Essays of an Information Scientist, Vol:3, p.54-60, 1977-78 Current Contents, #10, p.5-11, March 7, 1977

CURRENT COMMENTS

Highly Cited Articles. 36. Physics, Chemistry and Mathematics Papers Published in the 1940s

Number 10, March 7, 1977

Recently we published a list of the biochemical classics of the 1940s.[1] Here is a list of highly cited articles published in the 1940s in physics, physical and synthetic chemistry, and mathematics.

While the 101 articles on the list were published in 32 different journals, only six journals account for half of the articles. Twenty of the articles listed in Figure 1 were published in *Journal of Chemical Physics;* 14 in *Physical Review;* 12 in *Journal of the American Chemical Society;* and 5 articles each in *Bell System Technical Journal, Reviews of Modern Physics,* and *Transactions of the Faraday Society* (*Journal of the Chemical Society Faraday*).

Other journals which published more than one article on this list are *Proceedings of the Physical Society of London* (4 articles), *Analytical Chemistry* (3), *Journal of the Chemical Society* (3), *Journal of Physics USSR* (3), *Industrial and Engineering Chemistry Analytical Edition* (2), *Journal de Chimie Physique* (2), *Nature* (2), *Philosophical Transactions of the Royal Society A* (2), and *Proceedings of the Royal Society London A* (2). *Science* is notably absent from the list.

Most of the articles were published in English. Three were in French, two in German, and 96 in what was, as early as the 1940's, the world language of the physical sciences--English. The articles are listed alphabetically by author in Figure 2.

According to C.W. Ufford, professor emeritus of physics at the University of Pennsylvania, one-third of these articles deal with molecular and chemical structure. Eleven deal with solutions, 6 with crystals, 5 with chemical analysis, 5 with ferromagnetism, 4 with x-rays, 3 with plasmas, and 2 each with chemical bonds, dipole movement, Brownian motion, metals, and nuclear magnetic resonance. Overall, Dr. Ufford notes that the articles on the list are heavily chemical in nature.

Several of the papers on this list have amassed a remarkable number of citations. The paper by N. Bloembergen et al. (1), for example, was cited 1145 times in the period 1961-1975. It concerns nuclear magnetic resonance, a powerful tool for the study of chemical structure. Also, the paper by K. Bowden et al. (12), a methods paper in chemical preparation, was cited 1127

Figure 1. Journals that published the highly cited 1940s articles listed in Figure 2. **A** = number of articles. **B** = 1975 impact factor. (Present titles of journals are given in parentheses.)

A	B	Journal
1	1.357	Acta Crystallographica
1	— —	Acta Physicochemica URSS (disc.)
3	2.416	Analytical Chemistry
1	1.764	Annals of Mathematics
1	0.592	Annals Math. Statistics (Ann. Statistics)
1	0.641	Annalen der Physik
1	2.600	Annales de Physique
5	2.021	Bell Syst. Techn. J.
1	10.392	Chemical Reviews
1	0.465	Industr. Eng. Chem. (Chemical Technology)
2	2.416	Ind. Eng. Chem. Anal. Ed. (Analytical Chemistry)
12	4.671	J. Amer. Chem. Soc.
20	2.931	J. Chemical Physics
3	1.713	J. Chem. Soc.
2	0.780	J. Chimie Physique
1	1.881	J. Opt. Soc. America
1	2.171	J. Phys. Chemistry
3	— —	J. Physics USSR (disc.)
1	2.171	J. Phys. Colloid Chem. (J. Phys. Chemistry)
1	0.604	J. Sci. Instruments (J. Physics E Sci. Instr.)
1	0.109	Kolloid Zschr.
2	3.737	Nature
1	1.800	Philosophical Magazine
2	1.353	Phil. Trans. Roy. Soc. A
14	2.490	Physical Review
1	7.876	Proc. Nat. Acad. Sci. USA
4	1.767	Proc. Phys. Soc. London (J. Physics A, B, C, D, E, F)
2	1.737	Proc. Roy. Soc. London A
5	15.841	Rev. Mod. Physics
1	— —	Trans. Amer. Inst. Min. Engrs (Mining Engineering)
1	1.204	Trans. Electrochem. Soc. (J. Electrochem. Soc.)
5	1.720	Trans. Faraday Soc. (J. Chem. Soc. Faraday)

times in the same period. Other papers on this list with remarkable citation records include those by S. Chandrasekhar (15), J.B. Martin et al. (61), J.H. VanVleck (91)--also dealing with magnetic resonance--and A.J.C. Wilson (96).

