We hope that with further improvement and research in the new approach presented in this paper, the IMS algorithm will prove to be a better alternative than BP for the most predominant class of networks called Boolean neural networks.

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ACKNOWLEDGEMENT. N. N. Biswas thanks CSIR, New Delhi, for a grant supporting this research.

9 May 1990; revised 12 June 1990

RESEARCH COMMUNICATIONS

On the anomalous weight reduction in rotating gyroscopes

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A recent claim of an anomalous weight reduction in rotating gyroscopes is tested. The 2σ upper limit on any such effect is shown to be at least a factor of 60 lower than that claimed earlier. The present results are consistent with a null effect. Also, it is shown that weight change which could depend on the magnitude of spin of the gyroscope is constrained to 2 parts in 10^6.

THE recent claim[1] of the reduction in weight of a gyroscope rotating with its spin vector pointing downwards with respect to the local vertical (right rotation) has stirred up some interest as also criticisms and possible explanations[2]. The fractional weight reduction observed by Hayasaka and Takeuchi[1] is about 5×10^{-5} at a rotation rate of about 12,000 rpm, and they characterize the weight reduction with the expression,

$$\Delta W_R(\omega) = -2\times10^{-5}\, M r_{\mathrm{eq}}\, \omega \ \mathrm{g\,cm\,s^{-2}},$$

where M is the mass of the rotor, ω the angular frequency in rad/sec and r_{eq} the equivalent radius for the rotor.

Quite understandably, there could be various objections to this result from the conventional physics quarters. As Hayasaka and Takeuchi state, their experimental results cannot be explained by the usual theories of physics. (Objections from an engineer's point of view are of a different nature[2].) Considering the effort which had gone into the original experiment, and the importance of a possible anomalous effect, it seemed worthwhile to repeat the experiment to look for a possible weight reduction.

Here I describe an experiment done to check the claim of Hayasaka and Takeuchi. The experiment consists of measuring the weight of a commercial gyroscope (Smith Industries Ltd, UK) using two semi-micro, single pan electronic balances. A schematic diagram of the experimental set-up is shown in Figure 1. The weighing capacity of a standard semi-micro balance is less than 200 g, with a resolution of 100 μg. The weight of the gyro assembly, being around 300 g, needed to be nulled partially to be able to perform the experiment with the maximum accuracy. The difficulty in setting up a drift-free nulling scheme (with stability comparable to that of the balance itself) led to a two-balance set-up with a light weight gyro holder made of aluminium bridging the two balance pans. This bridge is a tripod, weighing 25 g and it rests freely on the balances with one of its legs on one pan and the other two on the second pan. The gyroscope is a sealed unit with a maximum rotation rate of 24,000 rpm (angular momentum $= 1.75\times10^5$ g cm^2/s)

