nuclei together. Superstring theory also holds the most promise for including gravity, the weakest of the traditional four forces and the most troublesome to GUT researchers, in a model that accounts for each force as one facet of a single, fundamental phenomenon.

Indeed, according to Weinberg, "the period covered in this survey saw the beginning of a new core area—that is, string theory—[in which there was] a tremendous wave of papers" in 1985 and 1986.[3] Weinberg singled out as seminal a paper by Witten ("Some properties of O(32) superstrings"), one coauthored by Daniel Friedan, Zongan Qiu, and Stephen Shenker, University of Chicago, Illinois, and another by Michael B. Green, Queen Mary College, University of London, and the California Institute of Technology (Caltech), Pasadena, and John H. Schwarz, also of Caltech. According to Weinberg, superstring theory is "now the center of attention of theoretical physicists who work in high-energy theory.... It's become a discipline to itself; it's just exploded in the last couple of years."[3] In an article based on a talk he gave at the American Physical Society Division of Particles and Fields, Weinberg attributes the upsurge in the popularity of superstring theory partly to physicists' frustration with other theoretical approaches.[9] String theories, he concludes, were just "too promising and too beautiful" to ignore.

The UA1 Collaboration

The 1984 physical-sciences article that was most cited in 1984 and 1985 is entitled "Experimental observation of events with large missing transverse energy accompanied by a jet or a photon (s) in $p\bar{p}$ collisions at $\sqrt{s} = 540$ GeV." It was coauthored by G. Arnison and 134 others in CERN's UA1 Collaboration, which includes Carlo Rubbia, CERN and Harvard, who shared the 1984 Nobel in physics with Simon van der Meer, also of CERN.[10] It reports the UA1 group's observation of five particle collisions that each released a large amount of energy that is unaccounted for by current theories. The authors suggest that one possible cause could be new, as-yet-unnamed particles. If so, the UA1 discovery promises to have significant impact on current cosmological theories. Cited 29 times in 1984 and 107 times in 1985, the paper was core to the research front on supergravity and supersymmetric particle production (#85-0698), mentioned earlier.

Table 2 provides a breakdown of the number of authors per article in the Bibliography. The UA1's most-cited article, mentioned above, is one of three papers with more than 130 authors; the other two are also by the UA1 Collaboration. Two papers had between 50 and 75 authors, and eight others had between 10 and 35 authors. There is little justification for listing scores of authors, since it is doubtful that all contributed enough thought and work to warrant authorship. And when large numbers of authors are listed, it is impossible to discern which are the leading members of the team. For instance, we had to call one of the authors of the paper by A. Chen and colleagues to learn that B. Gittelman, Cornell University, Ithaca, New York; R. Kass, Ohio State University, Columbus; and E.H. Thorndike and R. Poling, University of Rochester, New York, played leading roles in the research. Clearly, the scientific community must come to grips with the ethical issue of authorship, an issue I discussed in a recent essay.[11] This applies in clinical research as well as to physics.

In addition to the papers by Nobelists Rubbia, Anderson, and Weinberg, papers by Salam and by Kenneth G. Wilson, Cornell University, the 1982 winner in physics,[12] also appear in the 1984 Bibliography. Wilson's article was published with G.S. Pawley and D.J. Wallace, University of Edinburgh, Scotland, and R.H. Swendsen, IBM Zurich Research Laboratory, Rüschlikon, Switzerland. It concerns the type of renormalization-group calculations on critical behavior for which Wilson was awarded the Nobel. Salam coauthored his article with S. Randjbar-Daemi, International Centre for Theoretical Physics, Trieste, Italy, and the Institute for Theoretical Physics, Bern University, Switzerland, and J. Strathdee, also of the International Centre for Theoretical Physics. It presents equations supporting the Kaluza-Klein theory of cosmology. Incidentally, the International Centre for Theoretical Physics, headed by Salam, serves as a training center for physicists from around the world; it is also the headquarters for the Third World Academy of Sciences, where I gave a talk at a symposium in 1985.[13]

CERN's UA1 Collaboration not only has the most-cited article in this year's study, but it also produced the most-cited paper in the study of the 1983 most-cited physical-sciences papers.[1] In addition, CERN was listed as an author's affiliation more often than any other institution appearing in the study of the 1983 papers. As shown by Table 3, which lists the 117 institutional affiliations given by the authors in the Bibliography of 1984 papers, CERN is again represented the greatest number of times—15.

