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LONG TERM PERIODICITIES OF GEOMAGNETIC REVERSALS AND STABILITY OF ANCIENT GALACTIC MOTIONS OF THE SOLAR SYSTEM

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Abstract

Paleomagnetic records can be a rich source of empirical data in characteristic time scales of tremendous interest to solar astronomers and verifiable theories on the earth's evolution in its galactic environment The record of magnetic polarity changes beyond phanerozoic (600 million years before present) is quite unreliable However, phanerozoic polarity bias data can be analysed by sophisticated spectral techniques The long term spectral structure of frequently reversing axial geocentric dipole field has been re-examined in this paper by Fourier Analysis, Walsh spectrum and Maximum Entropy Spectrum Methods to the available worldwide paleomagnetic measurements The results of analysis of McElhinny's data suggest significant long term well resolved geomagnetic reversals (GMR) periods of 285, 114, 63, 47 and 34 million years The first and last periods in this sequence are significant at 99 percent confidence level It is quite surprising to find that the 285 million year term corresponds well to the cosmic year (Period of complete revolution of the solar system around the milky way galactic centre)

Similarly 34 million year period corresponds to the half period of vertical galactic oscillations of the solar system An examination of the stability of the Z-oscillations from HICKEN et al's data during various time zones suggest that the half period of vertical oscillations of the ancient solar system have remained remarkably stable at (34 5 ± 1 5) m y during last 600 million years This particular GMR periodicity is found in several other geological records including in impact cratering episodes and biological mass extinctions It would be interesting to confirm the invariance of the vertical oscillation during the phanerozoic by fossil records of ancient solar flare activity, micrometeroites on lunar surface and the cosmic ray flux The approach suggests, for the first time, paleomagnetism as a tool for paleo-solar astronomy to reveal change in ancient galactic dynamics of the solar system

1 Introduction

The fossil records of the magnetic history of the earth indicate that the North magnetic pole has been frequently flipping as the South magnetic pole and vice versa throughout the geological history Over long periods of time the records of ambient geo manetic field can be obtained from the frozen field in volcanic lava flows and sea floor sediments The studies suggest that the earth can be considered dominantly like a dipolar bar magnet exhibiting two stable polarity states The normal state corresponds to the behaviour of the present geomagnetic field, while the reverse state requires North pole flipping as South magnetic pole Interestingly, the first observation of reverse polarity in rocks came from Indian rocks when Joao de Castro, the Viceroy of Portugese India,who observed in December, 1538 that his compass needle was showing north pole in a wrong way in an unchartered island in Arabian sea near Bombay However, away from that particular rock his compass turned round to show the North in its proper direction Later classical studies by B Brunches in 1906 and M Matuyama in 1929 in Japan confirmed that the magnetic field has been changing frequently in its polarity Comprehensive global records of geomagnetic reversals have been observed and catalogued by Harland et al