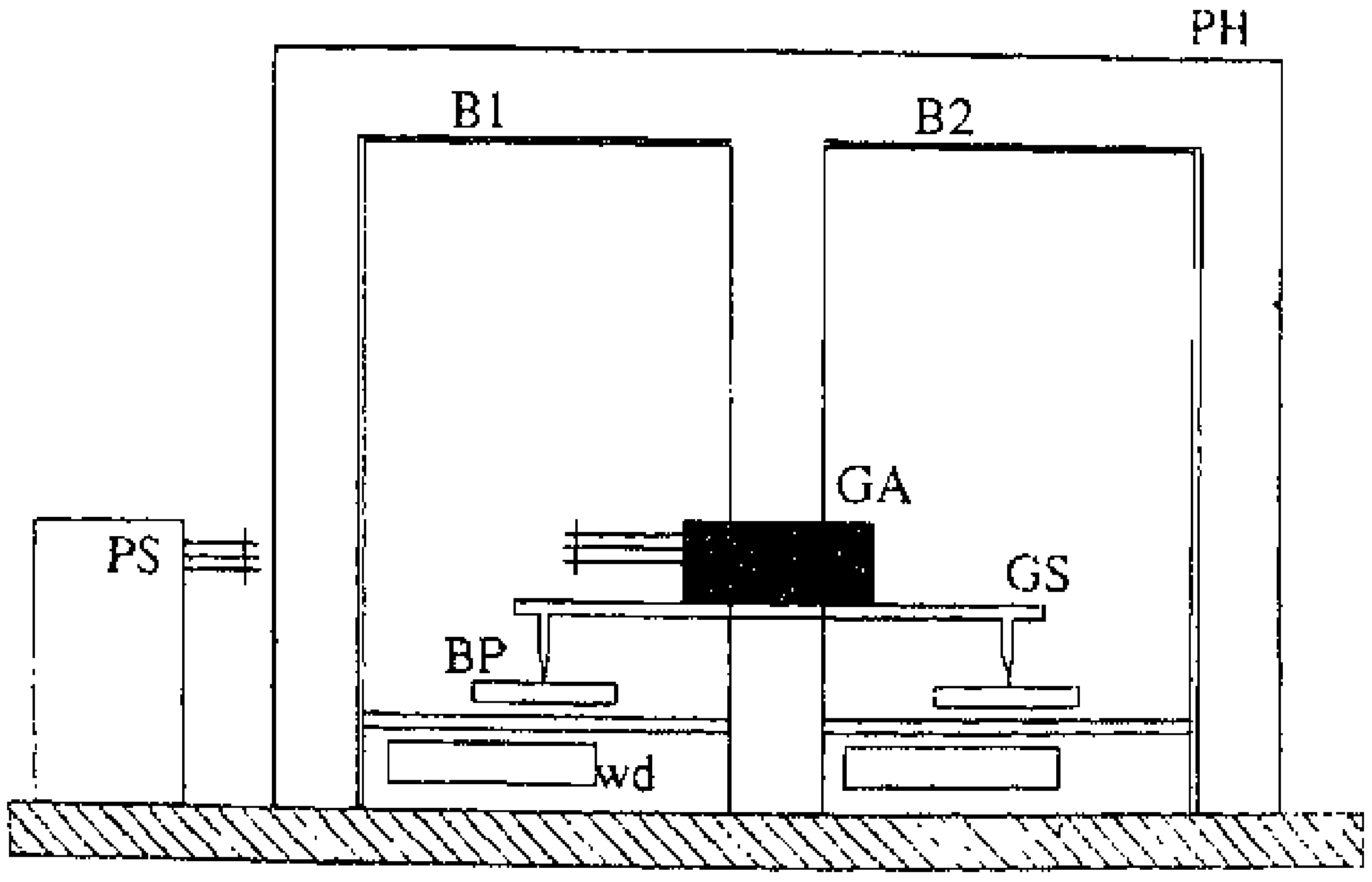

Figure 1. Schematic diagram showing the experimental set up. GA, gyroscope assembly; B1, B2, Balance 1 and balance 2; GS, gyroscope support (tripod); BP, balance pan; PS, power supply; PH, perspex hood; wd, weight display.

and once disconnected from the power line takes about 140 sec to slow down to rest. This spin-down generates a reaction torque that gets transmitted to the external supports and a long lever arm, with almost symmetric loading, in the two-balance configuration helps to reduce such forces on the balance pans. The existence of the reaction torque also means that one has to take special care to align the spin axis of the gyro parallel to the local gravity field so that these forces are minimized to avoid large fluctuations in the weight readings on the balance display. At the interface of the two balances, where the draft covers are open to allow the gyroscope assembly to be placed on the two pans, polythene sealing was provided to guard against air currents. Also, a perspex hood with one sliding door was used to cover the two balances.

In a typical run of the main experiment, the power supply is kept connected to the gyroscope for about 30 sec during which the rotor of the gyro attains a rotation speed of 24,000 rpm. Then the power supply is switched off and the wires disconnected, after starting a stop watch, and the balance draft covers and the door of the perspex hood are closed. These operations and the subsequent stabilization of the balance displays take less than 20 sec. Weight readings are taken from both balances for the next 120 sec, during which the gyro rotor decelerates from 16,000 rpm to rest. The spin-down curve of the gyroscope, i.e. the angular frequency of the rotor as a function of time, was determined in a preliminary experiment, by measuring the frequency of the induced back emf on the power supply terminals due to the residual magnetic field of the rotor. (The error in determining the frequency of rotation from this spin-down curve is about 5%.) Each of the data sets consisting of gyro weight (the sum of the readings from the two balances) and the gyro rotation rate is fitted to a straight line. The average of the slopes of the fit from several runs (about 50 each for right rotation and left rotation) gives the weight change as a function of the angular frequency of the gyroscope.

Systematic errors expected *a priori* in this experiment were mainly from three sources, viz. i) temperature changes of the air surrounding the gyro assembly giving rise to changes in buoyancy, ii) a magnetic dipole moment associated with the rotor interacting with the ambient magnetic field and its gradients and, iii) reaction torques from the decelerating rotor acting on the balance pans in some systematic way. The error source (i) is proportional to the change in air temperature and since the measured temperature change during one run of the experiment was less than 0.3°C, the weight change due to buoyancy change was estimated to be $< 100\ \mu g$. Magnetic fields were shown to be unimportant in the present experiment by applying an additional magnetic field of strength 1.5 G (~ 4 times the ambient field) and a gradient of about 0.02 G/cm in the vertical direction and 0.05 G/cm in the horizontal directions. These runs did not show any weight change as the gyroscope slowed down, to within the resolution of the balances. The reaction torque, on the other hand, was found to be troublesome, since it gives rise to large and rapid changes in individual balance readings and the sum of the readings are susceptible to large fluctuations exceeding the effect looked for. However, when the spin vector of the gyroscope is carefully aligned along the vertical direction, using a plumb line, these fluctuations are at the level of the resolution of the balance; once this is achieved, several runs are performed continuously without taking out the gyroscope from inside the balance.

