Essays of an Information Scientist, Vol:4, p.155, 1979-80
Current Contents, #20, p.18, May 14, 1979

Current Comments

Most-Cited Articles of the 1960s. 1. Physical Sciences

Number 21 May 21, 1979

In 1977 I completed a series of essays on the most-cited articles published in the 1930s, 1940s, and 1950s.[1-3] There were so many highly cited papers in the 1950s that we divided the study into three parts. To continue the series for the 1960s I've taken a similar approach. However, to accommodate the even larger number of papers, I've included 100 papers for each group. In this first part, the 100 most-cited physical sciences papers of the 1960s are covered. The most-cited papers in biomedicine and biochemistry will be covered in two essays in the near future.

We extracted these lists from the *Science Citation Index®* (*SCI®*) data base covering 1961 to 1978. Obviously the papers listed in this series are but a small fraction of those that were published or cited. The *SCI* from 1961-78 contains 71 million citations to authored items.[4] Of these, about 25% were citations to papers published in the 1960s. The *SCI Source Index* alone indexed 1,981,441 papers from 1961-69. Between 1961-78 hundreds of other papers were heavily cited. In fact, 409 were cited over 4000 times, 852 were cited over 3000 times, and 2058 were cited over 2000 times.

I want to stress again that citation frequency is not an absolute measure of importance or significance. While some readers may be in a position to say that some papers listed here made a greater contribution than others, this is not the purpose of our study. However, we can assert with reasonable confidence that each paper listed has had a significant impact or reflects an active area of interest to science. Small differences in citation frequency have no special significance. Large differences usually reflect activity rather than the intrinsic worth of the method or theory cited. To underscore this point I have listed the papers by subject and then alphabetically by first author, rather than by ranking them according to the number of citations.

Each item on the list was cited more than 500 times during the 18-year period from 1961 to 1978. Fifteen articles were cited more than 1000 times and six more than 1500 times. The average paper on the list received 839 citations.

The papers were published in 41 journals. Five account for exactly half of the 100 articles. *Journal of Chemical Physics* and *Physical Review* both published 13 articles. *Acta Crystallographica* published ten, *Journal of the American Chemical Society* nine, and *Physical Review Letters*, five. These journals consistently publish a significant number of highly cited papers. Table 1 lists all the journals represented in the study.

Fifty-five papers on the list have two or more authors. Thirty-eight papers have two, ten have three, three have four, three have five, and one paper has ten authors.

All 100 papers, except two, were originally written in English. The papers by Zubarev and Faddeev were written

Table 1: Journals that published the most-cited 1960's articles listed in Figure 1, according to number of articles.

Journal	Number of Articles
J. Chem. Phys.	13
Phys. Rev.	13
Acta. Crystallogr.	10
J. Amer. Chem. Soc.	9
Phys. Rev. Lett.	5
Nucl. Phys.	4
Rev. Mod. Phys.	4
Anal. Chem.	3
J. Geophys. Res.	3
Nuovo Cimento	3
Ann. Phys.	2
J. Phys. Chem.	2
Phys. Rev. A.	2
Prog. Theor. Phys.	2
Advan. Phys.	1
Angew. Chem.	1
Annu. Rev. Astron. Astrophys.	1
Can. J. Chem.	1
Chem. Rev.	1
Comput. J.	1
IBM J. Res. Develop.	1
Inorg. Chem.	1
J. Chem. Soc. A	1
J. Appl. Phys.	1
J. Exp. Theoret. Phys. (USSR)	1
J. Petrol.	1
J. Soc. Ind. Appl. Math.	1
Math Comput.	1
Mol. Phys.	1
Nature	1
Nucl. Data	1
Physics	1
Phys. Lett.	1
P. Roy. Soc. Lond. A	1
Quart. Rev.	1
Rep. Prog. Phys.	1
Rev. Pure Appl. Chem.	1
Sov. Phys. JETP.*	1
Sov. Phys. Usp.**	1
Spectrochim. Acta	1
Usp. Fiz. Nauk.	1

*translation of *J. Exp. Theoret. Phys. (USSR)* article.
**translation of *Usp. Fiz. Nauk.* article.

in Russian, but also appeared in translated versions.

Sixty institutions are represented on the list (shown in Table 2). Forty-seven of the authors come from just seven institutions.

American laboratories dominate the list with 36 of the 60 research institutions. The United Kingdom follows with ten. France is represented by three institutions; Australia, Japan and the Netherlands by two each. The Federal Republic of Germany, Italy, Norway, Sweden, Switzerland, and the USSR are represented by one each.

Twelve authors contributed two or more papers to the list. Pople authored six papers and Gell-Mann five. Four of Pople's papers are from a five-part series on molecular orbital theory published in *Journal of Chemical Physics.* Bjorken, Cromer, Segal, Weinberg, and Woodward account for three papers each. Clementi, Hoffmann, LePichon, and Scheraga each wrote two papers.

Nemethy and Scheraga co-authored a four-part series on the structure of water and hydrophobic bonding in proteins. Parts 1, 2 and 4 were published in *Journal of Chemical Physics.* Part 3 was published in *Journal of Physical Chemistry,* since it was presented at the Colloid Symposium of the American Chemical Society. Most of the papers presented at the symposium were subsequently published in *Journal of Physical Chemistry* or *Journal of Colloid Science.*[5]

Six Nobel laureates authored twelve of the articles listed. W.E. Lamb was awarded the prize for physics in 1955 for his research on the hydrogen spectrum. The 1965 prize for physics went to R. P. Feynman for his research on quantum electrodynamics of elementary particles. M. Gell-Mann received the 1969 physics prize for describing the structure of the particles of high energy physics. The 1977 prize for physics went to P. W. Anderson for his work in solid-state physics. R. B. Woodward received the 1965 prize in chemistry for developing methods for the synthesis of complex organic compounds. The 1973 chemistry prize was awarded to G. Wilkinson for his research on organometallic compounds.

