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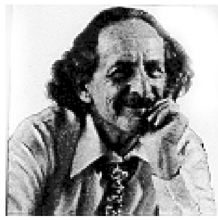

Current Comments®

Journal Citation Studies. 43. Astrosciences Journals— What They Cite and What Cites Them

Number 21 May 21, 1984

Over the years, we've published numerous studies identifying the significant journals from various fields in the sciences, social sciences, and arts and humanities. Most recently, we investigated the journals of anthropology,[1] entomology,[2] and analytical chemistry.[3] This essay examines the literature of the astronomical sciences, or "astrosciences," which are comprised of the disciplines of astronomy and astrophysics. It expands on a study we did ten years ago on the *Astrophysical Journal*.[4]

A persistent theme links each of these journal studies: the distinction between the literature *of* a field and the literature *of interest* to the scientists in that field. The literature of a field consists of the articles reporting results pertinent to that specialty. The literature of interest to researchers in a field may be another matter, however. In addition to their own specialty journals, researchers will also cite a common set of basic research journals cited by scientists in other specialties. This is what links the work of agricultural scientists, for instance, to that of other life scientists or biotechnologists.

The degree to which this is true varies from field to field. The literature of some fields is relatively narrow—that is, its authors cite papers mainly from the field's own specialized journals. An example is the dentistry literature, which we found to be relatively self-contained.[5] The literature of other fields, such as anthropology,[1] cite many diverse sources. As is shown in this essay, astronomers generally cite the same group of journals in which they publish.

The literature of the astrosciences includes not only astronomy and astrophysics, but non-optical astronomy, solar physics, and planetary science as well. Astronomy, by far the oldest science in the group, is the study of the motions, positions, and physical properties of celestial bodies. The term "astrophysics" refers to the study of the physical and chemical properties of celestial objects, including their origins and evolution. It is a relatively recent development of nineteenth- and twentieth-century astronomy. In fact, "astronomy" and "astrophysics" are often used interchangeably. Non-optical astronomy encompasses the collection and interpretation of radio frequency, gamma ray, X-ray, and infrared data, rather than the traditional type of information gathered by means of visible light. Solar physics concerns itself with the study of our sun. And with the advent of space exploration, astronomy has also grown to include planetary science, the study of the components of our solar system other than the sun, including the solid, liquid, and gaseous parts of other planets.

Table 1 lists the 25 "core" astrosciences journals used to initiate this study. Eight of the journals are published by

US organizations. Five each are published in the UK and the Netherlands. Canada, Czechoslovakia, the Federal Republic of Germany, India, Japan, and the USSR published one each. One journal, *Astronomy and Astrophysics*, may be considered a European, multinational publication.

Fourteen of these journals publish exclusively in English. The other 11 are multilingual, but English is the predominant language of four of these—*Icarus*, *Moon and the Planets*, *Solar Physics*, and *Space Science Reviews*. Incidentally, as of the first 1984 issue, *Moon and the Planets* changed its name to *Earth, Moon, and Planets*.

Table 1: Core astrosciences journals indexed by *SCI*® and the year each began publication.

Annual Review of Astronomy and Astrophysics—1963
Annual Review of Earth and Planetary Sciences—1973
Astronomical Journal—1849
*Astronomicheskii Zhurnal—1924
Astronomy and Astrophysics—1969
**Astrophysical Journal—1895
Astrophysical Letters—1967
Astrophysics and Space Science—1968
Bulletin of the Astronomical Institutes of Czechoslovakia—1947
Celestial Mechanics—1969
Geophysical and Astrophysical Fluid Dynamics—1970
Icarus—1962
Indian Journal of Radio & Space Physics—1972
Journal of the Royal Astronomical Society of Canada—1907
Monthly Notices of the Royal Astronomical Society—1827
Moon and the Planets—1969
Observatory—1877
Publications of the Astronomical Society of Japan—1949
Publications of the Astronomical Society of the Pacific—1889
Quarterly Journal of the Royal Astronomical Society—1960
Sky and Telescope—1941
Solar Physics—1967
Space Science Reviews—1962
Vistas in Astronomy—1955
Zeitschrift fur Naturforschung Teil A—Physik, Physikalische Chemie, Kosmophysik—1946

*Includes Soviet Astronomy—1957
**Includes Astrophysical Journal Supplement Series—1954

This basic or starting list of 25 journals does not include every astronomy journal published today. Nor does it include journals from other disciplines that publish research in the astrosciences. The *Journal of Geophysical Research—Space Physics* should be regarded as a core journal. Unfortunately, many scientists simply cite "*J. Geophys. Res.*," no matter which edition they are referring to. Thus, we are unable to include citation data on the *Space Physics* section of this journal, and did not treat it as a core journal. We face precisely the same problem with journals that split into several separate editions. Such journals provide nothing more than subtitles or letters to distinguish the new parts.[6] Citations to all three editions of the *Journal of Geophysical Research* have been combined for the purposes of this essay. We did the same thing in our study of the earth sciences.[7] Had we included *Journal of Geophysical Research—Space Physics* as a core journal we could at least have reported that it published over 370 items in 1982, as compared to 1,310 for *Astrophysical Journal*.

The oldest astrosciences journals covered in *Science Citation Index*® (*SCI*®) were established in the nineteenth century. They include: *Monthly Notices of the Royal Astronomical Society*, founded in England in 1827; *Astronomical Journal*, founded in 1849 by Benjamin A. Gould, and *Astrophysical Journal*, founded in 1895 by George E. Hale and James E. Keeler, which are both publications of the American Astronomical Society; *Observatory*, established by the Royal Greenwich Observatory in England in 1877; and *Publications of the Astronomical Society of the Pacific*, established in 1889 by the Astronomical Society of the Pacific, headquartered in San Francisco.

As in all our previous journal citation studies, we will consider the core journals of this field as if they comprised a single "Macro Journal of the Astrosciences." In other words, we'll pool their references to see which journals they collectively cite, and which journals cite them. Data were taken from the 1982 *Journal Citation Reports*® (*JCR*™), which is volume 14 of the 1982 *SCI*.

