matemáticos que hagan compatibles los distintos ángulos observados a lo largo del año y/o incluyan cualquiera de las funciones admitidas para la variación de velocidad con la latitud.

Mucho más serio es el problema creado por el hecho de que el desplazamiento esperado en el ecuador del Sol es de unos 40 mÅ y por tanto menor en sus componentes. La resolución del espectrógrafo de San Miguel es de unos 15 mÅ, comparable con otros de su género, y el ruido introducido por el grano de la placa empeora esta situación. Esto sólo puede mejorarse con estadística de muchas mediciones. Un problema similar ha llevado a Solonsky, por ejemplo, a operar con 800 valores medidos por cada valor definitivo en un trabajo sobre distintas velocidades a distintas alturas y latitudes.

Se piensa en completar el trabajo con otro realizado con estadística de manchas, determinando la deriva media día a día en latitud y luego haciendo correlación cruzada con la posición correspondiente de la Tierra y así determinar el ángulo del eje del Sol respecto del supuesto por Carrington con su azimut operando con datos actuales. Para ello pensamos aprovechar el hecho de que actualmente en San Miguel la rutina de manchas se hace parcialmente por computadora, y en consecuencia, tenemos los datos ya perforados.

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Comments on filament disintegration and its relation to other aspects of solar activity

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Resumen: Los estudios de desapariciones bruscas en los ciclos solares 19 y 20 (hasta 1969) indican que estos eventos suceden frecuentemente. Aproximadamente el 30 % de todos los filamentos mayores en estos ciclos se desintegraron en el curso de su trayecto a través del disco solar.

La frecuencia de las fulguraciones mayores observadas en el día anterior a la desaparición de 141 filamentos fue sobre el término medio. (1958-60; 1966-69). Se presentan relaciones entre un filamento en desintegración el 10-11 de julio de 1969, una fulguración mayor anterior, una mancha recientemente formada y un crecimiento concomitante de la fácula Hα. Se informa sobre la observación de material que desciende de una protuberancia dirigido, aparentemente, hacia la ubicación de la fulguración del 15 de julio de 1959 a las 19h 23'. Se describe el desarrollo de una fulguración asociada con un filamento del 13 de febrero de 1967.

1. *Introduction*

Studies of prominences in the course of their transit as filaments across the solar disk can add significantly to information relating to the life histories of prominences and to their possible connection with other solar phenomena. The relatively sudden disintegrations of filaments, the "disaparitions brusques", are the disk counterparts of at least some of the phenomena called eruptive or ascending prominences when such events occur at the limb of the Sun.

Statistics for "disaparitions brusques" appear in the tables of the Cartes Synoptiques published at Meudon Observatory. From these statistics, and from daily observations at the Mc Math-Hulbert Observatory, it is clear that the disintegration of a filament, even a great one, is a common event. In solar cycles 19 and 20 (to 1969) at least 252 large filaments "disappeared" during the transit across the solar disk. These filaments represented approximately 30 % of all filaments evaluated as importance 5 or greater on the Meudon scale. "Disaparitions brusques" were frequent during the years of high solar activity and few in the years near the solar minimum. These findings are in general accord with the results of study of "disaparitions brusques" in earlier years by M. and L. d'Azambuja (1948). In cycle 19, the greatest number of large filaments and major "disaparitions brusques" occurred in 1959, two years after sunspot maximum. (See Table I and Figure I).