Most laureates were awarded their prizes several years after their most-cited articles were published. However, there are two notable exceptions. Feynman received the prize in 1965. His

Table 2: Institutional affiliations of authors of the most-cited 1960s articles, according to number of authors.

Institutions		Number of Authors
Carnegie-Mellon Univ. (Pittsburgh, PA)		14
Univ. California		10
Berkeley	4	
La Jolla	1	
Los Alamos, NM	3	
Los Angeles	2	
California Inst. Technol. (Pasadena, CA)		6
Columbia Univ.		6
New York, NY	2	
Palisades, NY	4	
Cornell Univ. (Ithaca, NY)		6
Harvard Univ. (Cambridge, MA)		6
Bell Telephone Labs.		4
Murray Hill, NJ	3	
Whippany, NJ	1	
IBM Corp.		4
San Jose, CA	3	
Yorktown Heights, NY	1	
Stanford Univ. (Stanford, CA)		4
CERN (Switzerland)		3
Massachusetts Inst. Technol. (Cambridge, MA)		3
Northwestern Univ. (Evanston, IL)		3
Univ. London (Imperial; Westfield; and University Colleges), England		3
Univ. Minnesota (Minneapolis, MN)		3
Acad. Sci. USSR (USSR)		2
Atom. Energy Res. Est. (England)		2
E. I. DuPont de Nemours & Co., Inc. (Wilmington, DE)		2
Ecole Normale Superieure (France)		2
Oak Ridge Nat. Lab. (Oak Ridge, TN)		2
Princeton Univ. (Princeton, NJ)		2
Univ. Sydney (Australia)		2
Univ. Washington (Seattle, WA)		2
Argonne Nat. Lab. (Lemont, IL)		1
Brookhaven Nat. Lab. (Upton, NY)		1
Carnegie Inst. (Washington, DC)		1
Coll. France (Paris, France)		1
Duke Univ. (Durham, NC)		1
Electro-Techn. Lab. (Japan)		1
Faculte des Sciences (Orsay, France)		1
Inst. Kern Phys. (Amsterdam)		1
Kyoto Univ. (Japan)		1
Lockheed Missiles & Space Co. (Sunnyvale, CA)		1
Max Planck Inst. (FRG)		1
Nat. Bureau Standards (Washington, DC)		1
RCA Labs. (Princeton, NJ)		1
Rijks Univ. (Netherlands)		1
Rockefeller Univ. (New York, NY)		1
Royal Radar Est. (England)		1
Shell Dev. Co. (Emeryville, CA)		1
Univ. Arizona (Tucson, AZ)		1
Univ. Bergen (Norway)		1
Univ. Cambridge (England)		1
Univ. Chicago (Chicago, IL)		1
Univ. Cincinnati (Cincinnati, OH)		1
Univ. Coll. of Wales (Aberystwyth, Wales)		1
Univ. Illinois (Urbana, IL)		1
Univ. Leeds (England)		1
Univ. Melbourne (Australia)		1
Univ. Oxford (England)		1
Univ. Rochester (Rochester, NY)		1
Univ. Texas (Austin, TX)		1
Univ. Torino (Italy)		1
Univ. Uppsala (Sweden)		1
Univ. Wisconsin (Madison, WI)		1
US Naval Res. Lab. (Washington, DC)		1
Veteran's Administration Hosp. (Durham, NC)		1
Western Reserve Univ. (Cleveland, OH)		1
Yale Univ. (New Haven, CT)		1

most-cited paper was published in 1969. He also appeared on our list of most-cited physical sciences papers of the 1950s.[1]

Lamb received the award in 1955, but his most-cited paper was published in 1964. Columbia University sociologist Harriet Zuckerman points out that laureates are highly cited not only in the years before receiving the prize, but they continue to make significant contributions to science in the years following.[6]

Five of the articles have appeared as *Citation Classics* in *Current Contents*® . In this weekly feature, authors comment on their research and interpret why it attracted so much attention. The reference to each *Citation Classic* follows the full bibliographic data in the list.

We have divided the list into twelve physical sciences categories: high energy particle physics, nuclear physics, atomic physics, molecular physics, solid-state physics, geophysics, statistical physics, astrophysics, organic chemistry, inorganic chemistry, physical chemistry, and applied mathematics.

Sixteen papers are on high energy particle physics. High energy particle physics is the study of fundamental units of matter of subatomic size. Many of the particles discussed in articles on this list are "unstable"; that is, they do not exist naturally as particles for long.

These particles—mesons, baryons, leptons, and pions, for example—can be observed only through the use of high speed scattering experiments that convert them from radiation to particles. Seven papers in the elementary particles group describe such scattering experiments. The rest propose models to explain the existence of these particles.

Eleven papers are on nuclear physics, the study of the interaction of the constituents of the nucleus in an atom. By examining these interactions, nuclear physicists hope to understand nuclear forces and reactions.

The various structural properties of the nucleus, such as spin, mass, energy, and reaction threshold, are determined through nuclear scattering experiments. Six nuclear physics papers discuss different applications of these scattering experiments. Three more papers deal with determining the energy levels of nuclei with different atomic numbers. Physicists can learn more about how nuclear reactions vary by comparing the energy levels of different nuclei. One article discusses a unified theory of nuclear reactions.

The remaining article in the nuclear physics group presents an updated table of atomic masses. It is important for physicists to calculate exact values for atomic mass because nuclear reaction energies and rates are determined from these values.

