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CHROMOSPHERIC VARIATIONS IN MAIN-SEQUENCE STARS*

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ABSTRACT

Fluxes in 1 Å bands at the centers of H and K lines have been measured for 91 main-sequence stars, ranging from about F5 to M2, for time intervals of 9–11 years. Eighteen of the stars with minimal fluxes have been used as standards; only one of these standards has shown significant long-term variation. Sufficient counts have been made for each observation to attain statistical accuracy in the 1%–3% range.

All stars, including the standards, show scatter in the seasonal groups of observations, indicating changes on time scales from 1 day to several months; but the data points are too few to establish short-term periodicities such as rotational modulation.

Many, but not all, stars in the spectral range F5–early G appear to be undergoing a roughly secular decrease in H-K flux, and a possible explanation is offered.

About a dozen stars appear to have essentially completed a cycle of H-K flux variation, and approximately as many more may turn out to be cyclic if observations are continued. The earliest-type star with definitely cyclic behavior is HD 81809 at G2. The incidence of cycles appears to increase with later spectral types, but this is partially accounted for by the increase in visibility of chromospheric emission components in the same sense. Evidence is given that the observed cycles are analogous to that of the Sun.

It is pointed out that this work contains insufficient data to draw firm conclusions as to what fraction of stars with masses and ages similar to the Sun's are currently in a cyclical mode. But it is also indicated that the method used here could provide this information if continued in a more concentrated manner.

Subject headings: Ca II emission — stars: chromospheres — stars: late-type

I. INTRODUCTION

This work was undertaken to answer the general question, Does the chromospheric activity of main-sequence stars vary with time, and if so, how? The most accessible indices of chromospheric activity in these stars are the emission components centered in the broad, deep H and K absorption lines of Ca II. Fluxes in 1 Å bands centered in these lines have therefore been measured in a sample of main-sequence stars, extending from about F5 to M2, over time intervals of 9–11 years. For a long time it has been known from K spectroheliograms that Ca II emission in the solar chromosphere varies in step with the sunspot cycle, and thus Ca II flux measurements in stars might be expected to reveal analogous stellar cycles if they exist. Previous attempts to find such cycles by other methods (Jerzkiewicz and Serkowski 1966) have not been successful. Also, Popper (1956) obtained a number of spectrograms of five late-type main-sequence stars and examined them for variability in the Ca II emission without positive results; undoubtedly this method was too insensitive.

As will be seen, cyclic variation in the H-K fluxes is indeed present in a number of stars. But there is also a wide range of other types of variation, some of which might prove to be cyclic if observed over a longer time interval. In addition, there is rapid variation in practically all stars, where "rapid" means from one month to the next, or even between successive days. Whether there are periodicities involved in the rapid fluctuations cannot be determined from this work because the density of observations is too small. Frequent observations continued over several weeks might be required for adequate study of the rapid variations, and the same statements doubtless apply also to the discovery of rotational modulation of the chromospheric emission. This effect has been observed in the Sun (Bumba and Ruzechova-Topolova 1967) and is a consequence of the nonuniform longitudinal distribution of solar magnetic field. A search for rotational modulation could be important, both from the standpoint of its bearing on the structure of stellar magnetic fields and because it might yield rotational periods for late-type main-sequence stars, a subject about which very little seems to be known, other than that the rotational velocities must be fairly small.

This paper deals exclusively with stars on, or close to, the main sequence, although it was my original intention to include some giants in the program. However, after continuing the observations for a while, it was decided, for several reasons, to concentrate entirely on the main sequence. Hence the

* Portions of this paper were included in the 1977 Henry Norris Russell Lecture.

question as to what might be learned from a similar study of giant stars can be answered only if someone will undertake the task of accumulating the necessary data. This effort should be made if only from the standpoint of extending the survey into other regions of the H-R diagram.

II. APPARATUS AND PROCEDURES

The apparatus, the coudé scanner at the 100 inch (2.5 m) telescope on Mount Wilson, and the general procedures have been described previously (Wilson 1968). A few refinements have been introduced, but lack of space precludes their discussion here.

III. SELECTION OF STARS

a) *Standard Stars*

In order to have a continuous check on the output of the apparatus, it was decided to observe standard stars on each night, in addition to using the standard lamp each afternoon. Earlier work on stars from the Strömgren-Perry catalog (Wilson 1968, Fig. 1) had shown that, in a plot of H-K fluxes versus $b - y$, the distribution of points had a sharp, well-defined lower boundary below which no fluxes were found. It was therefore assumed that stars close to this boundary had either zero or minimal chromospheric activity and would thus be least affected by intrinsic variation. Eighteen such stars, distributed around the sky, were selected as standards. On any given night, at least five to nine of them were available for observation.

b) *Program Stars*

The primary goal of the investigation was to study chromospheric variations in main-sequence stars from about F5, where chromospheric emissions first appear in adequate strength, to as far down the main sequence as possible. In addition, since the chromospheric activity of main-sequence stars decreases with age (Wilson 1963; Wilson and Skumanich 1964; Wilson and Woolley 1970), an attempt was made to include both weak- and strong-emission-line stars as far as practicable. This was done in the hope of seeing what might be the effects of aging on cycles or other variations.

Spectrograms were available for all program stars, so that weak- and strong-line stars could be selected. In the region F5–G0, flux measures (Wilson 1968) permitted a selection of stars of strong, medium, and weak emission even though neither of the latter two groups showed H and K in emission on normally exposed 10 Å mm^{-1} spectrograms. Known spectroscopic binaries were rejected in order to avoid the complications encountered in some of these systems. A very few of the stars could still be binaries because of insufficient radial velocity measures or high inclination of the orbit plane, but it appears unlikely that their numbers would be significant.

IV. RESULTS

The total number of observations included in this study is close to 12,000, too many to attempt reproduction in this paper. All have been recorded on magnetic tape and can be made available.

Results are presented in two ways. Figures 1–5 show the mean H-K fluxes for each night of observation plotted against time for 50 stars, more than half the number observed. These diagrams include all stars that appear to have completed a cycle or that might reasonably be expected to have done so if observations were continued. They also include representative examples of other types of chromospheric variation.

Condensed summaries of the observations for all stars are given in Table 1. An asterisk preceding the HD number in this table indicates that the star was one of the 18 standards. Succeeding columns are, in order, the mean date of the observations in a season; the number of flux observations in the season; the average seasonal H-K flux; the standard deviation of the average flux; the standard deviation for a single flux observation; the number of observations used in the flux ratio, K/H; the average K/H; and the standard deviation of the flux ratio. All standard deviations are expressed as percent of the respective averages. The K/H values are missing in the early observations of some stars because of a change in the equipment made in 1967 August. The last row in the summary for each star gives the above quantities computed from all observations. Numbers to the far right of the last row indicate an estimate, or lower limit, for the period of flux variation in years. Symbols F, D, and C? have the respective meanings that the flux data are essentially constant (i.e., flat) when plotted against time, that they show a secular decrease, or that they may exhibit cyclical behavior which is rendered uncertain either by small amplitude or by insufficient time coverage.

All data in this paper are on purely instrumental scales, and no attempt has been made to calibrate them in any absolute manner. However, except for small shifts due to radial velocity differences, the monitor windows cover the same wavelength bands for all stars, and the flux measures for stars of nearly the same spectral class are therefore comparable. This is not true of stars of widely differing spectral type because the measured line fluxes depend not only upon the intrinsic emission strengths of the chromospheric components but also upon the residual photospheric fluxes in H_1 and K_1, upon the number and equivalent widths of absorption lines in the monitor windows, as well as upon the general intensity level in these windows, which declines as the stars become cooler and redder. Of course, flux measurements of a given star made at different times may be compared without question.

Of necessity, the flux measurements are the sum of two components—one due to the chromospheric emission and the other due to the residual photospheric emission at the bottom of the absorption line.

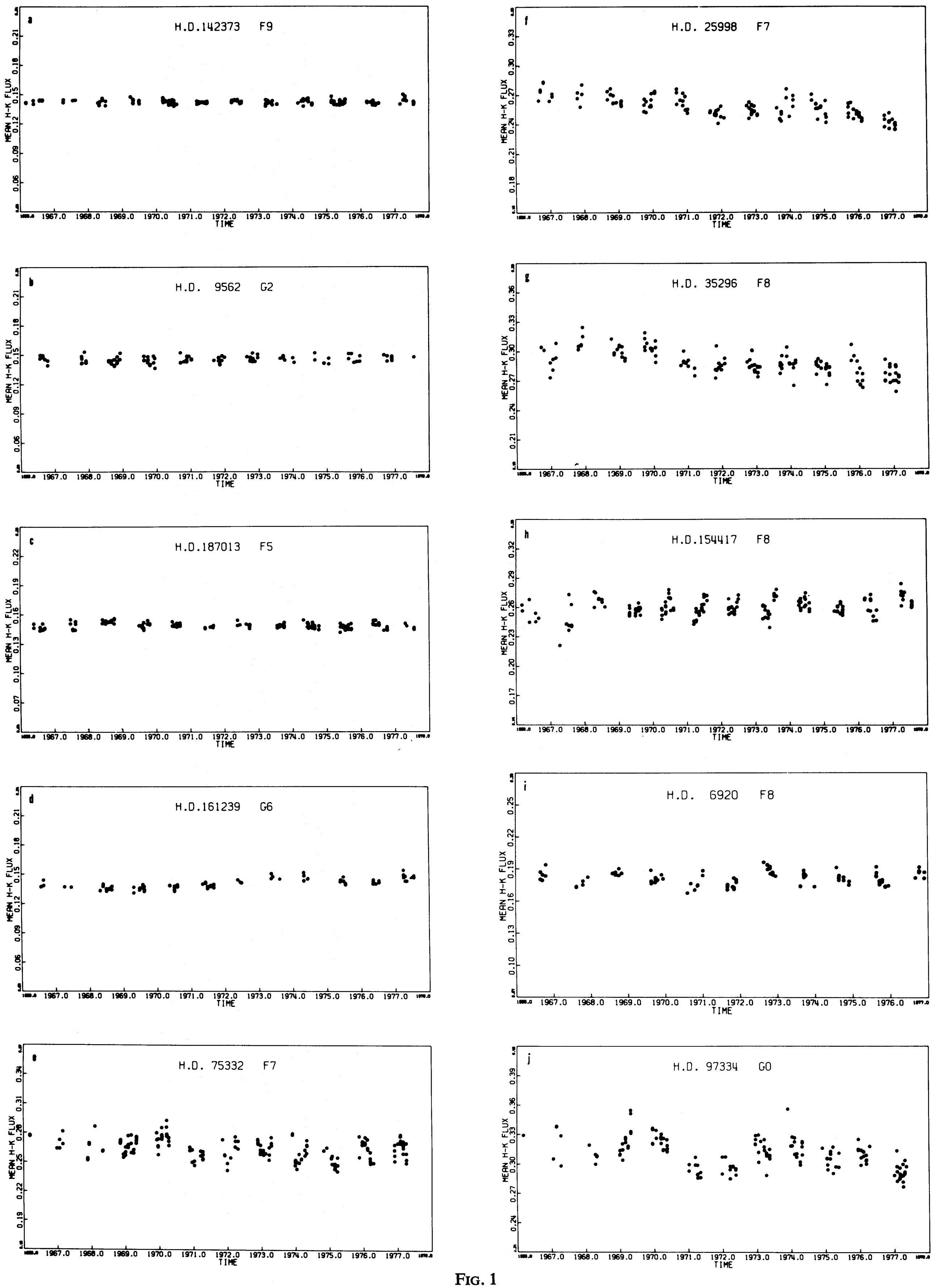

FIG. 1

FIGS. 1–5.—Mean H-K fluxes versus time

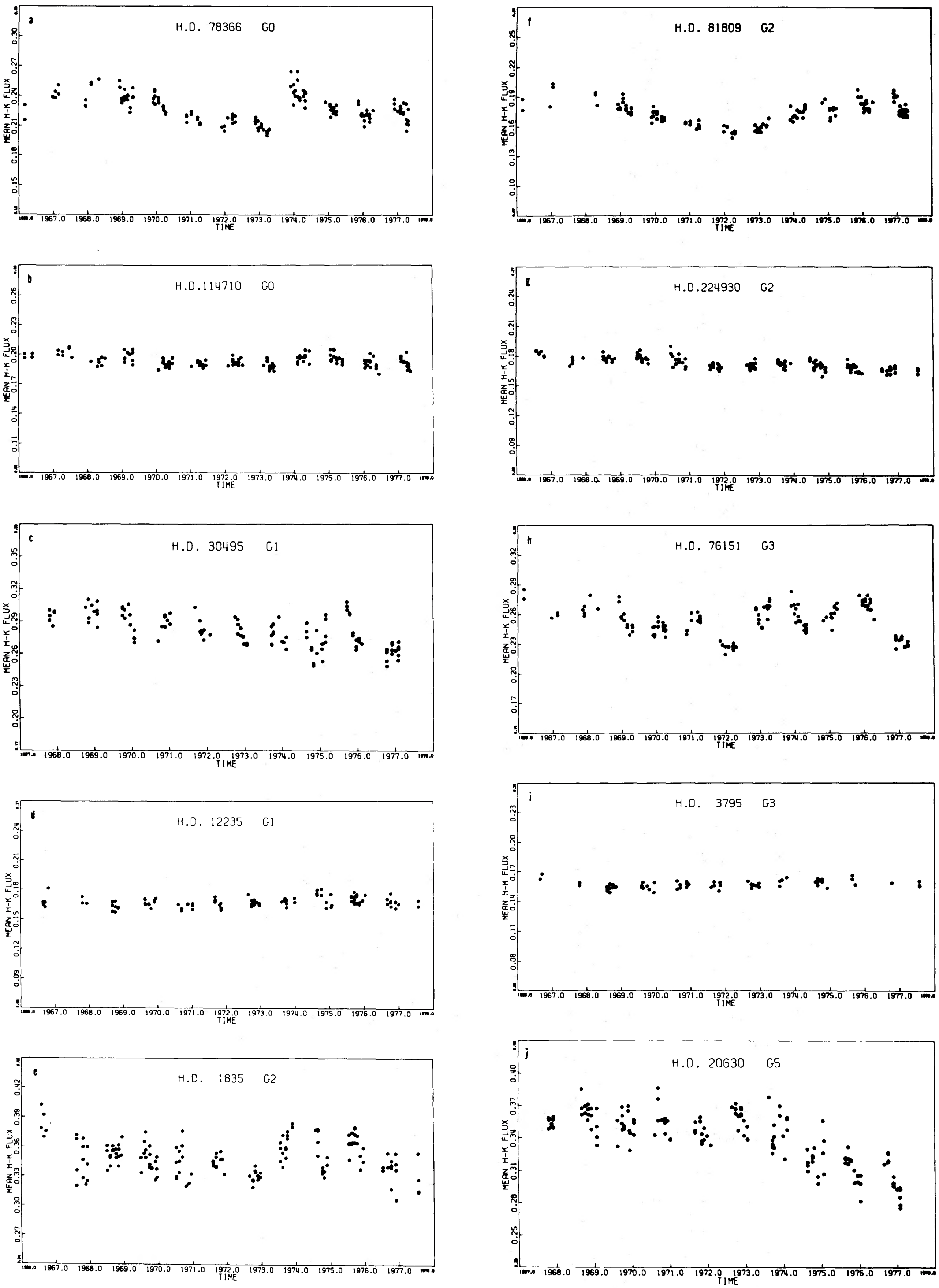
a
H.D. 78366 G0
b
H.D.114710 G0
c
H.D. 30495 G1
d
H.D. 12235 G1
e
H.D. 1835 G2
f
H.D. 81809 G2
g
H.D.224930 G2
h
H.D. 76151 G3
i
H.D. 3795 G3
j
H.D. 20630 G5
MEAN H-K FLUX
TIME

FIG. 2

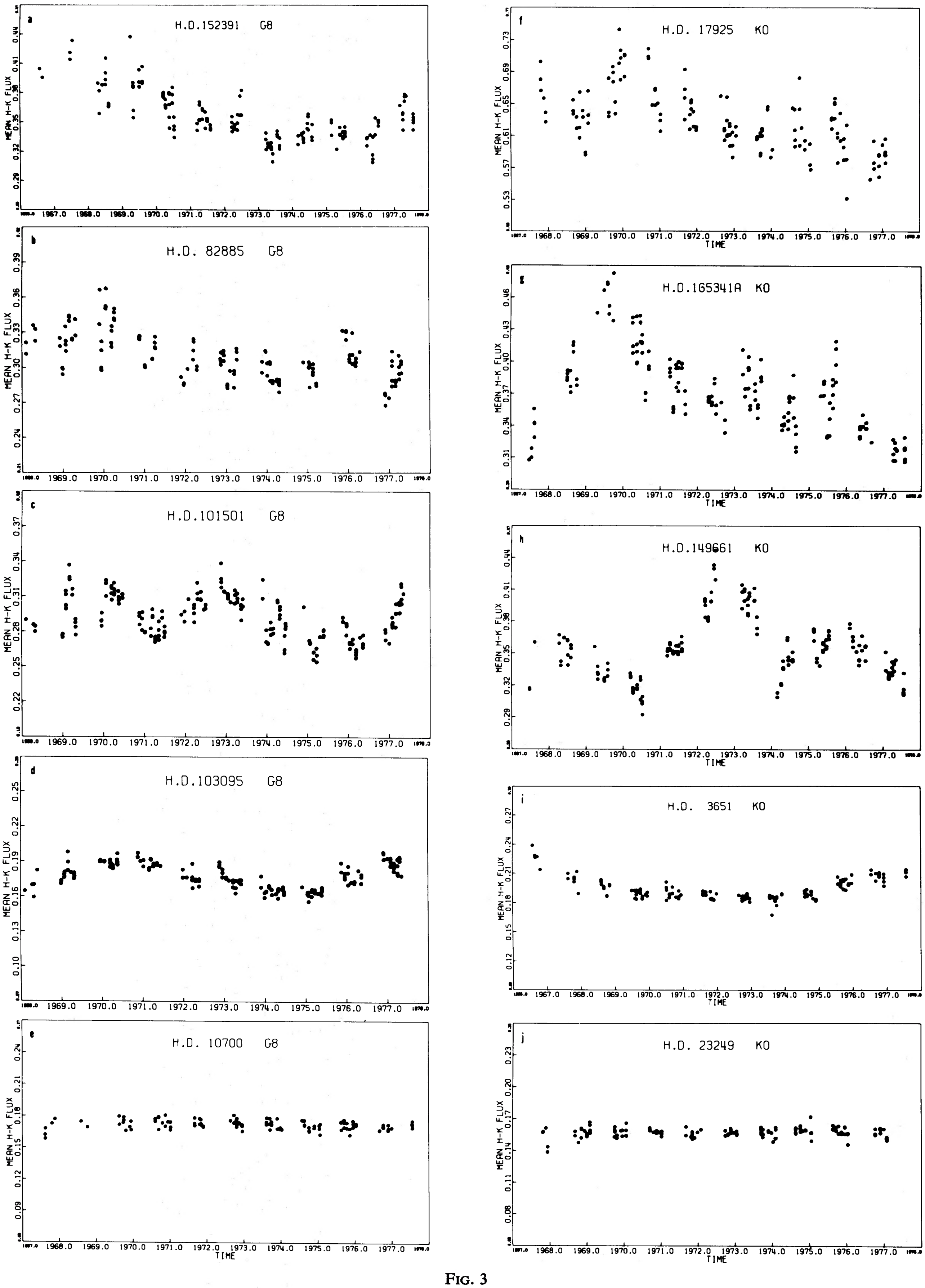
H.D.152391 G8
H.D. 82885 G8
H.D.101501 G8
H.D.103095 G8
H.D. 10700 G8
H.D. 17925 K0
H.D.165341A K0
H.D.149661 K0
H.D. 3651 K0
H.D. 23249 K0
MEAN H-K FLUX
TIME

