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ON THE RELATION BETWEEN SOLAR MOTION AND SOLAR ACTIVITY IN THE YEARS 1730-80 AND 1910-60 A. D.

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Received 28 April 1989

О СООТНОШЕНИИ МЕЖДУ ДВИЖЕНИЕМ СОЛНЦА И СОЛНЕЧНОЙ АКТИВНОСТЬЮ В 1730—80 И 1910—60 ГГ.

Доказывается, что движение Солнца по практически сходной орбите (упорядоченной по порядке Юпитер-Сатурн) на интервалах 1730—80 и 1910—60 гг. создает именно на этих двух интервалах практически сходные серии солнечных циклов.

It is proved that the motion of the Sun in nearly the same (ordered according to JS-order) orbit in the years 1730-80 and 1910-60 creates nearly the same series of sunspot cycles just in these two intervals.

Key words: solar motion, solar activity

Bull. Astron. Inst. Czechosl. **41** (1990), 200—204.

1. Introduction

In previous papers (Charvátová 1988, 1989, 1990) a direct and stable connection between solar motion round the barycentre of the solar system and solar variability has been exhibited. Only the outer planets were taken into consideration (Jupiter – Pluto). The epochs of the ordered motion of the Sun (according to JS-order) coincide with the epochs of prolonged high solar activity, in which ten-year cycles prevail. The epochs of chaotic motion coincide with prolonged minima in solar activity (e.g. the Maunder minimum, etc.), in which the mean length of solar cycles is about 12 yrs. This corresponds to the bimodality of the distribution of sunspot cycle periods (Wilson 1987). The prolonged extrema of solar activity occur in a basic cycle of about 180 yrs.

2. Comparison of two Intervals of Ordered Motion

Figure 1 demonstrates the ordered and chaotic orbits of the Sun, alternately reoccurring every ~180 yrs. While the chaotic orbits differ from one another, the ordered orbits are nearly the same (after rotating through 30° over 180 yrs). This similarity of the ordered orbits of the Sun in the years 1730 – 80 and 1910 – 60 is evident from Fig. 2.

The Wolf sunspot numbers have been recorded since 1700 A. D., with nonuniform quality and frequency of observations. Only approximate annual values exist before the year 1750 A. D., approximate monthly values from 1750 to 1849 A. D. and only since 1850 A. D. can Wolf numbers be considered as reliable.

From 1700 A. D. to the present, two intervals separated by about 180 yrs (Fig. 1, 2) occurred, in which the Sun moved along nearly the same orbit, i.e. in the years 1730 – 80 and 1910 – 60. Considering that chaotic orbits differ from one another (Fig. 1), these two intervals provide us with the only opportunity of understanding the relations between solar motion and solar cycles.

The pattern of solar motion characteristics (e.g., of velocity, acceleration, angular momentum, etc.) reoccurs once every 179 yrs, as already pointed out by Jose (1965). The motion characteristics of both the intervals are, therefore, nearly the same.

If solar variability is really caused by solar motion, the motion of the Sun along nearly the same orbit (with the same motion characteristics) should then create the same series of sunspot cycles.

The sunspot cycles in the years 1733 – 84 (i.e. cycles –1 to +3 – dotted line) and the sunspot cycles in the years 1912 – 63 (i.e. cycles 15 to 19 – solid line) are drawn in Fig. 3. One can see the similarity of both the series of cycles.

The differences between both the series could be caused by the ordered orbits of the Sun not being identical, by the inner planets not being considered or by the lack of our knowledge of the boundary of the solar system.

But, above all, they could be caused by substantially lower quality of observations of Wolf numbers in the 18th century. The annual percentages of daily observations of sunspots in the 18th century according to Mayaud (1977) are plotted at the bottom of Fig. 3. The number of daily observations is low particularly in the years, when there is little similarity between the two series e.g. in the years 1757 – 61; periods of no observations lasting from 3 to 6 months also