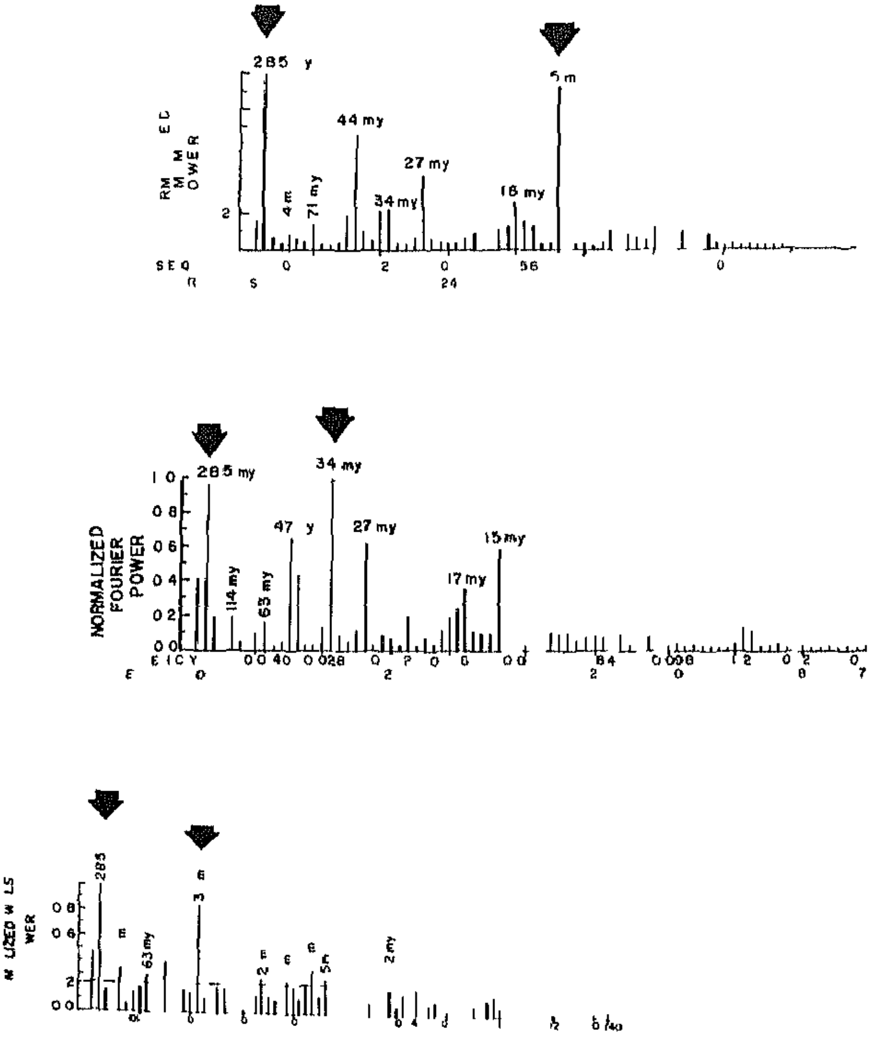

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Fig.1 Walsh Fourier and MEM power spectrum of 570 million year reversal data (Data source McElhinny, 1971)

1982, McElhinny 1971 and Hicken et al 1972 According to Cox (1981) the spectral analysis of global geomagnetic reversals shows no harmonic components However, Negi and Tiwari (1983) find peiodic components in their analysis of polarity bias data of McElhinny (1971) by Walsh spectrum analysis These periods were re confirmed by Fourier analysis and Maximum entropy analysis They represent for the first time that there are long term periodicities above 90 percent confidence level with reversal periods of 285, 114, 64, 47 and 34 million years (Figure 1) Later Raup (1985) examined reversal events of the last 165 million years and confirmed the 30 million year periodicity at a significant level However Raup s analysis was questioned by Lutz (1985) on the ground that the 30 million year periodicity obtained by Raup was a function of data length of the time series Raup was so impressed by the analysis of Lutz that in an unusual manner he retracted his claim of 30 million year periodicity Later, Stothers (1986) made a detailed analysis of the data length effect on reversal events of last 165 million years and confirmed the claim of periodicity of Negi and Tiwari (1983) Recently Paul and Creer (1986) have found spurts in reversal frequency with 30 million year intervals It is not unexpected since a periodic function will have a periodic time derivative All these analysis and re examinations suggest that there is a real existence of the 30 million year periodicity in geomagnetic reversals

In this paper we used other paleomagnetic data published by Hicken et al 1972 This data presents the percentage reversed polaritie observed from several studies related to different geological sub periods of Hicken s data

A Fourier spectrum analysis in Figure 2 shows periodicity of 33 5 million years and 285 million years at 99 percent confidence level Walsh spectrum analysis of the same data in Figure 3 gives better resolution and shows 285, 33 5, 21, 18 and 15 million year periods above 99 percent confidence level

2. Reversal Periodicities and the Sun's motions of Galactic Reversal

There is a remarkable correspondence between significant reversal periodicities and the Sun's motions in the galaxy The best estimates of the half period of Sun's vertical motions as given by Rampino and Stothers 1984 corresponds to 33 ± 3 million years and the Sun's motion around the galactic centre takes around 280 million years according to Steiner and Grillmair (1973) The correlation of other reversal periods can be established if we know the periods of interaction of the Sun's galactic orbit with spiral density waves These periodicities according to McCrea (1981) should vary between 30 to 90 million years Near correspondence of other periods are discussed in Negi and Tiwari (1983) These 99 percent significant level periods of geomagnetic reversals and the Sun's dominant motions have important implications Obviously, terrestrial observations reflect the variation of the ancient Sun's galacltic motions if these geomagnetic reversal periods stability (GMR) is examined

3 Stability of 34 Million Year Period

The time elapsed between successive crossings of the galactic plane according to Stothers (1985) is given by

$$P = \left(\frac{\pi}{4G\rho_0}\right)^{\frac{1}{2}}$$

where ρ_0 is the local mass density in the galactic plane and G is the universal gravitational constant Astronomers can measure the period by observations of relative motions of star near our solar system I examined the stability of 34 million year GMR periodicity to gain an insight into the variability of periods of vertical oscillations of the solar system in the milky way galaxy during last 570 million years, Table 1 shows clearly that these periods have remained remarkably stable between (34 5 ± 1 5) million years The The correlation suggests remarkable stability of the Sun's vertical motion in the galaxy