The 25 core journals in the astrosciences published about 4,500 articles in 1982, or about one percent of the 378,000 articles indexed in the 1982 *JCR*. Keep in mind that *JCR* does not include such items as editorials, news reports, obituaries, etc. By comparison, *Astronomy and Astrophysics Abstracts* indexed over 17,250 papers in 1982. The core journals cited 116,000 references in 1982, or about 1.5 percent of the eight million references processed by *JCR* during that year. The average 1982 astrosciences article cited 26 references, whereas the average *SCI* article cited 21.

The core astrosciences journals received 85,000 citations in 1982, or about one percent of all *JCR* citations that year. Just two journals account for over 60 percent of these citations: *Astrophysical Journal*, which received 41,500 citations, or almost half of all core citations, and *Astronomy and Astrophysics*, which received 11,200.

Table 2 lists the 50 journals that were most frequently cited by the core astrosciences journals in 1982. They are ranked in descending order by the number of citations received from the core group (column A). The table also shows the number of citations each journal received from all journals (column B), each journal's self-citations (column C), journal impacts (column G), immediacy indexes (column H), and the number of source items each journal published in 1982 (column I). Impact indicates how often, on average, an article published by a certain journal in a given two-year period was cited during a particular year. The 1982 impact in column G was arrived at by dividing the number of a journal's 1982 citations to articles published in 1980-1981 by the total number of 1980-1981 articles published by that journal. Immediacy is a measure of how often a journal's articles were cited in the same year in which they were published.

The 1982 source item counts, as well as impact and immediacy data, are unavailable for several journals in Table 2, for many reasons. Three are not yet included in *SCI*'s coverage: *Acta Astronomica*, *Bulletin of the American Astronomical Society*, and *Information Bulletin on Variable Stars*. The first two are being evaluated for future coverage. *Astronomische Nachrichten* was recently added to *SCI*'s coverage.

Memoirs of the Royal Astronomical Society ceased publication in 1978. However, articles published in it are still cited. *Zeitschrift für Astrophysik*, the *Bulletin of the Astronomical Institutes of the Netherlands*, and *Annales d'Astrophysique* merged to form *Astronomy and Astrophysics* in 1969. *Physical Review*, as it appears in Table 2, is the pre-1975 version. In that year it split into several editions, each of which now has its own separate source and citation information. In fact, *Physical Review A—General Physics* and *Physical Review D—Particles and Fields* also appear in Table 2.

The 50 journals in Table 2 received 80,000 citations from the core astrosciences journals, or almost 69 percent of all the references cited by the core group in 1982. Eighteen of the journals in Table 2 are themselves members of the core, and are indicated by asterisks. Altogether, these 18 journals received

Table 2: The 50 journals most cited by core astrosciences journals in 1982. An asterisk indicates a core journal. A = citations received from core journals. B = citations received from all journals. C = self-citations. D = percent of citations from all journals that are core journal citations (A/B). E = percent of citations from all journals that are self-citations (self-cit*ed* rate, C/B). F = percent of core citations that are self-citations (C/A). G = impact factor. H = immediacy index. I = 1982 source items.

	A	B	C	D	E	F	G	H	I
*Astrophys. J.[1]	34,526	41,464	17,544	83.3	42.3	50.8	4.07	1.20	1310
*Astron. Astrophys.	10,061	11,206	3390	89.8	30.3	33.7	2.28	.54	683
*Mon. Notic. Roy. Astron. Soc.	6965	8144	1754	85.5	21.5	25.2	2.39	.76	401
*Astron. J.	3228	3558	690	90.7	19.4	21.4	1.81	.34	199
*Sol. Phys.	2693	3341	1155	80.6	34.6	42.9	1.75	.67	212
J. Geophys. Res.	2409	25,430	—	9.5	—	—	2.84	1.02	1045
Nature	2348	110,293	—	2.1	—	—	8.75	2.10	1362
*Publ. Astron. Soc. Pac.	1713	1857	256	92.2	13.8	14.9	1.16	.27	188
*Annu. Rev. Astron. Astrophys.	1354	1711	61	79.1	3.6	4.5	11.96	1.45	20
*Astrophys. Space Sci.	1326	1814	458	73.1	25.3	34.5	.80	.34	287
*Icarus	1279	2386	672	53.6	28.2	52.5	1.92	.86	125
Science	769	70,867	—	1.1	—	—	6.81	1.73	988
*Astron. Zh. SSSR	755	1039	258	72.7	24.8	34.2	.48	.30	153
J. Chem. Phys.	569	71,173	—	.80	—	—	2.95	.63	1714
Bull. Amer. Astron. Soc.	523	647	—	80.8	—	—	—	—	—
*Publ. Astron. Soc. Jpn.	483	578	81	83.6	14.0	16.8	1.14	.44	41
*Space Sci. Rev.	456	1167	97	39.1	8.3	21.3	1.35	.78	41
Phys. Rev. Lett.	425	44,487	—	1.0	—	—	6.20	1.34	1036
*Z. Naturforsch. Teil A	411	3740	370	11.0	9.9	90.0	.88	.32	223
*Astrophys. Lett.	395	472	4	83.7	.9	1.0	1.36	.12	26
Phys. Fluids	365	5731	—	6.4	—	—	1.32	.26	339
Planet. Space Sci.	330	2303	—	14.3	—	—	1.63	.56	129
Geophys. Res. Lett.	325	3491	—	9.3	—	—	2.01	.53	341
Phys. Rev.	315	31,568	—	1.0	—	—	—	—	—
Austral. J. Phys.	313	886	—	35.3	—	—	.64	.24	63
Acta Astron.	312	357	—	87.4	—	—	—	—	—
*Celest. Mech.	304	386	211	78.8	54.7	69.4	.44	.30	104
J. Atmos. Sci.	280	6272	—	4.5	—	—	2.69	.70	234
*Bull. Astron. Inst. Czech.	278	297	140	93.6	47.1	50.4	.52	.30	53
J. Fluid Mech.	262	7094	—	3.7	—	—	1.47	.42	311
Sov. Astron. Lett.—Engl. Tr.	253	410	—	61.7	—	—	—	—	76
Z. Astrophys.	249	330	—	74.5	—	—	—	—	—
Rev. Geophys. Space Phys.	238	2028	—	11.7	—	—	4.46	.89	47
Bull. Astron. Inst. Neth.	233	254	—	91.7	—	—	—	—	—
Proc. Roy. Soc. London Ser. A	233	11,155	—	2.1	—	—	1.60	.20	164
Mem. Roy. Astron. Soc.	227	244	—	93.0	—	—	—	—	—
J. Phys.—B—At. Mol. Phys.	222	8749	—	2.5	—	—	2.89	.90	401
J. Quant. Spectrosc. Radiat.	218	1662	—	13.1	—	—	1.03	.31	121
*Observatory	213	237	16	89.9	6.8	7.5	.66	.17	29
Phys. Rev. D—Part. Fields	205	16,752	—	1.2	—	—	2.87	.65	837
Astron. Nachr.	203	232	—	87.5	—	—	—	—	—
*Moon Planets	202	394	87	51.3	22.1	43.1	1.14	.41	42
Rev. Mod. Phys.	200	6074	—	3.3	—	—	20.71	2.41	22
Phys. Scr.	194	2303	—	8.4	—	—	1.62	.30	280
Appl. Opt.	192	8262	—	2.3	—	—	1.74	.36	716
Ann. Astrophys.	184	224	—	82.1	—	—	—	—	—
J. Atmos. Terr. Phys.	184	1753	—	10.5	—	—	.98	.24	111
Phys. Rev. A—Gen. Phys.	182	16,706	—	1.1	—	—	2.58	.67	849
J. Amer. Chem. Soc.	179	111,901	—	.2	—	—	4.72	.90	1835
Inf. Bull. Variable Stars	177	177	—	100.0	—	—	—	—	—

