would also have disappeared. Crawford also predicts a redshift of the solar lines at the solar limb of 911 m s^{-1} in addition to the 636 m s^{-1} Einstein gravitational redshift (1.547 km s^{-1} in total). But observations at the solar limb give a value close (within ~50 m s^{-1}) to the gravitational redshift leaving an order of magnitude disagreement with the Crawford theory.

There is in our view no justification of Crawford's theory in terms of the observations of the solar limb effect. A major part, and possibly all, of the solar limb effect can be explained by simple physical processes in the solar atmosphere involving convective, wave and pressure shifts without taking recourse to any of the many exotic theories proposed. Observational and theoretical studies of the solar limb effect, from the point of view of solar atmospheric dynamics are obviously most important in setting limits to the magnitude of the effect predicted by theories of photon decay.

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The problem of thrown string

OUR attention has been drawn to the problem of the thrown string[1,2] by Bass and Bracken[3], who related the probability density of the distance between the ends of the string when in space to the volume of the ellipsoid in which the string must be contained. We[4] have already suggested a modification to this theory in an attempt to explain the experimental results of Synge[2]. However, we have recently reconsidered the problem.

We felt that in order to test the validity of the different possible models, an experimental distribution was required based on a large set of observations. The problem of generating the necessary data was solved by posing the problem of the thrown string to our first year engineering students as an exercise in data collection, descriptive statistics and fitting models to data. Each student had to obtain observations for at least a hundred throws of the string. The students were divided into two groups, one used a rather 'springy' red plastic, waxed, string, the other a flexible white cotton string of the same physical dimensions. All the strings were 54 cm long. The pooled data for each group is given separately in Table 1 and the corresponding histograms are shown in Fig. 1.

Table 1 Frequency distributions for $\lambda = D/L$

Interval	Frequency 'springy' string	Frequency flexible string
0.0–0.1	344	379
0.1–0.2	641	763
0.2–0.3	739	884
0.3–0.4	662	654
0.4–0.5	485	428
0.5–0.6	481	284
0.6–0.7	391	199
0.7–0.8	427	131
0.8–0.9	450	119
0.9–1.0	400	49
Total	5,020	3,890

The density function proposed by Bass and Bracken is shown in Fig. 1. This shows that the model does not give a realistic description of the physical situation.

Observing the thrown string lying on the table it seemed that the steady motion of a point moving along the string from one end towards the other would be some sort of continuous two-dimensional random walk. The problem is then not unlike that studied by Broadbent and Kendall[5] concerning the wanderings of the larvae of the helminth *Trichostrongylus retortaeformis*. They assumed that the orthogonal X and Y components of position were independent random functions of time with zero mean and equal variance. X and Y were then assumed to be Wiener processes. This was not reasonable because it implies that the velocities in the x and y directions would be white noise. Perhaps it would have been more reasonable to have assumed that X and Y were the outputs of identical third order lagging systems excited by separate independent white noises. However, provided the systems were linear, this would not affect the result that after a given time X and Y would have independent normal distributions with zero mean and equal variance.

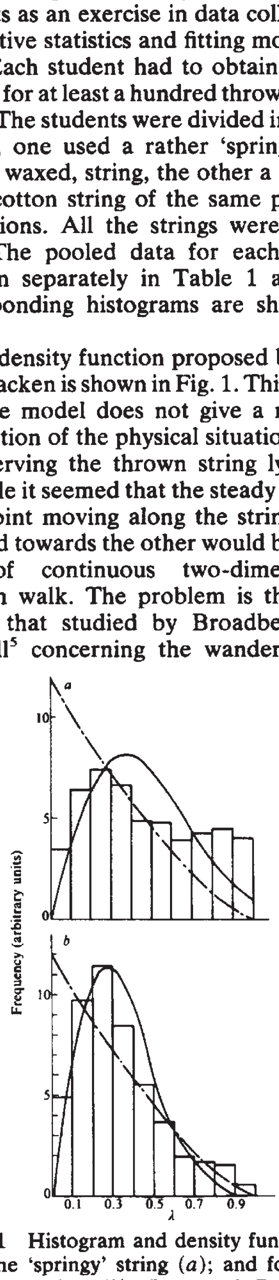

Fig. 1 Histogram and density functions for the 'springy' string (a); and for the flexible string (b). Bass and Bracken model (dashed line); Random walk model (solid line).

By analogy, our new hypothesis for the thrown string is that the distance D between the two ends will have probability density

$$f(D) = \frac{D}{\omega L^2} \exp\left(-\frac{D^2}{2\omega L^2}\right)$$

where L is the length of the string and ω is a constant dependent on the nature of the string and the experimental conditions. A similar result was reported by Kingman[6] using a slightly different model.

This density function is compared with the experimental results in Fig. 1 which shows that the proposed model reflects the general nature of the results reasonably well. The discrepancies between the theory and the experiment seem to be due to the lack of ability of the model to describe the upper tail of the distribution. We feel that the large frequencies at the upper tail are primarily a consequence of the impact of the string with the table resulting in a straightening out of the string; the effect is most noticeable in the 'springy' string.

We conclude first that the Bass and Bracken[3] and our previous[4] theories are false in that they are not borne out by experimental results. Second, a good approximation to the distribution is apparently given by the random walk model described above provided the string is not springy. The degree of flexibility of the string may be allowed for by suitable choice of the one parameter in this distribution. More experiments with different non-springy flexible strings are required to verify this second conclusion.

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