FIG. 3

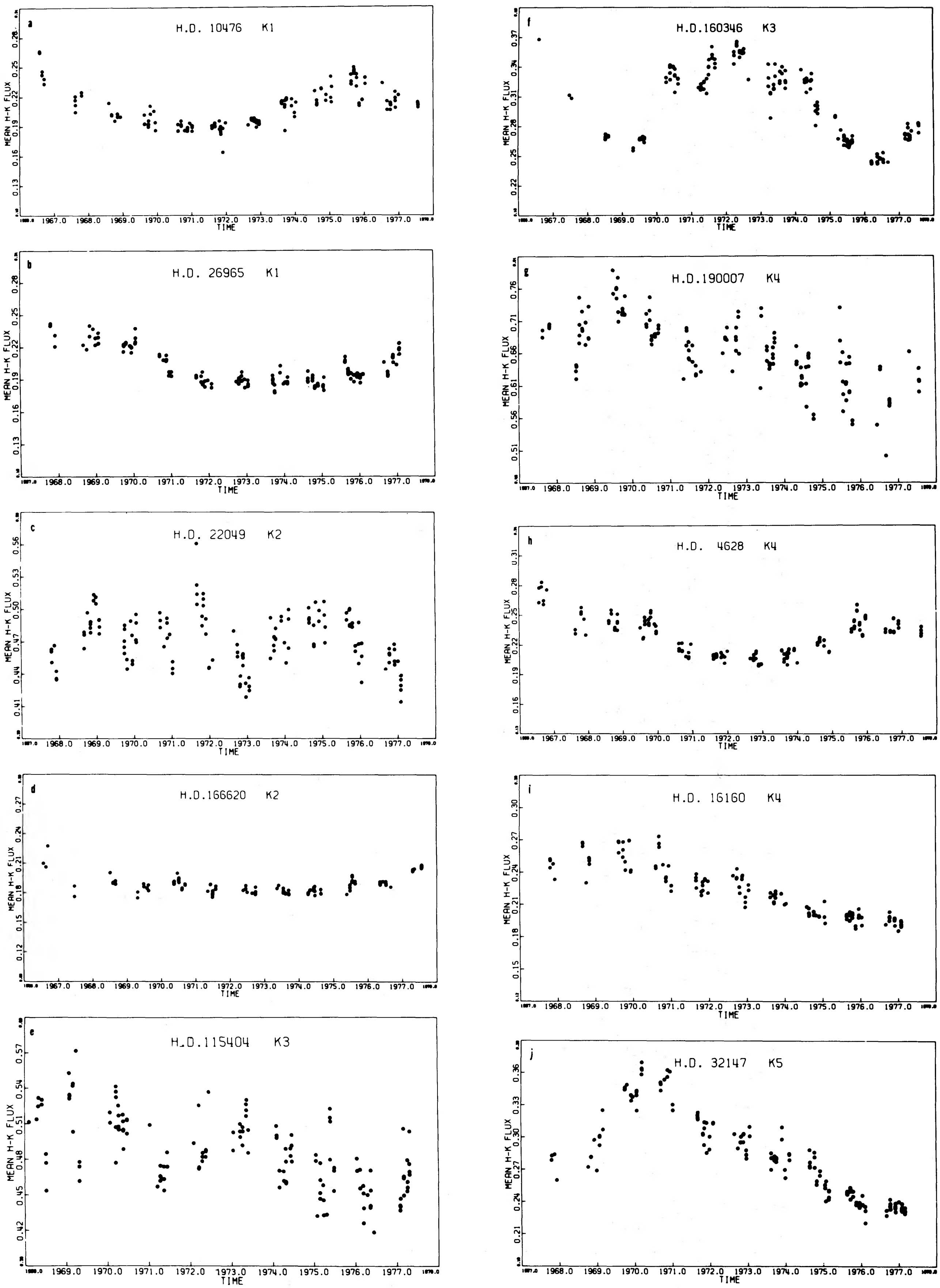
a
H.D. 10476 K1
b
H.D. 26965 K1
c
H.D. 22049 K2
d
H.D.166620 K2
e
H.D.115404 K3
f
H.D.160346 K3
g
H.D.190007 K4
h
H.D. 4628 K4
i
H.D. 16160 K4
j
H.D. 32147 K5
MEAN H-K FLUX
TIME

FIG. 4

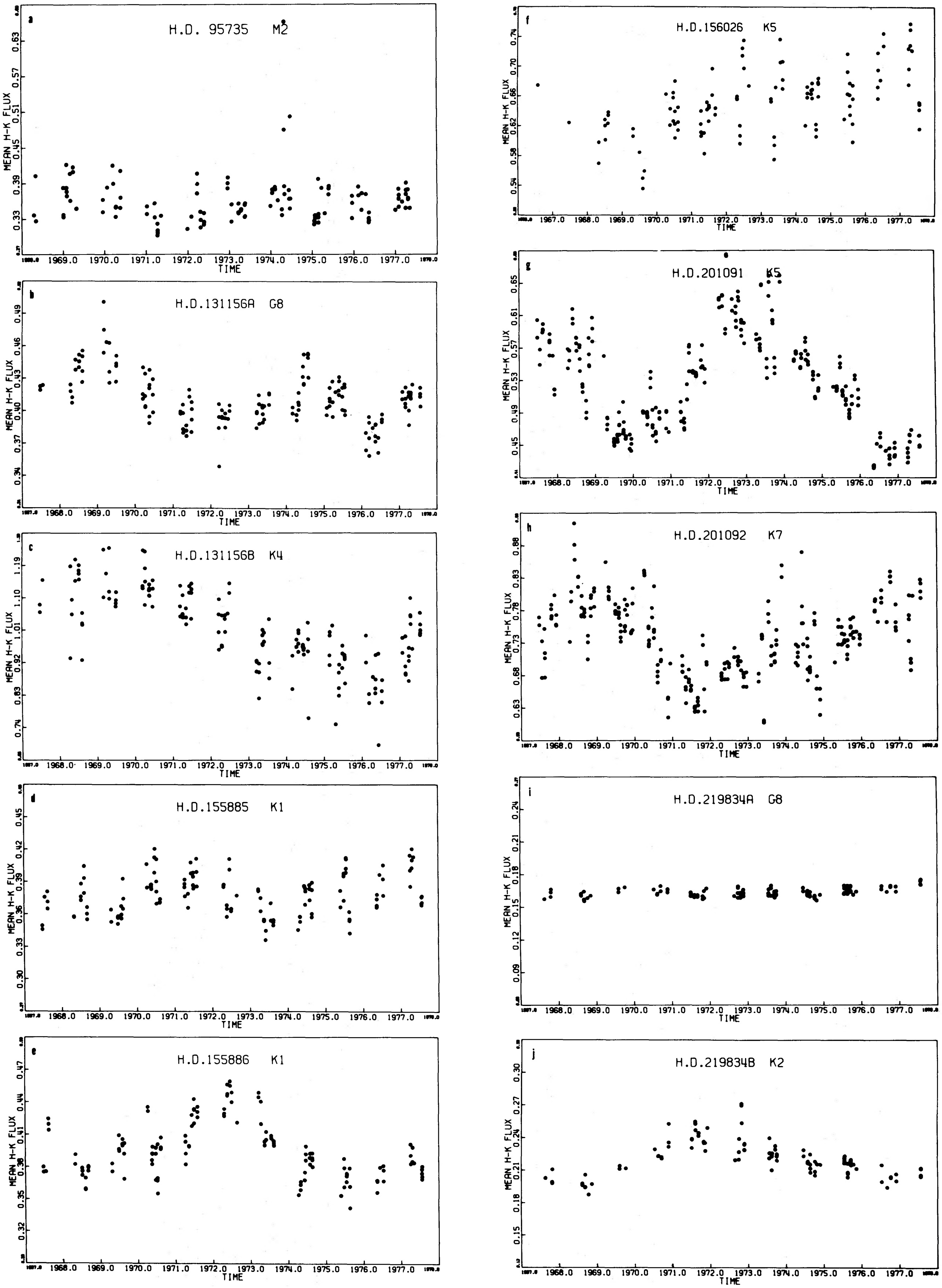
a H.D. 95735 M2
b H.D.131156A G8
c H.D.131156B K4
d H.D.155885 K1
e H.D.155886 K1
f H.D.156026 K5
g H.D.201091 K5
h H.D.201092 K7
i H.D.219834A G8
j H.D.219834B K2
MEAN H-K FLUX
TIME

FIG. 5

TABLE 1: Seasonal Data for Stars

STAR NAME	SP.	MEAN DATE	NO. OBS.	AVG FLUX	S. D. AVG.	S. D. OBS.	NO. OBS.	K/H RATIO	S. D. RATIO	
H. D. 1835		1966.647	5	0.384	2.003	3.469	0	0.0	0.0	
	G2	1967.786	12	0.345	1.776	5.615	10	0.970	0.466	
		1968.714	19	0.353	0.569	2.345	19	0.975	0.408	
		1969.729	21	0.346	0.787	3.430	21	0.977	0.493	
		1970.694	15	0.340	1.398	5.039	15	0.967	0.400	
		1971.727	12	0.345	0.589	1.863	12	0.970	0.416	
		1972.818	11	0.330	0.597	1.792	11	0.970	0.292	
		1973.694	15	0.363	0.981	3.538	15	0.974	0.490	
		1974.742	12	0.351	1.668	5.275	12	0.976	0.471	
		1975.713	18	0.363	0.809	3.236	18	0.976	0.314	
		1976.759	12	0.338	1.276	4.036	12	0.972	0.737	
		1977.561	4	0.327	3.971	5.616	4	0.965	1.031	
ALL OBS.		1972.014	156	0.349	0.402	4.991	149	0.973	0.135	
H. D. 2454		1966.692	7	0.171	0.970	2.168	0	0.0	0.0	
	F2	1967.861	4	0.171	2.118	2.995	4	0.888	0.689	
		1968.634	10	0.178	0.754	2.132	10	0.887	0.414	
		1969.681	14	0.170	0.806	2.791	14	0.888	0.490	
		1970.681	13	0.173	0.807	2.677	13	0.891	0.411	
		1971.727	12	0.173	0.614	1.941	12	0.890	0.402	
		1972.799	11	0.165	0.515	1.545	11	0.885	0.401	
		1973.703	10	0.175	0.739	2.090	10	0.895	0.647	
		1974.705	11	0.168	0.892	2.675	11	0.890	0.709	
		1975.745	15	0.176	0.679	2.448	15	0.906	0.531	
		1976.821	9	0.168	0.858	2.270	9	0.895	0.834	
		1977.561	4	0.163	1.395	1.973	4	0.904	0.545	
ALL OBS.		1972.302	120	0.171	0.296	3.215	113	0.892	0.164	F
H. D. 3229		1966.692	7	0.210	0.516	1.154	0	0.0	0.0	
	F2	1967.862	4	0.214	1.250	1.767	4	0.920	0.653	
		1968.685	9	0.212	0.596	1.577	9	0.913	0.503	
		1969.681	14	0.214	0.717	2.482	14	0.919	0.414	
		1970.695	12	0.212	0.412	1.302	12	0.916	0.403	
		1971.727	12	0.205	0.369	1.168	12	0.917	0.256	
		1972.799	11	0.213	0.526	1.579	11	0.917	0.370	
		1973.703	10	0.211	0.685	1.939	10	0.923	0.370	
		1974.694	10	0.210	0.762	2.156	10	0.925	0.477	
		1975.760	14	0.212	0.644	2.230	14	0.926	0.493	
		1976.792	10	0.205	0.687	1.944	10	0.918	0.405	
		1977.561	4	0.210	1.684	2.382	4	0.929	0.850	
ALL OBS.		1972.340	117	0.211	0.208	2.235	110	0.920	0.125	F
H. D. 3443		1966.700	2	0.191	1.333	1.333	0	0.0	0.0	
	G5	1967.766	5	0.184	1.663	2.881	5	0.844	0.891	
		1968.691	2	0.187	0.134	0.134	2	0.855	0.122	
		1969.771	8	0.188	1.339	3.280	8	0.858	0.752	
		1970.779	8	0.190	0.852	2.087	8	0.846	0.784	
		1971.752	9	0.182	0.333	0.881	9	0.842	0.749	
		1972.800	7	0.182	0.688	1.537	7	0.843	0.614	
		1973.671	7	0.184	0.600	1.341	7	0.832	1.124	
		1974.700	8	0.179	0.799	1.958	8	0.835	0.647	
		1975.707	8	0.185	0.676	1.655	8	0.848	0.839	
		1976.818	3	0.181	0.836	0.836	3	0.847	2.938	
		1977.560	3	0.178	3.511	3.511	3	0.851	3.298	
ALL OBS.		1972.442	70	0.184	0.327	2.701	68	0.844	0.252	F
H. D. 3651		1966.674	6	0.229	2.032	4.064	0	0.0	0.0	
	K0	1967.788	7	0.204	1.612	3.604	7	0.899	0.855	
		1968.733	12	0.196	0.802	2.535	12	0.903	0.636	
		1969.726	18	0.189	0.479	1.914	18	0.892	0.369	
		1970.694	15	0.190	0.748	2.697	15	0.883	0.488	
		1971.758	14	0.187	0.497	1.722	14	0.878	0.291	
		1972.818	13	0.185	0.389	1.289	13	0.883	0.408	
		1973.694	15	0.184	0.819	2.953	15	0.875	0.521	
		1974.711	13	0.188	0.582	1.931	13	0.885	0.801	
		1975.746	17	0.200	0.636	2.463	17	0.896	0.411	
		1976.759	12	0.207	0.721	2.281	12	0.909	0.599	
		1977.561	4	0.211	1.087	1.538	4	0.904	0.692	
ALL OBS.		1972.335	146	0.194	0.496	5.947	140	0.890	0.176	10
H. D. 3795		1966.700	2	0.165	2.295	2.295	0	0.0	0.0	
	G3	1967.811	3	0.158	1.042	1.042	3	0.831	1.203	
		1968.694	9	0.154	0.678	1.793	9	0.832	0.347	
		1969.741	8	0.155	0.915	2.241	8	0.831	0.837	
		1970.779	8	0.157	0.761	1.864	8	0.832	0.934	
		1971.744	6	0.156	1.076	2.152	6	0.822	0.889	
		1972.820	8	0.157	0.565	1.384	8	0.843	0.761	
		1973.620	4	0.160	1.626	2.300	4	0.820	1.279	
		1974.700	8	0.160	0.848	2.077	8	0.830	0.917	
		1975.679	4	0.161	2.077	2.937	4	0.833	1.895	
		1976.773	1	0.159	0.0	0.0	1	0.821	0.0	
		1977.560	3	0.157	1.746	1.746	3	0.826	1.513	
ALL OBS.		1971.811	64	0.157	0.310	2.439	62	0.831	0.245	C?
H. D. 4628		1966.681	7	0.272	1.464	3.274	0	0.0	0.0	
	K4	1967.788	7	0.244	2.061	4.609	7	0.936	0.515	
		1968.733	12	0.244	0.866	2.738	12	0.940	0.567	
		1969.737	19	0.240	0.825	3.402	19	0.941	0.489	
		1970.758	11	0.214	0.854	2.562	11	0.911	0.310	
		1971.758	14	0.209	0.414	1.434	14	0.896	0.298	
		1972.818	13	0.205	0.730	2.421	13	0.895	0.341	
		1973.724	15	0.210	0.736	2.652	15	0.900	0.461	
		1974.714	11	0.222	0.777	2.332	11	0.921	0.573	
		1975.749	18	0.243	0.996	3.985	18	0.940	0.460	
		1976.759	12	0.238	0.727	2.298	12	0.937	0.490	
		1977.561	4	0.233	1.233	1.743	4	0.934	0.550	
ALL OBS.		1972.325	143	0.229	0.708	8.402	136	0.922	0.221	9
H. D. 6920		1966.732	6	0.185	1.442	2.884	0	0.0	0.0	
	F8	1967.765	5	0.176	1.265	2.191	5	0.915	0.665	
		1968.735	8	0.186	0.426	1.044	8	0.924	0.442	
		1969.753	11	0.180	0.652	1.955	11	0.923	0.592	
		1970.867	8	0.178	1.828	4.479	8	0.918	0.625	
		1971.789	10	0.175	0.736	2.081	10	0.916	0.396	
		1972.804	10	0.189	0.836	2.366	10	0.931	0.402	
		1973.731	9	0.181	1.204	3.186	9	0.919	0.503	
		1974.723	9	0.182	0.950	2.513	9	0.926	0.745	
		1975.745	13	0.179	0.933	3.096	13	0.927	0.448	
		1976.796	7	0.186	0.896	2.004	7	0.926	0.577	
ALL OBS.		1972.157	96	0.182	0.355	3.444	90	0.923	0.156	
* H. D. 9562		1966.692	7	0.146	1.128	2.522	0	0.0	0.0	
	G2	1967.858	7	0.145	1.350	3.020	7	0.837	0.570	
		1968.787	13	0.144	0.881	2.923	13	0.845	0.432	
		1969.794	13	0.143	0.832	2.758	13	0.851	0.613	
		1970.870	11	0.145	0.728	2.186	11	0.848	0.561	
		1971.851	9	0.144	0.798	2.112	9	0.830	0.462	
		1972.811	11	0.146	0.673	2.020	11	0.840	0.451	
		1973.791	7	0.146	0.708	1.583	7	0.836	0.755	
		1974.867	6	0.144	1.501	3.003	6	0.849	0.599	
		1975.793	7	0.146	1.189	2.659	7	0.859	0.194	
		1976.822	6	0.147	0.913	1.827	6	0.851	1.060	
		1977.562	1	0.148	0.0	0.0	1	0.823	2.219	
ALL OBS.		1971.474	98	0.145	0.251	2.456	91	0.844	0.187	
H. D. 10476		1966.658	6	0.249	2.780	5.559	0	0.0	0.0	
	K1	1967.688	6	0.217	1.727	3.454	4	0.909	1.180	
		1968.775	8	0.202	1.056	2.587	8	0.908	0.732	
		1969.778	12	0.196	1.176	3.720	12	0.902	0.764	
		1970.814	14	0.189	0.522	1.807	14	0.881	0.328	
		1971.776	14	0.187	1.191	4.126	14	0.873	0.371	
		1972.833	14	0.194	0.395	1.367	14	0.894	0.412	
		1973.786	15	0.211	1.163	4.194	15	0.906	0.529	
		1974.821	14	0.221	1.113	3.854	14	0.924	0.411	
		1975.816	19	0.233	1.284	5.296	19	0.938	0.508	
		1976.799	12	0.215	1.177	3.724	12	0.919	0.614	
		1977.561	4	0.211	0.768	1.085	4	0.900	0.834	
ALL OBS.		1972.720	138	0.209	0.777	9.058	130	0.906	0.246	9
H. D. 10700		1967.718	5	0.168	2.614	4.528	4	0.857	0.539	
	G8	1968.688	2	0.172	2.269	2.269	2	0.856	3.174	
		1969.795	9	0.173	1.082	2.862	9	0.864	0.839	
		1970.825	12	0.174	0.864	2.732	12	0.844	0.543	
		1971.802	10	0.173	0.633	1.790	10	0.841	0.601	
		1972.829	13	0.174	0.668	2.216	13	0.855	0.553	
		1973.791	14	0.172	0.678	2.348	14	0.848	0.597	
		1974.821	14	0.171	0.688	2.383	14	0.855	0.555	
		1975.834	16	0.172	0.586	2.192	16	0.848	0.733	
		1976.823	11	0.170	0.429	1.286	11	0.859	0.778	
		1977.561	4	0.173	1.085	1.534	4	0.858	1.135	
ALL OBS.		1973.340	110	0.172	0.236	2.456	109	0.852	0.207	
H. D. 12235		1966.719	5	0.168	2.574	4.458	0	0.0	0.0	
	G1	1967.853	3	0.168	2.314	2.314	3	0.885	1.417	
		1968.756	8	0.163	1.017	2.490	8	0.876	0.421	
		1969.764	10	0.167	0.707	2.000	10	0.888	0.579	
		1970.843	10	0.163	0.591	1.672	10	0.876	0.364	
		1971.759	8	0.166	1.088	2.666	8	0.872	0.525	
		1972.829	13	0.167	0.571	1.893	13	0.881	0.407	
		1973.771	10	0.169	0.622	1.759	10	0.877	0.526	
		1974.825	11	0.173	1.418	4.254	11	0.888	0.493	
		1975.788	15	0.171	0.635	2.290	15	0.890	0.446	
		1976.815	10	0.167	0.892	2.523	10	0.883	0.667	
		1977.565	2	0.166	2.533	2.533	2	0.887	0.249	
ALL OBS.		1972.708	105	0.168	0.299	3.033	100	0.882	0.155	C?
* H. D. 13421		1966.718	5	0.135	1.362	2.360	0	0.0	0.0	
	F8	1967.815	10	0.135	0.990	2.800	10	0.839	1.015	
		1968.927	18	0.133	0.586	2.344	18	0.854	0.349	
		1969.819	12	0.132	0.475	1.501	12	0.851	0.516	
		1970.870	11	0.133	0.667	2.001	11	0.845	0.399	
		1971.834	10	0.131	0.626	1.772	10	0.846	0.419	
		1972.881	13	0.134	0.717	2.377	13	0.859	0.261	
		1973.819	7	0.134	0.370	0.827	7	0.863	0.706	
		1974.854	13	0.134	0.881	2.921	13	0.859	0.616	
		1975.838	17	0.132	0.666	2.581	17	0.858	0.455	
		1976.912	14	0.132	0.745	2.581	14	0.851	0.390	
ALL OBS.		1972.237	130	0.133	0.212	2.398	125	0.853	0.158	F
H. D. 16160		1967.852	5	0.246	1.797	3.113	5	0.938	0.771	
	K4	1968.776	9	0.251	2.120	5.610	9	0.961	0.439	
		1969.792	12	0.257	1.435	4.537	12	0.954	0.418	
		1970.830	13	0.243	1.996	6.618	13	0.938	0.389	
		1971.821	13	0.229	0.828	2.747	13	0.921	0.461	
		1972.862	17	0.228	1.140	4.415	17	0.927	0.434	
		1973.783	13	0.216	0.622	2.064	13	0.922	0.508	
		1974.803	14	0.202	0.699	2.421	14	0.912	0.549	
		1975.813	17	0.198	0.629	2.437	17	0.900	0.412	
		1976.918	15	0.194	0.629	2.269	15	0.899	0.288	
ALL OBS.		1972.947	128	0.223	0.940	10.556	128	0.924	0.229	>9
H. D. 16673		1966.706	3	0.202	0.786	0.786	0	0.0	0.0	
	F6	1967.877	5	0.222	1.451	2.514	5	0.910	0.576	
		1968.767	8	0.212	0.919	2.251	8	0.911	0.291	
		1969.778	11	0.206	0.908	2.724	11	0.919	0.668	
		1970.877	10	0.224	1.173	3.319	10	0.915	0.453	
		1971.847	11	0.216	1.171	3.513	11	0.910	0.351	
		1972.859	15	0.208	0.654	2.358	15	0.912	0.347	
		1973.797	12	0.218	0.573	1.813	12	0.916	0.507	
		1974.821	13	0.208	0.703	2.333	13	0.918	0.609	
		1975.840	16	0.213	0.861	3.221	16	0.911	0.396	
		1976.929	14	0.203	0.541	1.874	14	0.910	0.335	
ALL OBS.		1972.859	118	0.212	0.364	3.924	115	0.913	0.136	F
H. D. 17925		1967.866	6	0.662	2.081	4.161	6	1.044	0.877	
	K0	1968.894	17	0.629	0.939	3.637	17	1.054	0.378	
		1969.854	16	0.685	1.223	4.576	16	1.056	0.334	
		1970.870	11	0.663	1.730	5.191	11	1.045	0.461	
		1971.821	13	0.642	1.050	3.484	13	1.042	0.467	
		1972.862	17	0.617	0.815	3.156	17	1.053	0.309	
		1973.783	13	0.609	0.974	3.231	13	1.045	0.495	
		1974.803	14	0.613	1.462	5.065	14	1.050	0.397	
		1975.826	18	0.613	1.295	5.180	18	1.051	0.537	
		1976.929	14	0.582	0.757	2.623	14	1.051	0.334	
ALL OBS.		1972.629	139	0.629	0.524	6.137	139	1.050	0.130	>10

