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SIMULATION OF MEGALITHIC ALIGNMENTS

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For about 200 years, it has been claimed - sometimes on subjective and purely speculative grounds - that menhirs (stone circles, alignments, etc.) were orientated upon heavenly bodies. Since three decades, however, much scientific work has been done by A.Thom[1-11], G.Hawkins[12-15], R.J.C.Atkinson[16] and others[17-20]. This work was set up to test the astronomical hypothesis by means of objective measurements.

Why did people erect menhirs ? There is one simple answer : nobody knows for certain. A priori, there is no indication that the megalith builder had an interest for astronomy. Therefore, it seems proper to ignore a megalithic astronomy unless we can be reasonable sure that the megalithic alignments cannot been attributed to chance.

In the present study, the following working hypothesis has been adopted : megalithic monuments are orientated upon rising or setting points of significant heavenly bodies at about 2000 BC. By tacit consent, the types of orientation will not be considered here as well as structural considerations and practical aspects, amply described by D.C.Heggie[25]. Here I report the results of three simulation experiments : by means of random numbers, i.e. arbitrary choosen numbers, alignments are simulated. After this, it is checked how many alignments are astronomically significant. These results answer the question how many astronomical orientations could be occuring by chance. In this way, these simulations cannot prove the astronomical theory. All I have established is that the number of astronomical alignments, described in the literature, is significantly greater than would be expected by chance. In other words, if we reject the astronomical theory, we admit the occurrence of a highly unlikely number of coincidences, that must be explained.

In order that a megalithic alignment should be astronomically significant, the orientation must point to the horizon where a (significant) heavenly body rose or set at the archaeological epoch of about 2000 BC. Because of the precession of the earth, an alignment can now be astronomically significant, but completely unsignificant in, say, the neolithic period. Hence, the observed declination (δ_0) of a megalithic alignment must agree with the (expected) declination of one or other heavenly body, hereafter called the target declination (δ_e). Some typical target declinations are given in table I. The necessary parameters for the calculation of a declination (δ_0) are Azimuth (Az), Latitude (La) and Altitude (h) according to following formula :

$$\delta_0 = \mathrm{Sin}^{-1} (\mathrm{Cos\ Az} \cdot \mathrm{Cos\ La} \cdot \mathrm{Cos\ h} + \mathrm{Sin\ La} \cdot \mathrm{Sin\ h})$$

Using this formula, I simulated megalithic alignments by means of electronic equipment (Wang 2200, IBM, Apple and Pet 2001). These synthetic, chance orientations, hereafter called random orientations, are compared with actual megalithic alignments, reported by others[1-22].

METHODS AND RESULTS

In simulation experiment I, the declinations were computed of alignments, orientated at random at any location in the British territory and at any time of the year 1730 BC. Random numbers were generated for Az, La and h, taking into account the total horizon (Az = 0º to 360º), the situation of the British Isles (La = 50º to 60º) and the general appearance of the landscape (h = -0.50º to 3.50º). Fig.I shows that the frequency of random pointers is not equally distributed between the extreme values of the declination (-40.3 to +43.5) and displays a clear difference with 283 observed megalithic alignments, described in the literature. To test significance, the χ^2 -test was used. Table 2 reports the χ^2 -value of nine supposedly intentional megalithic alignments and their respective probabilities of occurrence by chance only. Declinations with a probability greater than 0.10 were withdrawn. Thus the smaller this probability is, the higher is the possibility that the alignments are not orientated by chance. Figures greater than 0.10 are considered not significant. A figure of 0.01 means that there is one chance in a hundred that the orientations would have been orientated in the same way by chance. Values between 0.01 and 0.10 are hard to interpret and are described as "suggestive"[27].

In simulation experiment 2, 219,475 random declinations were computed (corresponding to about one alignment to one km^2 of British territory) and the hits were counted within a range of one degree of a target declination of table I. Each time a random orientation falls within the limits (-0.5 to +0.5), this random alignment is accepted as a hit. Random alignments outside the range are therefore astronomically unsignificant. To trace the distribution of hits within the tolerance zone, the declination range was divided into ten parts from -0.5 to +0.5 (fig.2). Table 3 shows an equal number of hits within the declination parts for the sun as well as for the moon. Megalithic alignments, however, show a bimodal frequency, corresponding to the upper and lower limb of the heavenly body (fig.3).