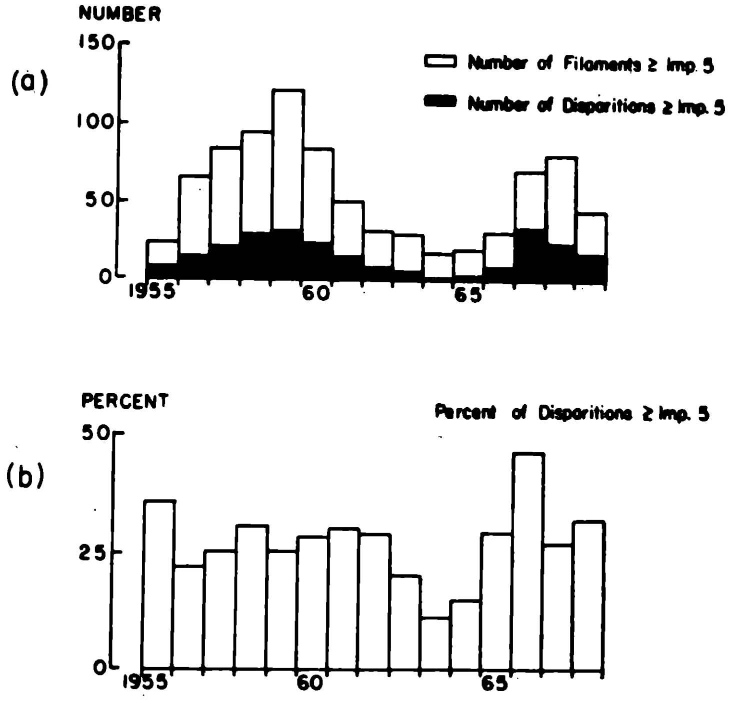

Fig. 1 — (a) Number of filaments of importance $\geqslant$ 5 in the Cartes Synoptiques (Meudon), and the number of these filaments that disappeared (disparition brusque) in the course of transit of the solar disk, 1955-1969. (b) Percent of filaments of importance $\geqslant$ 5 that disappeared during disk transit 1955-1969.

The phenomena that precede and follow the activation and subsequent disappearance of major filaments are varied. Years ago, Bruzek (1952, 1957) pointed out (1) the frequency of formation of new spots within 25° of disappearing filaments during the 5 days that preceded the "disaparition brusque", and (2) the occurrence of flares and chromospheric brightenings following activity in certain filaments. Bruzek deduced a velocity of $\sim$ 1 km s^{-1}, or 5° −6° per day, for the transport of a disturbance from newly formed spots to filaments. Furthermore, in 1958, Bruzek suggested that a disturbance travelling at $\sim$ 50 km s^{-1} ($> 10° h^{-1}$) from the site of some flares may cause the disruption of certain filaments. This effect is in addition to the more rapidly travelling wave emphasized by Athay and Moreton (1961) that causes the brief winking of certain filaments at the time of flares. The filament that crossed the equator at the time of the great flare of May 10, 1949 apparently experienced both types of flare-associated disturbances. It "winked" during the flare and "disappeared" before observations could be resumed on May 11. (Dodson, 1949; Dodson and Hedeman, 1964).

The association between filament activity and subsequent or concomitant flares has been noted by many investigators, and their work has been summarized and extended by Smith and Ramsey (1964). An interesting example of the brightening of the chromosphere to flare intensity at the apparent place of impact of descending prominence material is provided by the location of the flare of importance 1 +, 1959 July $15^d\ 19^h\ 23^m$ UT and that of a prior active prominence observed in proyection on the disk. A relatively large, arcshaped filament was visible on center-of-Hα records from $\sim$ $18^h\ 20^m$ to $19^h\ 03^m$ UT on July 15, 1959. Wavelength-sweep spectroheliograms from $18^h\ 21^m$ to $18^h\ 36^m$ show that the prominence, though rising, also was falling back to the solar surface along two paths that apparently were directed, respectively towards two segments of the large Hα plage then at N 09° W 15° (see Figure 2). At $19^h\ 23^m$ UT, approximately one hour after the observed prominence activity, the two plage segments, identified by dashed lines in Figure 2, suddenly increased to flare intensity. The flare consisted of two separate, relatively round, bright areas. The flare lasted for 28 min and was accompanied by ionospheric disturbance, distinctive events at radio frequencies, and a group of type III bursts.

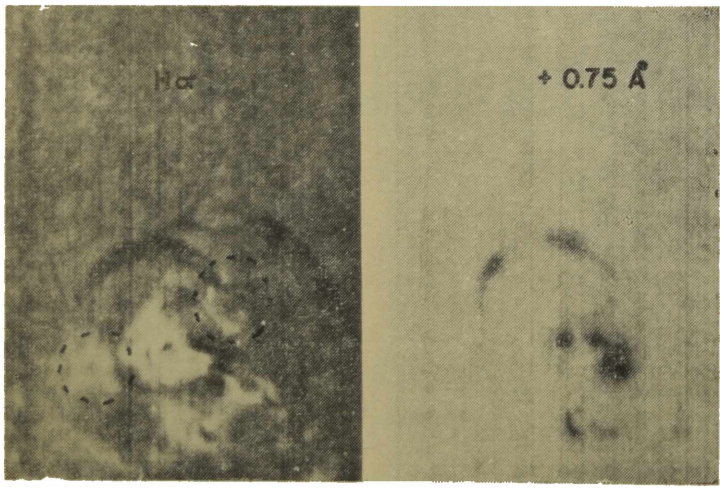

Fig. 2 — Left: Hα spectroheliogram 1959 July $15^d\ 18^h\ 26^m$ UT showing center of activity with plage and filaments. Dashed lines identify the location of the flare later at $19^h\ 23^m$ UT. Right: Spectroheliogram Hα + 0.75 Å, July $15^d\ 18^h\ 28^m$ UT showing portions of filament descending toward solar surface.