Twelve papers are on atomic physics. Atomic physics describes the physical properties of atoms in terms of the interaction between electrons and the nucleus. Atomic physics also describes the behavior of light and X-rays. Research in atomic physics contributed to the development of navigation and collision-control systems as well as radiologic equipment.

Scientists determine the structure of the atom through X-ray and electron scattering experiments. Eight papers in the atomic physics category describe these experiments. According to Harold Hanson of the University of Florida, X-ray scattering experiments are important because they "provide data, coefficients, parameters, etc., which are fundamental to a great number of experiments or studies.... The atomic scattering factors have utility for a much wider group of investigators [than quantum theorists alone], viz., X-ray crystallographers, electron diffractionists, and even high-energy theorists."[7]

In fact, the four most-cited articles on the list discuss X-ray scattering experiments. Stewart's paper specifically describes X-ray scattering for the hydrogen atom. Stewart says his paper is highly cited because "it contains a table of X-ray scattering factors... [that] has been incorporated in most standard X-ray crystallography computer packages and generates an 'automatic' citation each time a new crystal structure containing a hydrogen atom is solved."[8] Cromer authored three papers on the computation of X-ray scattering results. These four papers received a total of 10,308 citations. They account for 60% of all citations in atomic physics.

The other four atomic physics articles describe optical masers, self-consistent equations for a gas of electrons, open shell electron systems, and radiation fields.

Twelve papers are on solid-state physics, the study of the properties of metals, semiconductors, and other solids in terms of their atomic and electronic structure. From the structure of these materials, scientists can explain their electrical, magnetic, and conductive properties. This knowledge has contributed to developments in the radar, communications, and computer industries.

The molecular structure of crystals is determined by passing a beam of X-rays through a thin sheet of material, producing a patterned shadow on a photographic plate. The pattern of the shadow reveals the shape, size, and orientation of atoms in the sheet. Eight papers on the list discuss this X-ray diffraction technique in crystallography.

Three papers deal with the physical properties of magnetic metals and alloys. One paper discusses the temperatures below which metals and alloys lose all electrical resistance and become "superconductive."

Eighteen articles are on molecular physics. Molecular physics examines the bonding between atoms in a molecule. This research enables chemists and medical specialists to identify unknown molecular compounds and predict their reactivity and stability.

Researchers determine the identity of unknown compounds from nuclear magnetic resonance (NMR) and electron spin resonance (ESR) spectra. A series of peaks is registered on a recording graph when a compound absorbs magnetic and radio waves. Each peak identifies one of the atoms as a specific element within the particular molecular environment. Seven articles on the list deal with NMR and ESR analysis of molecular compounds.

Seven more molecular physics articles discuss molecular orbital theory. This theory defines the electronic structure of molecules and compounds. Researchers can predict the chemical behavior of a compound on the basis of its electronic structure. The four remaining articles cover a variety of topics, including atomic screening constants, Hückel theory, and atomic and molecular wave functions.

Four papers are on geophysics. They all discuss continental drift and seafloor spread—plate tectonics. Preston Cloud asserts that plate tectonics "seems well on its way to becoming to geology what relativity has been to physics, what atomic theory has been to chemistry, and what molecular biology has been to genetics—a general field theory within which a great number of seemingly unrelated phenomena can be coordinated and explained."[9]

Three papers are on applied mathematics. They deal with algorithms for computing Fourier series and least-squares of nonlinear parameters. Both are important for the calculation of scattering experiment results.

One paper is on astrophysics. The paper discusses astronomical measurements in the infrared spectrum. Astrophysicists calculate the distance, velocity, and composition of stars and galaxies from the radiation they emit.

Two papers are on statistical physics. Statistical physics computes physical properties from the mathematical behavior of large groups of atoms and molecules. The two papers discuss double-time Green functions and Brownian motion.

Nine papers are on organic chemistry. Two of them describe the bonding and synthesis of peptides and proteins. Three others deal with the synthesis and reaction of fatty acids, carbonyl compounds, and saturated ketones. One paper deals with the machine computation of molecular geometry. Other topics include stereochemistry, orbital symmetry and NMR shifts in polar molecules.

Four papers are on inorganic chemistry. Each paper deals with a separate topic, including metal-nitrogen bonds, acids and bases, and the properties of anions in solution.

Eight papers fall in the physical chemistry category. Two papers discuss thermodynamic properties of water and protein bonds. One deals with electronegativity. Other subjects include equilibrium critical phenomena, electrode polarography, and bond dissociation energies.

In the near future I will continue this study by taking a look at the most-cited life sciences articles of the 1960s.

As with all other studies in which we select papers by absolute citation frequency, we ignore many important papers and fields. It would be ridiculous to suggest that only one paper in astrophysics is worthy of mention. To work out an adequate system of classification to cover all disciplines or research areas is not a trivial task. Is it more important to list yet another highly cited paper in

particle physics or should we concentrate on fields that produce fewer but possibly more important papers? We can call attention to such work by looking for the most-cited papers in given journals, fields, clusters or whatever. The subjectivity of such selections need not be criticized so long as we are aware that they are indeed subjective.

REFERENCES

1. **Garfield E.** Highly cited articles. 38. Physics and chemistry papers published in the 1950s. *Current Contents* (23):5-9, 6 June 1977.
2. ----------. Highly cited articles. 39. Biochemistry papers published in the 1950s. *Current Contents* (25):5-12, 10 June 1977.
3. ----------. Highly cited articles. 40. Biomedical and behavioral papers published in the 1950s. *Current Contents* (29):5-12, 18 July 1977.
4. *Science Citation Index*. Guide and journal list. 1978 annual. Philadelphia: ISI Press. In press.
5. **Nemethy G.** Personal communication. 19 April 1979.
6. **Zuckerman H.** *Scientific elite: Nobel laureates in the United States.* New York: Free Press, 1977. 335 p.
7. **Hanson H P.** *Citation Classics*. HFS atomic scattering factors. *Current Contents* (30):16, 25 July 1977.
8. **Stewart R F.** *Citation Classics*. Coherent X-ray scattering for the hydrogen atom in the hydrogen molecule. *Current Contents* (48):15, 28 November 1977.
9. **Cloud P.** *Cosmos, earth and man*. New Haven: Yale University Press, 1978. 372 p.