Some of the articles listed here (numbers 8, 11, 13, 23, 27, 28, 29, 36, 37, 41, and 62) are still on the ascendency, since their citation rate in 1974 exceeds their average yearly citation rate for the years 1961-1975--and their 1975 citation rate is higher than that for 1974. It will be interesting to see if the number of citations these articles receive continues to increase in the future.

The significance of this group of articles is indicated by the fact that one fifth of them were written by Nobel Prize winners. Two fundamental papers on nuclear magnetic resonance helped F. Bloch (1) and E.M. Purcell (10), win the Nobel Prize for physics in 1952. R.P. Feynman, whose fundamental paper on quantum mechanics is on the list (27), won the Nobel Prize for physics in 1965. D. Gabor (32), who helped improve the microscope in the 1940s and later invented holography, won the Nobel for physics in 1971. W. Shockley (84), who developed the transistor, won the Nobel for physics in 1956. In recent years he has unfortunately involved himself in discussions of the genetics of intelligence. I do not agree with Shockley's theories, but I do defend at least his right to expound them.

My good friend Harold C. Urey, whose paper (90) on the thermodynamic properties of isotopic substances appears on this list, is best known for the discovery of deuterium, for which he won the Nobel Prize for chemistry in 1934. The public also knows him for his interest in the origin of the solar system. Professor Urey still serves as a member of ISI® 's board of directors.

Other Nobel winners whose names appear on this list include E.P. Wigner (7), physics in 1963; M. Calvin (13), chemistry in 1961; P. Debye (23), chemistry in 1936; L.D. Landau (25,55 and 56), physics in 1962; P.J. Flory (28), chemistry in 1974; R.S. Mulliken (65, 66, and 67), chemistry in 1966; L. Neel (68), physics in 1970; L. Onsager (70), chemistry in 1968; J. Schwinger (77), physics in 1965; and C.H. Townes (89), physics in 1964.

Of these 101 articles of the 1940s, only 30 were published in the years 1940 to 1944--6 in 1940, 8 in 1941, 9 in 1942, 2 in 1943 and 5 in 1944. The remaining 70 were published in the latter half of the decade. Six appeared in 1945, the last year of World War II. Eight were published in 1946, 11 in 1947, 24 in 1948, and 22 in 1949. This chronological distribution follows remarkably well the size of the literature during those years. An examination of the statistical data for any annual *Science Citation Index®* reflects the size of the literature for earlier years.

The data in columns D and E show the degree of current interest in the subjects represented by these papers. However, to obtain a more complete picture of what these data indicate one would have to examine the cluster maps in which these papers occur.[2]

The small number of papers in mathematics should be interpreted carefully. On average, math papers are not cited as heavily as others, because of the low average number of references in math papers.

Several of the journals in Figure 1 are no longer published or have changed title. One curiosity is the paper by L.S. Darken (21) on the interrelation of diffusion and mobility through free energy in binary metallic systems. I wonder why he published in a journal of mining engineers.

As a final personal note I was pleased to see a paper (38) by Professor Ralph Halford of Columbia University. He was one of my professors in undergraduate physical chemistry. Later when I became a graduate student, he helped me through the personal crisis that made me realize experimental physical chemistry was not my career bag.

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2. ———— . Clusters and classification. *Current Contents* No. 42, 20 October 1975, p. 354-65.

Figure 2. Highly cited articles in physics, physical and synthetic chemistry, and mathematics published in the 1940s. A = item number. **B** = total citations 1961-1975. **C** = average yearly citations 1961-1975. **D** = citations in 1974. **E** = citations in 1975. Articles are listed alphabetically by first author.