An interesting development this year is that more papers were produced by corporations than in previous studies. For instance, AT&T Bell Laboratories, Murray Hill and Holmdel, New Jersey, had 10 papers, while IBM's research facilities in Yorktown Heights, New York, and Rüschlikon, Switzerland, totaled 6. The General Motors Research Laboratories, Warren, Michigan, appeared for the first time in these annual studies, with two papers. Also new to the 1984 list, although not a corporation, is the Darmstadt Institute of Technology, FRG, with three papers.

Table 4 lists the national affiliations of the institutions in Table 3. Japan, absent from the 1983 study,[1] resurfaced in this study's Bibliography with three papers. The People's Republic of China and the USSR were also absent from the 1983 study but appear in this one. China, which had one paper in our 1981 study,[6] is represented by one paper in this study as well. The USSR had two papers in the 1982 study[5] and made the list with three in this one.

Soviet Articles

One of the Soviet articles, by E.B. Yagubskii and colleagues, Institute of Chemical Physics, Academy of Sciences of the USSR, Moscow, was originally published in Russian; a translation appeared in *JETP (Journal of Experimental and Theoretical Physics) Letters*, published by the American Institute of Physics. The original article and its translation received 17 citations in 1984 and 72 in 1985, making it the fifth most-cited paper in the present study. It discusses the synthesis of a new organic metal that can be cooled to the superconducting state under normal atmospheric pressures. The other two Soviet articles—an investigation of theories of massless, two-dimensional, interacting fields by A.A. Belavin and colleagues, L.D. Landau Institute for Theoretical Physics, Academy of Sciences of the USSR, Moscow, and a discussion of the evolution of the universe by A.D. Linde, P.N. Lebedev Physical Institute, Academy of Sciences of the USSR, Moscow—were published in English, as were all the other

Table 3: Institutional affiliations listed in papers in the Bibliography in descending order by number of appearances.

