branches of physics the assertion proposed here about the most general form of a physical theory that is based on a symmetry principle.

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Explanation of Apparent Diurnal Variation in Caesium Clock Rates

SIGNIFICANT diurnal variations in the time-keeping of two caesium beam clocks have recently been reported[1]. In view of the authors' final statement " . . . we believe we are observing a new phenomenon . . . ", we feel that it is pertinent to make the following observations.

The rates of the two clocks were compared by timing the arrival of "ticks" transmitted on a 100 kHz carrier. The path length was about 550 km. An apparent decrease in the frequency of the remote clock relative to the local standard of approximately one part in 10^{11} was observed in the hour following sunrise. The authors emphasize that the low frequency carrier propagates as a ground wave and that their instrumentation was such that signals arriving by way of the longer ionospheric path would be ignored. They also correctly point out that if sky-wave propagation were involved, an apparent increase in frequency would occur at sunrise as the ionosphere descends. The authors further argue that a ground wave propagation phenomenon is not involved, because the diurnal variation takes place irrespective of near-ground atmospheric conditions along the transmission path. This deduction implies some lack of understanding of the behaviour of the low frequency ground wave.

The ground wave is a surface wave, bound to, and guided by, the ground–air interface. At low frequencies, however, the wave is relatively loosely bound to the surface, and the field strength decays only slowly with altitude. Assuming some typical values for the electrical properties of the ground ($\varepsilon_r = 15$, $\sigma = 10^{-2}\ \Omega^{-1}\ m^{-1}$) the vertical decay coefficient is of the order of $3 \times 10^{-5}\ m^{-1}$, which means that at a height of 80 km the propagating energy density is as large as 1 per cent of its ground level value. By contrast, the skin depth in the ground is only about 15 m. In these conditions the establishment, during the daytime, of the ionospheric D and E regions would give rise to a hybrid mode of propagation—predominantly surface wave, but with a component guided by the ground-ionosphere cavity. The effect on the propagating low frequency wave would be slightly to increase its phase velocity, but to reduce its group velocity, causing an apparent slowing of the remote clock during the establishment of the D and E regions at sunrise, and an apparent increase in rate at dusk as these layers decay. The rates of change of electrical path length would be of similar form to the observed variation, and it is felt that the mechanism described is adequate to explain the phenomenon.

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Tritium Production from Nitrogen in Fission Reactors

TRITIUM is produced in various types of nuclear reactors. It is formed in abundance in heavy water reactors by the (n,γ) reaction on deuterium ($^{2}_{1}H$); much smaller quantities are produced in light water reactors, but there should be a marked increase in the amount of tritium produced in reactors as pressurized power plants become more numerous.

Theory cannot at present account for all the tritium produced in nuclear reactors. One reason may be that reactor water circulating in contact with overlying air is saturated with nitrogen, which should react with fast neutrons when close to the core. High pressure nitrogen gas may also serve as a primary heat exchanger in certain nuclear reactors, which would give another unexpected source of tritium. These possibilities prompted us to carry out this study.

An (n,T) reaction on $^{14}_{7}N$ with triton emission to only the ground state of $^{12}_{6}C$ is energetically possible with fast neutrons[1]. This was observed at neutron energies of more than 5·6 MeV, which is within the range of "fission" of neutrons, the cut-off energy of which is usually taken as 10 MeV. The cross-section for triton emission with neutrons above 7 MeV was approximately 40 mb.

Table 1. ACTIVATION SAMPLES

Sample No.	Vol. of NH_4NO_3 sol.	Irradiation time	c.p.m./unit vol. (20 min/count)	Σ	$\bar{n}$	σ
1	1·0 ml.	8·00 h	11,124·65			
			11,508·16			
			11,388·33	34,021·14	11,340·38	106·49
2	1·0 ml.	8·00 h	11,515·25			
			11,529·48			
			11,445·00	34,489·73	11,496·58	107·22
3	1·0 ml.	16·00 h	20,335·61			
			20,565·03			
			21,156·00	62,056·64	20,685·55	143·82
4	1·0 ml.	16·00 h	18,340·00			
			18,092·36			
			18,422·97	54,855·33	18,285·11	135·22
5	1·0 ml.	20·00 h	27,577·05			
			27,989·03			
			27,718·52	83,248·60	27,761·53	166·62
6	1·0 ml.	20·00 h	29,396·25			
			29,743·17			
			29,243·12	88,382·54	29,480·85	171·64
7	0·5 ml.	49·15 h	57,193·00			
			57,494·40			
			59,197·80	347,770·40	115,923·47	340·48
8	0·5 ml.	76·80 h	115,548·00			
			115,235·70			
			115,609·40	692,786·20	230,928·73	480·55
9	0·5 ml.	118·10 h	124,634·10			
			122,575·20			
			126,664·20	747,747·00	249,249·00	499·25
10	0·5 ml.	144·35 h	177,695·60			
			177,818·60			
			177,136·30	1,065,301·00	355,100·33	595·90

Samples of saturated aqueous ammonium nitrate (NH_4NO_3) solution were sealed in polyethylene or quartz vials and irradiated by neutrons at the face of the Texas A and M University (TAMU) MTR type reactor core. Irradiation time depended on the vial type, for polyethylene ruptures after about 20 h of neutron exposure at a power level of 100 kW.

Ten samples were irradiated for periods between 8 and 144·35 h. The first three samples were prepared in duplicate (a total of six), and were loaded into small ($\approx$3 ml.) plastic vials. The last four samples were placed in high-purity quartz vials because of their lack of undesirable impurities (impurities that might be activated).

Following irradiation, the contents of each vial were washed into a counting vial with scintillant (dioxane based, with naphthalene and 2,5-diphenyloxazole as fluors). Gamma-ray spectrometry revealed gamma activity in each sample, caused by neutron activation of trace