The minimum weight change expected, using the expression given by Hayasaka and Takeuchi, is approximately $2000\ \mu g$ as the gyro decelerates from 16,000 rpm to rest. (It is difficult to estimate correctly the effective radius of the sealed rotor unit. This minimum value for the weight change is estimated by first obtaining the value of Mr_{eq}^2 from the known value of angular momentum at 24,000 rpm and then, using the maximum possible radius of the rotor inside the gyro housing, calculating the value of $Mr_{\mathrm{eq}}w$ at 16,000 rpm. Mr_{eq}^2 is about 70 cgs units and the maximum possible value for the radius is 12 mm. A more realistic value for the weight change would be about $2600\ \mu g$.) In contrast to this, the average weight change observed (up to 16,000 rpm) in 72 runs for right rotation is $7 \pm 20\ \mu g$, consistent with no change in weight. (A positive sign for the change in weight corresponds to an increased weight at larger rotation rates.) The 2σ upper limit on weight reduction of the rotating gyroscope for right rotation (the spin direction for which Hayasaka and Takeuchi found a large weight reduction) is $33\ \mu g$, about a factor of 60 smaller than expected[3]. The experiment was repeated with the gyroscope rotated through 180°, so that the spin vector points upwards (left rotation). Average of 50 runs yielded the value $-84 \pm 21\ \mu g$ for the weight change in left rotation. Combining data for left rotation and right rotation constrains any weight change which depends on the magnitude of spin to $45 \pm 15\ \mu g$. The 2σ upper limit in this situation corresponds to a fractional weight change of less than 0.2×10^{-5}. The nonzero, though small, change in weight for left rotation is not taken as indication for any fundamental effect, since the possibility of systematic errors amounting to $100\ \mu g$ (mainly due to heating up of the air surrounding the gyroscope) is expected in this experiment.

When the spin direction of the gyroscope is misaligned to the extent of being horizontal (in a plane parallel to the plane of the balance pans), large increase and decrease in individual balance readings due to the reaction torque, larger in magnitude than the expected weight change, are seen. This might provide a clue to understanding the results obtained by Hayasaka and Takeuchi, though it is clear that it is difficult to explain their result in a simple model[2].

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ACKNOWLEDGEMENTS. I thank Prof. R. Cowsik for suggesting the two-balance scheme and for encouragement, and Prof. S. N. Tandon for many useful discussions and for lending me the gyroscope and power supply. Thanks are due to C. V. Tomy, Sandeep Modi, Prasenjit Guptasarma and Dr S. Ramakrishnan for lending equipment. I thank Prof. R. Vijayaraghavan and Prof. S. Mitra for providing the balances.

22 March 1990; revised 4 May 1990

Relationship between infant size and carrying of infants by hipposiderid mother bats

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The newborn individuals of a cave-dwelling insectivorous bat *Hipposideros speoris* are hairless, sightless and flightless. A study was undertaken on the details of how these are nursed under natural conditions. The mothers carry their infants of early stages along with them while leaving the cave for foraging after sunset. A few young ones are left behind while their mothers leave for foraging. More and more infants are left behind when they become larger in size and volant (able to fly). Interestingly a few volant young ones are still carried to the foraging area at the cost of increasing the wing loading of mothers. This process may be beneficial to the volant young in learning the topography at the foraging areas, prey detection and capture by using their echolocating system.

ONE of the fascinating areas in the behavioural repertoire of bats is the relationship between mother and infant. There are several reports on this component describing the lavishness of meticulous care showered by mothers on their infants[1]. In the earlier stages of life young ones attach themselves tenaciously to the body of the mothers and are even carried on foraging flights. At the later (volant) stages most of the females prefer to leave their young in the day roosts (caves, temples, etc.) while foraging[2]. However a few mothers continue to carry their volant young for foraging even though it causes an increase in wing loading (body wt/wing area) and needs more energy[3]. The present study deals with the mother–young relations in a cave-dwelling insectivorous bat *Hipposideros speoris* and explains how the mother bats carry even their volant young to the foraging areas in order to acquaint them with the topography and foraging strategies.

The study site is a natural cave situated on the Samanar Hill complex near the village Keela Kuyil Kudi about 8 km south-east of the Madurai Kamaraj University. A colony of about 500 individuals of *H. speoris* of both sexes inhabit this cave. Observations were made from August to December 1989.