CERN, Geneva, Switzerland		15
AT&T Bell Labs., NJ		10
Holmdel	2	
Murray Hill	8	
Univ. California, CA		10
Berkeley	5	
Irvine	1	
Los Angeles	1	
Santa Barbara	2	
Santa Cruz	1	
Caltech, Pasadena, CA		7
Princeton Univ., NJ		7
Harvard Univ., Cambridge, MA		6
IBM		6
Ruschlikon, Switzerland	1	
Yorktown Heights, NY	5	
Cornell Univ., Ithaca, NY		5
Los Alamos Natl. Lab., NM		5
CNRS, France		4
Grenoble	1	
Vitry	1	
Montpellier	2	
Max Planck Soc. Adv. Sci., FRG		4
Inst. Hydrodynam. Res., Gottingen	1	
Inst. Phys. Astrophys., Munich	2	
Inst. Solid-State Res., Stuttgart	1	
NASA		4
Goddard Space Flight Ctr., Greenbelt, MD	2	
Hdqtr., Washington, DC	2	
Univ. London, UK		4
Acad. Sci. USSR, Moscow, USSR		3
Darmstadt Inst. Technol., FRG		3
Fermi Natl. Accel. Lab., Batavia, IL		3
MIT, Cambridge, MA		3
Ohio State Univ., Columbus, OH		3
Paris Univ., France		3
Stanford Univ., CA		3
Univ. Chicago, IL		3
Univ. Pennsylvania, Philadelphia, PA		3
Amsterdam Univ., The Netherlands		2
Brookhaven Natl. Lab., Upton, NY		2
DESY, Hamburg, FRG		2
Exxon Res. Eng. Co., Annandale, NJ		2
Frankfurt Univ., FRG		2
General Motors Res. Labs., Warren, MI		2
Inst. Adv. Stud., Princeton, NJ		2
Kitt Peak Natl. Observ., Tucson, AZ		2
Leiden Observ., The Netherlands		2
Madrid Autonom. Univ., Spain		2
Michigan State Univ., East Lansing, MI		2
Natl. Bur. Stand.		2
Boulder, CO	1	
Gaithersburg, MD	1	
Natl. Lab. Frascati, Italy		2
Rome Univ., Italy		2
Rome	1	
Tor Vergata	1	
Rutgers Univ., NJ		2
New Brunswick	1	
Piscataway	1	
Rutherford Appleton Lab., Chilton, UK		2
SUNY, Stony Brook, NY		2
Swiss Fed. Inst. Technol., Zurich, Switzerland		2
Univ. Arizona, Tucson, AZ		2
Univ. Colorado, CO		2
Boulder	1	
Denver	1	
Univ. Edinburgh, UK		2
Univ. Rochester, NY		2
Aachen Inst. Technol., FRG		1
Acad. Sci., Beijing, China		1
Amer. Univ., Washington, DC		1
Argonne Natl. Lab., IL		1
Berne Univ., Switzerland		1
Bonn Univ., FRG		1
Brown Boveri Res. Ctr., Baden, Switzerland		1
Columbia Univ., NY		1
Dortmund Univ., FRG		1
Duke Univ., Durham, NC		1
Florida State Univ., Tallahassee, FL		1
Fokker B V, Schiphol-Oost, The Netherlands		1
Franklin and Marshall Coll., Lancaster, PA		1
Grenoble Nucl. Res. Ctr., France		1
Groningen State Univ., The Netherlands		1
Haldor Topsoe Res. Labs., Lyngby, Denmark		1
Heavy Iron Res. Lab., Darmstadt, FRG		1
Higher Normal Sch., Pisa, Italy		1
INFN, Rome, Italy		1
Inst. Astron., Cambridge, UK		1
Inst. Struct. Mat., Madrid, Spain		1
Intl. Ctr. Theor. Phys., Trieste, Italy		1
Israel Inst. Technol., Haifa, Israel		1
Ithaca Coll., NY		1
Jamieson Sci. Eng., Palo Alto, CA		1
Julich Nucl. Res. Ctr., FRG		1
Kapteyn Astron. Inst., Groningen, The Netherlands		1
Meiji Univ., Tokyo, Japan		1
Naples Univ., Italy		1
Natl. Ctr. Atmospher. Res., Boulder, CO		1
Natl. Inst. Nucl. Phys., Naples, Italy		1
Natl. Lab. Frascati, Italy		1
Neth. Fnd. Radio Astron., Dwingeloo, The Netherlands		1
NIH, Div. Comp. Res. Tech., Bethesda, MD		1
Nordita, Copenhagen, Denmark		1
NRC, Ottawa, Canada		1
Nucl. Energy Commis., Madrid, Spain		1
Petrol. Lab., Marseilles, France		1
RCA Labs., Princeton, NJ		1
Regensburg Univ., FRG		1
Regional Bell Operating Cos., Holmdel, NJ		1
Reims Univ., France		1
Saclay Nucl. Res. Ctr., Gif-sur-Yvette, France		1
Savoy Univ., Annecy-le-Vieux, France		1
Schlumberger-Doll Res., Ridgefield, CT		1
Sumitomo Special Metals Co., Osaka, Japan		1
Swiss Inst. Nucl. Res., Villigen, Switzerland		1
Syracuse Univ., NY		1
Texas A & M Univ., Coll. Station, TX		1
Tohoku Univ., Sendai, Japan		1
Univ. Athens, Greece		1

Univ. Cincinnati, OH	1
Univ. Delaware, Newark, DE	1
Univ. Geneva, Switzerland	1
Univ. Glasgow, UK	1
Univ. Helsinki, Finland	1
Univ. Illinois, Urbana, IL	1
Univ. Ioannina, Greece	1
Univ. Karlsruhe, FRG	1
Univ. Leeds, UK	1
Univ. Massachusetts, Amherst, MA	1
Univ. Michigan, Ann Arbor, MI	1
Univ. Missouri, Columbia, MO	1
Univ. Munich, FRG	1
Univ. Southern California, Los Angeles, CA	1
Univ. Stockholm, Sweden	1
Univ. Texas, Austin, TX	1
Univ. Washington, Seattle, WA	1
Univ. Wisconsin, Madison, WI	1
Vanderbilt Univ., Nashville, TN	1
Venezuela Sci. Res. Inst., Caracas, Venezuela	1
Virginia Polytech. Inst. State Univ., Blacksburg, VA	1
Wayne State Univ., Detroit, MI	1
Xerox Palo Alto Res. Ctr., CA	1

Table 4: National locations of the institutional affiliations listed by authors in the Bibliography, according to total appearances (column A). B=number of papers coauthored with researchers affiliated with institutions in other countries. C=national locations of institutions listed by coauthors.