[1] Includes Astrophys. J. Suppl. Series

about 84,000 citations in 1982, of which about 80 percent were from core citing journals. By comparison, the 32 *non*-core journals in the table received a total of about 570,000 citations, of which just two percent came from the astrosciences core group.

In general, a journal with a long history will accumulate a larger number of citations than a more recently established one, regardless of the current quality of the older journal's articles. The longer a journal has been in print, the greater the number of citable articles it has published, and, thus, the more citations it receives. Much the same type of cumulative advantage is enjoyed by newer journals that publish a large number of articles each year. The top two journals in Table 2 perhaps illustrate these points. *Astrophysical Journal* has been in print since 1895. Even though it "only" published 1,300 items in 1982, it received 41,500 citations. *Astronomy and Astrophysics* received about 11,200 citations. It was started in 1969—a difference of almost 75 years. However, it published "only" 680 items in 1982.

Table 3 lists the 50 journals that most frequently *cited* the core astrosciences

Table 3: The 50 journals which most frequently cited core astrosciences journals in 1982. An asterisk indicates a core journal. A = citations to core journals. B = citations to all journals. C = self-citations. D = percent of total citations that are core journal citations (A/B). E = percent of total citations that are self-citations (self-*citing* rate C/B). F = percent of citations to core journals that are self-citations (C/A). G = impact factor. H = immediacy index. I = 1982 source items.

	A	B	C	D	E	F	G	H	I
*Astrophys. J.[1]	27,144	40,382	17,544	67.2	43.5	64.6	4.07	1.20	1310
*Astron. Astrophys.	11,633	17,634	3390	66.0	19.2	29.1	2.28	.54	683
*Mon. Notic. Roy. Astron. Soc.	7350	10,551	1754	69.7	16.6	23.9	2.39	.76	401
*Astron. J.	3537	5168	690	68.4	13.4	19.5	1.81	.34	199
*Astrophys. Space Sci.	3279	6348	458	51.7	7.2	14.0	.80	.34	287
*Sol. Phys.	2333	4006	1155	58.2	28.8	49.5	1.75	.67	212
*Annu. Rev. Astron. Astrophys.	2227	3225	61	69.1	1.9	2.7	11.96	1.45	20
*Publ. Astron. Soc. Pac.	2145	3329	256	64.4	7.7	11.9	1.16	.27	188
Nature	1426	36,347	—	3.9	—	—	8.75	2.10	1362
*Astron. Zh. SSSR	1366	2749	258	49.7	9.4	18.9	.48	.30	153
J. Geophys. Res.	1246	30,880	—	4.0	—	—	2.84	1.02	1045
*Icarus	1184	4236	672	28.0	15.9	56.8	1.92	.86	125
*Space Sci. Rev.	819	3262	97	25.1	3.0	11.8	1.35	.78	41
Rev. Mod. Phys.	810	7313	—	11.1	—	—	20.71	2.41	22
Ann. N.Y. Acad. Sci.	587	19,644	—	3.0	—	—	1.65	.43	798
*Publ. Astron. Soc. Jpn.	528	782	81	67.5	10.4	15.3	1.14	.44	41
*Celest. Mech.	470	1228	211	38.3	17.2	44.9	.44	.30	104
*Moon Planets	416	1328	87	31.3	6.6	20.9	1.14	.41	42
*Z. Naturforsch. Teil A	408	4337	370	9.4	8.5	90.7	.88	.32	223
Sov. Astron. Lett.—Engl. Tr.	406	907	—	44.8	—	—	—	—	76
Science	398	27,145	—	1.5	—	—	6.81	1.73	988
Rev. Geophys. Space Phys.	375	5006	—	7.5	—	—	4.46	.89	47
*Vistas Astronomy	374	866	8	43.2	.9	2.1	—	—	19
J. Chem. Phys.	363	48,059	—	.8	—	—	2.95	.63	1714
*Bull. Astron. Inst. Czech.	351	906	140	38.7	15.5	39.9	.52	.30	53
*Astrophys. Lett.	296	415	4	71.3	1.0	1.4	1.36	.12	26
Phys. Rev. D—Part. Fields	291	19,806	—	1.5	—	—	2.87	.65	837
Phil. Trans. Roy. Soc. London A	287	5234	—	5.5	—	—	1.43	.17	149
Planet. Space Sci.	279	3155	—	8.8	—	—	1.63	.56	129
Phys. Rev. A—Gen. Phys.	273	19,758	—	1.4	—	—	2.58	.67	849
Geochim. Cosmochim. Acta	262	9756	—	2.7	—	—	3.06	.72	224
Rep. Progr. Phys.	261	4399	—	5.9	—	—	7.08	.48	27
Prog. Theor. Phys. Kyoto	255	7491	—	3.4	—	—	1.44	.54	294
*Quart. J. Roy. Astron. Soc.	249	909	9	27.4	1.0	3.6	1.12	.20	20
*Observatory	231	414	16	55.8	3.9	6.9	.66	.17	29
*Geophys. Astrophys. Fluid Dynam.	209	1032	34	20.3	3.3	16.3	.99	.46	57
J. Phys.—B—At. Mol. Phys.	199	10,527	—	1.9	—	—	2.89	.90	401
J. Quant. Spectrosc. Radiat.	196	2291	—	8.6	—	—	1.03	.31	121
Phys. Rep.—Rev. Sect. Phys. Lett.	188	11,682	—	1.6	—	—	6.39	.57	62
*J. Roy. Astron. Soc. Can.	186	454	40	41.0	8.8	21.5	.19	.18	28
Phys. Rev. Lett.	186	17,005	—	1.1	—	—	6.20	1.34	1036
Geophys. Res. Lett.	184	5037	—	3.7	—	—	2.01	.53	341
Nucl. Instrum. Method. Phys. Res.	181	15,520	—	1.2	—	—	1.17	.35	1058
*Annu. Rev. Earth Planet. Sci.	180	1834	8	9.8	.4	4.4	3.39	.16	19
J. Phys.—Paris	174	6332	—	2.8	—	—	1.13	.40	276
Nucl. Phys. A	147	20,385	—	.7	—	—	2.43	.89	572
Chem. Phys. Lett.	140	20,180	—	.7	—	—	2.19	.44	1110
Origins Life	139	1438	—	9.7	—	—	1.50	.35	26
Phys. Lett. A	134	9740	—	1.4	—	—	1.26	.34	837
J. Phys. Chem.	128	28,408	—	.5	—	—	2.44	.57	898