Figure 1: 100 most-cited articles of the 1960s in the physical sciences. Authors' affiliations follow each citation. If an article has appeared as a *Citation Classic*, a reference follows the author affiliations.

Total Citations 1961-1978*	Bibliographic Data
HIGH ENERGY PHYSICS	
580	Amati D[1], Stanghellini A[1] & Fubini S[1,2]. **Theory of high-energy scattering and multiple production.** *Nuovo Cimento* 26:896-954, 1962. (1) CERN, Geneva, Switzerland. (2) Univ. Torino, Ist. Fisica, Torino, Italy.
558	Bjorken J D. **Applications of the chiral $U(6)xU(6)$ algebra of current densities.** *Phys. Rev.* 148:1467-78, 1966. Stanford Univ., Stanford Linear Accelerator Ctr., Stanford, CA 94305.
622	Bjorken J D. **Asymptotic sum rules at infinite momentum.** *Phys. Rev.* 179:1547-53, 1969. Stanford Univ., Stanford Linear Accelerator Ctr., Stanford, CA 94305.
560	Bjorken J D & Paschos E A. **Inelastic electron-proton and α-proton scattering and the structure of the nucleon.** *Phys. Rev.* 185:1975-82, 1969. Stanford Univ., Stanford Linear Accelerator Ctr., Stanford, CA 94305.
675	Cabibbo N. **Unitary symmetry and leptonic decays.** *Phys. Rev. Lett.* 10:531-3, 1963. CERN, Geneva, Switzerland.
504	Chew G F & Mandelstam S. **Theory of the low-energy pion-pion interaction.** *Phys. Rev.* 119:467-77, 1960. Univ. Calif., Lawrence Radiat. Lab. & Dept. Phys., Berkeley, CA 94720.
825	Feynman R P. **Very high-energy collisions of hadrons.** *Phys. Rev. Lett.* 23:1415-7, 1969. California Inst. Technol., Pasadena, CA 91109.
700	Gell-Mann M[1,2] & Levy M[1,3]. **The axial vector current in beta decay.** *Nuovo Cimento* 16:705-26, 1960. (1) Ecole Normale Superieure, Paris, France. (2) Coll. France, Paris, France (3) Faculte Sci., Orsay, France.
624	Gell-Mann M[1], Oakes R J[2] & Renner B[1]. **Behavior of current divergences under $SU_3 \times SU_3$.** *Phys. Rev.* 175:2195-9, 1968. (1) California Inst. Technol., Pasadena, CA 91109. (2) Northwestern Univ., Evanston, IL 60201.
679	Gell-Mann M. **A schematic model of baryons and mesons.** *Phys. Lett.* 8:214-5, 1964. California Inst. Technol., Pasadena, CA 91109.
716	Gell-Mann M. **The symmetry group of vector and axial vector currents.** *Physics* 1:63-75, 1964. California Inst. Technol., Pasadena, CA 91109.

*or date of publication to 1978

1453 Gell-Mann M. **Symmetries of baryons and mesons.** *Phys. Rev.* 125:1067-84, 1962.
California Inst. Technol., Pasadena, CA 91109.

862 Veneziano G. **Construction of a crossing-symmetric, Regge-behaved amplitude for linearly rising trajectories.** *Nuovo Cimento* 57:190-7, 1968.
CERN, Geneva, Switzerland.

1256 Weinberg S. **A model of leptons.** *Phys. Rev. Lett.* 19:1264-6, 1967.
MIT, Phys. Dept., Lab. Nuclear Sci., Cambridge, MA 02139.

675 Weinberg S. **Pion scattering lengths.** *Phys. Rev. Lett.* 17:616-21, 1966.
Univ. California, Dept. Phys., Berkeley, CA 94720.

514 Weinberg S. **Precise relations between the spectra of vector and axial-vector mesons.** *Phys. Rev. Lett.* 18:507-9, 1967.
Univ. Calif., Dept. Phys., Berkeley, CA 94720.

NUCLEAR PHYSICS

626 Becchetti F D & Greenlees G W. **Nucleon-nucleus optical-model parameters, $A > 40$, $E < 50$ MeV.** *Phys. Rev.* 182:1190-1209, 1969.
Univ. Minnesota, Sch. Phys., Minneapolis, MN 55455

828 Endt P M & van der Leun C. **Energy levels of $Z = 11$-21 nuclei. 4.** *Nucl. Phys. A* 105:1-488, 1967.
Rijksuniv., Fysisch Lab., Bijlhouwerstraat G, Utrecht, Netherlands.

683 Feshbach H. **A unified theory of nuclear reactions. 2.** *Ann. Phys.* New York 19:287-313, 1962.
MIT, Dept. Phys., Lab. Nuclear Sci., Cambridge, MA 02139.

766 Hager R S & Seltzer E C. **Internal conversion tables part 1: K-, L-, M-shell conversion coefficients for $Z = 30$ to $Z = 103$.** *Nuclear Data A* 4:1-235, 1968.
California Inst. Technol., Pasadena, CA 91109.

774 Hamada T & Johnston I D. **A potential model representation of two-nucleon data below 315 MeV.** *Nucl. Phys.* 34:382-403, 1962.
Univ. Sydney, Sch. Phys., Daily Telegraph Theoret. Dept., Sydney NSW, Australia.