Country	A	B	C
US	74	21	Canada, Denmark, Finland, France, FRG, Greece, Israel, Italy, Japan, The Netherlands, Spain, Sweden, Switzerland, UK, Venezuela
Switzerland	20	11	Canada, Finland, FRG, Greece, Italy, Japan, Spain, Sweden, UK, US
FRG	14	8	Canada, Finland, France, Italy, Japan, The Netherlands, Spain, Sweden, Switzerland, UK, US
UK	9	9	Canada, Finland, FRG, Italy, Japan, The Netherlands, Spain, Sweden, Switzerland, UK, US
France	8	4	China, FRG, Israel, Italy, US
Italy	5	3	France, FRG, The Netherlands, Switzerland, UK, US
Spain	4	3	Canada, Finland, FRG, Japan, Sweden, Switzerland, UK, US
Japan	3	2	Canada, Finland, FRG, Spain, Sweden, Switzerland, UK, US
The Netherlands	3	3	FRG, Italy, UK, US
USSR	3	0	
Greece	2	2	Switzerland, US
Canada	1	1	Finland, FRG, Japan, Spain, Sweden, Switzerland, UK, US
China	1	1	France
Denmark	1	1	US
Finland	1	1	Canada, FRG, Japan, Spain, Sweden, Switzerland, UK, US
Israel	1	1	France, US
Sweden	1	1	Canada, Finland, FRG, Japan, Spain, Switzerland, UK, US
Venezuela	1	1	US

papers in the Bibliography. I would like to encourage our Soviet colleagues to continue publishing in English and to participate more fully in the international scholarly community; English has become the undisputed *lingua franca* of science.

Table 5 lists the 29 journals that published the 108 papers listed in the Bibliography. A majority of the articles were published by the same three journals that have dominated our studies for the last three years. With 26 articles, the *Physical Review Letters* published the greatest number of papers in the Bibliography (over 24 percent), while *Physics Letters B* had 22 papers (over 20 percent), and *Nuclear Physics B* accounted for 12 papers (over 11 percent). The four papers from the *Review of Modern Physics* include a contribution by C.G. Wohl and 22 colleagues, Berkeley Particle Data Group, University of California, that was published in a special supplement to the journal. It up-

Table 5: The 29 journals represented in the list of 1984 physical-sciences papers most cited in the *SCI®*, 1984-1985. The numbers in parentheses are the 1984 impact factors for the journals. (The 1984 impact factor equals the number of 1984 citations received by the 1982-1983 articles in a journal divided by the number of articles published by the journal during that same period.) Data were taken from the *JCR®*. The figures at the right indicate the number of papers from each journal that appear in the list.

Journal	Number of Papers
Phys. Rev. Lett. (6.50)	26
Phys. Lett. B (4.47)	22
Nucl. Phys. B (5.04)	12
Phys. Rev. B (3.13)	8
Astrophys. J. (4.24)	5
Rev. Mod. Phys. (16.33)	4
Appl. Phys. Lett. (2.94)	3
Nature (10.25)	3
J. Appl. Phys. (1.64)	2
J. Phys.—A—Math. Gen. (2.38)	2
Phys. Rep.—Rev. Sect. Phys. Lett. (7.06)	2
Phys. Rev. D (2.60)	2
Astrophys. J. Suppl. Ser. (3.66)	1
Bull. Amer. Phys. Soc. (—)	1
Commun. Math. Phys. (2.27)	1
Geophys. Res. Lett. (2.09)	1
IEEE J. Quantum Electron. (2.65)	1
J. Chem. Phys. (3.00)	1
J. Geophys. Res. (2.39)	1
J. Magn. Resonance (2.69)	1
J. Phys.—Paris (1.12)	1
J. Statist. Phys. (1.84)	1
Nucl. Phys. A (2.52)	1
*Pisma Zh. Eksp. Teor. Fiz. (1.30)	1
Proc. Nat. Acad. Sci. USA (8.93)	1
Rep. Progr. Phys. (6.92)	1
Solid State Commun. (1.76)	1
Surface Sci. (3.28)	1
Z. Phys. B—Condens. Matter (1.95)	1

*translated in JETP Lett.—Engl. Tr. (1.10)

dates a 1982 review of the properties of leptons, mesons, and baryons.[14]

It is also noteworthy that the *Bulletin of the American Physical Society*, an abstract journal, had one document in the Bibliography. It is remarkable that an abstract received enough citations (42) to be included in this study. Written by C.M. Varma, AT&T Bell Laboratories, Murray Hill, it promises a discussion of several experiments that can be used to distinguish a triplet from a singlet superconductor. Varma published the results of one of these experiments with D.J. Bishop, B. Batlogg, and E. Bucher, AT&T Bell Laboratories, and Fisk and Smith. Entitled "Ultrasonic attenuation in UPt_3," it was cited 49 times in 1984 and 1985 and thus appears in this study's Bibliography. A paper on heavy fermions that Varma wrote in 1985 also grew out of the ideas mentioned in his abstract.[15]