[1] Includes Astrophys. J. Suppl. Series

journals in 1982. Although these journals represent only a little over six percent of the 800 journals which cited the "Macro Journal of the Astrosciences" in 1982, they account for 90 percent of all the citations received by the core group that year. Almost half of the 50 journals in Table 3 are members of the core literature themselves, and, as in Table 2, these are indicated by asterisks. These 23 journals cited over 115,000 references in 1982, of which 58 percent were to the core literature in this study. In contrast, the non-core journals in Table 3 cited about 400,000 references, only two percent of which were to the core group.

Of the five core journals that rank highest in impact, four appear in both Tables 2 and 3. The other appears in Table 3 only. Since review journals in general have high impact, it is unsurprising to find that a review journal, the *Annual Review of Astronomy and Astrophysics*, is highest with an impact of about 12. In fact, its impact ranks fifteenth out of the 4,173 journals studied in the 1982 *JCR*. The second-ranked journal included in the core literature was *Astrophysical Journal*, with an impact of 4.1. The *Annual Review of Earth and Planetary Sciences*, which was the only one of the top five journals to appear only in Table 3, had an impact of 3.4. *Monthly Notices of the Royal Astronomical Society* was fourth among all core journals, with an impact of 2.4. Finally, *Astronomy and Astrophysics* had an impact of 2.3. By comparison, the average article in the "Macro Journal of the Astrosciences" had a 1982 impact of 1.1. The median impact of all the *SCI* journals in that year's *JCR* was .6.

Incidentally, an article in *Le Journal des Astronomes Français* reports that the journals which merged to form *Astronomy and Astrophysics* had a collective 1969 impact of only .8.[8] Apparently, in the case of *Astronomy and Astrophysics* at least, the whole is greater than the sum of its parts. The increase in the impact of *Astronomy and Astrophysics* may be due at least in part to the growth of the astrosciences and space-related fields in continental Europe. However, greater visibility and circulation seem to be correlated with better quality papers.

The relevance of using 1980 and 1981 as the base years for obtaining a 1982 impact factor depends on what the "peak" citation period may be for astrosciences journals. In other words, the core journals might have higher impact factors if we use a two-year base *earlier* than 1980-1981. Table 4 lists ten high-impact astrosciences journals, showing how their impacts vary when different two-year bases are used. The *Annual Review of Astronomy and Astrophysics'* impact of 12 rises to 16 when we consider 1982 citations to its articles published in 1979-1980. A majority of the other core journals in the table also increase in impact when the 1979-1980 baseline is used. So that baseline might be more relevant if we were comparing the impact of astrosciences journals to those in other fields. Whichever two-year base period is chosen, however, the *relative* rankings of the journals in Table 4 would not change significantly.

Table 4: 1982 impacts of selected astrosciences journals using various two-year bases. A=journal title. B=1980-1981. C=1979-1980. D=1978-1979. E=1977-1978. F=1976-1977.

A	B	C	D	E	F
Annu. Rev. Astron. Astrophys.	11.96	16.4	11.75	8.13	8.46
Astron. Zh. SSSR	0.33	0.29	0.27	0.21	0.14
Astron. J.	1.81	1.88	1.92	1.68	1.41
Astron. Astrophys.	2.28	2.35	2.23	2.03	1.66
Astrophys. J.	4.07	4.14	3.68	3.07	2.68
Astrophys. Space Sci.	0.80	0.67	0.77	0.68	0.57
Icarus	1.92	1.75	1.66	1.45	1.02
Mon. Notic. Roy. Astron. Soc.	2.39	2.28	2.29	2.04	1.79
Publ. Astron. Soc. Pac.	1.16	1.19	0.93	0.80	1.04
Sol. Phys.	1.75	1.87	1.61	1.37	1.40

The peak citation period for the core astrosciences journals can be determined by examining their cit*ed* and cit*ing* "half-lives." These half-lives are shown in Table 5. The cit*ed* half-life of a journal refers to the median age of its articles that were cited in a given year. For example, the core journal with the shortest cit*ed* half-life for 1982 is *Geophysical and Astrophysical Fluid Dynamics*, at 3.1 years. This means that half of the citations this journal received in 1982 were to articles published from 1980 through 1982.

The cit*ing* half-life of a journal indicates the age of the material it cites. It is calculated by determining the median year of publication for the items cited by a given journal in the current year. Going back from the current year, then, a journal's cit*ing* half-life is defined as the period to which half of its citations were given. A figure greater than ten indicates that more than 50 percent of the citations given by a journal in 1982 were to articles published before 1973. In the future, *JCR* will provide more precise data on half-lives for such journals. A few of the core astrosciences journals have cit*ed* and cit*ing* half-lives greater than ten years. This indicates that the astrosciences literature, in general, remains useful and significant over a long period of time. However, the journal with the shortest cit*ing* half-life is *Moon and the Planets*, at 3.2 years. This means that in half of its 1982 references, the articles cited were published from 1980 through 1982.