970 Kisslinger L S[1] & Sorensen R A[2]. **Spherical nuclei with simple residual forces.** *Rev. Mod. Phys.* 35:853-915, 1963.
(1) Western Reserve Univ., Cleveland, OH 44106. (2) Carnegie Inst. Technol., Pittsburgh, PA 15213.

531 Kuo T T S & Brown G E. **Structure of finite nuclei and the free nucleon-nucleon interaction. An application to ^{18}O and ^{18}F.** *Nucl. Phys.* 85:40-86, 1966.
Princeton Univ., Palmer Phys. Lab., Princeton, NJ 08540.

518 Mac Farlane M H[1,2] & French J B[2]. **Stripping reactions and the structure of light and intermediate nuclei.** *Rev. Mod. Phys.* 32:567-691, 1960.
(1) Argonne Nat. Lab., Lemont, IL 60439. (2) Univ. Rochester, Rochester, NY 14627.

682 Mattauch J H E[1], Thiele W[1] & Wapstra A H. **1964 atomic mass table.** *Nucl. Phys.* 67:1-31, 1965.
(1) Max-Planck-Inst. Chem., Otto-Hahn-Inst., Mainz, FRG. (2) Inst. Kernphys. Onderzoek, Amsterdam.

892 Perey F G. **Optical-model analysis of proton elastic scattering in the range of 9 to 22 MeV.** *Phys. Rev.* 131:745-63, 1963.
Oak Ridge Nat. Lab., Oak Ridge, TN 37830.

689 Reid R V. **Local phenomenological nucleon-nucleon potentials.** *Ann. Phys.* 50:411-43, 1968.
MIT, Lab. Nuclear Sci., Phys. Dept., Cambridge, MA 02139 and Cornell Univ., Phys. Dept., Ithaca, NY 14850.

ATOMIC PHYSICS

2062 Cromer D T. **Anomalous dispersion corrections computed from self-consistent field relativistic Dirac-Slater wave functions.** *Acta Crystallogr.* 18:17-23, 1965.
Univ. California, Los Alamos Scientif. Lab., Los Alamos, NM 81544.

2719 Cromer D T & Waber J T. **Scattering factors computed from relativistic Dirac-Slater wave functions.** *Acta Crystallogr.* 18:104-9, 1965.
Univ. California, Los Alamos Scientif. Lab., Los Alamos, NM 81544.

1845 Cromer D T & Mann J B. **X-ray scattering factors computed from numerical Hartree-Fock wave functions.** *Acta Crystallogr.* A24:321-4, 1968.
Univ. California, Los Alamos Scientif. Lab., Los Alamos, NM 81544.

744 Doyle P A & Turner P S. **Relativistic Hartree-Fock X-ray and electron scattering factors.** *Acta Crystallogr.* A24:390-7, 1968.
Univ. Melbourne, Sch. Phys., Melbourne, Australia.

567 Faddeev L D. **Scattering theory for a three-particle system.** *Sov. Phys. JETP* 12:1014-9, 1961. *J. Exp. Theoret. Phys.* (USSR) 39:1459-67, 1960.
Acad. Sci. USSR, Mathemat. Inst.

917 Fano U. **Effects of configuration interaction on intensities and phase shifts.** *Phys. Rev.* 124:1866-78, 1961.
Nat. Bureau Standards, Washington, DC 20234.
(Citation Classics. *Current Contents* (27):8, 4 July 1977.)

863 Glauber R J. **Coherent and incoherent states of the radiation field.** *Phys. Rev.* 131:2766-88, 1963.
Harvard Univ., Lyman Lab. Phys., Cambridge, MA 02138.

1455 Hanson H P[1], Herman F[2], Lea J D[1] & Skillman S[3]. **HFS atomic scattering factors.** *Acta Crystallogr.* 17:1040-4, 1964.
(1) Univ. Texas, Austin, TX 78712. (2) Lockheed Missiles & Space Co., Sunnyvale, CA 94088. (3) RCA Labs., Princeton, NJ 08540.
(Citation Classics. *Current Contents* (30):16, 25 July 1977.)

748 Kohn W & Sham L J. **Self-consistent equations including exchange and correlation effects.** *Phys. Rev. A* 140:1133-8, 1965.
Univ. California, LaJolla, CA 92037.

770 Lamb W E. **Theory of an optical maser.** *Phys. Rev. A* 134:1429-50, 1964.
Yale Univ., New Haven, CT 06520.

731 Roothaan C C J. **Self-consistent field theory for open shells of electronic systems.** *Rev. Mod. Phys.* 32:179-85, 1960.
Univ. Chicago, Dept. Phys., Lab. Molecular Structure & Spectra, Chicago, IL 60637.

3682 Stewart R F, Davidson E R & Simpson W T. **Coherent X-ray scattering for the hydrogen atom in the hydrogen molecule.** *J. Chem. Phys.* 42:3175-87, 1965.
Univ. Washington, Dept. Chem., Seattle, WA 98105.
(Citation Classics. *Current Contents* (48):15, 28 November 1977.)

SOLID STATE PHYSICS

1019 Anderson P W. **Localized magnetic states in metals.** *Phys. Rev.* 124:41-53, 1961.
Bell Telephone Labs., Murray Hill, NJ 07974.

562 Armstrong J A, Bloembergen N, Ducuing J & Pershan P S. **Interactions between light waves in a nonlinear dielectric.** *Phys. Rev.* 127:1918-39, 1962.
Harvard Univ., Div. Engineering & Applied Phys., Cambridge, MA 02138.

537 Busing W R & Levy H A. **The effect of thermal motion on the estimation of bond lengths from diffraction measurements.** *Acta Crystallogr.* 17:142-6, 1964.
Oak Ridge Nat. Lab., Chem. Div., Oak Ridge, TN 37830.