A	B	C	D	E	Bibliographic Data
1.	201	13	13	9	**Albert A, Goldacre R & Phillips J.** The strength of heterocyclic bases. **J. Chem. Soc.** p. 2240-49, 1948.
2.	347	23	31	38	**Anderson P W.** Pressure broadening in the microwave and infra-red regions. **Physical Review 76**:647-61, 1949.
3.	415	27	16	10	**Archibald W J.** A demonstration of some new methods of determining molecular weights from the data of the ultracentrifuge. **J. Phys. Coll. Chem. 51**:1204-14, 1947.
4.	256	17	24	21	**Avrami M.** Kinetics of phase change. 2. Transformation-time relations for random distribution of nuclei. **J. Chem. Physics 8**:212-24, 1940.
5.	174	11	21	16	**Avrami M.** Kinetics of phase change. 3. Granulation, phase change, and *microstructure*. **J. Chem. Physics 9**:177-84, 1941.
6.	201	13	13	10	**Bargmann V.** Irreducible unitary representations of the Lorentz group. **Annals Math. 48**:568-640, 1947.
7.	198	13	9	13	**Bargmann V & Wigner E P.** Group theoretical discussion of relativistic equations. **Proc. Nat. Acad. Sci. USA 34**:211-23, 1948.
8.	416	27	33	45	**Bates D R & Damgaard A.** The calculation of the absolute strengths of spectral lines. **Phil. Trans. Roy. Soc. A 242**:101-22, 1949.
9.	374	24	22	27	**Bloch F.** Nuclear induction. **Physical Review 70**:460-74, 1946.
10.	1145	76	72	68	**Bloembergen N, Purcell E M & Pound R V.** Relaxation effects in nuclear magnetic resonance absorption. **Physical Review 73**:679-712, 1948.
11.	203	13	19	20	**Bogolyubov N N.** On the theory of superfluity. **J. Physics USSR 11**:23-32, 1947.
12.	1127	75	45	63	**Bowden K, Heilbron I M, Jones E R H & Weedon B C L.** Researches on acetylenic compounds. 1. The preparation of acetylenic ketones by oxidation of acetylenic carbinols and glycols. **J. Chem. Soc.** p.38-45, 1946.
13.	268	17	27	37	**Calvin M & Wilson K W.** Stability of chelate compounds. **J. Amer. Chem. Soc. 67**:2003-07, 1945.
14.	195	13	20	14	**Casimir H B G & Polder D.** The influence of retardation in the London-van der Waals forces. **Physical Review 73**:360-72, 1948.
15.	876	58	97	68	**Chandrasekhar S.** Stochastic problems in physics and astronomy. **Rev. Mod. Physics 15**:1-89, 1943.
16.	595	39	48	37	**Cole D S & Cole R H.** Dispersion and absorption in dielectrics. 1. Alternating current characteristics. **J. Chem. Physics 9**:341-51, 1941.
17.	259	17	13	19	**Cottrell A H & Bilby B A.** Dislocation theory of yielding and strain ageing of iron. **Proc. Phys. Soc. London A 62**:49-62, 1949.
18.	207	13	13	24	**Coulson C A & Longuet-Higgins H C.** The electronic structure of conjugated systems. 1. General theory. **Proc. Roy. Soc. London A 191**:39-60, 1947.
19.	204	13	19	10	**Coulson C A & Moffitt W E.** The properties of certain strained hydrocarbons. **Philosophical Mag. 40**:1-35, 1949.
20.	384	25	7	7	**Cruickshank D W J.** The accuracy of electron-density maps in x-ray analysis with special reference to dibenzyl. **Acta Crystallogr. 2**:65-82, 1949.
21.	153	10	19	16	**Darken L S.** Diffusion, mobility and their interrelation through free energy in binary metallic systems. **Trans. Amer. Inst. Min. Eng. 175**:184-201, 1948.
22.	284	18	12	28	**Darken L S & Gurry R W.** The system iron-oxygen. 1. The Wustite field and related equilibria. **J. Amer. Chem. Soc. 67**:1398-1412, 1945.
23.	327	21	27	41	**Debye P.** Reaction rates in ionic solutions. **Trans. Electrochem. Soc. 82**:265-72, 1942.
24.	177	11	16	13	**Denbigh K G.** The polarisability of bonds. I. **Trans. Faraday Soc. 36**:936-48, 1940.

Figure 2 (cont.)