A glance at Table 5 tells you that both the cit*ed* and cit*ing* half-lives of the astrosciences core journals cluster around four to seven years. In fact, a 1981 paper in the *Publications of the Astronomical Society of the Pacific* on the long-term citation rates of 326 astrosciences articles published in 1961 concluded that, on the average, citations reached a maximum rate five years after publication.[9] The study, by Helmut A. Abt, Kitt Peak National Observatory, Tucson, Arizona, showed that theoretical and observational papers were cited with equal frequency, and exhibited the same rate of decline. Abt also showed that the most frequently cited papers are almost invariably long ones, although only half of the long papers are cited frequently. According to Abt, it takes about 27 years for the citation frequency of highly cited astrosciences articles to decline to half the maximum rate.

Among the core journals, the *Annual Review of Astronomy and Astrophysics* ranks first in immediacy as well as in impact—1.45. *Astrophysical Journal* follows with 1.20; *Icarus*, .86; *Space Science Reviews*, .78; and *Monthly Notices of the Royal Astronomical Society*, .76. The "Macro Journal of the Astrosciences" has a 1982 immediacy of .32, which compared with a median of .17 for

Table 5: 1982 *SCI*® cit*ed* and cit*ing* half-lives of core astrosciences journals. *Journals with no listing either received* less than 100 citations in 1982, or gave out less than 100 citations in 1982. A = cit*ed* half-life. B = cit*ing* half-life. C = core astrosciences journal.

A	B	C
5.4	3.9	Annu. Rev. Astron. Astrophys.
4.6	6.0	Annu. Rev. Earth Planet. Sci.
5.3	5.7	Astron. J.
6.5	7.1	Astron. Zh. SSSR
4.4	5.0	Astron. Astrophys.
4.9	4.6	*Astrophys. J.
9.9	5.2	Astrophys. Lett.
5.1	6.3	Astrophys. Space Sci.
7.2	7.8	Bull. Astron. Inst. Czech.
6.0	9.2	Celest. Mech.
3.1	7.5	Geophys. Astrophys. Fluid Dynam.
4.4	4.8	Icarus
—	> 10.0	Indian J. Rad. Sp. Phys.
> 10.0	> 10.0	J. Roy. Astron. Soc. Can.
5.3	5.4	Mon. Notic. Roy. Astron. Soc.
4.2	3.2	Moon Planets
8.9	6.2	Observatory
5.4	5.9	Publ. Astron. Soc. Jpn.
6.5	6.2	Publ. Astron. Soc. Pac.
6.7	5.3	Quart. J. Roy. Astron. Soc.
—	—	Sky Telesc.
6.8	6.3	Sol. Phys.
4.6	6.5	Space Sci. Rev.
—	—	Vistas Astronomy
> 10.0	8.4	Z. Naturforsch. Teil A

*Includes Astrophys. J. Suppl. Ser.

Table 6: Articles from the core astrosciences journals cited 300 or more times, according to 1961-1983 *SCI*®, in alphabetical order by first author. A = total *SCI* citations, 1961-1983. Additional citations to papers published in 1960 and earlier, based on data from the 1955-1964 *SCI* cumulation, appear in parentheses. B = bibliographic data.