TABLE 1—*Continued*

STAR NAME SP.	MEAN DATE	NO. OBS.	AVG FLUX	S. D. AVG.	S. D. OBS.	NO. OBS.	K/H RATIO	S. D. RATIO	
H. D. 18256	1966. 833	9	0. 174	1. 213	3. 209	0	0. 0	0. 0	
F5	1967. 860	4	0. 172	3. 175	4. 491	4	0. 891	0. 470	
	1968. 766	8	0. 176	1. 330	3. 259	8	0. 896	0. 427	
	1969. 855	17	0. 180	0. 759	2. 938	17	0. 900	0. 343	
	1970. 868	8	0. 176	0. 656	1. 608	8	0. 903	0. 798	
	1971. 878	8	0. 178	0. 941	2. 304	8	0. 896	0. 484	
	1972. 855	16	0. 181	0. 701	2. 623	16	0. 908	0. 262	
	1973. 866	11	0. 182	0. 762	2. 286	11	0. 902	0. 724	
	1974. 821	13	0. 176	0. 823	2. 730	13	0. 905	0. 582	
	1975. 856	12	0. 170	1. 076	3. 403	12	0. 900	0. 442	
	1976. 929	14	0. 168	0. 617	2. 137	14	0. 903	0. 270	
ALL OBS.	1972. 417	120	0. 176	0. 339	3. 682	111	0. 902	0. 140	F
H. D. 20630	1967. 876	8	0. 354	0. 518	1. 269	8	0. 996	0. 679	
G5	1968. 883	16	0. 360	0. 947	3. 545	16	1. 003	0. 365	
	1969. 872	17	0. 352	0. 832	3. 221	17	0. 992	0. 394	
	1970. 848	12	0. 354	1. 353	4. 277	12	0. 997	0. 396	
	1971. 841	12	0. 345	0. 782	2. 474	12	0. 991	0. 433	
	1972. 870	16	0. 357	0. 827	3. 094	16	1. 002	0. 289	
	1973. 857	15	0. 346	1. 333	4. 808	15	0. 979	0. 284	
	1974. 838	14	0. 321	1. 346	4. 662	14	0. 988	0. 302	
	1975. 849	15	0. 310	1. 143	4. 121	15	0. 980	0. 446	
	1976. 918	15	0. 301	1. 511	5. 448	15	0. 986	0. 285	
ALL OBS.	1972. 553	140	0. 339	0. 612	7. 184	140	0. 991	0. 129	>10
H. D. 22049	1967. 876	8	0. 453	1. 215	2. 976	8	1. 038	0. 431	
K2	1968. 902	16	0. 489	0. 775	2. 898	16	1. 046	0. 348	
	1969. 894	15	0. 470	0. 932	3. 360	15	1. 045	0. 556	
	1970. 870	11	0. 473	1. 387	4. 161	11	1. 037	0. 454	
	1971. 839	14	0. 494	1. 867	6. 468	14	1. 040	0. 441	
	1972. 870	16	0. 445	1. 064	3. 983	16	1. 042	0. 446	
	1973. 842	16	0. 475	0. 818	3. 060	16	1. 033	0. 347	
	1974. 838	14	0. 488	0. 801	2. 775	14	1. 045	0. 603	
	1975. 840	16	0. 476	1. 094	4. 094	16	1. 049	0. 515	
	1976. 918	15	0. 447	0. 965	3. 480	15	1. 036	0. 449	
ALL OBS.	1972. 630	141	0. 472	0. 442	5. 216	141	1. 041	0. 141	
H. D. 23249	1967. 878	5	0. 152	3. 825	6. 625	5	0. 879	0. 325	
K0	1968. 925	14	0. 157	0. 920	3. 189	14	0. 876	0. 263	
	1969. 901	13	0. 157	0. 809	2. 684	13	0. 877	0. 334	
	1970. 870	11	0. 158	0. 473	1. 418	11	0. 869	0. 496	
	1971. 855	9	0. 156	0. 917	2. 426	9	0. 853	0. 644	
	1972. 898	12	0. 157	0. 469	1. 483	12	0. 870	0. 420	
	1973. 874	14	0. 157	0. 745	2. 582	14	0. 863	0. 352	
	1974. 838	14	0. 159	0. 896	3. 103	14	0. 861	0. 455	
	1975. 849	15	0. 159	0. 800	2. 884	15	0. 868	0. 477	
	1976. 936	14	0. 156	0. 709	2. 454	14	0. 863	0. 572	
ALL OBS.	1972. 813	121	0. 157	0. 264	2. 881	121	0. 868	0. 148	
H. D. 25998	1966. 855	8	0. 273	1. 111	2. 722	0	0. 0	0. 0	
F7	1967. 876	5	0. 270	1. 773	3. 071	5	0. 957	0. 593	
	1968. 893	12	0. 265	0. 669	2. 117	12	0. 956	0. 277	
	1969. 908	13	0. 263	0. 858	2. 847	13	0. 955	0. 490	
	1970. 864	11	0. 263	1. 022	3. 066	11	0. 958	0. 419	
	1971. 867	12	0. 250	0. 573	1. 813	12	0. 941	0. 421	
	1972. 883	13	0. 254	0. 602	1. 997	13	0. 948	0. 406	
	1973. 867	12	0. 256	1. 330	4. 205	12	0. 940	0. 343	
	1974. 868	13	0. 256	0. 989	3. 280	13	0. 948	0. 399	
	1975. 917	15	0. 251	0. 679	2. 448	15	0. 944	0. 538	
	1976. 950	13	0. 241	0. 669	2. 219	13	0. 949	0. 390	
ALL OBS.	1972. 419	127	0. 257	0. 381	4. 263	119	0. 949	0. 136	
H. D. 26913	1966. 866	6	0. 397	1. 813	3. 625	0	0. 0	0. 0	
G3	1967. 865	4	0. 386	0. 452	0. 639	4	1. 003	0. 0	
	1968. 947	9	0. 377	1. 008	2. 667	9	1. 012	0. 151	
	1969. 919	11	0. 371	1. 054	3. 162	11	1. 009	0. 404	
	1970. 855	10	0. 360	0. 777	2. 198	10	1. 003	0. 513	
	1971. 872	11	0. 353	1. 646	4. 937	11	0. 997	0. 326	
	1972. 890	13	0. 359	1. 038	3. 442	13	1. 014	0. 326	
	1973. 880	13	0. 365	1. 278	4. 240	13	1. 007	0. 551	
	1974. 983	14	0. 364	0. 788	2. 729	14	0. 997	1. 489	
	1975. 915	12	0. 369	0. 727	2. 300	12	1. 007	0. 588	
	1976. 965	12	0. 349	0. 754	2. 385	12	1. 003	0. 641	
ALL OBS.	1972. 637	115	0. 365	0. 412	4. 385	109	1. 005	0. 219	D
H. D. 26923	1966. 866	6	0. 288	1. 768	3. 536	0	0. 0	0. 0	
G0	1967. 865	4	0. 282	1. 442	2. 040	4	0. 966	0. 0	
	1968. 960	10	0. 273	0. 701	1. 982	10	0. 969	0. 178	
	1969. 918	12	0. 280	1. 089	3. 443	12	0. 972	0. 322	
	1970. 870	11	0. 258	0. 746	2. 237	11	0. 963	0. 714	
	1971. 872	11	0. 259	1. 534	4. 603	11	0. 955	0. 565	
	1972. 890	13	0. 273	0. 897	2. 975	13	0. 964	0. 395	
	1973. 880	13	0. 277	0. 989	3. 281	13	0. 963	0. 401	
	1974. 983	14	0. 272	1. 141	3. 952	14	0. 962	0. 427	
	1975. 915	12	0. 267	0. 699	2. 210	12	0. 964	0. 647	
	1976. 965	12	0. 258	0. 494	1. 561	12	0. 958	0. 838	
ALL OBS.	1972. 570	118	0. 270	0. 414	4. 460	112	0. 963	0. 159	D
H. D. 26965	1967. 873	4	0. 234	2. 933	4. 148	4	0. 934	1. 088	
K1	1968. 948	11	0. 228	0. 998	2. 995	11	0. 933	0. 568	
	1969. 905	14	0. 223	0. 702	2. 432	14	0. 931	0. 374	
	1970. 881	10	0. 204	1. 407	3. 981	10	0. 900	0. 459	
	1971. 875	12	0. 189	0. 753	2. 381	12	0. 878	0. 573	
	1972. 910	12	0. 189	0. 697	2. 204	12	0. 880	0. 300	
	1973. 874	14	0. 189	0. 995	3. 447	14	0. 882	0. 340	
	1974. 837	15	0. 188	0. 735	2. 652	15	0. 876	0. 646	
	1975. 858	19	0. 196	0. 798	3. 290	19	0. 893	0. 502	
	1976. 918	15	0. 208	1. 379	4. 971	15	0. 916	0. 571	
ALL OBS.	1973. 064	126	0. 202	0. 735	8. 183	126	0. 900	0. 262	>9
* H. D. 29645	1966. 945	7	0. 142	0. 898	2. 009	0	0. 0	0. 0	
G3	1967. 882	9	0. 138	0. 392	1. 037	9	0. 851	0. 450	
	1968. 991	19	0. 138	0. 330	1. 360	19	0. 850	0. 253	
	1969. 951	10	0. 139	0. 605	1. 712	10	0. 847	0. 312	
	1970. 855	10	0. 138	0. 639	1. 808	10	0. 858	0. 316	
	1971. 941	8	0. 138	0. 753	1. 843	8	0. 850	0. 476	
	1972. 896	11	0. 137	0. 269	0. 806	11	0. 852	0. 269	
	1974. 031	6	0. 138	1. 386	2. 772	6	0. 838	0. 606	
	1974. 923	10	0. 138	0. 377	1. 066	10	0. 848	0. 659	
	1976. 025	8	0. 138	0. 790	1. 935	8	0. 857	0. 448	
	1977. 016	9	0. 137	0. 515	1. 364	9	0. 860	0. 321	
ALL OBS.	1971. 680	107	0. 138	0. 165	1. 695	100	0. 852	0. 126	F
H. D. 30495	1967. 866	6	0. 295	0. 963	1. 926	6	0. 950	0. 887	
G1	1968. 960	10	0. 299	0. 985	2. 786	10	0. 968	0. 569	
	1969. 914	12	0. 290	1. 367	4. 323	12	0. 961	0. 798	
	1970. 894	8	0. 288	1. 162	2. 847	8	0. 951	0. 438	
	1971. 862	9	0. 283	1. 193	3. 158	9	0. 941	0. 513	
	1972. 897	11	0. 280	1. 080	3. 240	11	0. 950	0. 412	
	1973. 852	12	0. 277	1. 016	3. 213	12	0. 949	0. 377	
	1974. 902	19	0. 272	1. 246	5. 136	19	0. 945	0. 396	
	1975. 886	13	0. 283	1. 668	5. 531	13	0. 944	0. 653	
	1976. 936	14	0. 262	0. 737	2. 552	14	0. 947	0. 384	
ALL OBS.	1973. 017	114	0. 281	0. 503	5. 321	114	0. 950	0. 169	
H. D. 32147	1967. 862	4	0. 276	2. 867	4. 055	4	0. 964	0. 610	
K5	1968. 986	11	0. 292	1. 890	5. 671	11	0. 972	0. 538	
	1969. 994	15	0. 347	0. 978	3. 527	15	1. 001	0. 696	
	1970. 855	10	0. 350	1. 318	3. 728	10	1. 003	0. 502	
	1971. 856	15	0. 308	1. 048	3. 779	15	0. 972	0. 887	
	1972. 878	15	0. 296	0. 761	2. 744	15	0. 976	0. 464	
	1973. 826	17	0. 281	0. 967	3. 747	17	0. 965	0. 683	
	1974. 902	19	0. 263	1. 359	5. 603	19	0. 947	0. 566	
	1975. 850	20	0. 242	0. 801	3. 399	20	0. 931	0. 456	
	1976. 944	19	0. 234	0. 406	1. 673	19	0. 932	0. 376	
ALL OBS.	1973. 215	145	0. 284	1. 154	13. 796	145	0. 962	0. 277	>9
H. D. 33608	1967. 111	4	0. 209	0. 355	0. 502	0	0. 0	0. 0	
F5	1967. 947	5	0. 225	1. 361	2. 357	5	0. 933	3. 180	
	1969. 007	9	0. 214	1. 434	3. 794	9	0. 924	0. 604	
	1969. 939	11	0. 223	1. 083	3. 249	11	0. 919	0. 618	
	1970. 929	6	0. 212	1. 045	2. 091	6	0. 916	0. 559	
	1971. 931	7	0. 211	0. 841	1. 881	7	0. 916	0. 194	
	1972. 933	12	0. 207	1. 093	3. 458	12	0. 922	0. 407	
	1973. 979	8	0. 205	1. 163	2. 849	8	0. 913	0. 384	
	1974. 986	14	0. 203	0. 719	2. 490	14	0. 912	0. 382	
	1975. 978	10	0. 207	0. 849	2. 402	10	0. 904	0. 317	
	1976. 950	13	0. 208	0. 865	2. 869	13	0. 929	0. 389	
ALL OBS.	1972. 768	99	0. 210	0. 421	4. 144	95	0. 919	0. 195	D
H. D. 35296	1966. 993	8	0. 293	1. 650	4. 042	0	0. 0	0. 0	
F8	1967. 877	6	0. 310	1. 345	2. 691	6	0. 961	0. 945	
	1969. 000	11	0. 300	0. 738	2. 213	11	0. 972	0. 527	
	1969. 912	13	0. 304	0. 753	2. 499	13	0. 969	0. 657	
	1970. 980	10	0. 288	0. 795	2. 248	10	0. 955	0. 803	
	1971. 921	11	0. 285	0. 989	2. 966	11	0. 964	0. 347	
	1972. 934	17	0. 285	0. 653	2. 529	17	0. 969	0. 237	
	1973. 919	15	0. 287	0. 844	3. 043	15	0. 960	0. 273	
	1974. 972	15	0. 283	0. 657	2. 370	15	0. 964	0. 444	
	1975. 981	12	0. 279	1. 563	4. 944	12	0. 961	0. 297	
	1976. 976	17	0. 276	0. 810	3. 138	17	0. 969	0. 256	
ALL OBS.	1972. 629	135	0. 288	0. 383	4. 413	127	0. 965	0. 133	
H. D. 39587	1966. 192	2	0. 286	3. 687	3. 687	0	0. 0	0. 0	
G0	1966. 993	8	0. 305	1. 198	2. 934	0	0. 0	0. 0	
	1967. 877	6	0. 305	1. 097	2. 193	6	0. 967	0. 915	
	1969. 036	11	0. 292	0. 839	2. 516	11	0. 972	0. 283	
	1970. 007	17	0. 297	1. 108	4. 293	17	0. 978	0. 738	
	1970. 980	10	0. 282	1. 719	4. 863	10	0. 976	0. 626	
	1971. 921	11	0. 288	1. 168	3. 504	11	0. 977	0. 573	
	1972. 934	17	0. 285	0. 643	2. 492	17	0. 976	0. 278	
	1973. 978	13	0. 290	1. 098	3. 642	13	0. 967	0. 431	
	1974. 972	15	0. 292	1. 029	3. 712	15	0. 974	0. 404	
	1975. 972	13	0. 285	0. 935	3. 101	13	0. 976	0. 380	
	1976. 976	17	0. 271	0. 838	3. 245	17	0. 976	0. 422	
ALL OBS.	1972. 484	140	0. 289	0. 387	4. 542	130	0. 974	0. 149	D
H. D. 43587	1966. 986	2	0. 168	1. 798	1. 798	0	0. 0	0. 0	
G0	1968. 109	1	0. 157	0. 0	0. 0	1	0. 855	0. 0	
	1969. 040	12	0. 159	0. 585	1. 849	12	0. 865	0. 0	
	1970. 052	15	0. 159	0. 747	2. 693	15	0. 867	0. 448	
	1970. 980	10	0. 157	0. 632	1. 787	10	0. 853	1. 092	
	1972. 017	13	0. 157	0. 816	2. 706	13	0. 853	0. 485	
	1972. 930	14	0. 156	0. 463	1. 602	14	0. 851	0. 306	
	1973. 998	13	0. 156	1. 016	3. 369	13	0. 851	0. 320	
	1974. 986	14	0. 155	0. 815	2. 824	14	0. 852	0. 398	
	1976. 038	15	0. 156	0. 680	2. 452	15	0. 850	0. 428	
	1977. 039	13	0. 154	0. 549	1. 822	13	0. 865	0. 685	
ALL OBS.	1972. 965	122	0. 157	0. 247	2. 708	120	0. 856	0. 164	F
* H. D. 45067	1966. 985	2	0. 140	0. 912	0. 912	0	0. 0	0. 0	
F8	1967. 904	10	0. 141	0. 409	1. 157	10	0. 845	0. 0	
	1969. 018	16	0. 141	0. 649	2. 430	16	0. 845	0. 232	
	1970. 035	8	0. 141	1. 049	2. 571	8	0. 860	0. 961	
	1970. 956	9	0. 142	0. 587	1. 553	9	0. 845	0. 611	
	1972. 017	12	0. 140	0. 869	2. 750	12	0. 843	0. 390	
	1972. 952	13	0. 142	0. 563	1. 866	13	0. 848	0. 418	
	1974. 005	13	0. 141	0. 693	2. 299	13	0. 847	0. 352	
	1974. 972	15	0. 142	0. 762	2. 747	15	0. 845	0. 406	
	1976. 054	15	0. 143	0. 485	1. 750	15	0. 848	0. 402	
	1977. 020	14	0. 141	0. 580	2. 010	14	0. 854	0. 387	
ALL OBS.	1972. 708	127	0. 142	0. 193	2. 163	125	0. 848	0. 127	F

