LETTERS TO NATURE

PHYSICAL SCIENCES

Sunspots and Planetary Orbits

THE possibility of a relationship between the periods of the sunspot cycle and the periods of the rotation of the planets has been investigated by several authors[1-5]. Such an interaction could be mediated by non-linear processes of gravitational wave conversion of the type which may, for example, be responsible for the acceleration of the equator of the Sun[6,7]. On the face of things, the most likely relationship should be that between the sunspot cycle and the period of rotation of Jupiter, gravitationally the dominant planet, but non-linear may imply that cross modulation products representing the combined effects of two or more planets may be the most easily recognizable.

What follows is a successful correlation between the harmonic periods of the sunspot cycle as revealed by Anderson's single and double period analysis of the sunspot cycle and the cross modulation products of the sidereal periods of the four largest planets, Jupiter, Saturn, Uranus and Neptune. The reciprocals of the cross modulation frequencies (in years) are shown in Table 1.

Table 1. COMPARISON OF SUNSPOT CYCLE AND PLANETARY ORBIT ANALYSIS

Planets	Frequency (days^{-1})	Periods (yr)		338 Year fundamental	Anderson's sunspot cycle analysis (yr)		
		Upper side-bands	Lower side-bands	Harmonic No.	Single period	Double period	Relative amplitude
J + S	0·000323753	8·46		40	None		
J − S	0·000137865		19·86	17	9·95	19·9	13
J + S + U	0·000356342	7·68		44	None		
J + S − U	0·000291164	9·40		36	None		
J − S + U	0·000170454		16·06	21	8·05	16·1	13
J − S − U	0·000105276		26·01	13	13·00	26·0	11
J + S + N	0·000340367	8·04		42	8·05	16·1	13
J + S − N	0·000307139	8·91		38	8·90	17·75	26
J − S + N	0·000154479		17·72	19	8·90	17·75	26
J − S − N	0·000121251		22·58	15	11·26	22·5	70
J + S + U + N	0·000372956	7·34		46	7·35	14·7	3
J + S + U − N	0·000339728	8·06		42	8·05	16·1	13
J + S − U + N	0·000307778	8·90		38	8·90	17·75	26
J + S − U − N	0·000274549	9·97		34	9·95	19·9	13
J − S + U + N	0·000187068		14·64	23	7·35	14·7	3
J − S + U − N	0·000153840		17·80	19	8·90	17·75	26
J − S − U + N	0·000121890		22·46	15	11·26	22·5	70
J − S − U − N	0·000088662		30·88	11	15·36	30·75	10

The upper sideband values match components of Anderson's single period sunspot analysis, and the lower sidebands match double period components. These modulation products were calculated and grouped together as upper and lower sidebands of the orbital period of Jupiter:

Planet		(Sidereal period)$^{-1}$
Jupiter (J)		0·00023080895 days^{-1}
Saturn (S)		0·00009294371 days^{-1}
Uranus (U)		0·00003258899 days^{-1}
Neptune (N)		0·00001661419 days^{-1}
J − S − U + N	=	0·00012189044 days^{-1}
	=	22·46 yr

Periods from the Explanatory Supplement, 1961 Ephemeris (Great Britain).

Six of seven of the highest amplitude sunspot harmonic components match these sideband periods. There seems to be a definite relationship between the orbital periods of the planets and the periodic nature of the sunspot cycle, and the relationship depends on a non-linearity in the solar energy conversion system.

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R. A. BUREAU
L. B. CRAINE

Electrical Engineering Section,
College of Engineering,
Washington State University,
Pullman, Washington 99163.

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Mid-latitude Atmospheric Emission of N_2^+ First Negative Bands

THE first negative bands of N_2^+ are excited in the atmosphere by energetic particle precipitation. The cross section data of Srivastava and Mirza[1] imply an associated N_2^+ ion production rate of 14·1 ion pairs per photon in the 0–0 band or 41·5 ion pairs per photon in the 0–1 band. The total ion production rate for all species may be a few times greater and depends on the relative concentration of N_2, a function of the height at which the ionizing radiation is stopped.

Intensities of several Rayleighs for the 0–0 band at 3914 Å have been reported in middle latitudes by Yano[2] and others. The associated total ionization rates of order 10^8 (cm^2 column)$^{-1}$ s^{-1} could be important in the maintenance of the night time ionosphere. Broadfoot and Hunten[3], on the other hand, placed an upper limit of 1 R on the 0–0 band.

Photometric measurements on the 0–1 band at 4278 Å have been made at Adelaide since August 1969. The photometer, with a field of view of 2·5° semi-angle, uses a 3 inch diameter, 8 Å bandwidth interference filter which is periodically tilted to scan through the 4278 Å band head. The output from the photomultiplier is fed to a signal averager. Using total scanning times of 30 min to 60 min (giving detection sensitivities of 0·05 to 0·1 R) observations through more than 10 moonless nights of low geomagnetic activity ($Kp \leq 3$) have revealed that intensities of up to 0·1 may be present during some periods.

We conclude that the night time intensity of the 0–1 band does not usually exceed 0·1 R, implying a maximum total ionization rate of order 10^7 (cm^2 column)$^{-1}$ s^{-1}. Compared with the loss rate of ions through dissociative recombination in the F region this rate is small and cannot