A		B
421	(3)	**Abell G O.** The distribution of rich clusters of galaxies. *Astrophys. J. Suppl. Ser.* 3(31):211-88, 1958.
394		**Anders E.** Origin, age, and composition of meteorites. *Space Sci. Rev.* 3:583-714, 1964.
328		**Bless R C & Savage B D.** Ultraviolet photometry from the orbiting astronomical observatory. II. Interstellar extinction. *Astrophys. J.* 171:293-308, 1972.
378		**Brocklehurst M.** Calculations of the level populations for the low levels of hydrogenic ions in gaseous nebulae. *Mon. Notic. Roy. Astron. Soc.* 153:471-90, 1971.
340	(2)	**Burgess A & Seaton M J.** A general formula for the calculation of atomic photo-ionization cross sections. *Mon. Notic. Roy. Astron. Soc.* 120:121-51, 1960.
477		**Cameron A G W.** Abundances of the elements in the solar system. *Space Sci. Rev.* 15:121-46, 1970.
338		**Colgate S A & White R H.** The hydrodynamic behavior of supernovae explosions. *Astrophys. J.* 143:626-81, 1966.
367		**Cox D P & Tucker W H.** Ionization equilibrium and radiative cooling of a low-density plasma. *Astrophys. J.* 157:1157-67, 1969.
327		**Eggen O J, Lynden-Bell D & Sandage A R.** Evidence from the motions of old stars that the galaxy collapsed. *Astrophys. J.* 136:748-66, 1962.
338	(29)	**Forster T.** Experimentelle und theoretische Untersuchung des zwischenmolekularen Ubergangs von Elektronenanregungsenergie. (Experimental and theoretical study of the intramolecular surface of electron-stimulated energy.) *Z. Naturforsch. Teil A* 4:321-7, 1949.
350		**Giacconi R, Murray S, Gursky H, Kellogg E, Schreier E, Matilsky T, Koch D & Tananbaum H.** The third *Uhuru* catalog of X-ray sources. *Astrophys. J. Suppl. Ser.* 27(237):37-64, 1974.
522		**Gingerich O, Noyes R W, Kalkofen W & Cuny Y.** The Harvard-Smithsonian reference atmosphere. *Sol. Phys.* 18:347-65, 1971.
324		**Goldberg L, Muller E A & Aller L H.** The abundances of the elements in the solar atmosphere. *Astrophys. J. Suppl. Ser.* 5(45):1-138, 1960.
366		**Goldreich P & Julian W H.** Pulsar electrodynamics. *Astrophys. J.* 157:869-80, 1969.
321		**Hayes D S.** An absolute spectrophotometric calibration of the energy distribution of twelve standard stars. *Astrophys. J.* 159:165-76, 1970.
343		**Herbst E & Klemperer W.** The formation and depletion of molecules in dense interstellar clouds. *Astrophys. J.* 185:505-33, 1973.
333	(37)	**Hiltner W A.** Photometric, polarization, and spectrographic observations of O and B stars. *Astrophys. J. Suppl. Ser.* 2(24):389-462, 1956.
681	(68)	**Humason M L, Mayall N U & Sandage A R.** Redshifts and magnitudes of extragalactic nebulae. *Astron. J.* 61:97-162, 1956.
389		**Iben I.** Stellar evolution within and off the main sequence. *Annu. Rev. Astron. Astrophys.* 5:571-626, 1967.
1090		**Johnson H L.** Astronomical measurements in the infrared. *Annu. Rev. Astron. Astrophys.* 4:193-206, 1966.
596	(245)	**Johnson H L & Morgan W W.** Fundamental stellar photometry for standards of spectral type on the revised system of the Yerkes spectral *Atlas*. *Astrophys. J.* 117:313-52, 1953.
493		**Jordan C.** The ionization equilibrium of elements between carbon and nickel. *Mon. Notic. Roy. Astron. Soc.* 142:501-21, 1969.
500		**Kellermann K I, Pauliny-Toth I I K & Williams P J S.** The spectra of radio sources in the revised 3C catalogue. *Astrophys. J.* 157:1-34, 1969.
542	(3)	**Maier W & Saupe A.** Eine einfache molekular-statistische Theorie der nematischen kristallinflussigen Phase. Teil I. (A simple molecular-statistical theory of the nematic crystalline-liquid phase. Part I.) *Z. Naturforsch. Teil A* 14:882-9, 1959.
540	(2)	**Maier W & Saupe A.** Eine einfache molekular-statistische Theorie der nematischen kristallinflussigen Phase. Teil II. (A simple molecular-statistical theory of the nematic crystalline-liquid phase. Part II.) *Z. Naturforsch. Teil A* 15:287-92, 1960.
420	(62)	**Moliere G.** Theorie der Streuung schneller geladener. Teilchen I. Einzelstreuung am abgeschirmten Coulomb-Feld. (Theory of the scattering of rapid charged particles. I. Single scattering in the shielded Coulomb-field.) *Z. Naturforsch. Teil A* 2:133-45, 1947.
308		**Morton D C & Adams T F.** Effective temperatures and bolometric corrections of early-type stars. *Astrophys. J.* 151:611-21, 1968.
458		**Oke J B & Schild R E.** The absolute spectral energy distribution of Alpha Lyrae. *Astrophys. J.* 161:1015-23, 1970.
384		**Panagia N.** Some physical parameters of early-type stars. *Astron. J.* 78:929-34, 1973.
402	(22)	**Parker E N.** Dynamics of the interplanetary gas and magnetic fields. *Astrophys. J.* 128:664-76, 1958.
389		**Penzias A A & Wilson R W.** Letter to editor. (A measurement of excess antenna temperature at 4080 Mc/s.) *Astrophys. J.* 142:419-21, 1965.
349		**Pringle J E & Rees M J.** Accretion disc models for compact X-ray sources. *Astron. Astrophys.* 21:1-9, 1972.
336		**Reifenstein E C, Wilson T L, Burke B F, Mezger P G & Altenhoff W J.** A survey of H 109 recombination line emission in galactic H II regions of the northern sky. *Astron. Astrophys.* 4:357-77, 1970.
323		**Schraml J & Mezger P G.** Galactic H II regions. IV. 1.95-cm observations with high angular resolution and high positional accuracy. *Astrophys. J.* 156:269-301, 1969.

417		**Shakura N I & Sunyaev R A.** Black holes in binary systems. Observational appearance. *Astron. Astrophys.* 24:337-55, 1973.
345		**Van Regemorter H.** Rate of collisional excitation in stellar atmospheres. *Astrophys. J.* 136:906-15, 1962.
321		**Wagoner R V, Fowler W A & Hoyle F.** On the synthesis of elements at very high temperatures. *Astrophys. J.* 148:3-49, 1967.
344	(6)	**Whitford A E.** The law of interstellar reddening. *Astron. J.* 63:201-7, 1958.

all *SCI* journals included in the 1982 *JCR*.

While statistical analyses of journals are revealing, it is always fascinating to look at the individual articles that have contributed to their high impact and long-term cumulative counts. Table 6 lists articles from the core astrosciences journals that have been cited 300 or more times. They are arranged alphabetically by first author. The number of citations each article received from 1961 through 1983 is shown. At the time we began this study, data from the 1955-1964 *SCI* cumulation were not available. Since it is now published, we have added, in parentheses, the counts for 1955-1960 when relevant.

Eight of the 25 core journals are represented in Table 6. *Astrophysical Journal* accounts for 20 of the 38 papers listed. *Zeitschrift für Naturforschung Teil A—Physik, Physikalische Chemie, Kosmophysik* published four of the most-cited astrosciences articles. The *Astronomical Journal, Astronomy and Astrophysics*, and the *Monthly Notices of the Royal Astronomical Society* each account for three articles. The *Annual Review of Astronomy and Astrophysics* and *Space Science Reviews* each published two of the most-cited papers, while *Solar Physics* published one.

The most-cited paper is by H.L. Johnson, then of the Lunar and Planetary Laboratory, University of Arizona, Tucson. Published in 1966 in the *Annual Review of Astronomy and Astrophysics*, it discusses the development of the field of infrared astronomy, and the various methods used to make observations using the long-wavelength radiation in the infrared part of the electromagnetic spectrum. The paper has been cited almost 1,100 times since its publication. Johnson also has the second most-cited paper on the list. It was coauthored with W.W. Morgan when they were both affiliated with Yerkes and McDonald Observatories. Yerkes is in Williams Bay, Wisconsin, and is administered by the University of Chicago, Illinois. The McDonald Observatory is located in Fort Davis, Texas, and is operated by the University of Texas, Austin. The paper describes a method of classifying stars by their spectral type, or the way in which the components of the light given off by an object relate to that object's physical and chemical composition. It has been cited over 840 times from 1953 to 1983.

The third most-cited paper was coauthored in 1956 by M.L. Humason, N.U. Mayall, and A.R. Sandage. Humason and Sandage were affiliated, at the time, with Mount Wilson and Palomar Observatories, operated jointly by the Carnegie Institution of Washington, Washington, DC, and the California Institute of Technology, Pasadena. Mayall was at the Lick Observatory, Mount Hamilton, California. Incidentally, Mount Wilson and Palomar Observatories were renamed the Hale Observatories in 1969. The paper, published in the *Astronomical Journal*, contains observational data on the redshifts of numerous galaxies. Redshift refers to the relationship between an object's distance from the Earth, the speed and direction of its travel, and how these factors affect the spectral pattern of the light emitted by that object. The paper has been cited over 750 times.