TABLE 1—*Continued*

STAR NAME SP.	MEAN DATE	NO. OBS.	AVG FLUX	S. D. AVG.	S. D. OBS.	NO. OBS.	K/H RATIO	S. D. RATIO	
H. D. 75332	1966. 192	2	0. 277	0. 265	0. 265	0	0. 0	0. 0	
F7	1967. 087	5	0. 270	1. 563	2. 708	0	0. 0	0. 0	
	1968. 059	7	0. 265	1. 955	4. 372	7	0. 953	0. 606	
	1969. 097	20	0. 267	0. 629	2. 667	20	0. 963	0. 329	
	1970. 101	18	0. 275	0. 762	3. 048	18	0. 965	0. 436	
	1971. 083	13	0. 257	0. 692	2. 295	13	0. 964	0. 263	
	1972. 102	12	0. 263	1. 278	4. 043	12	0. 961	0. 350	
	1973. 063	19	0. 264	0. 606	2. 499	19	0. 964	0. 273	
	1974. 127	18	0. 259	1. 048	4. 193	18	0. 956	0. 404	
	1975. 094	13	0. 251	0. 901	2. 989	13	0. 962	0. 344	
	1976. 069	16	0. 264	0. 973	3. 641	16	0. 955	0. 493	
	1977. 093	18	0. 266	0. 845	3. 380	18	0. 970	0. 282	
ALL OBS.	1972. 546	161	0. 264	0. 310	3. 914	154	0. 962	0. 117	
H. D. 76151	1966. 185	2	0. 281	2. 382	2. 382	0	0. 0	0. 0	
G3	1967. 102	3	0. 259	0. 983	0. 983	0	0. 0	0. 0	
	1968. 069	7	0. 266	1. 110	2. 481	7	0. 939	0. 500	
	1969. 132	15	0. 254	1. 139	4. 106	15	0. 944	0. 381	
	1970. 101	18	0. 246	0. 591	2. 364	18	0. 938	0. 428	
	1971. 107	11	0. 253	0. 976	2. 929	11	0. 937	0. 413	
	1972. 119	11	0. 227	0. 519	1. 557	11	0. 911	0. 481	
	1973. 064	17	0. 262	0. 878	3. 399	17	0. 943	0. 315	
	1974. 136	17	0. 256	1. 174	4. 545	17	0. 938	0. 402	
	1975. 083	12	0. 261	0. 934	2. 954	12	0. 942	0. 693	
	1976. 083	15	0. 270	0. 651	2. 349	15	0. 943	0. 357	
	1977. 085	16	0. 232	0. 490	1. 832	16	0. 932	0. 330	
ALL OBS.	1972. 650	144	0. 253	0. 503	5. 991	139	0. 937	0. 145	
*H. D. 76572	1966. 192	2	0. 145	1. 566	1. 566	0	0. 0	0. 0	
F3	1967. 039	3	0. 139	3. 211	3. 211	0	0. 0	0. 0	
	1968. 116	10	0. 148	0. 582	1. 647	10	0. 870	0. 824	
	1969. 043	18	0. 142	0. 425	1. 702	18	0. 871	0. 238	
	1970. 102	17	0. 144	0. 605	2. 344	17	0. 868	0. 378	
	1971. 083	13	0. 143	0. 316	1. 048	13	0. 874	0. 357	
	1972. 107	8	0. 144	0. 628	1. 539	8	0. 866	0. 346	
	1973. 090	14	0. 143	0. 464	1. 607	14	0. 870	0. 383	
	1974. 097	9	0. 146	0. 690	1. 825	9	0. 875	0. 496	
	1975. 095	10	0. 144	0. 823	2. 328	10	0. 873	0. 422	
	1976. 017	5	0. 146	2. 010	3. 482	5	0. 881	0. 431	
	1977. 218	8	0. 142	0. 917	2. 245	8	0. 872	0. 451	
ALL OBS.	1971. 695	117	0. 144	0. 213	2. 285	112	0. 871	0. 127	F
H. D. 78366	1966. 185	2	0. 223	4. 770	4. 770	0	0. 0	0. 0	
G0	1967. 087	5	0. 242	1. 220	2. 113	0	0. 0	0. 0	
	1968. 060	6	0. 242	2. 553	5. 106	6	0. 963	0. 688	
	1969. 128	17	0. 239	0. 817	3. 165	17	0. 956	0. 399	
	1970. 103	17	0. 232	0. 833	3. 228	17	0. 954	0. 420	
	1971. 107	11	0. 217	0. 726	2. 179	11	0. 939	0. 562	
	1972. 147	10	0. 215	0. 900	2. 546	10	0. 934	0. 534	
	1973. 063	19	0. 209	0. 572	2. 360	19	0. 927	0. 337	
	1974. 127	18	0. 244	1. 037	4. 148	18	0. 957	0. 327	
	1975. 117	12	0. 227	0. 640	2. 023	12	0. 950	0. 392	
	1976. 069	16	0. 222	0. 759	2. 842	16	0. 935	0. 283	
	1977. 121	20	0. 225	0. 922	3. 912	20	0. 954	0. 381	
ALL OBS.	1972. 741	153	0. 227	0. 486	5. 977	146	0. 947	0. 154	
H. D. 81809	1966. 185	2	0. 182	4. 245	4. 245	0	0. 0	0. 0	
G2	1967. 039	3	0. 194	6. 323	6. 323	0	0. 0	0. 0	
	1968. 307	3	0. 189	3. 612	3. 612	3	0. 904	1. 105	
	1969. 131	14	0. 180	0. 914	3. 166	14	0. 901	0. 482	
	1970. 103	17	0. 170	0. 667	2. 583	17	0. 882	0. 341	
	1971. 130	10	0. 161	0. 737	2. 084	10	0. 865	0. 551	
	1972. 174	9	0. 154	0. 902	2. 385	9	0. 864	0. 809	
	1973. 051	17	0. 160	0. 666	2. 580	17	0. 874	0. 278	
	1974. 136	17	0. 174	0. 768	2. 976	17	0. 886	0. 618	
	1975. 083	12	0. 177	1. 073	3. 394	12	0. 886	0. 375	
	1976. 069	16	0. 182	0. 929	3. 476	16	0. 883	0. 471	
	1977. 121	20	0. 178	1. 114	4. 726	20	0. 891	0. 469	
ALL OBS.	1973. 006	140	0. 173	0. 546	6. 415	135	0. 883	0. 178	10
H. D. 82885	1968. 238	5	0. 325	1. 724	2. 986	5	0. 993	0. 279	
G8	1969. 128	17	0. 324	1. 258	4. 871	17	0. 982	0. 426	
	1970. 103	17	0. 335	1. 580	6. 121	17	0. 986	0. 561	
	1971. 107	11	0. 316	1. 063	3. 188	11	0. 983	0. 299	
	1972. 147	10	0. 303	1. 620	4. 582	10	0. 973	0. 473	
	1973. 064	18	0. 302	0. 963	3. 854	18	0. 971	0. 313	
	1974. 136	17	0. 295	0. 923	3. 575	17	0. 966	0. 444	
	1975. 108	11	0. 296	0. 921	2. 764	11	0. 975	0. 334	
	1976. 083	15	0. 314	1. 008	3. 635	15	0. 971	0. 326	
	1977. 121	20	0. 291	1. 060	4. 497	20	0. 978	0. 385	
ALL OBS.	1973. 024	141	0. 309	0. 539	6. 353	141	0. 977	0. 138	
H. D. 88737	1966. 192	2	0. 223	1. 162	1. 162	0	0. 0	0. 0	
F5	1967. 143	7	0. 229	1. 972	4. 411	0	0. 0	0. 0	
	1968. 119	6	0. 231	1. 412	2. 825	6	0. 937	1. 240	
	1969. 163	15	0. 232	0. 642	2. 315	15	0. 937	0. 485	
	1970. 103	17	0. 231	0. 984	3. 812	17	0. 942	0. 398	
	1971. 246	12	0. 222	0. 477	1. 509	12	0. 932	0. 355	
	1972. 186	10	0. 221	0. 626	1. 769	10	0. 933	0. 375	
	1973. 061	15	0. 224	0. 812	2. 929	15	0. 936	0. 326	
	1974. 151	16	0. 218	0. 712	2. 666	16	0. 936	0. 383	
	1975. 123	12	0. 217	0. 701	2. 216	12	0. 938	0. 382	
	1976. 098	14	0. 217	0. 526	1. 822	14	0. 931	0. 549	
	1977. 132	21	0. 215	0. 590	2. 571	21	0. 935	0. 348	
ALL OBS.	1972. 689	147	0. 222	0. 317	3. 815	138	0. 936	0. 129	D
*H. D. 89744	1966. 194	1	0. 138	0. 0	0. 0	0	0. 0	0. 0	
F6	1967. 289	2	0. 135	2. 580	2. 580	0	0. 0	0. 0	
	1968. 271	10	0. 137	0. 687	1. 943	10	0. 853	0. 335	
	1969. 131	19	0. 136	0. 505	2. 083	19	0. 861	0. 420	
	1970. 105	16	0. 137	0. 366	1. 371	16	0. 866	0. 560	
	1971. 236	11	0. 136	0. 189	0. 568	11	0. 862	0. 297	
	1972. 238	7	0. 137	0. 680	1. 519	7	0. 856	0. 528	
	1973. 119	11	0. 135	0. 523	1. 570	11	0. 861	0. 466	
	1974. 161	15	0. 136	0. 340	1. 225	15	0. 859	0. 595	
	1975. 107	11	0. 137	0. 984	2. 953	11	0. 862	0. 337	
	1976. 106	10	0. 137	0. 448	1. 268	10	0. 867	0. 310	
	1977. 134	20	0. 135	0. 421	1. 788	20	0. 864	0. 482	
ALL OBS.	1972. 585	133	0. 136	0. 153	1. 756	130	0. 862	0. 146	F
H. D. 95735	1968. 324	3	0. 356	11. 660	11. 660	3	0. 896	17. 947	
M2	1969. 138	13	0. 376	2. 450	8. 125	13	0. 979	1. 136	
	1970. 213	11	0. 369	2. 588	7. 765	11	0. 993	1. 126	
	1971. 209	9	0. 329	2. 225	5. 888	9	0. 961	1. 344	
	1972. 252	12	0. 347	2. 827	8. 940	12	0. 981	1. 601	
	1973. 192	14	0. 354	1. 801	6. 238	14	0. 975	0. 862	
	1974. 266	17	0. 398	5. 236	20. 278	17	0. 996	1. 268	
	1975. 194	13	0. 352	2. 349	7. 791	13	0. 991	0. 812	
	1976. 184	12	0. 352	1. 896	5. 995	12	0. 992	1. 138	
	1977. 196	14	0. 365	1. 112	3. 851	14	1. 000	1. 002	
ALL OBS.	1973. 246	118	0. 362	1. 074	11. 565	118	0. 984	0. 428	
H. D. 97334	1966. 194	1	0. 329	0. 0	0. 0	0	0. 0	0. 0	
G0	1967. 190	5	0. 322	3. 375	5. 846	0	0. 0	0. 0	
	1968. 272	5	0. 309	1. 299	2. 249	5	0. 985	0. 689	
	1969. 163	16	0. 323	1. 175	4. 395	16	0. 986	0. 435	
	1970. 197	19	0. 323	0. 572	2. 357	19	0. 989	0. 369	
	1971. 224	10	0. 294	0. 836	2. 365	10	0. 984	0. 427	
	1972. 232	13	0. 295	0. 722	2. 394	13	0. 975	0. 358	
	1973. 172	18	0. 315	0. 831	3. 325	18	0. 985	0. 481	
	1974. 161	15	0. 318	1. 185	4. 272	15	0. 985	0. 423	
	1975. 161	14	0. 305	0. 801	2. 775	14	0. 981	0. 255	
	1976. 098	14	0. 310	0. 676	2. 341	14	0. 975	0. 761	
	1977. 190	17	0. 292	0. 801	3. 102	17	0. 984	0. 229	
ALL OBS.	1972. 747	147	0. 310	0. 406	4. 894	141	0. 983	0. 135	
H. D. 100180	1968. 257	4	0. 168	2. 200	3. 112	4	0. 867	1. 367	
F7	1969. 144	12	0. 161	1. 017	3. 218	12	0. 866	0. 425	
	1970. 265	14	0. 166	0. 571	1. 978	14	0. 878	0. 410	
	1971. 227	9	0. 162	0. 395	1. 046	9	0. 864	0. 495	
	1972. 277	11	0. 158	0. 431	1. 292	11	0. 863	0. 416	
	1973. 169	12	0. 160	0. 864	2. 732	12	0. 862	0. 555	
	1974. 217	10	0. 160	0. 415	1. 174	10	0. 869	0. 738	
	1975. 154	9	0. 162	1. 232	3. 259	9	0. 881	0. 384	
	1976. 234	11	0. 157	0. 887	2. 660	11	0. 855	0. 406	
	1977. 174	12	0. 163	0. 649	2. 053	12	0. 879	0. 439	
ALL OBS.	1972. 916	104	0. 161	0. 291	2. 935	104	0. 869	0. 167	
H. D. 100563	1967. 200	3	0. 195	3. 435	3. 435	0	0. 0	0. 0	
F5	1968. 247	3	0. 194	1. 536	1. 536	3	0. 900	0. 762	
	1969. 157	10	0. 190	0. 577	1. 631	10	0. 909	0. 625	
	1970. 280	13	0. 196	0. 506	1. 677	13	0. 913	0. 592	
	1971. 240	10	0. 193	0. 648	1. 833	10	0. 901	0. 467	
	1972. 283	10	0. 198	0. 482	1. 364	10	0. 912	0. 495	
	1973. 200	12	0. 199	0. 666	2. 106	12	0. 918	0. 484	
	1974. 217	10	0. 194	0. 840	2. 377	10	0. 911	0. 421	
	1975. 178	10	0. 187	0. 534	1. 511	10	0. 905	0. 589	
	1976. 234	11	0. 186	0. 649	1. 947	11	0. 902	0. 544	
	1977. 174	12	0. 190	0. 805	2. 545	12	0. 913	0. 495	
ALL OBS.	1972. 916	104	0. 193	0. 290	2. 930	101	0. 909	0. 163	
H. D. 101501	1968. 270	4	0. 285	1. 047	1. 481	4	0. 976	0. 689	
G8	1969. 163	16	0. 301	1. 789	6. 694	16	0. 984	0. 433	
	1970. 226	24	0. 309	0. 707	3. 316	24	0. 987	0. 388	
	1971. 215	27	0. 284	0. 615	3. 076	27	0. 973	0. 286	
	1972. 259	17	0. 303	0. 761	2. 947	17	0. 980	0. 354	
	1973. 140	25	0. 311	0. 638	3. 058	25	0. 984	0. 333	
	1974. 218	23	0. 287	1. 188	5. 446	23	0. 977	0. 487	
	1975. 193	17	0. 270	1. 127	4. 366	17	0. 969	0. 401	
	1976. 128	19	0. 273	0. 871	3. 591	19	0. 965	0. 311	
	1977. 155	21	0. 295	1. 087	4. 737	21	0. 988	0. 331	
ALL OBS.	1973. 036	193	0. 293	0. 450	6. 225	193	0. 979	0. 128	
H. D. 103095	1968. 299	5	0. 169	2. 943	5. 098	5	0. 883	0. 963	
G8	1969. 158	15	0. 179	1. 051	3. 789	15	0. 909	0. 388	
	1970. 210	18	0. 189	0. 421	1. 683	18	0. 928	0. 497	
	1971. 166	19	0. 189	0. 521	2. 149	19	0. 921	0. 433	
	1972. 232	13	0. 175	0. 931	3. 089	13	0. 899	0. 541	
	1973. 144	24	0. 176	0. 832	3. 905	24	0. 896	0. 412	
	1974. 218	23	0. 165	0. 530	2. 428	23	0. 879	0. 451	
	1975. 191	16	0. 164	0. 529	1. 980	16	0. 878	0. 481	
	1976. 128	19	0. 177	0. 754	3. 111	19	0. 898	0. 735	
	1977. 155	21	0. 189	0. 689	3. 005	21	0. 929	0. 350	
ALL OBS.	1973. 210	173	0. 178	0. 455	5. 947	173	0. 903	0. 215	
H. D. 106516	1966. 296	4	0. 209	1. 766	2. 498	0	0. 0	0. 0	
F6	1967. 068	1	0. 209	0. 0	0. 0	0	0. 0	0. 0	
	1968. 367	4	0. 209	1. 333	1. 885	4	0. 903	1. 940	
	1969. 087	5	0. 206	1. 230	2. 130	5	0. 920	0. 510	
	1970. 263	11	0. 208	0. 942	2. 825	11	0. 910	1. 203	
	1971. 286	7	0. 198	0. 861	1. 926	7	0. 890	0. 830	
	1972. 278	8	0. 207	0. 496	1. 216	8	0. 908	0. 600	
	1973. 324	7	0. 202	1. 120	2. 504	7	0. 896	0. 918	
	1974. 271	10	0. 198	0. 786	2. 225	10	0. 906	0. 452	
	1975. 178	10	0. 202	1. 156	3. 269	10	0. 900	0. 293	
	1976. 260	9	0. 201	0. 562	1. 486	9	0. 898	0. 643	
	1977. 201	10	0. 207	0. 508	1. 438	10	0. 898	0. 514	
ALL OBS.	1972. 871	86	0. 204	0. 315	2. 889	81	0. 903	0. 230	
*H. D. 107213	1966. 295	4	0. 137	1. 343	1. 900	0	0. 0	0. 0	
F8	1967. 068	1	0. 135	0. 0	0. 0	0	0. 0	0. 0	
	1968. 301	7	0. 138	0. 833	1. 864	7	0. 855	0. 685	
	1969. 174	15	0. 138	0. 595	2. 144	15	0. 851	0. 436	
	1970. 279	11	0. 138	0. 379	1. 137	11	0. 860	0. 480	
	1971. 232	8	0. 139	0. 508	1. 245	8	0. 854	0. 536	
	1972. 310	6	0. 139	0. 394	0. 787	6	0. 861	0. 406	
	1973. 229	5	0. 139	1. 042	1. 806	5	0. 853	0. 617	
	1974. 237	8	0. 137	0. 917	2. 247	8	0. 861	0. 537	
	1975. 193	8	0. 137	0. 858	2. 102	8	0. 853	0. 539	
	1976. 115	1	0. 134	0. 0	0. 0	1	0. 841	0. 0	
	1977. 041	2	0. 139	0. 788	0. 788	2	0. 863	1. 736	
ALL OBS.	1971. 260	76	0. 138	0. 208	1. 793	71	0. 856	0. 167	