1279 Hamilton W C. **Significance tests on the crystallographic *R* factor.** *Acta Crystallogr.* 18:502-10, 1965.
Brookhaven Nat. Lab., Chem. Dept., Upton, NY 11973.

682 Hubbard J. **Electron correlations in narrow energy bands.** *P. Roy. Soc. Lond. Ser. A.* 276:238-57, 1963.
AERE, Theoret. Phys. Div., Harwell, Didcot, Berkshire, England.

1147 Karle J & Karle I L. **The symbolic addition procedure for phase determination for centrosymmetric and non-centrosymmetric crystals.** *Acta Crystallogr.* 21:849-59, 1966.
U.S. Naval Res. Lab., Washington, DC 20390.
(Citation Classics. *Current Contents* (17):11, 25 April 1977.)

642 Kondo J. **Resistance minimum in dilute magnetic alloys.** *Progr. Theor. Phys.* 32:37-49, 1964.
Electro-techn. Lab., Nagatacho, Chiyodaku, Tokyo, Japan.

611 Loudon R. **The Raman effect in crystals.** *Adv. Phys.* 13:423-82, 1964.
Royal Radar Establishment, Malvern, Worcestershire, England.

757 McMillan W L. **Transition temperature of strong-coupled superconductors.** *Phys. Rev.* 167:331-44, 1968.
Bell Telephone Labs., Murray Hill, NJ 07974.

640 Schomaker V[1] & Trueblood K N[2]. **On the rigid-body motion of molecules in crystals.** *Acta Crystallogr. B* 24:63-76, 1968.
(1) Univ. Washington, Dept. Chem., Seattle, WA 98105. (2) Univ. California, Dept. Chem., Los Angeles, CA 90024.

1102 Shannon R D & Prewitt C T. **Effective ionic radii in oxides and fluorides.** *Acta Crystallogr. B* 25:925-46, 1969.
E.I.Du Pont de Nemours & Co., Central Res. Dept. Exptl. Stn., Wilmington, DE 19898.

569 White D L. **Amplification of ultrasonic waves in piezoelectric semiconductors.** *J. Appl. Phys.* 33:2547-54, 1962.
Bell Telephone Labs. Inc., Whippany, NJ 07981.

MOLECULAR PHYSICS

638 Castellano S & Bothner-By A A. **Analysis of NMR spectra by least squares.** *J. Chem. Phys.* 41:3863-9, 1964.
Mellon Inst., Pittsburgh, PA 15213.

880 Clementi E. ***Ab initio* computations in atoms and molecules.** *IBM J. Res. Develop.* 9:2-19, 1965.
IBM Corp., Res. Lab., San Jose, CA 95114.

860 Clementi E & Raimondi D L. **Atomic screening constants from SCF functions.** *J. Chem. Phys.* 38:2686-9, 1963.
IBM Corp., San Jose Res. Lab., San Jose, CA 95114.

987 Fessenden R W & Schuler R H. **Electron spin resonance studies of transient alkyl radicals.** *J. Chem. Phys.* 39:2147-95, 1963.
Mellon Inst., Radiat. Res. Labs., Pittsburgh, PA 15213.

937 Hehre W J, Stewart R F & Pople J A. **Self-consistent molecular-orbital methods. 1. Use of Gaussian expansions of Slater-type atomic orbitals.** *J. Chem. Phys.* 51:2657-64, 1969.
Carnegie-Mellon Univ., Dept. Chem., Pittsburgh, PA 15213.

1754 Hoffmann R. **An extended Hückel theory. 1. Hydrocarbons.** *J. Chem. Phys.* 39:1397-1412, 1963.
Harvard Univ., Chem. Dept., Cambridge, MA 02138.

841 Huzinaga S. **Gaussian-type functions for polyatomic systems. 1.** *J. Chem. Phys.* 42:1293-1302, 1965.
IBM, San Jose Res. Lab., San Jose, CA 95114.

546 Kadanoff L P[1], Gotze W[1], Hamble N D[1], Hecht R[1], Lewis E A S[1], Palciauskas V V[1], Rayl M[1], Swift J[1], Aspnes D[2] & Kane J[3]. **Static phenomena near critical points: theory and experiment.** *Rev. Mod. Phys.* 39:395-431, 1967.
(1) Univ. Illinois, Dept. Phys. & Mat. Res. Lab., Urbana, IL 61801. (2) Brown Univ., Dept. Phys., Providence, RI 02912. (3) Cornell Univ., Lab. Atomic & Solid State Phys., Ithaca, NY 14853.

1145 Karplus M. **Vicinal proton coupling in nuclear magnetic resonance.** *J. Amer. Chem. Soc.* 85:2870-1, 1963.
Columbia Univ., IBM Watson Lab. & Dept. Chem., New York, NY 10028.

679 McLachlan A D. **Self-consistent field theory of the electron spin distribution in π-electron radicals.** *Mol. Phys.* 3:233-52, 1960.
Univ. Cambridge, Chem. Lab., Dept. Theoret. Chem., Lensfield Rd., Cambridge, England.

762 Pople J A[1,2], Santry D P[1] & Segal G A[1]. **Approximate self-consistent molecular orbital theory. 1. Invariant procedures.** *J. Chem. Phys.* 43:S129-35, 1965.
(1) Carnegie Inst. Technol., Pittsburgh, PA 15213. (2) Mellon Inst., Pittsburgh, PA 15213.

668 Pople J A[1,2] & Segal G A[1]. **Approximate self-consistent molecular orbital theory. 2. Calculations with complete neglect of differential overlap.** *J. Chem. Phys.* 43:S136-49, 1965.
(1) Carnegie Inst. Technol., Pittsburgh, PA 15213. (2) Mellon Inst., Pittsburgh, PA 15213.