The 1971 paper in *Solar Physics* was coauthored by O. Gingerich, R.W. Noyes, and W. Kalkofen, all of the Smithsonian Astrophysical Observatory and Harvard College Observatory, Cambridge, Massachusetts; and Y. Cuny, Observatoire de Paris, Section d'Astrophysique, Meudon, France. It was discussed by Gingerich in 1981 in *Current Contents®*.[10] Four other papers in Table 6 have also been reviewed in *Citation Classics*™ commentaries.[11-14]

Table 7 lists the most-cited article from each core journal in this study that does not already appear in Table 6. Only those journals that published at least one paper cited 50 or more times from 1961 through 1983 are listed. Twenty-three of the 25 core journals in this study met or exceeded this threshold. Table 7 also includes the number of papers published by each journal cited 50 or more times. Data for *Astronomicheskii Zhurnal* and its translation, *Soviet Astronomy*, have been combined. Incidentally, *Moon and the Planets* was called simply *Moon* in 1971, when it published the article included in this table.

It is important to remember that Tables 6 and 7 do not include highly cited astrosciences articles published in non-core journals, such as *Science*, *Nature*, *Reviews of Modern Physics*, *Philosophical Transactions of the Royal Society of London Series A—Mathematical and Physical Sciences*, etc. We have identified a sample of astrosciences articles published in these non-core journals which have been cited at least 15 times by the core group in 1982. We then counted their citations from 1955 through 1983 in *SCI*. Table 8 lists the 18 most-cited astrosciences articles from this sample. It is also important to stress that we attribute no qualitative significance to the differences in citation frequency of the high-impact papers in this

Table 7: Most-cited articles from core astrosciences journals cited 50 or more times, 1961-1983 *SCI®*, in alphabetical order by journal title. Articles already listed in Table 6 are not repeated in this table. A = total *SCI* citations, 1961-1983. Additional citations to papers published in 1960 and earlier, based on data from the 1955-1964 *SCI* cumulation, appear in parentheses. B = bibliographic data. C = total number of papers from that journal cited 50 or more times.

A		B	C
95		**Karig D E.** Evolution of arc systems in the western Pacific. *Annu. Rev. Earth Planet. Sci.* 2:51-75, 1974.	7
134		**Syrovat-skii S I.** Dynamic dissipation of a magnetic field and particle acceleration. *Astron. Zh.* 43:340-55, 1966. (*Sov. Astron.* 10:270-80, 1966.)	9
110		**Radhakrishnan V & Cooke D J.** Magnetic poles and the polarization structure of pulsar radiation. *Astrophys. Lett.* 3:225-9, 1969.	16
168		**Arnett W D.** A possible model of supernovae: detonation of 12C. *Astrophys. Space Sci.* 5:180-212, 1969.	17
123		**Plavec M & Kratochvil P.** Tables for the Roche Model of close binaries. *Bull. Astron. Inst. Czech.* 15:165-70, 1964.	2
90		**Deprit A.** Canonical transformations depending on a small parameter. *Celest. Mech.* 1:12-30, 1969.	1
114		**Garrett C & Munk W.** Space-time scales of internal waves. *Geophys. Astrophys. Fluid Dynam.* 3:225-64, 1972.	12
231		**Irvine W M & Pollack J B.** Infrared optical properties of water and ice spheres. *Icarus* 8:324-60, 1968.	52
64		**van den Bergh S.** The galaxies of the local group. *J. Roy. Astron. Soc. Can.* 62:145-80, 1968.	1
72		**Hartmann W K & Wood C A.** Moon: origin and evolution of multi-ring basins. *Moon* 3:3-78, 1971.	2
130	(1)	**Unno W.** Line formation of a normal Zeeman triplet. *Publ. Astron. Soc. Jpn.* 8:108-25, 1956.	8
270		**Robinson L B & Wampler E J.** The Lick Observatory image-dissector scanner. *Publ. Astron. Soc. Pac.* 84:161-6, 1972.	27
127		**Stromgren B.** Problems of internal constitution and kinematics of main sequence stars. *Quart. J. Roy. Astron. Soc.* 4:8-36, 1963.	5
162		**Iriarte B, Johnson H L, Mitchell R I & Wisniewski W K.** Five-color photometry of bright stars. *Sky Telesc.* 30:21-4, 1965.	1
65		**Pottasch S R.** The diffuse emission nebulae. *Vistas Astronomy* 6:149-204, 1965.	6

Table 8: Sample of highly cited astrosciences articles published in non-core journals, in alphabetical order by first author. A = total *SCI*® citations, 1955-1983. B = bibliographic data.