Finally, in simulation experiment 3, the hits were counted for random declinations for stars in the period of 2500 BC to 1500 BC. The precession of the terrestrial axis, namely, influences greatly the declination of stars, even within a relative short period. Table 4 shows that random declinations are equally, but fluctuatingly, distributed over the epochs. Megalithic declinations, however, produce a peak value around 2100 BC, roughly in accordance with ^{14}C-data for British stone circles.

DISCUSSION

The megalithic astronomy looses its credibility among archaeologists and others, owing to following reasons. Firstly, it leads to extravagant and purely speculative assertions with regard to the knowledge, that prehistoric man had concerning the motions of heavenly bodies and the cosmos in general (prediction of eclipses, measurement of refraction, detection of the lunar nodes and nutation, etc.). This knowledge cannot been accomplished without writing and has never been confirmed by written sources[26]. Secondly, archaeologists have not yet traced a fundamental scientific interest of prehistoric man, and the megalith builder in particular. Megalithic astronomy, in this way, can be regarded as a projection of our own scientific thought. Finally, much harm is done to the astronomical theory because of a frequent disregard of the possibility that megalithic alignments can fit an astronomical orientation quite by chance. The three simulation experiments were done to study this latter objection.

In contrast with some claims[24], simulation experiment I shows that a declination of about $\pm$ 32 occur more frequently than other declinations. A method to compress this effect is described by Cooke et al.[21]. Especially the declination of about $\pm$ 24 (solstice) occurs more frequently and can be accepted as an intentional orientation. Furthermore, the declination histogram of the megalithic orientation shows a clustering of declinations which cannot be seen when the azimuths of the orientations are plotted (results not shown). This settlement cannot be explained without an astronomical interpretation. This clustering suggested to A. Thom a calendrical function of the stone circles. In any case, megalithic orientations exceed significantly the number we expect by chance. Study is in the progress to apply Freeman's test[28] to the simulations here reported.

A crucial piece of evidence for the megalithic astronomy is obvious solely by visual inspection of fig.2. It can be expected that the megalith builders too must have done mistakes in erecting those heavily menhirs, even though they had the intention to orientate them properly to the horizon. In other words, one expect an equal part of megaliths on either side of the target declination, just like a statistical Gauss distribution. Actually, we find two peaks separated (in declination) by about the apparent diameter of the heavenly body showing that it was mostly the upper and lower edges of the disc that were observed. This humped shape cannot be obtained by simulation.

Finally the third simulation experiment support the astronomical hypothesis because random orientation do not occur more often in one or other prehistoric period. Without the hypothesis it is difficult to explain the incidence of hits around 2100 BC, roughly in accordance with ^{14}C-dataion. The evidence, apported by these simulation experiments, would place the investigator, still rejecting the astronomical hypothesis in the difficult position of looking for a more suitable explanation.

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Astronomical object	δe
Sun : equinox	0.51
solstice	23.93
Moon : minor standstill	18.78
major standstill	29.08
Aldebaran (Tau α)	0.49
Capella (Aur α)	31.41
Rigel (Ori β)	-20.71
Bellatrix (Ori γ)	- 6.04
Betelgeuse (Ori α)	- 2.70
Adhara (CMa ε)	-30.84
Castor (Gem α)	28.80
Procyon (CMi α)	5.84
Pollux (Gem β)	26.41
Regulus (Leo α)	24.09
Spica (Vir α)	10.52
Arcturus (Boo α)	42.76
Antares (Sco α)	- 9.51
Wega (Lyr α)	41.44
Altaïr (Aql α)	7.36
Deneb (Cyg α)	36.49
Sirius (CMa α)	-19.40

Table 1: Target declinations (δ_e) for Sun, Moon and Stars (magn.<2.0) 2000 B.C. (after Hawkins-Rosenthal[15]).

Declination		χ^2(d.f.=1)	Prob.	Interpretation
-24	-22.5	8.45	< 0.01	significant
-22.5	-21.0	14.45	< 0.001	significant
-17.5	-15.0	5.06	< 0.05	suggestive
- 9.0	- 7.5	10.56	< 0.01	significant
0	+ 1.5	3.06	< 0.10	suggestive
+ 6	+ 7.5	3.06	< 0.10	suggestive
+16.5	+18.0	10.56	< 0.01	significant
+22.5	+24.0	4.05	< 0.05	suggestive
+31.5	+33.0	10.32	< 0.01	significant

Table 2: χ^2-test of nine supposedly intentional megalithic alignments.