1605 Pople J A[1,2] & Segal G A[1]. **Approximate self-consistent molecular orbital theory. 3. CNDO results for AB_2 and AB_3 systems.** *J. Chem. Phys.* 44:3289-96, 1966.
(1) Carnegie Inst. Technol., Pittsburgh, PA 15213. (2) Mellon Inst., Pittsburgh, PA 15213.

848 Pople J A[1,2], Beveridge D L[1] & Dobosh P A[1]. **Approximate self-consistent molecular-orbital theory. 5. Intermediate neglect of differential overlap.** *J. Chem. Phys.* 47:2026-33, 1967.
(1) Carnegie Inst. Technol., Dept. Chem., Pittsburgh, PA 15213. (2) Mellon Inst., Pittsburgh, PA 15213.

662 Pople J A[1,2] & Gordon M[1]. **Molecular orbital theory of the electronic structure of organic compounds. 1. Substituent effects and dipole moments.** *J. Amer. Chem. Soc.* 89:4253-61, 1967.
(1) Carnegie Inst. Technol., Dept. Chem., Pittsburgh, PA 15213. (2) Mellon Inst., Pittsburgh, PA 15213.

MOLECULAR PHYSICS (continued)

557 Schachtschneider J H & Snyder R G. **Vibrational analysis of the n-paraffins. 2. Normal co-ordinate calculations.** *Spectrochim. Acta* 19:117-68, 1963.
Shell Dev. Co., Emeryville, CA 94608.

538 Sternhell S. **Long-range H'-H' spin-spin coupling in nuclear magnetic resonance spectroscopy.** *Rev. Pure Appl. Chem.* 14:15-46, 1964.
Univ. Sydney, Dept. Organ. Chem., Sydney 2006, New S. Wales, Australia.

686 Swift T J & Connick R E. **NMR—relaxation mechanisms of O^{17} in aqueous solutions of paramagnetic cations and the lifetime of water molecules in the first coordination sphere.** *J. Chem. Phys.* 37:307-20, 1962.
Univ. California, Dept. Chem., Lawrence Radiat. Lab., Berkeley, CA 94720.

GEOPHYSICS

531 Heirtzler J R, Dickson G O, Herron E M, Pitman W C & LePichon X. **Marine magnetic anomalies, geomagnetic field reversals, and motions of the ocean floor and continents.** *J. Geophys. Res.* 73:2119-36, 1968.
Columbia Univ., Lamont Geolog. Observ., Palisades, NY 10964.

533 Isacks B[1], Oliver J[1] & Sykes L R[2]. **Seismology and the new global tectonics.** *J. Geophys. Res.* 73:5855-99, 1968.
(1) Columbia Univ., Lamont Geolog. Observ., Palisades, New York 10964. (2) Columbia Univ., Lamont Geolog. Observ., ESSA, Earth Sciences Labs., Palisades, NY 10964.

588 Le Pichon X. **Sea-floor spreading and continental drift.** *J. Geophys. Res.* 73:3661-97, 1968.
Columbia Univ., Lamont Geolog. Observ., Palisades, NY 10964.

611 Yoder H S & Tilley C E. **Origin of basalt magmas: an experimental study of natural and synthetic rock systems.** *J. Petrol.* 3:342-532, 1962.
Carnegie Inst. Washington, Geophys. Lab., Washington, DC 20008.

APPLIED MATHEMATICS

975 Cooley J W & Tukey J W. **An algorithm for the machine calculation of complex Fourier series.** *Math. Comput.* 19:297-301, 1965.
IBM Watson Res. Ctr., Yorktown Heights, NY 10598; Bell Telephone Labs., Murray Hill, NJ 07974; Princeton Univ., Princeton, NJ 08540.

841 Fletcher R[1] & Powell M J D[2]. **A rapidly convergent descent method for minimization.** *Comput. J.* 6:163-8, 1963.
(1) Univ. Leeds, Leeds, Yorkshire, England. (2) Atom. Energy Res. Estab., Harwell, Berkshire, England.

910 Marquardt D W. **An algorithm for least-squares estimation of nonlinear parameters.** *J. Soc. Ind. Appl. Math.* 11:431-41, 1963.
E.I. du Pont de Nemours & Co., Inc., Engineering Dept., Wilmington, DE 19801.

ASTROPHYSICS

605 Johnson H L. **Astronomical measurements in the infrared.** *Annu. Rev. Astron. Astrophys.* 4:193-206, 1966.
Univ. Arizona, Lunar & Planetary Lab., Tucson, AZ 85724.

STATISTICAL PHYSICS

699 Mori H. **Transport, collective motion, and Brownian motion.** *Progr. Theor. Phys. Kyoto* 33:423-55, 1965.
Kyoto Univ., Res. Inst. Fundamental Phys., Kyoto, Japan.

745 Zubarev D N. **Double-time Green functions in statistical physics.** *Sov. Phys. Usp.* 3:320-45, 1960. *Usp. Fiz. Nauk.* 71:71-116, 1960.
Acad. Sci. USSR, Va Steklov Math. Inst., Moscow, USSR.

ORGANIC CHEMISTRY

985 Axen R, Porath J & Ernback S. **Chemical coupling of peptides and proteins to polysaccharides by means of cyanogen halides.** *Nature* 214:1302-4, 1967.
Univ. Uppsala, Inst. Biochem., Uppsala, Sweden.

679 Buckingham A D. **Chemical shifts in the nuclear magnetic resonance spectra of molecules containing polar groups.** *Can. J. Chem.* 38:300-7, 1960.
Univ. Oxford, Inorgan. Chem. Lab., Oxford, England.