2. *Comparison of "Disaparitions Brusques" and Frequency of Flare Occurrence*

Although many large filaments disintegrate without the occurrence of obviously associated prior or subsequent flares (e.g. Mc Cabe, 1970), a study of "disaparitions brusques" of large filaments in solar cycles 19 and 20 indicates that "major" flares have tended to occur with above average frequency on the last day on which a disappearing filament was observed. (See Figure 3). Superposed values of the Comprehensive Flare Index (Dodson and Hedeman, 1971) have been derived for "major" flares 7 days before and 7 days after the disappearance of 141 large filaments in the years 1958-60 and 1966-69. The greatness of the "disaparition brusque" was confirmed in each case by the evaluation in the Cartes Synoptiques (i.e. importance $\geqslant$ 5) and by direct examination of the Fraunhofer Solar Maps or spectroheliograms at the Mc Math-Hulbert Observatory. The day on which the filament was last seen was taken as day "zero" in the calculations. For the preceding and following seven days, values of the "Comprehensive Flare Index" for all "major" flares were tabulated and summed.

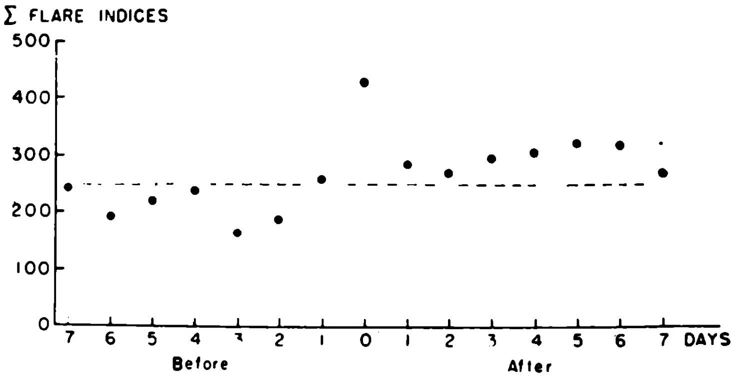

Fig. 3 — Summation of Comprehensive Flare Indices for all "major" flares for seven days before and seven days after the "disparition brusque" of large filaments, 1958-60 and 1966-69. Day zero is the day the filament was last seen.

The category, "major" flare, included all flares that satisfied any one of the following criteria: Hα importance $\geqslant$ 3, accompanying ionospheric disturbance of importance $\geqslant$ 3, 10 cm flux $\geqslant$ 500 x 10^{-22} Wm^{-2} $(Hz)^{-1}$, type II burst, or type IV radiation with duration > 10 min. The results of the calculations are shown in Figure 3. The sums of the superposed Comprehensive Flare Indices give a high peak on the day the filament was last seen, and slightly higher values on the days following, than on the days preceding, the disappearance of the filament. It should be noted that these figures do not distinguish between cases of major flares on day zero that preceded, and those that accompanied or followed, the disintegration of the filaments.

3. *Observations of two disappearing filaments*

The diversity of phenomena that sometimes attend the disappearance of filaments or eruptive prominences can be illustrated by consideration of the circumstances apparently related to specific instances of the disintegration of large filaments. The observations suggest that prominence activity may be playing a broad role in several aspects of solar activity.

A. DISINTEGRATING FILAMENT, JULY 10-11, 1959, AND A GROWING CENTER OF ACTIVITY

The existence of the "continuous" Hα record of the Sun, prepared through international cooperation by H. Smith at Sacramento Peak Observatory, for two weeks in July 1959, suggested the suitability of this interval for the study of a disappearing filament and its large scale attendant phenomena. Fortunately, a relatively large filament disintegrated during the days July 10 and 11, and the phenomenon can be followed on the continuous film and, in part, on the Mc Math-Hulbert records. On July 10 this filament was centered at ~ S 24° E 53°. It was in the same longitude as the great flare-rich center of activity of July 1959 (Mc Math plage 5265), but on the opposite side of the equator (see Figure 4). The area of the filament, in units of the solar disk, has been measured on center-of-Hα pictures. The results are shown in Figure 5.