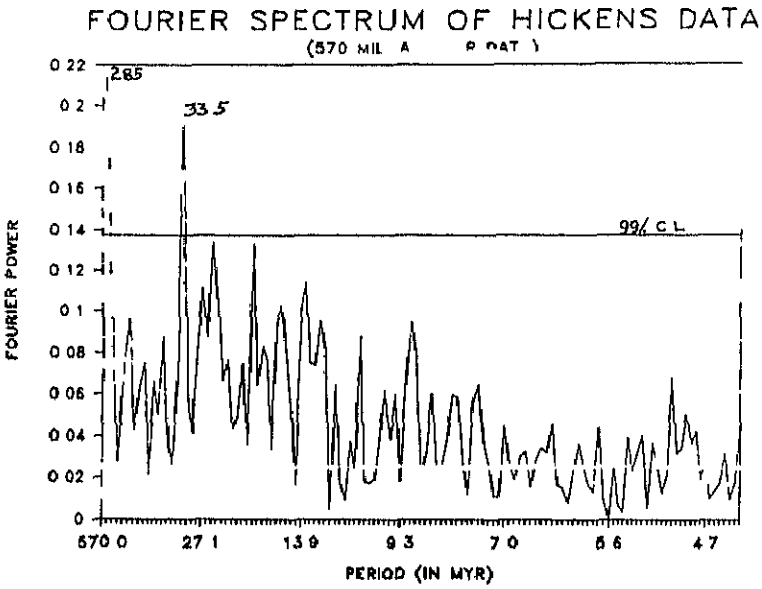

Fig.2. Fourier power spectrum of 570 million year geomagnetic reversal record (Source Hicken et al, 1972)

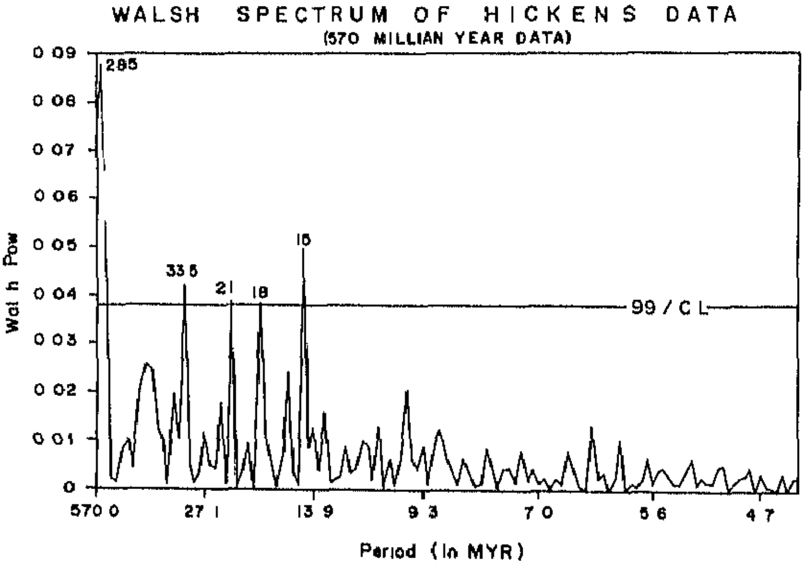

Fig.3 Walsh power spectrum of 570 million year geomagnetic reversal record (Source Hicken's et al, 1972)

Table 1

Variation of 34 my periodicity during past 570 million years
(Data Hicken s et al 1972)

Time Record		Period
(First half)	0 285 M Y	34 5
(Second half)	285 570 M Y	33 9
(Total Record)	0 570 M Y	33 5
	(0 400 M Y)	35 1
	(0 360 M Y)	35 6
	(0 240 M Y)	35 8
	(0 160 M Y)	33 0

Paleomagnetic data used here is quite insufficient to study, the stability/invariability of cosmic year term Stothers (1985a) analysis of reversal events for the period 20 165 million years also reflects a spectral peak of 33 million year period It is a remarkable match between analysis of reversal events and polarity bias data The solar flare and cosmic ray data in future might throw further light on the conclusion about the invariance of the period of vertical oscillations of the ancient Sun

4 Possible Mechanism for 34 Million Year Term

It is not difficult to envisage a scenario (Figure 4) in which the Sun s cometary cloud configurations in vertical oscillations are disturbed when the Sun's is immersed in the turbulent high star density galactic plane Gravitational encounters between the Solar system and interstellar clouds can periodically disturb the outer system of comets (estimated number = 10^{11} comets) Few of these disturbed comet orbits can periodically hit the earth The periodic component of heightened cometary orbit disturbances will come from the harmonic oscillation of the Sun (Stothers, 1985) in the galaxy As explained in the simplified diagram (Figure 5) these cometary impacts when of diameter larger than 10 km and disturb the fluid motions in the core and hence cause fluctuations in geomagnetic field They would also cause changes in sea floor spreading, tectonic activity, relative sea level changes, volcanic activities and biological mass extinctions A study of several geological rhythms matching with this expectation is given by Rampino and Stothers (1984) in Table 2 below