25.	153	10	12	19	**Derjaguin B V & Landau L.** Theory of the stability of strongly charged lyophobic sols and of the addition of strongly charged particles in solutions of electrolytes. **Acta Physicochim. URSS 14**:633-662, 1941.
26.	253	16	14	10	**Doub L & Vandenbelt J M.** The ultraviolet absorption spectra of simple unsaturated compounds. I. Mono- and p-disubstituted benzene derivatives. **J. Amer. Chem. Soc. 69**:2714-23, 1947.
27.	197	13	15	27	**Feynman R P.** Space-time approach to non-relativistic quantum mechanics. **Rev. Mod. Physics 20**:367-87, 1948.
28.	286	19	21	25	**Flory P J.** Thermodynamics of high polymer solutions. **J. Chem. Physics 10**:51-61, 1942.
29.	381	25	33	46	**Forster T.** Zwischenmolekulare Energiewanderung und Fluoreszenz (Intermolecular energy transfer and fluorescence). **Ann. Physik 2**:55-77, 1948.
30.	782	52	36	57	**Frank H S & Evans M W.** Free volume and entropy in condensed systems. 3. Entropy in binary liquid mixtures; partial molal entropy in dilute solutions; structure and thermodynamics in aqueous electrolytes. **J. Chem. Physics 13**:507, 1945.
31.	193	12	12	9	**Gabor D.** Microscopy by reconstructed wave-fronts. **Proc. Roy. Soc. London A 197**:454-87, 1949.
32.	228	15	13	12	**Gabor D.** A new microscopic principle. **Nature 161**:777-78, 1948.
33.	165	11	19	19	**Garlick G F J & Gibson A F.** The electron trap mechanism of luminescence in sulphide and silicate phosphors. **Proc. Physical Soc. 60**:574-90, 1948.
34.	178	11	19	12	**Gordy W.** A relationship between bond force constants, bond orders, bond lengths, and the electronegativities of the bonded atoms. **J. Chem. Physics 14**:305-20, 1946.
35.	399	26	26	21	**Grahame D C.** The electrical double layer theory and the theory of electrocapillarity. **Chemical Reviews 41**:441-502, 1947.
36.	299	19	22	30	**Grunwald E & Winstein S.** The correlation of solvolysis rates. **J. Amer. Chem. Soc. 70**:846-54, 1948.
37.	178	11	23	27	**Guggenheim E A.** A proposed simplification in the procedure for computing dipole movement. **Trans. Faraday Soc. 45**:714-20, 1949.
38.	266	17	13	11	**Halford R S.** Motions of molecules in condensed systems. I. Selection rules, relative intensities, and orientation effects for Raman and infra-red spectra. **J. Chem. Physics 14**:8-15, 1946.
39.	488	32	29	38	**Halverstadt I F & Kumler W D.** Solvent polarization error and its elimination in calculating dipole moments. **J. Amer. Chem. Soc. 64**:2988-92, 1942.
40.	183	12	16	5	**Herring C & Nichols M H.** Thermionic emission. **Rev. Mod. Physics 21**:185-270, 1949.
41.	326	21	25	31	**Holstein T.** Imprisonment of resonance radiation in gases. **Physical Review 72**:1212-33, 1947.
42.	333	22	19	20	**Holstein T & Primakoff B.** Field dependence of the intrinsic domain magnetization of a ferromagnet. **Physical Review 58**:1098-1113, 1940.
43.	187	12	8	9	**Hornig D F.** The vibrational spectra of molecules and complex ions in crystals. I. General theory. **J. Chem. Physics 16**:1063-76, 1948.
44.	365	24	12	12	**Huang Min Lon** A simple modification of the Wolff-Kishner reduction. **J. Amer. Chem. Soc. 68**:2487-88, 1946.
45.	215	14	20	14	**Huggins M L.** The viscosity of dilute solutions of long-chain molecules. 4. Dependence on concentration. **J. Amer. Chem. Soc. 64**:2716-18, 1942.
46.	205	13	4	9	**Johnston J P & Ogston A G.** A boundary anomaly found in the ultracentrifugal sedimentation of mixtures. **Trans. Faraday Soc. 42**:789-99, 1946.
47.	278	18	28	17	**Kellermann E W.** Theory on the vibrations of the sodium chloride lattice. **Phil. Trans. Roy. Soc. A 238**:513-48, 1940.
48.	174	11	11	13	**Kilpatrick J E, Pitzer K S & Spitzer R.** The thermodynamics and molecular structure of cyclopentane. **J. Amer. Chem. Soc. 69**:2483-88, 1947.

Figure 2 (cont.)