TABLE 1—*Continued*

STAR NAME SP.	MEAN DATE	NO. OBS.	AVG FLUX	S.D. AVG.	S.D. OBS.	NO. OBS.	K/H RATIO	S.D. RATIO	
H.D. 114378	1966.292	4	0.243	2.266	3.205	0	0.0	0.0	
F5	1967.273	7	0.239	1.407	3.146	0	0.0	0.0	
	1968.334	6	0.230	1.132	2.265	6	0.928	0.501	
	1969.198	12	0.230	1.145	3.621	12	0.933	0.574	
	1970.246	17	0.237	0.802	3.106	17	0.944	0.548	
	1971.288	12	0.225	0.285	0.901	12	0.931	0.376	
	1972.296	12	0.227	0.805	2.545	12	0.929	0.656	
	1973.269	15	0.223	0.507	1.828	15	0.930	0.471	
	1974.257	13	0.219	0.586	1.945	13	0.937	0.480	
	1975.211	16	0.221	0.681	2.547	16	0.939	0.379	
	1976.218	15	0.219	0.640	2.308	15	0.936	0.377	
	1977.208	17	0.221	0.513	1.987	17	0.940	0.408	
ALL OBS.	1972.715	146	0.226	0.325	3.900	135	0.936	0.146	D
H.D. 114710	1966.292	4	0.199	0.870	1.230	0	0.0	0.0	
G0	1967.343	7	0.202	0.919	2.054	0	0.0	0.0	
	1968.347	7	0.192	0.850	1.900	7	0.906	1.147	
	1969.200	11	0.198	0.907	2.722	11	0.913	0.482	
	1970.280	20	0.190	0.523	2.220	20	0.915	0.349	
	1971.288	12	0.190	0.422	1.334	12	0.906	0.412	
	1972.309	13	0.192	0.540	1.791	13	0.910	0.261	
	1973.303	13	0.189	0.682	2.261	13	0.902	0.561	
	1974.257	13	0.197	0.762	2.527	13	0.921	0.702	
	1975.211	16	0.197	0.714	2.670	16	0.918	0.498	
	1976.218	15	0.190	0.782	2.821	15	0.911	0.375	
	1977.208	17	0.191	0.717	2.775	17	0.918	0.498	
ALL OBS.	1972.662	148	0.193	0.251	3.032	137	0.913	0.153	C?
H.D. 115383	1966.293	4	0.322	3.921	5.546	0	0.0	0.0	
F8	1967.343	7	0.310	0.736	1.645	0	0.0	0.0	
	1968.347	7	0.304	1.115	2.494	7	0.970	0.607	
	1969.201	11	0.312	0.428	1.283	11	0.973	0.452	
	1970.318	17	0.311	0.452	1.749	17	0.982	0.287	
	1971.312	11	0.291	0.556	1.667	11	0.966	0.530	
	1972.309	13	0.284	1.285	4.263	13	0.968	0.445	
	1973.303	13	0.288	0.645	2.140	13	0.961	0.341	
	1974.257	13	0.302	0.523	1.736	13	0.977	0.512	
	1975.254	19	0.295	0.549	2.264	19	0.968	0.373	
	1976.218	15	0.281	1.607	5.793	15	0.963	0.353	
	1977.199	16	0.277	0.630	2.356	16	0.974	0.221	
ALL OBS.	1972.752	146	0.295	0.433	5.193	135	0.970	0.126	D
H.D. 115404	1968.397	10	0.504	1.899	5.370	10	1.046	1.025	
K3	1969.186	11	0.521	2.306	6.919	11	1.056	0.783	
	1970.292	19	0.512	0.730	3.011	19	1.061	0.532	
	1971.296	11	0.471	1.098	3.293	11	1.041	0.464	
	1972.292	12	0.490	1.329	4.202	12	1.044	0.369	
	1973.280	14	0.507	0.775	2.684	14	1.046	0.413	
	1974.296	16	0.481	0.922	3.450	16	1.053	0.484	
	1975.264	18	0.468	1.478	5.913	18	1.049	0.407	
	1976.231	14	0.452	1.147	3.975	14	1.017	0.916	
	1977.199	16	0.464	1.176	4.402	16	1.055	0.400	
ALL OBS.	1973.074	141	0.486	0.531	6.256	141	1.048	0.191	>9
H.D. 120136	1967.311	5	0.186	1.326	2.297	0	0.0	0.0	
F7	1968.442	5	0.185	1.223	2.119	5	0.905	0.769	
	1969.188	11	0.186	1.172	3.517	11	0.899	0.513	
	1970.318	17	0.188	0.620	2.400	17	0.917	0.394	
	1971.317	10	0.184	0.695	1.966	10	0.902	0.496	
	1972.311	11	0.180	0.692	2.075	11	0.902	0.578	
	1973.318	12	0.180	0.422	1.334	12	0.900	0.457	
	1974.270	12	0.180	0.921	2.912	12	0.910	0.394	
	1975.254	19	0.182	0.576	2.376	19	0.912	0.314	
	1976.231	14	0.181	0.648	2.243	14	0.905	0.385	
	1977.206	15	0.180	0.817	2.947	15	0.907	0.316	
ALL OBS.	1973.048	131	0.183	0.255	2.896	126	0.907	0.134	F
*H.D. 124570	1966.292	4	0.139	0.914	1.292	0	0.0	0.0	
F6	1967.432	5	0.140	0.919	1.592	0	0.0	0.0	
	1968.365	9	0.137	1.053	2.787	9	0.853	0.649	
	1969.267	12	0.136	0.546	1.727	12	0.837	0.451	
	1970.285	14	0.138	0.581	2.013	14	0.863	0.752	
	1971.275	10	0.138	0.450	1.274	10	0.845	0.485	
	1972.292	12	0.136	0.527	1.666	12	0.850	0.513	
	1973.318	12	0.137	0.511	1.615	12	0.847	0.385	
	1974.323	14	0.136	0.507	1.756	14	0.848	0.461	
	1975.265	18	0.137	0.465	1.858	18	0.850	0.359	
	1976.218	15	0.138	0.561	2.022	15	0.846	0.483	
	1977.206	15	0.139	0.862	3.107	15	0.851	0.371	
ALL OBS.	1972.778	140	0.137	0.180	2.109	131	0.849	0.156	F
H.D. 124850	1967.306	6	0.211	0.904	1.808	0	0.0	0.0	
F7	1968.442	5	0.208	1.806	3.128	5	0.906	1.212	
	1969.341	10	0.199	0.952	2.694	10	0.903	0.484	
	1970.318	17	0.206	0.623	2.413	17	0.922	0.598	
	1971.302	12	0.200	0.489	1.546	12	0.902	0.464	
	1972.311	11	0.200	0.640	1.919	11	0.904	0.846	
	1973.335	13	0.204	0.837	2.775	13	0.910	0.508	
	1974.323	14	0.199	0.602	2.085	14	0.916	0.584	
	1975.278	17	0.197	0.592	2.292	17	0.909	0.457	
	1976.316	15	0.197	0.456	1.644	15	0.904	0.420	
	1977.216	14	0.193	0.514	1.781	14	0.906	0.296	
ALL OBS.	1973.019	134	0.200	0.273	3.141	128	0.909	0.169	D
H.D. 126053	1966.192	2	0.176	4.809	4.809	0	0.0	0.0	
G3	1967.415	3	0.168	3.355	3.355	0	0.0	0.0	
	1968.483	5	0.165	1.275	2.208	5	0.862	0.979	
	1969.343	7	0.170	1.838	4.111	7	0.850	0.486	
	1970.318	17	0.168	0.555	2.150	17	0.866	0.580	
	1971.312	11	0.167	0.844	2.531	11	0.850	0.435	
	1972.340	13	0.164	0.513	1.702	13	0.857	0.345	
	1973.341	12	0.166	0.593	1.876	12	0.851	0.588	
	1974.323	14	0.164	0.786	2.721	14	0.874	1.422	
	1975.329	11	0.165	0.638	1.914	11	0.846	0.452	
	1976.348	12	0.165	0.477	1.508	12	0.854	0.705	
	1977.246	11	0.165	0.748	2.244	11	0.851	0.654	
ALL OBS.	1972.856	118	0.166	0.237	2.550	113	0.857	0.242	F
H.D. 131156A	1967.509	3	0.422	0.578	0.578	0	0.0	0.0	
G8	1968.468	14	0.436	1.020	3.533	14	1.036	0.370	
	1969.337	11	0.453	1.628	4.885	11	1.019	0.378	
	1970.334	15	0.415	1.056	3.806	15	1.036	0.492	
	1971.350	16	0.395	0.874	3.272	16	1.025	0.457	
	1972.340	13	0.392	1.126	3.735	13	1.028	0.416	
	1973.364	15	0.401	0.700	2.524	15	1.019	0.306	
	1974.396	17	0.423	1.329	5.148	17	1.025	0.446	
	1975.330	21	0.413	0.635	2.770	21	1.026	0.331	
	1976.324	16	0.381	0.840	3.141	16	1.017	0.504	
	1977.308	20	0.412	0.501	2.126	20	1.027	0.432	
ALL OBS.	1973.133	161	0.411	0.450	5.679	158	1.026	0.131	
H.D. 131156B	1967.509	3	1.096	4.284	4.284	0	0.0	0.0	
K4	1968.468	14	1.096	2.476	8.579	14	1.074	1.882	
	1969.354	10	1.133	1.876	5.307	10	1.120	0.880	
	1970.334	15	1.138	1.113	4.011	15	1.126	0.373	
	1971.350	16	1.083	0.987	3.695	16	1.121	0.694	
	1972.340	13	1.038	1.674	5.553	13	1.115	0.291	
	1973.364	15	0.942	1.748	6.302	15	1.104	1.901	
	1974.396	17	0.952	1.672	6.476	17	1.075	2.135	
	1975.373	17	0.917	1.919	7.433	17	1.070	1.800	
	1976.343	14	0.864	2.477	8.580	14	1.091	0.593	
	1977.308	20	0.979	1.534	6.506	20	1.088	0.592	
ALL OBS.	1973.067	154	1.009	0.868	10.703	151	1.097	0.417	10
*H.D. 136202	1966.387	5	0.146	2.017	3.493	0	0.0	0.0	
F8	1967.431	5	0.144	1.490	2.581	0	0.0	0.0	
	1968.384	9	0.143	0.578	1.530	9	0.851	0.700	
	1969.355	9	0.142	1.123	2.970	9	0.846	0.554	
	1970.318	17	0.144	0.704	2.727	17	0.860	0.477	
	1971.302	12	0.142	0.541	1.712	12	0.853	0.409	
	1972.340	13	0.141	0.421	1.397	13	0.853	0.311	
	1973.364	15	0.140	0.529	1.907	15	0.856	0.358	
	1974.341	13	0.138	0.593	1.967	13	0.857	0.313	
	1975.307	15	0.140	0.461	1.663	15	0.849	0.556	
	1976.324	16	0.138	0.419	1.568	16	0.848	0.319	
	1977.270	14	0.139	0.693	2.402	14	0.851	0.349	
ALL OBS.	1972.720	143	0.141	0.216	2.569	133	0.853	0.131	F
H.D. 141004	1966.387	5	0.167	1.950	3.378	0	0.0	0.0	
G0	1967.484	5	0.161	2.129	3.688	1	0.861	0.0	
	1968.468	8	0.161	0.616	1.509	8	0.871	0.593	
	1969.452	11	0.160	0.751	2.253	11	0.867	0.462	
	1970.356	21	0.163	0.464	2.024	21	0.880	0.427	
	1971.350	16	0.159	0.576	2.157	16	0.857	0.417	
	1972.340	13	0.158	0.765	2.538	13	0.864	0.553	
	1973.364	15	0.157	0.525	1.894	15	0.856	0.195	
	1974.341	13	0.161	0.578	1.917	13	0.879	0.479	
	1975.357	19	0.157	0.473	1.952	19	0.859	0.459	
	1976.355	14	0.156	1.106	3.832	14	0.853	0.546	
	1977.334	18	0.156	0.662	2.649	18	0.862	0.318	
ALL OBS.	1972.781	158	0.159	0.234	2.928	149	0.865	0.155	F
*H.D. 142373	1966.458	8	0.143	0.470	1.150	0	0.0	0.0	
F9	1967.439	4	0.144	0.635	0.897	1	0.860	0.0	
	1968.396	8	0.142	0.738	1.808	8	0.855	0.0	
	1969.373	9	0.144	0.607	1.607	9	0.848	0.619	
	1970.373	21	0.143	0.344	1.501	21	0.866	0.156	
	1971.360	15	0.142	0.171	0.618	15	0.855	0.374	
	1972.340	13	0.143	0.271	0.900	13	0.858	0.451	
	1973.350	14	0.142	0.365	1.265	14	0.848	0.436	
	1974.400	15	0.143	0.471	1.700	15	0.865	0.295	
	1975.364	18	0.143	0.410	1.639	18	0.856	0.312	
	1976.354	12	0.142	0.351	1.110	12	0.850	0.586	
	1977.385	13	0.144	0.668	2.215	13	0.852	0.321	
ALL OBS.	1972.550	150	0.143	0.122	1.489	139	0.856	0.121	
*H.D. 143761	1966.459	8	0.147	1.094	2.680	0	0.0	0.0	
G2	1967.491	5	0.147	1.373	2.378	2	0.849	0.035	
	1968.446	12	0.148	0.472	1.492	12	0.852	0.003	
	1969.362	7	0.147	0.630	1.408	7	0.842	0.760	
	1970.444	16	0.147	0.513	1.920	16	0.864	0.377	
	1971.395	18	0.147	0.302	1.206	18	0.854	0.301	
	1972.357	12	0.147	0.461	1.457	12	0.847	0.490	
	1973.372	9	0.147	0.545	1.441	9	0.853	0.464	
	1974.417	14	0.145	0.594	2.059	14	0.866	0.320	
	1975.427	14	0.145	0.468	1.621	14	0.849	0.383	
	1976.400	11	0.144	0.373	1.119	11	0.846	0.393	
	1977.335	15	0.145	0.622	2.242	15	0.857	0.367	
ALL OBS.	1972.442	141	0.146	0.158	1.862	130	0.854	0.129	F
H.D. 149661	1967.535	3	0.331	7.670	7.670	1	0.984	0.0	
K0	1968.468	14	0.355	0.817	2.829	14	1.001	0.499	
	1969.432	13	0.332	0.803	2.663	13	0.992	0.372	
	1970.365	20	0.317	0.748	3.174	20	0.984	0.421	
	1971.398	20	0.354	0.304	1.289	20	0.987	0.344	
	1972.349	14	0.404	1.484	5.141	14	1.006	0.515	
	1973.406	18	0.397	0.826	3.306	18	0.996	0.440	
	1974.385	16	0.338	1.254	4.693	16	0.993	0.507	
	1975.364	18	0.360	0.741	2.966	18	0.992	0.393	
	1976.333	15	0.357	0.892	3.218	15	0.988	0.314	
	1977.308	19	0.331	0.816	3.363	19	0.980	0.344	
ALL OBS.	1972.900	170	0.353	0.637	8.260	168	0.991	0.133	8
H.D. 152391	1966.631	2	0.400	1.559	1.559	0	0.0	0.0	
G8	1967.506	3	0.423	2.316	2.316	0	0.0	0.0	
	1968.478	11	0.384	1.468	4.405	11	1.009	0.514	
	1969.432	13	0.390	1.548	5.135	13	1.007	0.692	
	1970.365	20	0.366	0.971	4.119	20	0.996	0.347	
	1971.398	18	0.353	0.614	2.458	18	0.991	0.269	
	1972.349	14	0.353	1.042	3.611	14	0.988	0.581	
	1973.406	18	0.328	0.602	2.409	18	0.977	0.454	
	1974.385	16	0.340	0.718	2.686	16	0.995	0.435	
	1975.399	15	0.339	0.584	2.106	15	0.988	0.449	
	1976.368	13	0.334	1.335	4.429	13	0.982	0.604	
	1977.373	14	0.360	0.991	3.433	14	0.995	0.435	
ALL OBS.	1972.705	157	0.355	0.559	6.959	152	0.992	0.154	>10