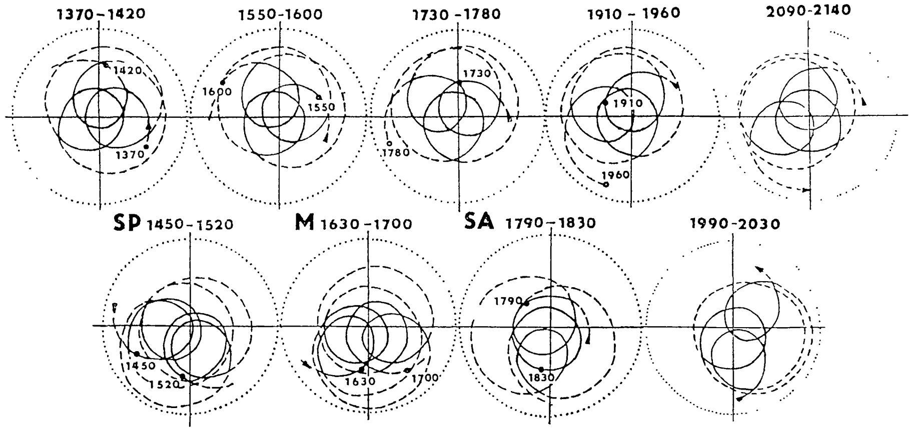


Fig. 1. The ordered and chaotic motion of the Sun alternately reoccurring every ~180 yrs in the years 1730 to 2150 A. D. (SP — the Spörer, M — the Maunder, SA — the Sabine minima in solar activity). The dotted circle, radius $2{\cdot}2\, r_s$ (r_s is the solar radius) limits the area, in which the Sun moves.

exist in these years (Schove 1983). Moreover, the metodology of observation in the 18th century was not uniform. The comparison of the maximum monthly values in the maximum of cycle No 3 (the year 1778: 238·9) and in the corresponding maximum of cycle No 19 (the year 1957, 179 yrs later: 235·8, 253·8, 210·9, 239·4) is also interesting. One may, therefore, infer that a substantial part of the differences in the cycle patterns could be explained by the low quality of observations in the 18th century.

Cycles -1 to $+3$ have been designated as series A, cycles 15 to 19 as series A′. Fig. 4 shows the F-spectra of Wolf numbers for series A (dotted line) and for series A′ (solid line). The spectra have the same period pattern, i.e. in both cases periods of 38·1, 19·9, 13·7, 10·1, 8·0, 6·8 yrs have been found (the dominant period is 10·1 yrs). Only the amplitudes are slightly different.

The F-spectra of successive groups of five cycles from 1700 A. D. to the present (in steps of 1 cycle) have also been computed. None of these spectra has the above mentioned properties of spectrum A or A′. The value of the dominant period varies from 10·1 yrs for series A to 12 yr for the groups of cycles Nos 4–8, and back to 10·1 for series A′ (see also Charvátová and Střeštík 1988). Also these results support the conclusion that the series A and A′ could be very similar had the observations in the 18th century been reliable.

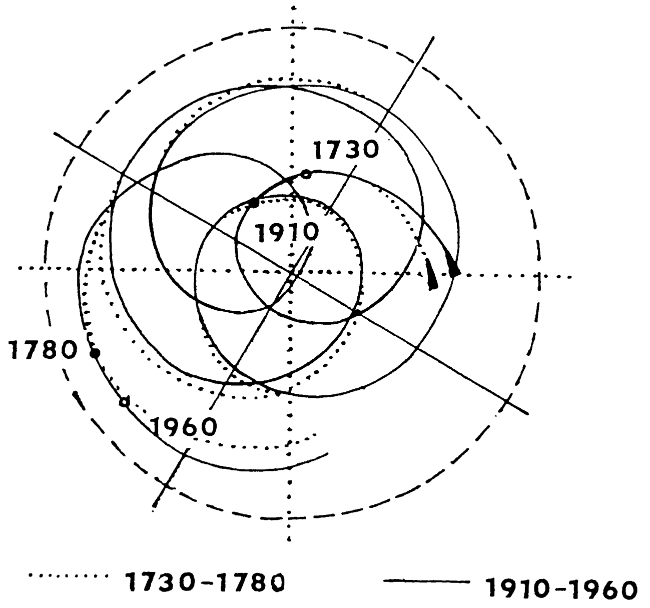


Fig. 2. The orbits of the Sun in the years 1730—80 (dotted line) and 1910—60 (solid line) — after rotating through 30° over 180 yrs.