575 Hendrickson J B. **Molecular geometry. 1. Machine computation of the common rings.** *J. Amer. Chem. Soc.* 83:4537-47, 1961.
Univ. California, Dept. Chem., Los Angeles, CA 90024.

852 Merrifield R B. **Solid phase peptide synthesis. 1. The synthesis of a tetrapeptide.** *J. Amer. Chem. Soc.* 85:2149-54, 1963. Rockefeller Univ., New York, NY 10021.

529 Moffitt W, Woodward R B, Moscowitz A, Klyne W & Djerassi C. **Structure and the optical rotatory dispersion of saturated ketones.** *J. Amer. Chem. Soc.* 83:4013-18, 1961.
(1) Harvard Univ., Dept. Chem., Cambridge, MA 02138. (2) Univ. Minnesota, Sch. Chem., Minneapolis, MN 55455. (3) Univ. London, Westfield College, Dept. Chem., London, England. (4) Stanford Univ., Dept. Chem., Stanford, CA 94305.

593 Schlenk H & Gellerman J L. **Esterification of fatty acids with diazomethane on a small scale.** *Anal. Chem.* 32:1412-4, 1960. Univ. Minnesota, Hormel Inst., Austin, MN 55912.

683 Stork G, Brizzolara A, Landesman H, Szmuszkovicz J & Terrell R. **The enamine alkylation and acylation of carbonyl compounds.** *J. Amer. Chem. Soc.* 85:207-22, 1963.
Columbia Univ., Chandler Labs., New York, NY 10027.

849 Woodward R B[1] & Hoffmann R[2]. **The conservation of orbital symmetry.** *Angew. Chem. Int. Ed.* 8:781-853, 1969.
(1) Harvard Univ., Dept. Chem., Cambridge, MA 02138. (2) Cornell Univ., Dept. Chem., Ithaca, NY 14850.

622 Woodward R B & Hoffmann R. **Stereochemistry of electrocyclic reactions.** *J. Am. Chem. Soc.* 87:395-7, 1965. Harvard Univ., Dept. Chem., Cambridge, MA 02138.

INORGANIC CHEMISTRY

635 Corfield P W R, Doedens R J & Ibers J A. **Studies of metal-nitrogen multiple bonds. 1. The crystal and molecular structure of nitridodichlorotris (diethylphenylphosphine) rhenium (V), $ReNCl_2[P(C_2H_5)_2C_6H_5]_3$.** *Inorg. Chem.* 6:197-204, 1967. Northwestern Univ., Dept. Chem., Evanston, IL 60201.

665 Osborn J A, Jardine F H, Young J F & Wilkinson G. **The preparation and properties of tris (triphenylphosphine)halogenorhodium(I) and some reactions thereof including catalytic homogeneous hydrogenation of olefins and acetylenes and their derivatives.** *J. Chem. Soc. A.* A1966:1711-32, 1966.
Imperial Coll., Inorgan. Chem. Res. Labs., London, England.

672 Parker A J. **Effects of solvation on the properties of anions in dipolar aprotic solvent.** *Quart. Rev.* 16:163-87, 1962.
Univ. Bergen, Chem. Inst., Norway and Univ. College, Wm. Ramsay & R. Forster Labs., London.

PHYSICAL CHEMISTRY

795 Pearson R G. **Hard and soft acids and bases.** *J. Amer. Chem. Soc.* 85:3533-9, 1963.
Northwestern Univ., Dept. Chem., Evanston IL 50201.

657 Fisher M E. **The theory of equilibrium critical phenomena.** *Rep. Progr. Phys.* 30:615-730, 1967. Cornell Univ., Baker Lab., Ithaca, NY 14853.

596 Glasoe P K & Long F A. **Use of glass electrodes to measure acidities in deuterium oxide.** *J. Phys. Chem.* 64:188-90, 1960.
Cornell Univ., Dept. Chem., Ithaca, NY 14858.

810 Hinze J & Jaffe H H. **Electronegativity. 1. Orbital electronegativity of neutral atoms.** *J. Amer. Chem. Soc.* 84:540-6, 1962.
Univ. Cincinnati, Dept. Chem., Cincinnati, OH 45221.

533 Kerr J A. **Bond dissociation energies by kinetic methods.** *Chem. Rev.* 66:465-500, 1966.
Univ. Coll. Wales, Edward Davies Chem. Lab., Aberystwyth, UK.

662 Nemethy G & Scherage H A. **Structure of water and hydrophobic bonding in proteins. 1. A model for the thermodynamic properties of liquid water.** *J. Chem. Phys.* 36:3382-400, 1962.
Cornell Univ., Dept. Chem., Ithaca, NY 14853.
(Citation Classics. *Current Contents* (22):11, 29 May 1978.)

617 Nemethy G & Scheraga H A. **The structure of water and hydrophobic bonding in proteins. 3. The thermodynamic properties of hydrophobic bonds in proteins.** *J. Phys. Chem.* 66:1773-89, 1962.
Cornell Univ., Dept. Chem., Ithaca, NY 14853.

769 Nicholson R S & Shain I. **Theory of stationary electrode polarography. Single scan and cyclic methods applied to reversible, irreversible, and kinetic systems.** *Anal. Chem.* 36:706-23, 1964.
Univ. Wisconsin, Chem. Dept., Madison, WI 53706.

1070 Patterson M S & Greene R C. **Measurement of low energy beta-emitters in aqueous solution by liquid scintillation counting of emulsions.** *Anal. Chem.* 37:854-7, 1965.
(1) Veterans Admin. Hosp., Radioisotope Service, Durham, NC 27705. (2) Duke Univ. Sch. Med., Dept. Biochem., Durham, NC 27706.