Table 2

Periods (in million years) corresponding to the highest peaks in the spectral analysis of five phanerozoic time series (based on Rampino and Stothers, Science 226, 1427 1431, 1984)

Impact craters (N = 65)	Tectonic episodes (N = 18)	Carbonite intrusions (N = 28)	Kimberlite intrusions (N = 38)	Geomagnetic reversals (Negi and Tiwari, 1983)
12	12	13	12	12
16	16	16	16	16
20	20	23 ± 4	23	21
32 ± 1	33 ± 3	34 ± 5	35 ± 1	33 ± 1
49	44	50 ± 3	56	47
61	61		68	63
70	81	74		
90		90	(138)	114
260	270	235	280	285

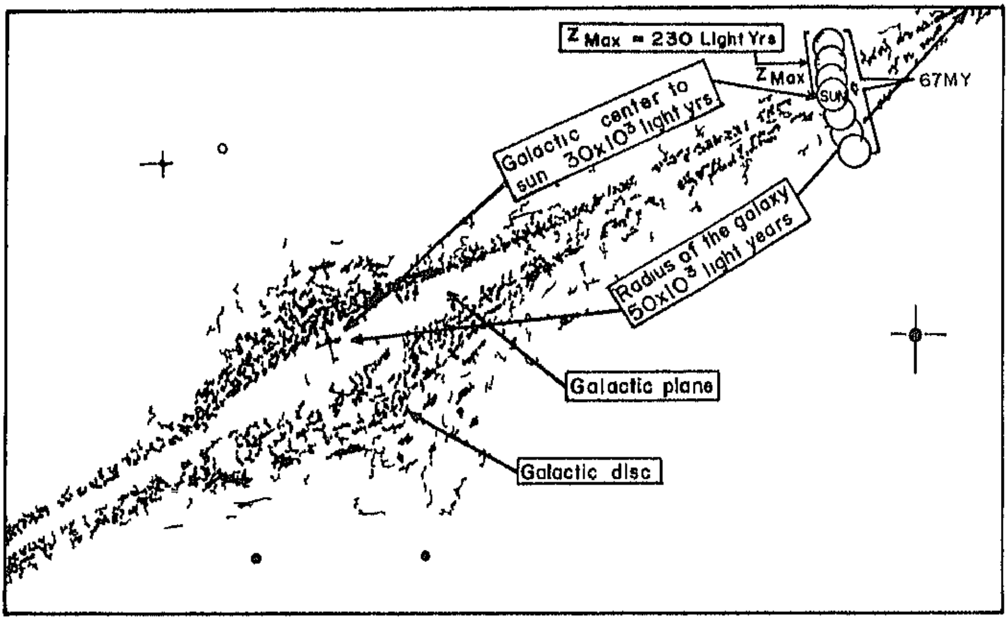

Fig.4. Side view of our galaxy and vertical (perpendicular to galactic plane) oscillations of the solar system

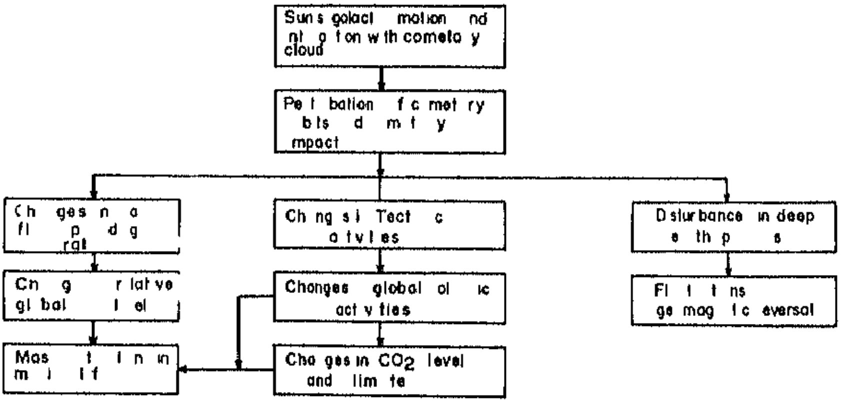

Fig.5 A simplified diagram showing the relationship of global catastrophism with Sun's motion in the galaxy

5 Conclusion

The earth is a dancing partner of the Sun in our galaxy. Large number of terrestrial catastrophies are occurring with regular intervals. The characteristic time scales point towards extraterrestrial forcing of these phenomena. The interrelated phenomenon are discussed in Negi (1987). Next phase of research activity will require an extension of the correlation to study variability of the ancient Sun's other galactic motions. The stability of geomagnetic reversal periodicity of (34.5 ± 1.5) million years points towards an intriguing possibility of stability of solar system galacto vertical motions during last two cosmic years.

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