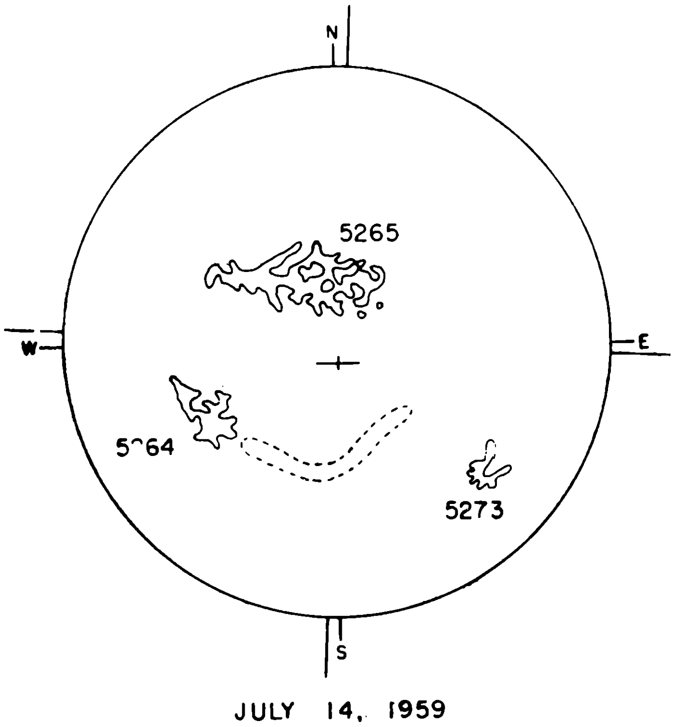

Fig. 4 — Diagram of the Sun on 1959 July 14 showing three of the principal calcium plages and the position (in dashed lines) that a large filament would have occupied, had it not disintegrated, Juy 10-11. Region 5265 was the site of many great flares July 10-16; region 5264 grew as the filament disintegrated; region 5273, without large spots, was the site of large flares on July 13 and 14.

In the early hours of July 10 a flare of outstanding magnitude, importance 3+ occurred in the great center of activity ~ 37° to the North of the filament. The flare lasted for more than 7h. By the early hours of July 11, the filament in the south was clearly diminishing in size. There may or may not be a relationship between the occurrence of the great flare and the subsequent disappearance of the filament.

Additionally, a new spot had formed on July 10 close to the western tip of the filament. The spot was visible by 12^h UT on July 10. Throughout the remainder of July 10, the Hα plage associated with the new spot was not bright and did not increase in area. According to our measurements, the plage (Mc Math 5264) began to increase in intensity and grow in area simultaneously with the onset of disintegration of the adjacent filament. (See Figure 5). The filament disintegration continued during a 20 h interval.

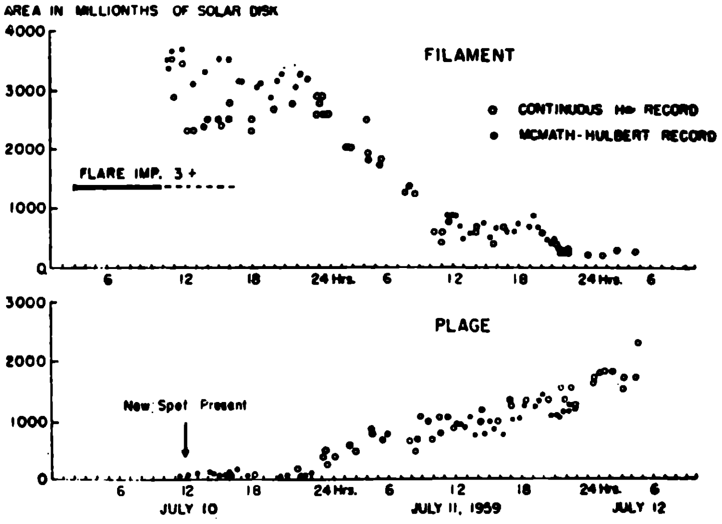

Fig. 5 — Diagrams showing the time relatioships of the disintegration of a filament, the occurrence of a large flare, the formation of a new spot and the growth of the associated plage. Top: Measurements of area of the filament in millionths of the solar disk on center of Hα records, July 10-11, 1959. Bottom: Measurements of area of Hα plage (5264) in millionths of solar disk, July 10-11, 1969.

