ing the spectrum. A reactor with a nonthermal spectrum would be advantageous.

Schroeder *et al.* remarked that lead is not readily measurable by activation analysis and hence they were not able to test its presence in the old printed matter they analyzed. Silver is a common impurity in commercial lead even today. Perhaps the silver content of old lead objects could provide a clue in correlation with the appearance of silver in printed matter.

J. H. MANLEY
Los Alamos Scientific Laboratory, Los Alamos, New Mexico 87544
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Statistical Analysis in Toxicity Experiments

Three points should be made about Lindsay and Kullman's "Pentobarbital sodium: variation in toxicity" [*Science* **151**, 576 (1966)].

First, their statistical analysis gives no appreciable basis for the notion that dependence of toxicity upon hour of the day varies from experiment to experiment. Only one of eight tests reached the conventional 5-percent significance level. This should be expected by chance in 34 percent of such analyses, and in 14 percent of such analyses with the actual level reached, 0.019. Further, the comprehensive test of this interaction reaches only the probability of 0.092. If this slight observed tendency toward significant interaction needs explanation, one is readily available in that the arcsin transformation would not preserve the shape of the curve as dose (or sensitivity) changes.

Second, there is appreciable evidence that time of day has *some* effect, which is apparently roughly quadratic, with a maximum near the middle of the interval studied. (The "significant" term of seventh degree is subject to discussion parallel to that above.) Thus the concluding paragraph is misleading at best: no substantial evidence has been presented that the "full complexity of the toxicity curve" is more than that of the diurnal fluctuation which is familiar in many phenomena.

Third, it is a serious deficiency in the design of these experiments that "Two cages were taken in sequence for the experiment at each time period." Any observed effect might have been a consequence of differences between cages, and it cannot be argued logically that the effect is even partly ascribable to time of day, unless this possibility is taken into account in the statistical analysis and interpretation.

H. W. NORTON
Department of Animal Science, College of Agriculture, University of Illinois, Urbana
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Quasar Red Shifts: Can They Be Due to Implosion?

Halton Arp [*Science* **151**, 1214 (1966)] has given significant observational evidence for believing that at least some of the quasars are not as distant as has been generally supposed. If his evidence can properly be extrapolated to embrace all the quasars, their power output will no longer pose a formidable problem. But, as he points out, a new problem will arise because we shall no longer be able to attribute their very large red shifts to extreme distance.

As one possibility, he has suggested that the red shifts may be due to high collapse velocity of material toward the centers of the quasars regarded as very compact objects. It is the purpose of this note to mention two possible difficulties with this suggestion. The first is suggestive rather than compelling. It has to do with the size and longevity of the quasars. Fluctuations in brightness place an upper limit on the size of at least some of them. If their outer radiating matter is falling inward with radial speeds that are significant fractions of the speed of light, and if the these speeds are not ephemeral, then the quasars would have to have been much larger in the past. For example, 3C273 has been traced back to the year 1888, and it exhibits fluctuations in brightness, one period being of length 15 years and the smallest being of length of about a year. If we assume that the red shift corresponding to a recession velocity of approximately $0.15c$ has been substantially constant since 1888, and if we assume that the red shift is due to the implosion suggested by Arp, then 3C273 will have shrunk in diameter by about an order of magnitude, and one has to ask whether it is likely that the periodicity of the fluctuations in brightness would have been maintained during so great a shrinkage in size.

The second difficulty is more precise. Think of a quasar as an imploding sphere presenting a visual appearance of an imploding disk. The light from the center of the observed disk will indeed exhibit the full Doppler red shift, but light from other parts of the disk will exhibit smaller shifts, since the luminous matte remitting the light will be moving toward the center of the sphere and thus will not be moving away from us along the line of sight. Indeed, light from the edge of the disk will come from matter moving transversely to the line of sight and will exhibit at most only the small second order Doppler effect of $\frac{1}{2}v^2/c^2$ (plus such gravitational and Hubble shifts as may be present, but these, on the present hypothesis, are small compared with the observed shift). Consequently, there would be not a red *shift* but rather a red *smear*. The spectral lines would not be displaced while remaining relatively sharp but would be spread out, stretching from their gravitational-plus-Hubble-shifted positions. Photos of the shifted lines do not seem to exhibit such a broadening.

If there is merit in either of the foregoing points, it would seem that the red shifts of the quasars cannot be attributed to the implosion process tentatively put forward by Arp, and this leaves only his other alternative of an unknown process.

Arp does remark that fairly narrow spectral lines could result if only parts of the imploding shell were luminous at a given time, though he does not specifically link this to the foregoing Doppler-shift argument. Since, according to that argument, different parts of the shell should exhibit shifts ranging over a very broad interval, the existence of two localized luminous regions at different distances from the center of the disk would result in a doubling of the spectral lines, and this effect has not been reported.

The situation thus remains as puzzling as before, with only the location of the puzzle having changed. If we take the red shifts to be proof of extreme distance, we are confronted with the problem of their power output and also of their visual relation to the peculiar galaxies. If we accept Arp's results as evidence for the relative nearness of the quasars, we are confronted by the problem of the red shifts themselves.

BANESH HOFFMANN
Department of Mathematics Queens College, City University of New York, Flushing 11358
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