A	B
80	**Batten A H, Fletcher J M & Mann P J.** Seventh catalogue of the orbital elements of spectroscopic binary systems. *Publ. Dominian Astrophys. Observ.* 15:121-295, 1978.
222	**Boggess A, Carr F A, Evans D C, Fischel D, Freeman H R, Fuechsel C F, Klinglesmith D A, Krueger V L, Longanecker G W, Moore J V, Pyle E J, Rebar F, Sizemore K O, Sparks W, Underhill A B, Vitagliano H D, West D K, Macchetto F, Fitton B, Barker P J, Dunford E, Gondhalekar P M, Hall J E, Harrison V A W, Oliver M B, Sandford M C W, Vaughan P A, Ward A K, Anderson B E, Boksenberg A, Coleman C I, Snijders M A J & Wilson R.** The IUE spacecraft and instrumentation. *Nature* 275:372-7, 1978.
167	**Boggess A, Bohlin R C, Evans D C, Freeman H R, Gull T R, Heap S R, Klinglesmith D A, Longanecker G R, Sparks W, West D K, Holm A V, Perry P M, Schiffer F H, Turnrose B E, Wu C C, Lane A L, Linsky J L, Savage B D, Benvenuti P, Cassatella A, Clavel J, Heck A, Macchetto F, Penston M V, Selvelli P L, Dunford E, Gondhalekar P, Oliver M B, Sandford M C W, Stickland D, Boksenberg A, Coleman C I, Snijders M A J & Wilson R.** In-flight performance of the IUE. *Nature* 275:377-85, 1978.
379	**Brown R L & Gould R J.** Interstellar absorption of cosmic X-rays. *Phys. Rev. D—Part. Fields* 1:2252-6, 1970.
91	**Davidson K & Netzer H.** The emission lines of quasars and similar objects. *Rev. Mod. Phys.* 51:715-66, 1979.
84	**Gabriel A H.** A magnetic model of the solar transition region. *Phil. Trans. Roy. Soc. London A* 281:339-52, 1976.
91	**Hanel R, Conrath B, Flasar F M, Kunde V, Maguire W, Pearl J, Pirraglia J, Samuelson R, Herath L, Allison M, Cruikshank D, Gautier D, Gierasch P, Horn L, Koppany R & Ponnamperuma C.** Infrared observations of the Saturnian system from Voyager 1. *Science* 212:192-200, 1981.
46	**Ku W H-M, Helfand D J & Lucy L B.** X-ray properties of quasars. *Nature* 288:323-8, 1980.
226	**Lynden-Bell D.** Galactic nuclei as collapsed old quasars. *Nature* 223:690-4, 1969.
70	**Milne D K.** A new catalogue of galactic SNRs corrected for distance from the galactic plane. *Aust. J. Phys.* 32:83-92, 1979.
41	**Nandy K, Morgan D H, Willis A J, Wilson R, Gondhalekar P M & Houziaux L.** Interstellar extinction in the Large Magellanic Cloud. *Nature* 283:725-9, 1980.
300	**Paczynski B.** Evolution of single stars. I. Stellar evolution from main sequence to white dwarf or carbon ignition. *Acta Astron.* 20:47-58, 1970.
64	**Rees M J.** Accretion and the quasar phenomenon. *Phys. Scr.* 17:193-200, 1978.
267	**Ross J E & Aller L H.** The chemical composition of the sun. *Science* 191:1223-9, 1976.
110	**Scheuer P A G & Readhead A C S.** Superluminally expanding radio sources and the radio-quiet QSOs. *Nature* 277:182-5, 1979.
138	**Smith B A, Soderblom L A, Beebe R, Boyce J, Briggs G, Bunker A, Collins S A, Hansen C J, Johnson T V, Mitchell J L, Terrile R J, Carr M, Cook A F, Cuzzi J, Pollack J B, Danielson G E, Ingersoll A, Davies M E, Hunt G E, Masursky H, Shoemaker E, Morrison D, Owen T, Sagan C, Veverka J, Strom R & Suomi V E.** Encounter with Saturn: Voyager 1 imaging science results. *Science* 212:163-91, 1981.
177	**Smith B A, Soderblom L A, Johnson T V, Ingersoll A P, Collins S A, Shoemaker E M, Hunt G E, Masursky H, Carr M H, Davies M E, Cook A F, Boyce J, Danielson G E, Owen T, Sagan C, Beebe R F, Veverka J, Strom R G, McCauley J F, Morrison D, Briggs G A & Suomi V E.** The Jupiter system through the eyes of Voyager 1. *Science* 204:951-72, 1979.
122	**Vogt S S, Tull R G & Kelton P.** Self-scanned photodiode array: high performance operation in high dispersion astronomical spectrophotometry. *Appl. Opt.* 17:574-92, 1978.

study. That's why they've been arranged alphabetically by first author—or, as in the case of Table 7, by journal title—rather than by number of citations.

Comparing Tables 2 and 3, we see that 13 core journals appear among the top 20 in both. They are: *Annual Review of Astronomy and Astrophysics*; *Astronomical Journal*; *Astronomicheskii Zhurnal*; *Astronomy and Astrophysics*; *Astrophysical Journal*; *Astrophysics and Space Science*; *Icarus*; *Monthly Notices of the Royal Astronomical Society*; *Publications of the Astronomical Society of Japan*; *Publications of the Astronomical Society of the Pacific*; *Solar Physics*; *Space Science Reviews*; and *Zeitschrift für Naturforschung Teil A—Physik, Physikalische Chemie, Kosmophysik*. These journals ranked highest in terms of their references to the core and in the number of citations they received from the core. They also ranked among the top 20 journals in this study in terms of their impact and immediacy. However, there is considerable variation in their production of superstar papers, or should I say superastronomical!

In a look backward at our original small-scale study of astrophysics in 1974,[4] it is interesting to observe that a citation analysis of the obvious and central journal in the field can often provide a remarkably accurate picture of that field. Examination of the 1982 citing journal *JCR* entry for the *Astrophysical Journal* provides a remarkable confirmation of the complete census for the field.

This concludes our look at the core literature of the astrosciences. In the weeks to come, our journal citation series will continue with an examination of the core journals in physical chemistry.

* * * * *

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3. --------------. Journal citation studies. 42. Analytical chemistry journals—what they cite and what cites them. *Current Contents* (13):3-12, 26 March 1984.
4. --------------. Journal citation studies. XII. *Astrophysical Journal* and its *Supplements*. *Essays of an information scientist*. Philadelphia: ISI Press, 1977. Vol. 2. p. 120-4.
5. --------------. Journal citation studies. 34. The literature of dental science *vs*. the literature used by dental researchers. *Essays of an information scientist*. Philadelphia: ISI Press, 1983. Vol. 5. p. 373-9.
6. -------------. What a difference an "A" makes. *Essays of an information scientist*. Philadelphia: ISI Press, 1981. Vol. 4. p. 208-15.
7. --------------. Journal citation studies. 38. Earth sciences journals: what they cite and what cites them. *Essays of an information scientist*. Philadelphia: ISI Press, 1983. Vol. 5. p. 791-800.
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12. **Colgate S A.** Citation Classic. Commentary on *Astrophys. J.* 143:626-81, 1966. *Current Contents/Physical, Chemical & Earth Sciences* 21(4):16, 26 January 1981.
13. **Iben I.** Citation Classic. Commentary of *Annu. Rev. Astron. Astrophys.* 5:571-626, 1967. *Current Contents/Physical, Chemical & Earth Sciences* 22(13):20, 29 March 1982.
14. **Penzias A A.** Citation Classic. Commentary on *Astrophys. J.* 142:419-21, 1965. *Current Contents/Physical, Chemical & Earth Sciences* 21(18):16, 4 May 1981.