Declination interval		1	2	3	4
-0.5	-.4	418	545	502	788
-0.4	-.3	438	547	519	821
-0.3	-.2	401	531	512	846
-0.2	-.1	456	610	485	882
-0.1	- 0	438	566	518	854
0	+.1	428	589	507	845
+0.1	+.2	438	600	507	809
+0.2	+.3	415	591	514	848
+0.3	+.4	391	586	499	862
+0.4	+.5	454	624	515	810

Table 3 : Number of random hits within one degree of the target declination of the sun (1 = equinox; 2 = solstice) and the moon (3 = minor standstill; 4 = major standstill) from 219,475 simulations.

Alignment type	2500	2300	2100	1900	1700	1500
Megalithic	0.102	0.237	0.475	0.322	0.153	0.186
Random	0.104	0.110	0.106	0.114	0.111	0.126

Table 4 : Frequency of random and megalithic hits upon stars (magn.$<$ 2.0).

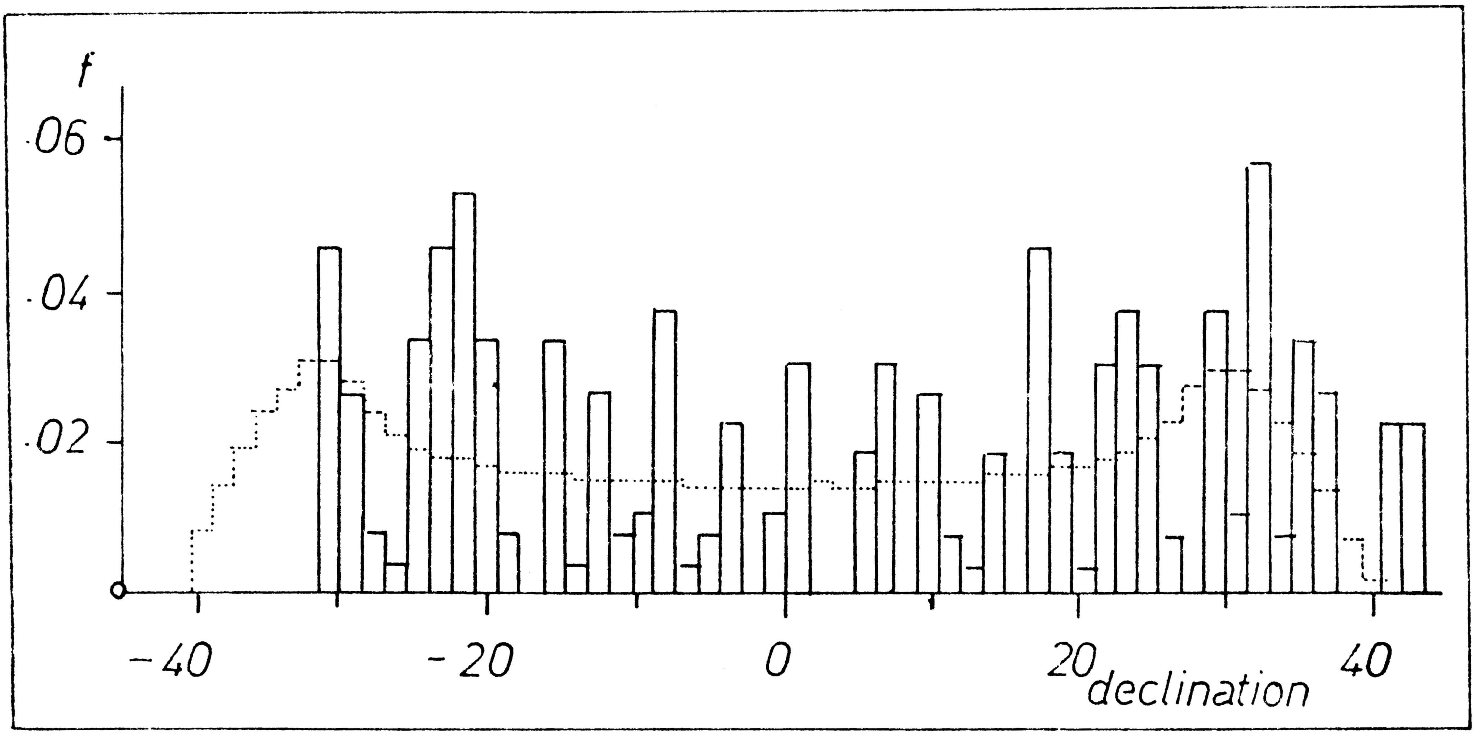

Fig. 1 : Frequency distribution of 7.7 x 10^6 random orientations (.....) and 283 megalithic alignments (———).