Nuclear Winter and Extinction

A controversial topic discussed in a paper in the 1983 study is also the subject of a paper in the 1984 study. This topic, the concept of "nuclear winter," was introduced in the now-famous TTAPS paper, which derives its acronym from the first letters of the surnames of its coauthors (R.P. *T*urco, O.B. *T*oon, T.P. *A*ckerman, J.B. *P*ollack, and Carl *S*agan). It presented one-dimensional calculations of the atmospheric effects of a massive nuclear exchange.[16] In the 1984 study, Curt Covey, Stephen H. Schneider, and Starley L. Thompson, National Center for Atmospheric Research, Boulder, Colorado, expand on the implications of the TTAPS paper and report three-dimensional calculations of regional and global climatic effects of smoke generated by a large-scale nuclear war. This is an extremely important area of interest for atmospheric scientists and might well appear in our most-cited lists for some time to come.

A controversial theory presented in a paper in this study attempts to explain why so many animal and plant species have died out over the past 250 million years in a series of distinct, periodic episodes or "events." The theory was first proposed in the late 1970s by A.G. Fischer and M.A. Arthur, Department of Geological and Geophysical Sciences, Princeton,[17,18] and has received support from a paper in the 1984 Bibliography by D.M. Raup and J.J. Sepkoski, University of Chicago, Illinois. Fischer and Arthur's theory challenged the characterization of extinction as a gradual, continuous process caused by relatively mild increases in environmental stress and replaced it with the idea of a relatively abrupt event caused by special periods of high stress, interspersed with long periods of virtually no stress. However, they based their conclusions on limited data and did no statistical tests. Raup and Sepkoski tested the Fischer-Arthur model by sampling the record of marine extinctions of vertebrates, invertebrates, and protozoans from the late Permian era to the Holocene, or Recent, era. Their results support the view that extinctions occur in a cycle of 26 million years.

Astronomy and the Earth Sciences

The Bibliography of the 1984 most-cited physical-sciences papers is heavily slanted toward high-energy physics, theoretical physics, and materials science. These are all relatively large, fast-moving areas whose impact is disproportionate when citation data are not adjusted for the size of a given field. Articles in certain smaller fields, including astronomy, the earth sciences, and botany, often do not achieve the citation threshold of our annual studies. And even larger disciplines, such as chemistry, do not reach these thresholds for several years. For that reason, our studies of highly cited chemistry articles, for example, are based on three years of data rather than two.

Let me call attention to some papers from a few of the smaller fields. In astronomy, the structure and properties of galaxies were the subjects of intense research activity. For example, Mitchell C. Begelman, Joint Institute for Laboratory Astrophysics, University of Colorado, and the National Bureau of Standards, Boulder, and colleagues authored a paper on radio waves emanating from distant galaxies with extremely compact centers. These centers, referred to as nuclei, are more luminous than the combined light of a thousand normal galaxies. Galaxies with such peculiar nuclei may be called quasars, Seyfert galaxies, radio galaxies, BL Lac objects, or other designations, depending on their structure and behavior. The paper by Begelman and colleagues explains how to use observations of these galactic centers to make assumptions about the pressures, densities, and velocities of the materials composing them. The authors base their theory of the origins and development of these galactic nuclei on the jets of plasma the nuclei spew out for vast distances.

The earth sciences are represented by several papers in addition to those on periodic extinctions and nuclear winter. These include a study of the structure and evolution of Tibet and the northern Himalaya mountains, by C.J. Allègre, Institute of Earth Physics, Paris University, and colleagues, and a description of the structure and behavior of part of the earth's magnetic field, by E.W. Hones, Los Alamos National Laboratory, and colleagues. A separate study of highly cited papers in the earth sciences is being planned.

Conclusion

It is worth reiterating how frustrating it is to limit these listings to a few hundred papers each year. Out of the hundreds of thousands of papers published in 1984, surely even one-fourth of one percent deserve mention. While we have little difficulty identifying the preliminary list of the top 1,000 or so, checking the accuracy of our data is not a trivial consideration. Lack of space is another problem. However, the advent of *The Scientist*™—ISI®'s newspaper for science professionals[19,20]—makes it possible to contemplate biweekly, abbreviated listings taken directly from our computer tapes. Your reaction to this possibility would be of interest.

* * * * *

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