TABLE 1—*Continued*

STAR NAME SP.	MEAN DATE	NO. OBS.	AVG FLUX	S. D. AVG.	S. D. OBS.	NO. OBS.	K/H RATIO	S. D. RATIO	
H. D. 154417	1966.428	7	0.254	1.535	3.433	0	0.0	0.0	
F8	1967.530	9	0.245	2.325	6.153	2	0.935	2.836	
	1968.422	8	0.268	0.890	2.181	8	0.943	0.662	
	1969.492	16	0.257	0.406	1.520	16	0.942	0.316	
	1970.427	18	0.262	0.787	3.148	18	0.943	0.280	
	1971.390	18	0.258	0.896	3.585	18	0.939	0.403	
	1972.349	14	0.261	0.681	2.359	14	0.943	0.475	
	1973.394	17	0.259	1.075	4.162	17	0.937	0.294	
	1974.417	14	0.264	0.612	2.120	14	0.954	0.403	
	1975.461	12	0.258	0.521	1.647	12	0.950	0.506	
	1976.369	11	0.260	1.232	3.697	11	0.939	0.337	
	1977.389	13	0.269	0.792	2.626	13	0.953	0.501	
ALL OBS.	1972.217	157	0.260	0.295	3.670	143	0.944	0.126	
H. D. 155885	1967.568	6	0.365	1.962	3.924	2	0.970	1.707	
K1	1968.551	11	0.374	1.465	4.394	11	0.985	0.874	
	1969.528	11	0.363	1.095	3.285	11	0.986	0.740	
	1970.457	17	0.389	1.024	3.967	17	0.995	0.436	
	1971.428	15	0.390	0.849	3.060	15	0.981	0.644	
	1972.423	11	0.379	1.511	4.532	11	0.989	0.724	
	1973.421	14	0.359	1.100	3.812	14	0.980	0.578	
	1974.488	16	0.372	1.058	3.959	16	0.989	0.558	
	1975.536	13	0.381	1.859	6.164	13	0.976	1.070	
	1976.435	8	0.382	1.516	3.715	8	0.994	0.898	
	1977.402	12	0.392	1.596	5.046	12	1.005	0.600	
ALL OBS.	1972.622	134	0.378	0.439	5.047	130	0.987	0.208	
H. D. 155886	1967.568	6	0.398	2.975	5.950	2	1.012	2.037	
K1	1968.551	11	0.375	0.855	2.566	11	0.976	0.462	
	1969.528	11	0.393	1.086	3.257	11	0.993	0.543	
	1970.457	17	0.392	1.389	5.378	17	0.988	0.310	
	1971.428	15	0.417	1.209	4.360	15	0.986	0.560	
	1972.423	11	0.442	0.976	2.928	11	1.007	0.574	
	1973.421	14	0.414	1.214	4.207	14	0.987	0.486	
	1974.488	16	0.380	0.972	3.637	16	0.994	0.326	
	1975.536	13	0.366	1.032	3.423	13	0.984	0.418	
	1976.435	8	0.370	0.920	2.255	8	0.989	0.577	
	1977.402	12	0.384	0.904	2.860	12	1.002	0.414	
ALL OBS.	1972.622	134	0.394	0.580	6.660	130	0.991	0.149	8
H. D. 156026	1966.592	1	0.675	0.0	0.0	0	0.0	0.0	
K5	1967.488	1	0.624	0.0	0.0	0	0.0	0.0	
	1968.503	8	0.614	1.523	3.732	8	1.036	0.700	
	1969.494	6	0.575	2.789	5.578	6	1.032	0.928	
	1970.489	13	0.639	1.069	3.546	13	1.026	0.772	
	1971.446	15	0.635	1.175	4.237	15	1.027	0.569	
	1972.423	11	0.667	2.361	7.082	11	1.037	0.882	
	1973.459	11	0.659	2.545	7.636	11	1.025	1.227	
	1974.488	16	0.656	1.029	3.850	16	1.041	0.528	
	1975.547	12	0.656	1.569	4.961	12	1.053	0.843	
	1976.421	7	0.699	2.037	4.554	7	1.035	0.566	
	1977.402	12	0.688	2.167	6.852	12	1.062	0.801	
ALL OBS.	1973.039	113	0.651	0.638	6.727	111	1.038	0.249	>10
H. D. 157856	1966.586	2	0.182	0.411	0.411	0	0.0	0.0	
F5	1967.481	2	0.192	0.547	0.547	0	0.0	0.0	
	1968.591	9	0.187	0.953	2.522	9	0.899	0.301	
	1969.521	11	0.188	0.517	1.551	11	0.885	0.415	
	1970.423	15	0.192	0.625	2.254	15	0.903	0.363	
	1971.424	15	0.187	0.431	1.554	15	0.891	0.271	
	1972.441	12	0.189	0.521	1.649	12	0.903	0.381	
	1973.541	13	0.190	0.878	2.911	13	0.889	0.579	
	1974.417	14	0.192	0.490	1.699	14	0.906	0.359	
	1975.475	11	0.192	0.825	2.476	11	0.900	0.441	
	1976.420	9	0.192	0.749	1.983	9	0.903	0.801	
	1977.393	12	0.189	1.024	3.238	12	0.898	0.532	
ALL OBS.	1972.728	125	0.190	0.218	2.416	121	0.898	0.143	F
* H. D. 159332	1966.551	6	0.137	0.797	1.595	0	0.0	0.0	
F4	1967.451	4	0.143	0.854	1.208	0	0.0	0.0	
	1968.469	8	0.140	0.425	1.042	8	0.853	0.449	
	1969.503	14	0.144	0.357	1.236	14	0.859	0.509	
	1970.458	13	0.145	0.696	2.310	13	0.873	0.385	
	1971.446	14	0.143	0.388	1.345	14	0.863	0.388	
	1972.446	11	0.144	0.430	1.291	11	0.872	0.481	
	1973.427	10	0.144	0.564	1.595	10	0.852	0.465	
	1974.418	15	0.144	0.459	1.655	15	0.876	0.411	
	1975.461	12	0.146	0.653	2.066	12	0.863	0.298	
	1976.443	11	0.146	0.555	1.665	11	0.869	0.567	
	1977.393	12	0.143	0.731	2.313	12	0.869	0.200	
ALL OBS.	1972.522	130	0.144	0.188	2.122	120	0.866	0.146	F
H. D. 160346	1966.592	1	0.368	0.0	0.0	0	0.0	0.0	
K3	1967.523	2	0.310	0.733	0.733	0	0.0	0.0	
	1968.547	6	0.269	0.342	0.683	6	0.975	0.660	
	1969.529	11	0.265	0.565	1.694	11	0.960	0.480	
	1970.461	16	0.332	0.629	2.355	16	0.994	0.884	
	1971.461	19	0.333	1.026	4.232	19	0.986	0.393	
	1972.380	14	0.353	0.776	2.687	14	0.992	0.568	
	1973.461	22	0.325	0.861	3.851	22	0.981	0.414	
	1974.450	19	0.315	1.258	5.189	19	0.993	0.561	
	1975.437	20	0.269	0.873	3.705	20	0.948	0.374	
	1976.398	13	0.246	0.453	1.502	13	0.932	0.644	
	1977.347	16	0.274	0.605	2.264	16	0.958	0.509	
ALL OBS.	1973.243	159	0.303	0.943	11.813	156	0.973	0.234	8
* H. D. 161239	1966.627	4	0.139	1.617	2.287	0	0.0	0.0	
G6	1967.418	3	0.137	0.157	0.157	0	0.0	0.0	
	1968.510	10	0.135	0.607	1.718	10	0.844	0.463	
	1969.529	11	0.135	0.587	1.761	11	0.847	0.541	
	1970.509	8	0.137	0.686	1.680	8	0.850	0.676	
	1971.540	13	0.138	0.449	1.489	13	0.842	0.375	
	1972.455	4	0.142	0.704	0.996	4	0.858	1.254	
	1973.445	4	0.147	1.239	1.753	4	0.845	0.942	
	1974.363	6	0.146	1.144	2.289	6	0.870	0.631	
	1975.477	6	0.143	0.996	1.992	6	0.855	0.833	
	1976.421	7	0.142	0.501	1.120	7	0.861	0.536	
	1977.376	9	0.147	0.868	2.296	9	0.871	0.436	
ALL OBS.	1972.071	85	0.140	0.391	3.566	78	0.853	0.206	>10
H. D. 165341A	1967.572	8	0.326	2.310	5.658	3	0.996	2.093	
K0	1968.621	12	0.391	1.246	3.939	12	1.015	0.699	
	1969.597	8	0.459	1.460	3.575	8	1.032	0.984	
	1970.472	22	0.411	1.245	5.567	22	1.020	0.412	
	1971.462	20	0.381	1.101	4.670	20	1.003	0.323	
	1972.471	13	0.361	1.100	3.649	13	1.006	0.465	
	1973.483	20	0.378	1.119	4.748	20	1.005	0.397	
	1974.473	18	0.347	1.280	5.122	18	1.008	0.436	
	1975.555	19	0.368	1.752	7.224	19	1.005	0.384	
	1976.458	10	0.337	0.782	2.212	10	0.999	0.244	
	1977.402	12	0.317	0.786	2.486	12	0.996	0.394	
ALL OBS.	1972.722	162	0.372	0.802	10.140	157	1.008	0.149	10
H. D. 165341B	1967.572	8	0.809	4.141	10.144	3	1.106	3.572	
K5	1968.621	12	0.893	2.357	7.453	12	1.113	1.308	
	1969.597	8	0.809	3.258	7.981	8	1.085	0.918	
	1970.493	16	0.834	1.884	7.049	16	1.090	0.557	
	1971.459	15	0.834	1.865	6.726	15	1.089	0.670	
	1972.481	9	0.855	3.415	9.036	9	1.084	1.654	
	1973.532	12	0.777	3.216	10.169	12	1.066	1.307	
	1974.506	13	0.737	1.644	5.453	13	1.092	1.035	
	1975.603	15	0.685	1.610	5.807	15	1.069	1.074	
	1976.551	3	0.645	2.447	2.447	3	1.053	1.253	
	1977.383	6	0.779	5.058	10.116	6	1.091	1.002	
ALL OBS.	1972.233	117	0.795	1.037	11.121	112	1.086	0.327	C?
H. D. 166620	1966.661	3	0.215	5.270	5.270	0	0.0	0.0	
K2	1967.489	2	0.182	4.124	4.124	0	0.0	0.0	
	1968.613	7	0.193	1.222	2.733	7	0.900	0.547	
	1969.501	7	0.184	1.215	2.718	7	0.886	0.770	
	1970.506	14	0.190	0.652	2.259	14	0.897	0.538	
	1971.500	10	0.183	0.851	2.407	10	0.881	0.808	
	1972.604	9	0.182	0.659	1.744	9	0.883	0.722	
	1973.580	10	0.181	0.617	1.746	10	0.873	0.537	
	1974.452	15	0.182	0.426	1.537	15	0.888	0.474	
	1975.547	12	0.189	0.926	2.928	12	0.881	0.610	
	1976.461	9	0.190	0.397	1.049	9	0.894	0.441	
	1977.450	9	0.205	0.428	1.133	9	0.911	0.754	
ALL OBS.	1972.906	107	0.188	0.471	4.831	102	0.889	0.206	>11
H. D. 176095	1966.592	8	0.180	1.245	3.049	0	0.0	0.0	
F5	1967.540	5	0.204	1.995	3.456	1	0.906	0.0	
	1968.619	10	0.186	0.886	2.507	10	0.904	0.438	
	1969.513	12	0.190	0.798	2.523	12	0.910	0.622	
	1970.525	15	0.186	0.642	2.317	15	0.905	0.454	
	1971.522	13	0.190	0.896	2.971	13	0.900	0.404	
	1972.559	12	0.188	0.750	2.372	12	0.907	0.425	
	1973.599	17	0.195	0.517	2.004	17	0.909	0.536	
	1974.514	16	0.194	0.435	1.628	16	0.925	0.378	
	1975.578	17	0.192	0.643	2.489	17	0.919	0.500	
	1976.461	9	0.190	0.989	2.618	9	0.909	0.575	
	1977.518	6	0.192	0.852	1.703	6	0.911	1.044	
ALL OBS.	1972.356	140	0.190	0.288	3.389	128	0.910	0.162	F
H. D. 182101	1966.592	8	0.207	0.778	1.905	0	0.0	0.0	
F6	1967.577	9	0.211	1.164	3.081	3	0.891	0.673	
	1968.619	10	0.209	0.888	2.512	10	0.915	0.491	
	1969.594	10	0.201	0.674	1.906	10	0.907	0.585	
	1970.510	15	0.205	0.623	2.246	15	0.916	0.301	
	1971.546	13	0.203	0.273	0.906	13	0.907	0.307	
	1972.559	12	0.202	0.827	2.614	12	0.916	0.334	
	1973.645	14	0.202	0.964	3.341	14	0.907	0.304	
	1974.514	16	0.200	0.510	1.909	16	0.929	0.282	
	1975.590	16	0.203	0.502	1.879	16	0.920	0.313	
	1976.573	10	0.198	0.736	2.082	10	0.911	0.509	
	1977.561	5	0.199	1.888	3.269	5	0.921	0.648	
ALL OBS.	1972.224	138	0.203	0.237	2.759	124	0.915	0.131	F
* H. D. 187013	1966.592	8	0.147	0.732	1.792	0	0.0	0.0	
F5	1967.563	7	0.149	1.340	2.997	2	0.834	0.594	
	1968.614	11	0.153	0.413	1.240	11	0.874	0.487	
	1969.662	13	0.149	0.533	1.767	13	0.878	0.550	
	1970.583	10	0.150	0.409	1.157	10	0.878	0.446	
	1971.585	7	0.147	0.353	0.790	7	0.877	0.240	
	1972.607	8	0.149	0.666	1.631	8	0.879	0.514	
	1973.672	12	0.149	0.310	0.979	12	0.868	0.353	
	1974.567	18	0.148	0.471	1.886	18	0.885	0.255	
	1975.569	18	0.146	0.410	1.641	18	0.873	0.416	
	1976.547	14	0.149	0.624	2.162	14	0.876	0.394	
	1977.482	6	0.147	0.824	1.648	6	0.880	0.406	
ALL OBS.	1972.547	132	0.148	0.178	2.032	119	0.876	0.141	
* H. D. 187691	1966.592	8	0.148	1.360	3.332	0	0.0	0.0	
F8	1968.615	11	0.146	0.326	0.979	11	0.858	0.547	
	1969.658	14	0.147	0.429	1.485	14	0.860	0.467	
	1970.616	9	0.150	1.035	2.737	9	0.857	0.419	
	1971.546	13	0.147	0.552	1.829	13	0.853	0.252	
	1972.617	9	0.147	0.538	1.423	9	0.867	0.430	
	1973.682	11	0.144	0.741	2.224	11	0.848	0.374	
	1974.582	17	0.147	0.493	1.909	17	0.868	0.542	
	1975.600	19	0.146	0.431	1.778	19	0.867	0.378	
	1976.658	8	0.147	0.718	1.760	8	0.860	0.618	
	1977.561	4	0.150	1.265	1.790	4	0.850	0.804	
ALL OBS.	1972.517	123	0.147	0.191	2.099	115	0.860	0.154	F
H. D. 190007	1967.740	5	0.698	0.658	1.140	5	1.081	1.751	
K4	1968.669	17	0.686	1.342	5.198	17	1.093	1.166	
	1969.668	14	0.742	0.934	3.235	14	1.079	0.582	
	1970.536	16	0.700	0.742	2.776	16	1.081	0.399	
	1971.548	14	0.655	1.116	3.867	14	1.066	0.580	
	1972.645	13	0.682	1.104	3.663	13	1.085	0.416	
	1973.613	16	0.664	1.248	4.671	16	1.074	0.692	
	1974.541	19	0.620	1.349	5.564	19	1.079	0.624	
	1975.625	17	0.621	1.925	7.454	17	1.068	0.564	
	1976.658	8	0.582	3.082	7.550	8	1.066	0.569	
	1977.510	5	0.626	2.175	3.767	5	1.081	0.860	
ALL OBS.	1972.471	144	0.663	0.659	7.856	144	1.078	0.214	>10