The coefficient of correlation between the series of Wolf numbers of series A and A′ has been computed. This coefficient has the significant value of 0·805. The coefficients of correlation between series A and the successive groups of five cycles from 1700 A. D. to the present have also been computed. The same was done for the series A′. The resulting coefficients, in each related to the central cycle of the respective group, are plotted in Fig. 5. One can see that the

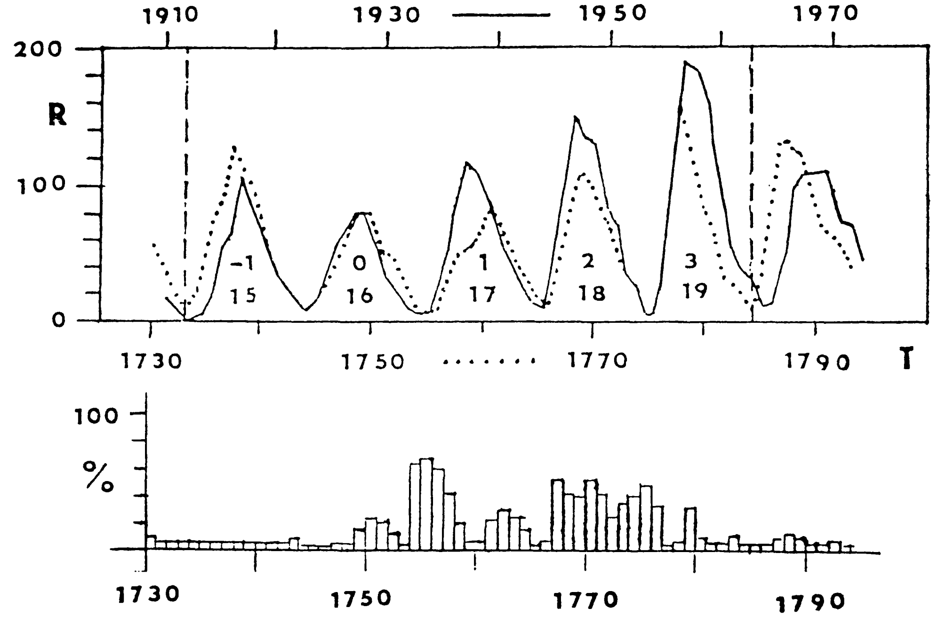


Fig. 3. The sunspot cycles in the years 1730-80 (i.e. cycles -1 to $+3$ — dotted line) and in the years 1910-60 (i.e. cycles 15 to 19 — solid line). The percentages of daily observations in the respective years of the 18th century are plotted at the bottom of the figure (after Mayaud 1977).

highest and only significant coefficient is the one between series A and A′. The smallest coefficients (positive and negative) were found for the epoch of chaotic motion of the Sun (~1790–1830 A. D.). This also proves that the closest connection is between series A and A′ and that a similar group of five cycles did not exist at any other time since 1700 A. D. The basic 180 yr cycle, in which the prolonged extrema of solar activity occur, is evident. (There are 16 cycles with a mean length of 11·2 yrs in the Wolf numbers.) The curve of the coefficients of correlation as well as the inverse curve of dominant periods of the spectra (in fact of the mean length of the cycles in the groups of five) approximately fit the long-term pattern of solar activity.

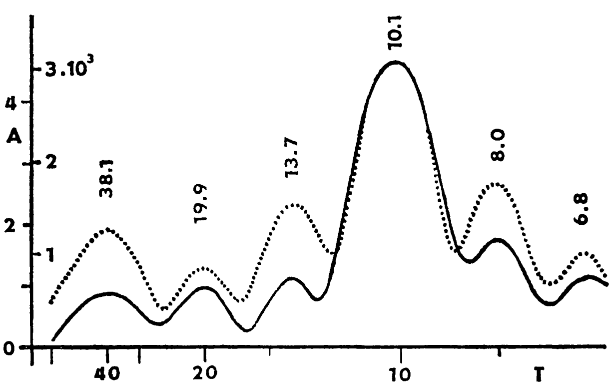
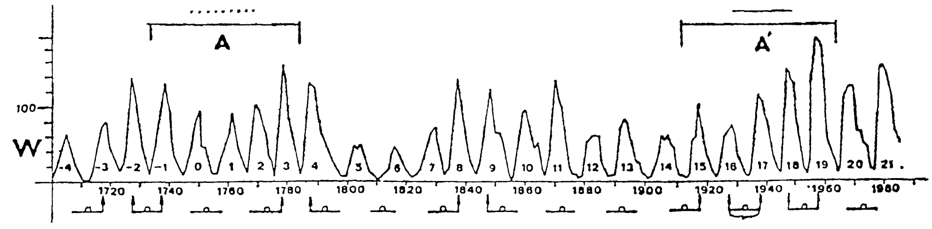