49.	221	14	17	13	**Kirkwood J G.** The statistical mechanical theory of transport processes. **J. Chem. Physics 14**:180-201, 1946.
50.	277	18	28	19	**Kirkwood J G & Riseman J.** The intrinsic viscosities and diffusion constants of flexible macromolecules in solution. **J. Chem. Physics 16**:565-73, 1948.
51.	253	16	13	12	**Kittel C.** Physical theory of ferromagnetic domains. **Rev. Mod. Physics 21**:541-83, 1949.
52.	162	10	11	8	**Klevens H B & Platt J R.** Spectral resemblances of cata-condensed hydrocarbons. **J. Chem. Physics 17**:470-81, 1949.
53.	164	10	13	12	**Kubelka P.** New contributions to the optics of intensely light-scattering materials. 1. **J. Optical Soc. Amer. 38**:448-57, 1948.
54.	183	12	10	13	**Kuhn W & Grün F.** Beziehungen zwischen elastischen Konstanten und Dehnungsdoppelbrechung hochelastischer Stoffe (Relation between elastic constants and stress double fracture of highly elastic substances). **Kolloid Zschr. 101**:248-71, 1942.
55.	360	24	17	20	**Landau L.** On the vibrations of the electronic plasma. **J. Physics USSR 10**:25-34, 1946.
56.	214	14	22	18	**Landau L D.** The theory of superfluity of helium III. **J. Physics USSR 5**:71-90, 1941.
57.	315	21	13	10	**Lewis G N & Kasha M.** Phosphorescence and the triplet state. **J. Amer. Chem. Soc. 66**:2100-16, 1944.
58.	247	16	10	13	**Lyddane R H, Sachs R G & Teller E.** On the polar vibrations of alkali halides. **Physical Review 59**:673-6, 1941.
59.	285	19	10	11	**Ma T S & Zuazaga G.** Micro-Kjeldahl determination of nitrogen. **Ind. Eng. Chem. Anal. Ed. 14**:280-2, 1942.
60.	277	18	23	23	**Mann H B.** On a test of whether one of two random variables is stochastically larger than the other. **Annals Math. Statistics 18**:50-60, 1947.
61.	942	62	58	67	**Martin J B & Doty D M.** Determination of inorganic phosphate modification of isobutyl alcohol procedure. **Analytical Chem. 21**:965-67, 1949.
62.	300	20	32	34	**Mayo F R & Lewis F M.** Copolymerization. 1. A basis for comparing the behavior of monomers in copolymerization; the copolymerization of *styrene and methyl methacrylate*. **J. Amer. Chem. Soc. 66**:1594-1601, 1944.
63.	375	25	25	24	**McClure D S.** Triplet-singlet transitions in organic molecules; lifetime measurements of the triplet state. **J. Chem. Physics 17**:905-13, 1949.
64.	173	11	18	7	**Meites L & Meites T.** Removal of oxygen from gas streams. **Analytical Chem. 20**:984-85, 1948.
65.	382	25	25	15	**Mulliken R S.** Quelques aspects de la theories des orbitales moleculaires (On some aspects of the molecular orbital theory). **J. Chim. Physique 46**:497-542, 1949.
66.	164	10	10	9	**Mulliken R S.** Quelques aspects de la theorie des orbitales moleculaires. (Some aspects of the molecular orbital theory). **J. Chim. Physique 46**:675-713, 1949.
67.	580	38	27	23	**Mulliken R S, Riecke C A, Orloff D & Orloff H.** Formulas and numerical tables for overlap integrals. **J. Chem. Physics 17**:1248, 1949.
68.	301	20	13	20	**Neel L.** Proprietes magnetiques des ferrites; ferrimagnetisme et antiferromagnetisme. **Annales Physique 3**:137-95, 1948.
69.	331	22	19	10	**Nelson J B & Riley D P.** An experimental investigation of extrapolation methods in the derivation of accurate unit-cell dimensions of crystals. **Proc. Physical Soc. London 57**:160-77, 1945.
70.	432	28	46	35	**Onsager L.** Crystal statistics. 1. A two-dimensional model with an order-disorder transition. **Physical Review 65**:117-49, 1944.
71.	306	20	9	18	**Pake G E.** Nuclear resonance absorption in hydrated crystals; fine structure of the proton line. **J. Chem. Physics 16**:327-36, 1948.
72.	328	21	21	15	**Platt J R.** Classification of spectra of cata-condensed hydrocarbons. **J. Chem. Physics 17**:484-95, 1949.
73.	453	30	33	24	**Racah G.** Theory of complex spectra. 2. **Physical Review 62**:438-62, 1942.
74.	337	22	21	12	**Racah G.** Theory of complex spectra. 3. **Physical Review 63**:367-82, 1943.
75.	215	16	12	10	**Racah G.** Theory of complex spectra. 4. **Physical Review 76**:1352-65, 1949.