TABLE 1—*Continued*

STAR NAME SP.	MEAN DATE	NO. OBS.	AVG FLUX	S. D. AVG.	S. D. OBS.	NO. OBS.	K/H RATIO	S. D. RATIO	
H. D. 190406	1966. 628	9	0. 214	2. 589	6. 850	0	0. 0	0. 0	
G1	1967. 563	7	0. 207	1. 517	3. 392	2	0. 925	0. 080	
	1968. 591	11	0. 183	0. 856	2. 568	11	0. 890	0. 599	
	1969. 550	14	0. 193	0. 600	2. 079	14	0. 905	0. 734	
	1970. 574	15	0. 181	0. 765	2. 760	15	0. 898	0. 394	
	1971. 582	15	0. 185	0. 359	1. 295	15	0. 888	0. 345	
	1972. 594	10	0. 190	1. 089	3. 081	10	0. 906	0. 462	
	1973. 596	17	0. 180	0. 619	2. 396	17	0. 881	0. 380	
	1974. 506	22	0. 191	0. 503	2. 249	22	0. 913	0. 412	
	1975. 625	17	0. 180	0. 568	2. 199	17	0. 897	0. 384	
	1976. 658	8	0. 185	1. 211	2. 967	8	0. 900	0. 632	
	1977. 561	4	0. 187	1. 213	1. 716	4	0. 917	0. 738	
ALL OBS.	1972. 199	149	0. 188	0. 466	5. 654	135	0. 899	0. 174	D
H. D. 194012	1966. 606	6	0. 192	0. 861	1. 723	0	0. 0	0. 0	
F5	1967. 564	6	0. 199	1. 352	2. 704	2	0. 910	2. 197	
	1968. 633	10	0. 192	0. 506	1. 432	10	0. 915	0. 642	
	1969. 584	11	0. 196	0. 596	1. 788	11	0. 906	0. 507	
	1970. 571	13	0. 188	0. 597	1. 982	13	0. 905	0. 360	
	1971. 592	14	0. 188	0. 518	1. 794	14	0. 902	0. 291	
	1972. 665	12	0. 192	0. 457	1. 446	12	0. 912	0. 211	
	1973. 672	12	0. 185	0. 459	1. 452	12	0. 899	0. 257	
	1974. 567	17	0. 184	0. 492	1. 906	17	0. 913	0. 297	
	1975. 639	15	0. 185	0. 588	2. 121	15	0. 908	0. 369	
	1976. 658	8	0. 184	1. 023	2. 506	8	0. 903	0. 746	
	1977. 561	4	0. 183	1. 523	2. 154	4	0. 900	0. 941	
ALL OBS.	1972. 325	128	0. 189	0. 264	2. 966	118	0. 907	0. 125	D
H. D. 201091	1967. 719	16	0. 568	1. 391	5. 206	11	1. 066	0. 716	
K5	1968. 626	28	0. 560	1. 211	6. 175	28	1. 073	0. 332	
	1969. 642	30	0. 468	0. 888	4. 700	30	1. 037	0. 336	
	1970. 556	27	0. 487	0. 815	4. 078	27	1. 044	0. 211	
	1971. 550	28	0. 526	1. 199	6. 116	28	1. 059	0. 368	
	1972. 646	25	0. 618	0. 899	4. 311	25	1. 082	0. 292	
	1973. 578	23	0. 596	1. 545	7. 080	23	1. 053	0. 580	
	1974. 578	27	0. 549	0. 700	3. 500	27	1. 066	0. 363	
	1975. 649	27	0. 514	0. 735	3. 674	27	1. 049	0. 328	
	1976. 638	17	0. 440	0. 763	2. 957	17	1. 038	0. 509	
	1977. 375	12	0. 451	0. 867	2. 743	12	1. 054	0. 455	
ALL OBS.	1972. 299	260	0. 529	0. 699	11. 235	255	1. 056	0. 139	7
H. D. 201092	1967. 719	16	0. 749	1. 350	5. 051	11	1. 056	1. 384	
K7	1968. 638	27	0. 797	1. 137	5. 685	27	1. 086	0. 292	
	1969. 642	30	0. 777	0. 661	3. 500	30	1. 078	0. 293	
	1970. 551	26	0. 732	1. 670	8. 183	26	1. 077	0. 228	
	1971. 550	28	0. 666	0. 928	4. 730	28	1. 069	0. 287	
	1972. 646	25	0. 690	0. 454	2. 175	25	1. 077	0. 347	
	1973. 578	23	0. 726	1. 705	7. 814	23	1. 057	0. 590	
	1974. 578	27	0. 716	1. 443	7. 214	27	1. 077	0. 398	
	1975. 649	27	0. 739	0. 469	2. 344	27	1. 063	0. 309	
	1976. 638	17	0. 791	0. 939	3. 638	17	1. 086	0. 337	
	1977. 375	12	0. 769	2. 061	6. 519	12	1. 092	0. 560	
ALL OBS.	1972. 321	258	0. 738	0. 481	7. 691	253	1. 074	0. 129	>6
H. D. 206860	1966. 662	9	0. 323	0. 694	1. 837	0	0. 0	0. 0	
G0	1967. 567	9	0. 315	1. 323	3. 501	2	0. 976	0. 194	
	1968. 606	12	0. 318	1. 116	3. 529	12	0. 994	0. 393	
	1969. 619	14	0. 318	1. 516	5. 252	14	0. 981	0. 331	
	1970. 624	16	0. 303	0. 778	2. 911	16	0. 969	0. 437	
	1971. 624	16	0. 302	0. 620	2. 318	16	0. 966	0. 337	
	1972. 716	17	0. 306	0. 583	2. 260	17	0. 982	0. 359	
	1973. 662	13	0. 311	1. 139	3. 779	13	0. 973	0. 239	
	1974. 603	17	0. 304	0. 789	3. 057	17	0. 981	0. 265	
	1975. 651	19	0. 303	0. 564	2. 324	19	0. 982	0. 339	
	1976. 708	12	0. 290	0. 853	2. 697	12	0. 976	0. 481	
	1977. 561	4	0. 289	0. 980	1. 386	4	0. 980	0. 746	
ALL OBS.	1972. 222	158	0. 307	0. 333	4. 164	142	0. 978	0. 123	D
* H. D. 207978	1966. 694	8	0. 149	0. 861	2. 108	0	0. 0	0. 0	
F0	1967. 667	13	0. 151	0. 528	1. 750	7	0. 862	0. 233	
	1968. 695	14	0. 152	0. 541	1. 874	14	0. 861	0. 514	
	1969. 658	15	0. 152	0. 398	1. 437	15	0. 872	0. 475	
	1970. 649	19	0. 151	0. 274	1. 128	19	0. 865	0. 233	
	1971. 627	17	0. 152	0. 394	1. 526	17	0. 864	0. 295	
	1972. 664	13	0. 152	0. 478	1. 585	13	0. 866	0. 457	
	1973. 672	12	0. 152	0. 611	1. 933	12	0. 860	0. 529	
	1974. 615	18	0. 153	0. 356	1. 425	18	0. 881	0. 425	
	1975. 682	16	0. 152	0. 458	1. 712	16	0. 878	0. 382	
	1976. 717	10	0. 154	0. 599	1. 695	10	0. 872	0. 411	
	1977. 561	4	0. 153	1. 464	2. 070	4	0. 887	1. 295	
ALL OBS.	1971. 943	159	0. 152	0. 137	1. 721	145	0. 869	0. 138	F
* H. D. 212754	1966. 694	8	0. 139	0. 669	1. 638	0	0. 0	0. 0	
F5	1967. 773	9	0. 140	0. 614	1. 625	7	0. 852	0. 413	
	1968. 783	12	0. 140	0. 548	1. 731	12	0. 858	0. 214	
	1969. 662	15	0. 140	0. 592	2. 133	15	0. 867	0. 534	
	1970. 680	12	0. 142	0. 573	1. 813	12	0. 857	0. 784	
	1971. 654	13	0. 141	0. 464	1. 541	13	0. 848	0. 408	
	1972. 800	12	0. 141	0. 462	1. 460	12	0. 869	0. 366	
	1973. 700	14	0. 142	0. 348	1. 205	14	0. 856	0. 277	
	1974. 665	11	0. 141	0. 506	1. 519	11	0. 872	0. 405	
	1975. 682	16	0. 143	0. 365	1. 365	16	0. 866	0. 552	
	1976. 738	6	0. 142	0. 289	0. 579	6	0. 853	1. 354	
	1977. 561	4	0. 140	0. 979	1. 384	4	0. 861	1. 609	
ALL OBS.	1971. 977	132	0. 141	0. 149	1. 701	122	0. 861	0. 167	F
* H. D. 216385	1966. 694	8	0. 140	0. 642	1. 574	0	0. 0	0. 0	
F7	1967. 694	16	0. 140	0. 340	1. 272	9	0. 849	0. 640	
	1968. 822	16	0. 144	0. 499	1. 867	16	0. 853	0. 343	
	1969. 695	14	0. 142	0. 626	2. 169	14	0. 860	0. 420	
	1970. 674	13	0. 142	0. 507	1. 680	13	0. 855	0. 421	
	1971. 759	10	0. 143	0. 498	1. 408	10	0. 851	0. 525	
	1972. 801	13	0. 142	0. 715	2. 372	13	0. 856	0. 345	
	1973. 712	13	0. 143	0. 444	1. 473	13	0. 855	0. 371	
	1974. 700	17	0. 142	0. 554	2. 146	17	0. 864	0. 431	
	1975. 682	16	0. 141	0. 452	1. 693	16	0. 863	0. 436	
	1976. 781	8	0. 142	0. 700	1. 715	8	0. 863	0. 461	
	1977. 561	4	0. 142	0. 626	0. 886	4	0. 856	1. 686	
ALL OBS.	1971. 885	148	0. 142	0. 155	1. 876	133	0. 857	0. 133	F
H. D. 219834A	1967. 767	4	0. 162	1. 792	2. 534	4	0. 873	0. 522	
G8	1968. 695	7	0. 160	0. 881	1. 969	7	0. 875	0. 691	
	1969. 647	3	0. 166	1. 389	1. 389	3	0. 880	0. 185	
	1970. 724	8	0. 165	0. 641	1. 571	8	0. 864	0. 935	
	1971. 667	14	0. 161	0. 480	1. 664	14	0. 850	0. 365	
	1972. 800	12	0. 163	0. 691	2. 186	12	0. 870	0. 520	
	1973. 658	12	0. 163	0. 641	2. 027	12	0. 855	0. 668	
	1974. 662	14	0. 161	0. 560	1. 940	14	0. 868	0. 474	
	1975. 661	14	0. 166	0. 523	1. 811	14	0. 867	0. 483	
	1976. 728	7	0. 167	0. 656	1. 466	7	0. 865	0. 898	
	1977. 561	4	0. 173	1. 001	1. 415	4	0. 878	0. 501	
ALL OBS.	1973. 119	99	0. 164	0. 252	2. 479	99	0. 865	0. 191	C?
H. D. 219834B	1967. 767	4	0. 202	2. 027	2. 867	4	0. 872	1. 234	
K2	1968. 695	7	0. 196	1. 238	2. 768	7	0. 884	0. 491	
	1969. 647	3	0. 212	0. 725	0. 725	3	0. 889	3. 981	
	1970. 724	8	0. 230	1. 884	4. 615	8	0. 908	1. 119	
	1971. 667	14	0. 241	0. 956	3. 311	14	0. 925	0. 700	
	1972. 805	11	0. 239	2. 552	7. 657	11	0. 941	1. 043	
	1973. 658	12	0. 226	1. 066	3. 373	12	0. 917	1. 053	
	1974. 662	14	0. 216	0. 882	3. 055	14	0. 917	0. 567	
	1975. 661	14	0. 215	0. 767	2. 659	14	0. 909	1. 045	
	1976. 728	7	0. 203	1. 443	3. 227	7	0. 908	1. 112	
	1977. 561	4	0. 208	1. 359	1. 922	4	0. 888	1. 329	
ALL OBS.	1973. 122	98	0. 221	0. 768	7. 526	98	0. 912	0. 329	B
H. D. 224930	1966. 692	7	0. 183	0. 614	1. 373	0	0. 0	0. 0	
G2	1967. 664	6	0. 175	0. 994	1. 989	3	0. 864	2. 132	
	1968. 642	12	0. 178	0. 543	1. 718	12	0. 900	0. 0	
	1969. 626	16	0. 178	0. 529	1. 980	16	0. 896	0. 353	
	1970. 655	15	0. 176	0. 987	3. 558	15	0. 894	0. 509	
	1971. 727	12	0. 170	0. 492	1. 557	12	0. 887	0. 616	
	1972. 801	13	0. 171	0. 553	1. 835	13	0. 887	0. 407	
	1973. 694	15	0. 172	0. 512	1. 846	15	0. 881	0. 451	
	1974. 700	17	0. 170	0. 700	2. 712	17	0. 888	0. 331	
	1975. 698	17	0. 168	0. 610	2. 365	17	0. 886	0. 344	
	1976. 759	12	0. 166	0. 558	1. 766	12	0. 878	0. 621	
	1977. 561	4	0. 166	1. 111	1. 571	4	0. 865	2. 545	
ALL OBS.	1972. 398	146	0. 173	0. 284	3. 413	136	0. 887	0. 155	

The separation of these components is not an easy matter; in fact, there seems to be no simple direct way to accomplish it. If one could find stars known to be devoid of a chromospheric component, the flux values of such stars could be subtracted from the values of other stars of similar spectral type to yield the latter's chromospheric components. Unfortunately, as will be seen, even the measures of the standard stars appear to contain chromospheric components, and it is not possible to say with confidence that any star in the program has zero chromospheric emission. For these reasons, all flux data in this paper are given in "raw" form with no attempt to correct them for the residual photospheric emission. An obvious consequence of this is that variations in measured fluxes are smaller than they would be if the residual photospheric fluxes could be allowed for, and hence that amplitudes of purely chromospheric variation are larger than those shown in Figures 1–5.

A large majority of the observations consisted of two 10^4 counts in both H and K. Since the counts in the monitor channel always exceed those in the line channel by factors of 3 or 4 to as much as 20, they contribute insignificantly to the statistical error, which, for 4×10^4 counts, should be 0.5%.

However, in order to conserve time in a heavy program, statistical accuracy was sacrificed somewhat for a number of stars by using reduced counts. For the following stars, many, and in some cases all, observations depend upon a total of 2×10^4 counts in the lines: HD 3443, 3651, 3795, 4628, 16160, 26913, 32147, 103095, 126053, 115404, 131156 B, 152391, 156026, 160346, 165341 B, 166620, and 190007. For most of the other stars (except standards), this same reduced count was used on occasions when poor seeing and/or clouds would have required overlong integration times for the standard count. Two stars, HD 95735 and 219834 B, were so faint that their total line counts were always restricted to 10^4.

V. DISCUSSION

In Figure 1, the first four plots are for standard stars; thereafter the arrangement is in order of spectral class, and in each spectral subdivision the order is that of decreasing flux (i.e., increasing age) through Figure 5*a*. The remainder of Figure 5 is composed of the components of three visual double stars and one triple system. One other close double star (HD 165341 = 70 Oph) was observed; however, the separation of the stars was such that the secondary could be observed only on nights of good seeing, and even then there was some doubt about contamination of the secondary by light from the primary. Hence this star is not illustrated in the figures, but its summary is in Table 1, and comparison of the K/H ratios for the two components shows that contamination may not have been very serious.

a) *Standard Stars*

HD 142373, 9562, and 187013 (Figs. 1*a*, 1*b*, and 1*c*) are typical of the standards. The first and second of these have, respectively, the smallest and largest s.d. for a single observation for standard stars computed from all the observations, although their average H-K fluxes are virtually identical; these facts are apparent in the diagrams (see Table 1). The plot of the third, HD 187013, suggests a slight waviness, but this is too small for certainty. HD 161239 (Fig. 1*d*) has obviously varied over the time of the observations and is the only one of the 18 standards to have done so. Several consequences appear to follow from the observations of the standard stars:

First, the standard stars must have some residual chromospheric activity, although their H-K fluxes are minimal. Second, it is clear that the chromospheric emissions in these stars are certainly small; hence the fluctuations in the fluxes, as measured by the s.d., may, in fact, amount to considerable fractions of the total chromospheric fluxes and may therefore be of more theoretical importance than a mere inspection of the diagrams would suggest. Third, the apparatus and procedures are capable of uncovering quite small differences in average fluxes and their variances. Fourth, it is incorrect to assume that any of the standard stars have zero chromospheric H-K flux and to subtract the mean measured fluxes of the standards from those of other stars of similar spectral type in order to derive the purely chromospheric fluxes of the latter, as was done previously (Wilson 1968). Fifth, a more detailed study of the variations in flux of the standards, with more frequent observations over longer continuous periods of time than was possible in this work, might be of value. Sixth, the overall s.d. of a single observation for HD 142373, 1.49%, may exceed the value of 0.5% aimed for in this work because of intrinsic variation. In any case, it is clear that we have approached the theoretical accuracy limit based on statistical considerations, which depends only upon the number of counts, to a reasonably satisfactory degree. Hence it is very probable that most of the flux variations down to about the 2%–3% level seen in Figures 1–5 are intrinsic to the stars themselves and are not artifacts produced by the apparatus or procedures, especially for those stars where a single observation consisted of 2×10^4 counts in both H and K.

b) *Spectral Types F7–G3* (Figs. 1*e*–2*i*)

The spectral types of these stars overlap those of most of the standards, but these stars have larger flux values and considerably more scatter than the latter. The scatter appears to be of two kinds. In all, there is very noticeable dispersion in the groupings of points for each season, which implies variations on time scales of days, weeks, or a few months. In addition, other stars, e.g., HD 97334 (Fig. 1*j*) and HD 78366, 1835, 76151 (Figs. 2*a*, 2*e*, 2*h*), exhibit seasonal groupings which differ substantially from adjacent ones and imply time scales of the order of 1–2 years.