At intervals of 3–4 days, we entered the cave past-midnight hours and counted the number of young bats of mixed ages and sex left behind by their mothers in the several pockets of the cave. Their right-hand forearm length, which is a good measure of size, was measured by using vernier calipers. The home-flying bats were trapped at the entrance of the cave during the pre-dawn hours (03.00–06.00 h) using a mosquito nylon net. The young bats clinging to the body of the returning mothers were also measured. A test was done to find out the relationship between the size of the young ones and their being carried or left inside the cave by the mothers.

During the early part of August the majority of the females were in an advanced stage of pregnancy. Parturition occurred till the end of December and the maximum number of infant bats was recorded during September and October. The newborn babies were altricial-naked body with eyes and ears closed. Figure 1 depicts the pattern of mothers i) carrying their young and ii) leaving them behind as a function of the size of the young ones. The two distributions differ significantly (Kolmogrov Smirnov test, $P = 0.05$) and thus more young ones are left inside the cave as they become

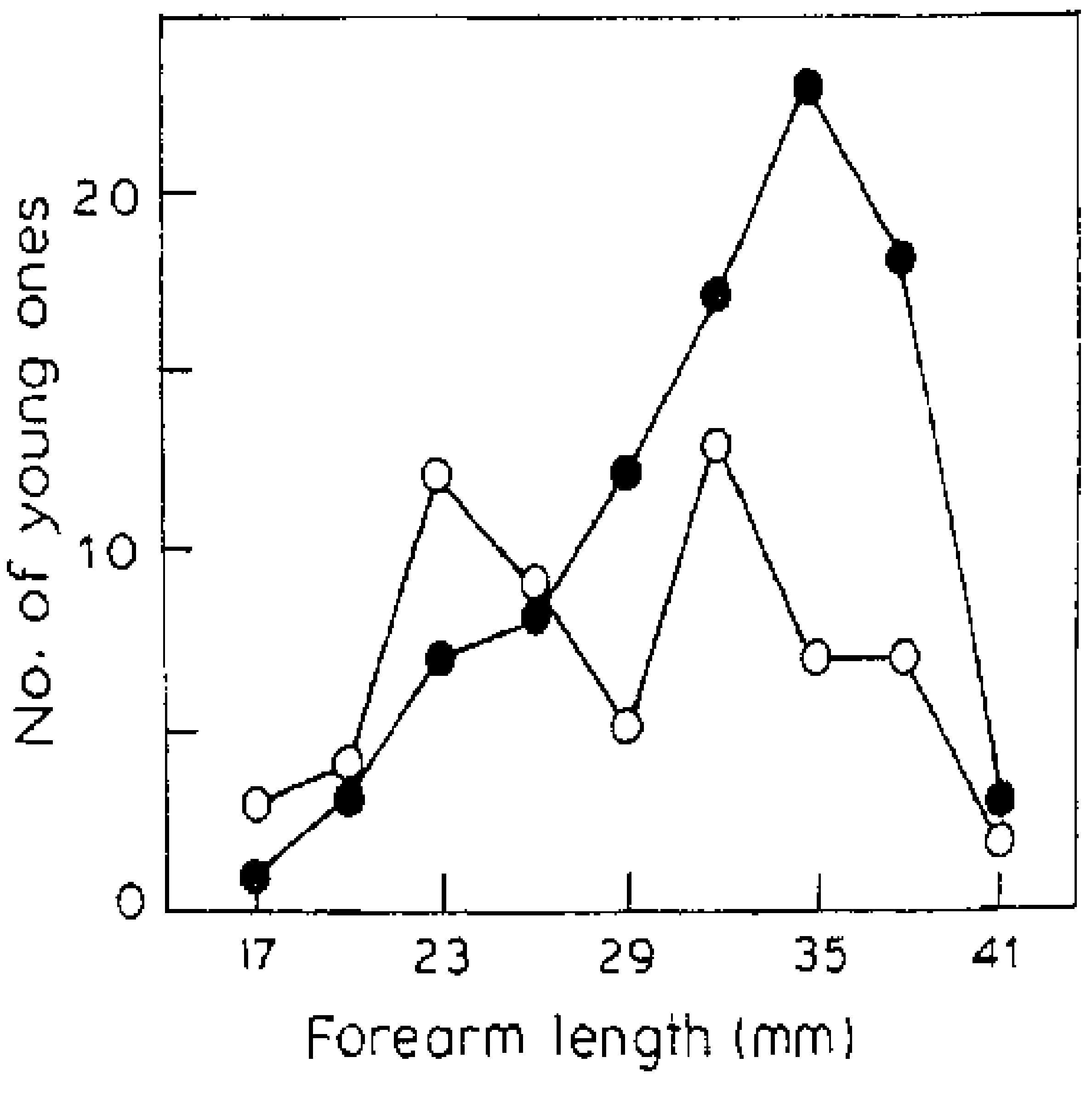

Figure 1. The pattern of mother bats carrying their young (hollow circles) or leaving them behind at the cave (solid circles) as a function of the size of the young ones.