Figure 2 (cont.)

76.	175	11	11	10	**Rachinger W A.** A correction for the $\alpha_1 \alpha_2$ double in the measurement of widths of x-ray diffraction lines. **J. Sci. Instruments 25**:254-56, 1948.
77.	187	12	8	14	**Rarita W & Schwinger J.** On a theory of particles with half-integral spin. **Physical Review 60**:61, 1941.
78.	236	15	19	12	**Redlich O & Kister A T.** Algebraic representation of thermodynamic properties and the classification of solutions. **Ind. Eng. Chem. Anal. Ed. 40**:345-56, 1948.
79.	399	26	18	20	**Rice S O.** Mathematical analysis of noise. 3. Statistical properties of random noise currents. **Bell Syst. Tech. J. 24**:46-156, 1945.
80.	410	27	17	20	**Rice S O.** Mathematical analysis of random noise. **Bell Syst. Tech. J. 23**:282-332, 1944.
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82.	501	33	33	50	**Shannon C E.** A mathematical theory of communications. **Bell Systm. Tech. J. 27**:379-423, 1948.
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84.	281	18	17	10	**Shockley W.** The theory of p-n junctions in semiconductors and p-n junction transistors. **Bell Syst. Tech. J. 28**:435-89, 1949.
85.	173	11	14	9	**Simha R.** The influence of Brownian movement on the viscosity of solutions. **J. Phys. Chem. 44**:25-34, 1940.
86.	260	17	14	19	**Stokes A R.** A numerical Fourier-analysis method for the correction of widths and shapes of lines on x-ray powder photographs. **Proc. Phys. Soc. London 61**:382-92, 1948.
87.	232	15	10	10	**Stull D R.** Vapor pressure of pure substances; organic compounds. **Ind. Eng. Chem 39**:517-40, 1947.
88.	188	12	11	11	**Szigeti B.** Polarisability and dielectric constant of ionic crystals. **Trans. Faraday Soc. 45**:155-66, 1949.
89.	288	19	26	21	**Townes C H & Dailey B P.** Determination of electronic structure of molecules from nuclear quadrapole effects. **J. Chem. Physics 17**:782-796, 1949.
90.	151	10	13	15	**Urey H C.** The thermodynamic properties of isotopic substances. **J. Chem. Soc.** p. 562-81, 1947.
91.	907	60	52	59	**Van Vleck J H.** The dipolar broadening of magnetic resonance in crystals. **Physical Review 74**:1168-83, 1948.
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95.	162	10	5	4	**Wheland G W.** A quantum mechanical investigation on the orientation of substituents in aromatic molecules. **J. Amer. Chem. Soc. 64**:900-08, 1942.
96.	824	54	65	81	**Wilson A J C.** Determination of absolute from relative x-ray intensity data. **Nature 150**:151-52, 1942.
97.	332	22	13	11	**Wilson E B.** Some mathematical methods for the study of molecular vibrations. **J. Chem. Physics 9**:76-84, 1941.
98.	434	28	26	27	**Yoe J H & Jones A L.** Colorimetric determination of iron with disodium-1,2-hydroxybenzene-3,5,-disulfonate. **Analytical Chem. 16**:111-15, 1944.
99.	348	23	30	21	**Zimm B H.** Apparatus and methods for measurement and interpretation of the angular variation of light scattering; preliminary results on polystyrene solutions. **J. Chem. Physics 16**:1099-1116, 1948.
100.	283	18	21	15	**Zimm B H.** The scattering of light and the radical distribution function of high polymer solutions. **J. Chem. Physics 16**:1093-99, 1948.
101.	197	13	16	14	**Zimm E H & Stockmayer E.** The dimensions of chain molecules containing branches and rings. **J. Chem. Physics 17**:1301-14, 1949.