Many, but not all, of these stars show what appears to be a secular decrease of flux over times of 10–11 years, e.g., HD 75332, 25998, 35296 (Figs. 1*e*, 1*f*, 1*g*) and HD 30495, 224930 (Figs. 2*c*, 2*g*); but there are exceptions, notably HD 154417 and 6920 (Figs. 1*h* and 1*i*).

Taking HD 25998 as typical, one finds from the data in Table 1 that, if the flux decrease were to continue at the same rate for about 40 years more, this star would have a flux value of 0.140, which is equal to that of many of the standards. Flux measurements of a number of similar stars in the Hyades (Wilson 1970) do not show nearly so large a scatter; hence I do not believe that the decreases mentioned above can continue for such periods of time. If, then, these stars are presumed to recover from time to time, the fact that so many are found in the decreasing state would indicate that the recovery times are short compared to 10 years, and that their flux curves might have a sawtooth aspect, with short increasing phases and much longer declines. If this is indeed true, only one star, HD 78366 (Fig. 2*a*), may possibly have been caught in the act of recovery, but I do not feel that this evidence is entirely convincing. In any event, further observations of stars of this kind over long time intervals might prove to be of great interest.

HD 12235 and 3795 (Figs. 2*d* and 2*i*) may be undergoing cyclic variations of small amplitude, but the data are insufficient for a definite statement. However, HD 81809 (Fig. 2*f*) has clearly completed one cycle in a period of about 10 years. This star is rather similar to the Sun in spectral type and period, but its average flux and amplitude are both significantly larger than the Sun's, at least during the last solar cycle (see § VI).

c) Stars G5 and Later (Figs. 2*j*–5*j*)

This entire group of stars exhibits a wide variety of H-K flux variations. Some stars show extraordinarily large fluctuations in the seasonal observations, again indicating changes on short time scales. In addition, a number of them have completed one cycle, while several more appear to be close to completion of a cycle. The opinions of the writer on these matters can be found in Table 1 (see § IV).

Comments on some of the individual stars in this group are worthwhile. HD 101501 (Fig. 3*c*) obviously has an active and variable chromosphere, but is difficult to interpret in terms of cyclical behavior. Note the sharp spike in 1969; it is possible that portions of other spikes are present, but if so, they have for the most part been lost during times when the star was out of reach.

HD 103095 (Fig. 3*d*) is of particular interest, since it is the metal-deficient subdwarf Groombridge 1830. There can, however, be no doubt of the cyclical behavior of the H-K flux between 1968 and 1977. On the other hand, HD 10700 (Fig. 3*e*), which has nearly the same average flux, remained essentially constant during the same interval.

HD 149661 (Fig. 3*h*) has an unusual flux curve. Note that, in 1974, there was a large rise during the observing season, and the three observations in 1967 suggest that this might be a regular feature of the curve. The amplitude is also large; the highest observed point is superposed on the first digit 6 of the HD number identifying the plot at 0.447, and the lowest, in 1970, is at 0.291.

HD 22049 (Fig. 4*c*) is noteworthy for the very large scatter in the seasonal point groups, but it is doubtful whether there is any good evidence for a cycle. There are three low groups of points, in 1967, 1972, and 1976, but the separations between them are 5 and 4 years; if this is a cycle of short period, the period must be of variable length.

HD 115404 and HD 190007 (Figs. 4*e* and 4*g*) are both very "noisy" and are reminiscent of the more or less steady declines found in many of the F7–G3 stars. If these stars are in a cyclic mode, the periods must be considerably in excess of 10 years.

HD 95735 (Fig. 5*a*) is the latest-type star in the program. Note the three high points obtained in 1974. (The highest is just above the number 2 of the spectral type.) These are very transient phenomena, as illustrated by the individual observations given in Table 2. They suggest that the star, although old, can still produce minor flare activity at times, though not frequently, since it is seen in only three out of a total of 118 observations.

TABLE 2

Some Flux Values for HD 95735

Date (1974)	Mean H-K Flux
4/29	480
4/30	385
5/1	662
5/2	372
6/20	348
6/21	502
6/22	364

The remainder of Figure 5 consists of multiple systems. In HD 131156 A = ξ Boo (Fig. 5*b*), it is hard to see anything cyclic in the plot for the primary. The secondary, however, does appear, in spite of the large scatter, to have nearly completed a cycle with a period of 10–11 years.

HD 155885, 155886,[1] and 156026 (Figs. 5*d*, 5*e*, and 5*f*) form a triple system. The first two are members of a close pair with nearly identical magnitudes, while the third, a short distance away, is judged to be a member of the system on the grounds of closely similar proper motion and radial velocity. The flux curves for HD 155885 and 155886 are clearly different. The latter appears to be in a cyclic mode, and, if the minima occurred in 1968 and 1975–1976, the period is about 7–8 years. In the former, if minima in a cycle are identified in 1967 and 1973, the period would be about 6 years; but the evidence for cyclic behavior is not compelling. The third member of the group, HD 156026, is unusual in that it shows a nearly secular increase in flux between 1968 and 1977. If there is a cycle involved, the period must exceed 10 years.

HD 201091 and 201092 are the primary and secondary, respectively, of 61 Cygni. These stars could be observed in every month except January, February, and March, and efforts were made each year to begin the observations in April and carry them through December; hence they were followed more nearly continuously than any other stars. Their flux curves are very different. That of the primary might almost be called classical in the sense that the rise time is significantly shorter than the decline time, as is generally true of the Sun. The secondary had a minimum in 1971; if the observations of 1968 and 1976 correspond to maxima, the period would be about 8 years, similar to that of the primary. However, in that case the secondary would have a long rise and a short decline time, opposite to the primary and to

[1] HD 155885 and 155886 were misidentified at the beginning of the program, and the error was not caught in time to make the necessary changes in the diagrams or in Table 1. Their HD numbers should be interchanged throughout. In the text they are referred to as shown in Fig. 5.

the Sun. On the available evidence, one should probably not yet draw this conclusion. Incidentally, the differences between the components of 61 Cygni also extend to the night-to-night observations. More often than not, the fluxes of the two stars will change in opposite senses, or by different amounts, from one night to the next within an observing run, and the differences can exceed substantially the statistical error. Since the two stars are observed within a few minutes of each other, these facts exclude the possibility of an instrumental origin for such fluctuations of short period and show that they must be largely intrinsic.

The last two diagrams in Figure 5 again show differences between the two members of a binary system. For the primary, there is a slight suggestion of a cycle of small amplitude, but one cannot be certain of cyclical behavior. The secondary, however, has probably gone through a cycle with a period of 8–9 years.

VI. THE SUN

It was considered important to see whether the apparatus and procedures employed in this work could detect the solar cycle in integrated sunlight, and the simplest way to accomplish this was to observe the Moon. Lunar observations were begun in 1966 September, well up on the rising branch of the last solar cycle, and were continued at every opportunity across the maximum until 1970 October. They were then stopped, except for a few scattered observations, for about 4 years (to conserve observing time), resumed in 1975 January, and continued through the minimum until 1977 April. The only difference between the lunar and stellar observations was that the total count in the lines was larger for the former, 2×10^5 instead of 4×10^4, thus reducing the statistical error to relative insignificance.

Table 3 contains a summary of the essential results for the Sun, omitting only a few scattered observations through 1971–1974.

Running means of the lunar observations in groups of five were made; they show considerable scatter across the maximum and do not define it with any accuracy. The minimum, however, appears to have been located with fair precision, since the lowest group is that with the mean date 1976.684 at a flux value of 0.161. All other groups on either side of this one have larger mean fluxes. This location of the minimum agrees well with that found from a plot of the Zurich data (Waldmeier 1966–1977).

The amplitude of the last solar cycle determined in this way seems rather small, but it must be remembered that it is not corrected for the residual photospheric flux in the central 1 Å bands of H_1 and K_1. If we assume the latter to be of the order of 0.140, the chromospheric flux at maximum would be about 50% larger than at minimum. Sheeley (1967) has given an estimate of 40% for the cycle preceding the last one, based on study of K_2 spectroheliograms. When one considers the uncertainties involved, this rough agreement is satisfactory. In any case, the apparatus appears to have detected the last solar cycle unambiguously.

VII. RATIO OF K TO H

The ratio of the chromospheric emission components K/H is of importance in considering the optical thickness of the emitting gas, but, as we have seen, it is not easy to disentangle the chromospheric emission from the residual photospheric fluxes in H_1 and K_1.

For the standard stars with mean measured fluxes in the range 0.13–0.15, the measured K/H ratios are 0.84–0.87. Both fluxes and line ratios in these stars must be dominated by the residual central fluxes in H_1 and K_1. The F7–G3 stars discussed in § V*b* are similar to the standards except that more chromospheric emission has been added at the line centers, and K/H for this group increases with the flux and approaches, but does not exceed, 1 for any of them. This result would follow if the chromospheric K/H were either greater than or equal to 1, but it is not possible to determine with certainty which of these ratios is correct.

However, among the later-type stars there are a number in which the measured K/H definitely exceeds 1, since the s.d. for this quantity is only a few tenths of 1%. In Table 4, the stars of later type with minimum and maximum fluxes have been collected. The interpretation of Table 4 can only be that the chromospheric K/H flux ratio must be greater than 1, probably by significant amounts, at least for the stars with strong emission; it follows that the optical thickness of the emitting elements of gas may be fairly small. Even though some of the stellar emission components appear very strong on spectrograms and suggest saturation, they may well originate in a vast number of small elements over the stellar surfaces. This seems to be true of the Sun, judging from the fine structure of the H and K emission observed with large angular and wavelength resolution. Hence there

TABLE 3

EVIDENCE FOR THE SOLAR CYCLE

Mean Date	No. Obs.	Mean H-K Flux	s.d. (%)	Time Interval
1967.255	29	0.174	0.78	1966 Sept.–1967 Oct.
1969.531	51	0.178	0.44	1968 Feb.–1970 Oct.
1975.538	32	0.168	0.43	1975
1976.652	35	0.164	0.34	1976–1977 Apr.

TABLE 4

MINIMUM AND MAXIMUM FLUXES IN LATER-TYPE STARS, AND K/H RATIOS

Star (HD)	Sp. Type	Mean H-K Flux	Mean K/H	s.d. of Mean K/H (%)
10700	G8	0.172	0.85	0.21
131156 A	G8	0.411	1.03	0.13
219834 A	G8	0.164	0.86	0.19
3651	K0	0.194	0.89	0.18
17925	K0	0.629	1.05	0.13
23249	K0	0.157	0.87	0.15
165341 A	K0	0.372	1.01	0.15
10476	K1	0.209	0.91	0.25
26965	K1	0.202	0.90	0.26
22049	K2	0.472	1.04	0.14
219834 B	K2	0.221	0.91	0.33
115404	K3	0.486	1.05	0.19
4628	K4	0.229	0.92	0.22
16160	K4	0.223	0.92	0.23
190007	K4	0.663	1.08	0.21
131156 B	K4	1.009	1.10	0.42
156026	K5	0.651	1.04	0.25
165341 B	K5	0.795	1.09	0.33
201091	K5	0.528	1.06	0.14
201092	K7	0.738	1.07	0.13

appears to be no strong argument against a relatively small optical thickness.

VIII. CONCLUSION

At best, this work is only a preliminary first-order survey of chromospheric variability in main-sequence stars and as such has many deficiencies. Conclusions based upon it must be drawn with caution and not pushed beyond the capabilities of the data. In this section, I summarize my own feelings about what may legitimately be concluded and in which areas great uncertainty remains.

a) Short-Term Fluctuation

First, it is likely that no stellar chromospheres are constant in time. Figures 1–5 abound with evidence of short-term chromospheric fluctuations, from the feeble chromospheres of the standard stars to the strongest in the program. Various physical processes may be involved in producing these more rapid variations, but their universality cannot be denied.

Inspection of the plots gives the impression that the short-term fluctuations increase in size with the average flux. To examine this question and to minimize the effects of changes from season to season, mean seasonal s.d. values in percent for a single observation were computed, including all observing seasons which contained eight or more observations. The results given in Figure 6 for three groups of stars, F7–G3, G8–K1, and later than K1, show that there is indeed a fairly close correlation between seasonal scatter and mean flux. Stars with spectral types not included in these groups fit into the correlation but are not shown. Figure 6 seems to indicate that the physical causes of the short-term scatter are likely to be the same for all spectral types.

b) Cyclical Variations

The evidence for cyclical variations in stars seems to me to be quite good, since, fortunately, the time base was sufficiently long in several instances to include at least parts of more than one cycle. Extrapolating from these objects to those which appear to have gone through a partial cycle and including the latter in the cyclical group are probably permissible, though caution is advisable. If this is done, the cyclical periods range from about 7 years to probably at least twice as long, thus placing the solar-cycle period well within the indicated range for stars.

But, it may be asked, are the stellar cycles observed in H and K flux really evidence for analogs of the solar

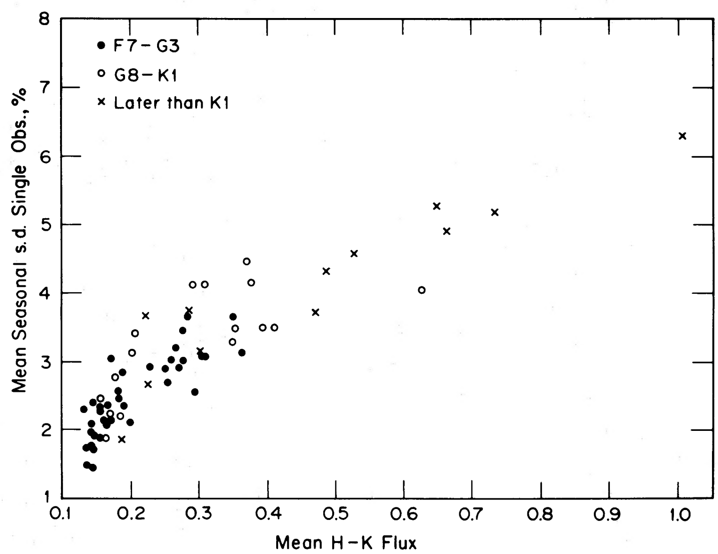

FIG. 6.—Mean H-K flux versus mean seasonal s.d. for a single observation, in percent

TABLE 5

CYCLIC BEHAVIOR IN THREE SPECTRAL-TYPE GROUPS

SPECTRAL RANGE	NUMBER OF STARS	CYCLIC BEHAVIOR Definite	Possible
F7–G3	37	1	3
G8–K1	16	6	2
K2 and later	15	6	7

cycle? The results from the lunar observations (§ VI), together with the principle of conservation of hypotheses, indicate that they should be considered as such unless there is an imperative reason for thinking otherwise.

Inspection of Figures 1–5 also shows that the incidence of complete or probable partial cycles increases toward later spectral types. The first example of the former occurs in HD 81809 at spectral type G2, and of the latter in HD 20630 at G5. Thereafter the incidence of cycles becomes increasingly common as the spectral types become later. More detailed analysis in small spectral-type zones is hampered by paucity of data. However, I have divided the stars into three spectral groups, F7–G3, G8–K1, and later than K1; Table 5 gives my own assessment of the cyclic behavior in these groups. Part of the systematic differences in Table 5 are certainly due to the fact that a given chromospheric emission, in energy per surface area, will become increasingly prominent the redder the star on which it is produced, and its variability correspondingly easier to observe. Thus the three possible cases in the first group of Table 5 are uncertain because of very small measured amplitudes, whereas in the later groups the uncertainty is more often due to an insufficient time of observation.

Students of the solar cycle have had the advantage, at least in modern times, of the ability to study how a number of observable solar phenomena vary in the course of a cycle. But they have also had one serious disadvantage: all this information applies to a single star of given mass, age, and chemical composition. This survey has demonstrated that other stars, with different parameters, have analogous cycles, and it has given at least a rough idea of how the frequency of cyclical behavior varies along the relevant part of the main sequence. To be sure, the information content is rather small—only periods, amplitudes, and curve shapes. Even these are vastly better than nothing and in time should help lead theoreticians to a general theory of solar-type cycles.

c) Small-Amplitude Cycles

It is as important to know which stars are definitely not in a cyclic mode as to know which are, and on this point there is great uncertainty. Many of the program stars have at most only a dozen observations per season, and often fewer, especially those which did not appear to be particularly interesting. Under these circumstances, would the solar cycle have been seen? Possibly, but I think it is by no means certain; yet this is the only cycle known up to now. Clearly, to uncover small-amplitude cycles such as the Sun's, much more continuous observing while stars are within reach, and many more data points, would be required for definitive statements.

This question of small-amplitude cycles has recently become more important because of work by Eddy (1977). He has produced convincing evidence that, for a period of about 70 years, beginning around 1640, the Sun was not in a cyclic mode, and that knowledge of when and for how long in earlier times there has been a solar cycle is virtually nonexistent. In principle, stellar observations should be able to answer the question of how many solar-type stars are in a cyclic phase at a given time and hence what fraction of their lives are spent in this state. To do so requires that the stars observed have both spectral types and mean H-K fluxes, i.e., masses and ages, close to that of the Sun.

Unfortunately, this survey is not capable of giving a satisfactory answer to this question. There are 20 stars with spectral types F8–G3 (including HD 161239, whose $b - y$ color of 0.420 and whose spectrum suggest that it is really about G2–G3 rather than G6) and with mean fluxes in the approximate range 0.14–0.20. Of these, one, HD 81809, has clearly completed a cycle and another, HD 161239, has changed significantly and might prove to be cyclical if observed further. An additional three stars, HD 3795, 12235, and 114710, are weak and uncertain possibilities. Clearly, this work is unable to establish any hard evidence as to the frequency of cyclic behavior of solar-type stars.

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