In 1952 Bruzek wrote that the formation of a spot in the vicinity of a filament is followed, almost without exception, by the inmediate disappearance of the latter, or at least by its shrinking in size. The "disaparition brusque" of July 10-11, 1959 fits this pattern. Furthermore, the increase in size and brightness of the plage, concomitant with the interval of disintegration of the filament, recalls the numerous reports of chromospheric brightenings in association with "disaparitions brusques". The pictures of the growing plage on July 11 show that it extended in a direction that merged with the western tip of the disintegrating filament, and gave an impression of association between the two phenomena. The formation of the spot may have upset the stability of the filament and initiated its disintegration. Descending prominence material, as part of the disintegration of the filament, may have facilitated the growth and brightening of the plage (Dodson and Hedeman, 1952; Hyder, 1967).

B. DISINTEGRATING FILAMENT, FEBRUARY 13, 1967, AND ASSOCIATED FLARE

The greatness of flares that are sometimes associated directly with the "disaparitions brusques" of filaments can be illustrated by the flare of importance 3 at $17^h 47^m$ UT on February 13, 1967. (See Solar Physics 13, 408). This flare consisted of two or more bright ribbons that followed closely the position of a large previously existing dark filament. The flare and filament crossed a bright plage in a declining center of activity. The associated spot had diminished to minute umbrae that fluctuated in visibility from day to day. On February 13 there were two tiny umbrae, each no larger than 3 millionths of the solar hemisphere. There is no confirmed evidence for the formation of an enduring spot in the neighbourhood of this filament in the hours or days just prior to its disintegration.

The region in which the filament and flare occurred was Mc Math plage 8687, which has been identified (Dodson and Hedeman, 1969) as the possible site on the invisible hemisphere, of the source of energetic cosmic rays on January 28, 1967. The flare was bright and very large. It rose to maximum relatively slowly (33 min from start to maximum) and was of long duration ($3^h 43^m$). The most unusual feature of the event, other than the great size of the Hα flare was the extent of the associated filament. According to Mc Math-Hulbert observations and those reported by Shimabukuro (1968), the first signs of activity in the region were pre-flare brightenings that took place at ~ $17^h 00^m$ UT. By $17^h 30^m$ the dark filament showed motion, and by $17^h 47^m$ the flare had started. The disintegration of the filament, on center of Hα records, began during the first 8 min of the Hα flare and before the marked growth in area of the flaring regions occurred.

This filament-associated flare in a center of activity with almost no spots was accompanied by radio frequency bursts of types II, III, and IV. At 10 cm the peak flux was only 50×10^{-22} Wm^{-2} (Hz)$^{-1}$ and the event did not have a U-type burst (Castelli et al., 1967). Nevertheless protons with energies $\geqslant$ 19 MeV were observed within 2 h by satellites, and PCA was recorded (Masley and Goedike, 1968). Study of the X-ray spectrum of this flare by Walker and Rugge (1968) revealed strong enhancement of lines of high ionization potential (Fe XVII, Ne X, Mg XI, Fe XVIII, and Ni XIX). The flare was followed in slightly less than 2 days (February 15) by the onset of a severe, geomagnetic storm with sudden commencement. Satellites recorded the concomitant arrival of protons with energies greater than 90 MeV. Additionally Hirshberg et al. (1969) report increased helium to hydrogen ratio in the solar wind, February 15 and 16, 1967.

The filament-associated flare of February 13, 1967 was an example of a great isolated major flare in a declining center of activity. Its occurrence did not lead to a resurgence of activity in the region in the subsequent days or rotations. If one believes that the energy of a flare stems ultimately from a loss of magnetic energy, then the occurrence of such filament-associated flares in old and dying regions is a visible demonstration that the region is losing magnetic energy. From this point of view, filament disintegration and flare occurrence may be considered to represent one aspect of the probably complex process by which centers of activity finally disappear.

4. *Discussion*

The frequent occurrence of filament-disintegration and the vast extent of this phenomenon on the solar surface suggest that such events warrant more than casual consideration in overall studies of solar activity. Filaments, born in one center of activity, (d'Azambuja, 1948) perhaps disrupted by the formation of a neighbouring spot or flare, apparently may contribute to the brightening of another center of activity. From time to time, filaments apparently act as liason between individual centers of activity, and play a role in the growth of large activity zones. It seems of interest that the great July 1946 center of activity (CMP July 27), with the third largest spot since 1874, developed in the midst of a filament 7 rotations old, that had drifted ~ 100° in longitude from its origin in the neighbourhood of the second largest of all known spots (CMP, February 6, 1946) (see Cartes Synoptiques and Greenwich Photoheliographic Results). The drift of great filaments marks the migration of old magnetic fields. The descending prominence material of a disintegrating filament apparently results in transient brightening of the chromosphere or sometimes in the occurrence of a great flare, or the rapid growth of a center of activity.