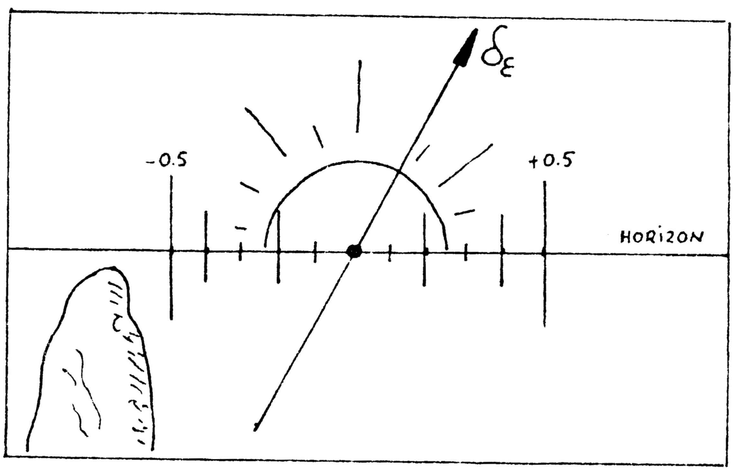

Fig. 2 : Division of the declination range, within an alignment is accepted as hit.

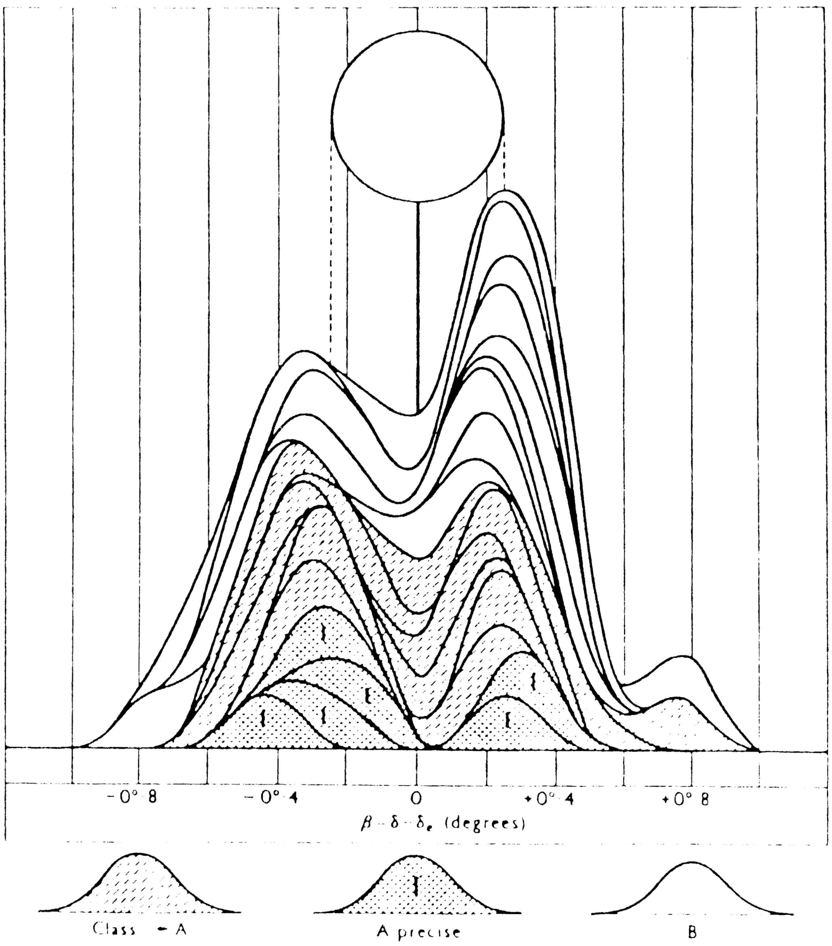

Fig. 3 : Distribution of megalithic lunar alignments within the range of -I to +I of the target declination. (after A. Thom[25])