Fig. 4. F-spectra of the periods of Wolf numbers for the series of cycles −1 to +3 (dotted line) and for the series of cycles 15 to 19 (solid line).

3. Conclusion

The above results give further evidence of the close connection between solar motion and solar variability. It is even possible to conclude that solar cycles are essentially created by solar motion due to the giant planets. It seems that the inner planets participate only in the short-term fluctuations of the Wolf numbers. The proper "mechanism" required to explain solar variability will probably be found in solar motion. This would provide the possibility of realiable prediction for any length of time in advance, because the motions of the planets are given and known. The current cycle No 22 is probably the last of the high ones. It should be followed by an epoch of about 30 yrs, in which the motion of the Sun will be chaotic (Fig. 1) and solar activity, therefore, should be low. The cycles will probably be longer and irregular. No concrete prediction for these cycles can now be made. After 2040 A. D., high ten-year cycles will



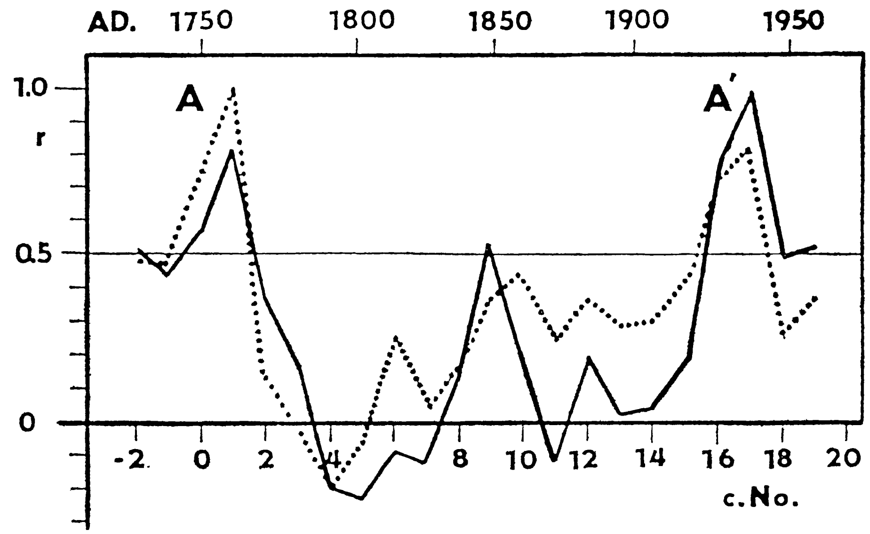


Fig. 5. The coefficients of correlation between series A (of cycles −1 to +3 — dotted line) and the successive groups of five cycles (in steps of 1 cycle), related always to the central cycle of the group and the same for series A′ (of cycles 15 to 19 — solid line).

probably occur (Charvátová 1988). The Sun will begin to move along nearly the same orbit as in the years 1730–80 and 1910–60, approximately after 2090 A. D. This probably means that in the years 2091–2142 nearly the same series as series A′ (of cycles 15–19) could occur, with the cycle maxima close to the 5–6th year of the respective decades.

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BOOK REVIEWS

LARGE-SCALE STRUCTURES IN THE UNIVERSE OBSERVATIONAL AND ANALYTICAL METHODS LECTURE NOTES IN PHYSICS, Vol. 310

Eds W. C. Seitter, H. W. Duerbeck, and M. Tacke; Springer-Verlag, Berlin, Heidelberg, 1988; 335 pp.; Price DM 59·00 Hardcover.