There is growing evidence that single centers of activity or single flares should not be considered as isolated, independent phenomena. The various aspects of solar activity, even at relatively great separations on the solar surface appear, at times, to have a dependence one on the other (Wild, 1969). In studies of the formation of zones of activity and in surveys of the evolutional development of the solar cycle, it would seem appropriate to give due consideration to the possible role of the large filaments, their disintegration, and their formation.

ACKNOWLEDGEMENTS

This research was supported in part by the National Aeronautics and Space Administration Contract NGL-23-005-275.

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TABLE I

Filaments and "Disparitions brusques", 1955-1969
From Cartes Synoptiques published by Meudon Observatory

Year	Total number	Filaments with importance ⩾ 5 With disparitions brusques Number	%
1955	25	9	36
1956	67	15	22
1957	84	21	25
1958	94	30	32
1959	121	36	30
1960	84	26	31
1961	50	15	30
1962	31	9	29
1963	30	6	20
1964	18	2	11
1965	20	3	15
1966	31	9	29
1967	71	33	46
1968	81	23	28
1969	46	15	33
Total	853	252	30

Eu, La and Sm in sunspot spectra

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Resumen: Se obtuvieron valores de abundancias relativas para Eu, La y Sm a partir de espectros de manchas de alta resolución.

Los resultados son (en la escala $\log \varepsilon^{H} = 12.00$)

	$\log \varepsilon$
Eu	0,70 ± 0,30
La	2,14 ± 0,27
Sm	2,30 ± 0,35

La dependencia de la abundancia con el potencial de excitación del nivel inferior es grande para Eu, menor para La y está ausente para Sm. Esto señala la presencia de errores sistemáticos en los valores de fuerza de oscilador usados para este trabajo.

Se presenta además una lista de nuevas líneas identificadas en el espectro de manchas.

1. *Introduction*

The determination of the relative abundances of heavy elements, specially of those of the Lanthanides, is a straightforward test of the modern theory of nucleosynthesis. This theory assumes these elements are produced by s and r processes and predicts that their relative abundance is inversely proportional to their neutron capture cross-section.

The anomalous behaviour of the Lanthanides in Ap and Am stars and their overabundance in magnetic stars have been the subject of numerous investigations. Pikelner and Kokhlova (1971) and Sargent and Burbidge (1970) discussed possible explanations for these observations. Lines of Lanthanides also show an anomalous behaviour in the solar spectrum occurring in emission on the solar disk in the wings of the H and K lines of Ca II and near the solar limb (see eg. Jenssen and Orrall (1963) and Canfield (1971)). The first determination of the abundance of rare earths was made by Russell (1929) followed by investigations by Wallerstein (1966), Righini and Rigutti (1966) and Grevesse and Blanquet (1969). Most recently Bachmann et al. (1970) have investigated, with improved methods, the abundance of La and Eu from photospheric and sunspot spectra (for details see table 1).

TABLE 1

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A summary of rare earth abundance determinations published so far.

Russell (1929)

Visual estimation of intensities for photospheric lines of many ionized heavy elements. Oscillator strengths from Russell et al. (1928).

Wallerstein (1966)

Curve of growth method for photospheric lines of many ionized heavy elements (adopted excitation temperature: 5.000 K.).

Righini and Rigutti (1966)

Weighting function method computations for ionized heavy elements in the photosphere. Equivalent widths from Utrecht Atlas. Photospheric model: Müller and Mutschlecner (1964). Oscillator strengths: Corliss and Bozman (1962).

Grevesse and Blanquet (1969)

Computation of equivalent widths of many lines of ionized rare earths for different photospheric models. Oscillator strengths from Corliss and Bozman (1962). Equivalent widths from high resolution spectra.

Bachmann et al. (1970)

Line profile computations of either one line of La and Eu in the photosphere and umbra. Isotope effects and hyperfine structure were taken into account. Oscillator strengths from Corliss and Bozman (1962). Observational data: mean profiles obtained photographycally and protoelectrically.