The volume presents the proceedings of a workshop held at the Physikzentrum Bad Hönnef, Federal Republic of Germany in December 1987. The extended introduction by one of the editors Waltraut C. Seitter (Münster) contains a large number of historical annotations on "Large Scales — Large Numbers — Large Efforts" by W. de Sitter, A. S. Eddington, A. Einstein, G. Gamow, O. Heckmann, J. F. W. Herschel, E. Holmberg, E. Hubble, G. Lemâitre, E. A. Milne, E. Öpik, J. H. Oort, K. Schwarzschild, C. Wirtz, Th. Wright, F. Zwicky and others. It is worth reading to see their deep and clear formulations predating almost all subjects of modern cosmology, including the cosmological inflation, link to particle physics, etc.

The volume is divided into seven parts: Two-Dimensional Distribution of Galaxies, Three-Dimensional Distribution of Galaxies, Clusters of Galaxies, Superclusters and Intergalactic Dust, Quasars, Evolution on Large Scales, and Methods and Tools.

The invention of high-speed, flying spot scanning microdensitometers of the COSMOS type, which can digitise the deep direct and objective prism plates from Schmidt telescopes, has increased the number of data substantially: there are several million galaxies in the game by now. This volume presents some results from large projects such as the Edinburgh/Durham or APM Gafaxy Survey, or Münster Redshift Project. The three-dimensional studies of galaxy distribution are difficult and various rather sophisticated mathematical tools are also introduced. The bubble theorem is used in the interpretation of large-scale morphology, which can be the product of a process known as the Voronoi tessallation creating the Voronoi foam (the contribution by V. Icke).

There are several centres which produce surveys of galaxies: the two of them are in England (Cambridge and Edinburgh-Durham). Quite recently they were joined by a third in Münster (F.R.G.). This volume, which is really Münster-centred (35% of all contributions come from Münster), is only another result of the efforts in Münster. But we can also see that some progress is also being made in Poland (15% of all contributions) and Hungary (10% of all contributions).

The present volume is certainly worth reading since it presents abundant material which is partly on the textbook level, partly reviews, and partly contributed papers. It should not be missed by any cosmologists or interested individual.

Jan Palouš

NEUTRINO PHYSICS

Proceedings of an International Workshop held in Heidelberg, October 20–22, 1987; edited by H. V. Klapdor and B. Povh; published by Springer-Verfag Berlin—Heidelberg—New York —London—Paris—Tokyo, 1988; ix + 333 pages, 167 figures, index; hard cover DM 98.

Since the neutrino entered physics more than fifty years ago, it has played a key role in our understanding of the weak interactions. However, neutrinos are important not only for particle physics, but they also play an intriguing role in astrophysics and cosmology. No matter how striving effort has been made in this field, our knowledge of neutrino interactions remains gappy. The book under review reflects the present status of both theory and experiment.

The Proceedings of the Tenth Workshop on problems of particle physics contain 32 contributions grouped under 6 subject headings: *Neutrinos in Gauge Theories and Cosmology* (66 pages), *Neutrino Reactions and Properties* (55 pages), *Double Beta Decay and Neutrino Mass* (65 pages), *Solar and Cosmological Neutrinos* (49 pages), *Neutrinos from Collapsing Stars* (35 pages), and *Future Neutrino Projects* (12 pages). Several papers serve as a review with extensive references (let us mention at least Massive Neutrinos by P. Langacker, Small Neutrino Masse in Gauge Theories by R. N. Mohapatra, and Neutrinos in Cosmology by G. Gelmini). Most of the papers describe concrete measurements or submit propositions for future experiments. Emphasis is put on non-accelerator and beyond-accelerator experiments. Naturally a considerable part of the contributions deals with neutrino oscillations, search for neutrinoless double beta decay and further evidence for neutrino mass. Astrophysicists will be interested in possible consequences for the dark matter problem, which are also discussed in some detail. As the workshop was held shortly after the SN 1987 A event, the book contains the first analyses of the detected neutrino burst and comparisons with theoretical predictions. Unfortunately, discussions on open problems have not been included in the proceedings although they should form an integral part of any workshop and also readers benefit from them.

Summarizing, I can recommend the book to experts in particle physics and to all theoretical and experimental physicists interested in the field.

Vladimír Karas