LETTERS TO THE EDITOR

ASTRONOMY

Are the Optical Luminosity Fluctuations of 3C 273 Random ?

WE have shown[1] that a light curve similar to that of the quasi-stellar source *3C* 273 can be generated by a superposition of unit light curves occurring at random times. Gudzenko, Ozernoy and Chertoprud[2] have argued (1) that the distribution of the observed luminosities should be expected to be Gaussian on our model, and (2) that the observed distribution is not Gaussian, so that the luminosity curve cannot be regarded as the superposition of random events. The purpose of this communication is to question the validity of both arguments and to show that the luminosity record may still be considered to be of random origin.

Regarding the first argument, the probability distribution of a shot noise process will not usually be Gaussian; only in the limit when the number of pulses per unit time approaches infinity is the probability distribution rigorously Gaussian[5]. In our model, the ratio of the number of pulses per unit time to their "time constant" is about 40, so that it is difficult to say to what extent the distribution on our model should be expected to be Gaussian. Furthermore, it should be noted that, if a random variable has a Gaussian distribution, a function of s usually does not. Specifically, $\log(s)$, or the astronomical magnitude of s, would not have a Gaussian probability distribution.

Regarding the second argument, if the observed luminosity is written as

$$\begin{aligned} I(t) &= x(t)\cos 2\pi f_0 t + y(t)\sin 2\pi f_0 t \\ &= \sqrt{x^2(t)+y^2(t)}\,(\cos 2\pi f_0 t + \tan^{-1} x(t)/y(t)) \\ &= R(t)\cos(2\pi f_0 t + \theta(t)) \end{aligned}$$

then, if $x(t)$ and $y(t)$ are independent Gaussian processes so that $I(t)$ is Gaussian, $R(t)$ is a Rayleigh distribution[3]. It was argued that the hypothesis of Rayleigh distribution for R calculated from the data may be rejected with 99 per cent confidence and hence that $I(t)$ is not Gaussian distributed.

For $R(t)$ to be Rayleigh distributed, it is crucial that $x(t)$ and $y(t)$ be Gaussian and independent. The $x(t)$ and $y(t)$ are calculated from the observational record by forming trigonometric sums the coefficients of which are weighted time averages of the observed $I(t)$. Demonstration of the independence of $x(t)$ and $y(t)$ requires that the time over which the averages are made is very large. In the case of *3C* 273, if the dominant frequency of about 0·10 yr^{-1} is taken for f_0, the total observation time is only about seven times the supposed periodicity and it seems questionable whether this can ensure the independence of $x(t)$ and $y(t)$.

Probably the most straightforward way of testing the Gaussian hypothesis is to apply the χ^2 test[4]. We have done this with both the actual luminosity curve and our simulation. In the case of the luminosity data, the original photometer data in magnitudes were converted to intensities. The samples used in the test must be independent, and so the luminosity curve samples must be separated by an interval of the order of the correlation time which for our simulation is about 1 year. Hence for 73 years of observations seventy-three samples were taken. The calculated ("observed") value of χ_ν^2, $\hat{\chi}_\nu^2$, and the probability that χ_ν^2 exceeds $\hat{\chi}_\nu^2$, $P(\chi^2 > \hat{\chi}_\nu^2)$, are shown in Table 1. We see that the Gaussian hypothesis for *3C* 273 may be accepted at a 7 per cent confidence level, which is about the same level as that for the simulation which was constructed by a random process. We conclude that the observed luminosity record may still be regarded as the result of a high density random process.

Table 1. APPLICATION OF THE χ_ν^2 TEST TO THE GAUSSIAN HYPOTHESIS

	ν (degrees of freedom)	$\hat{\chi}_\nu^2$	$P(\chi_\nu^2 > \hat{\chi}_\nu^2)$
3C 273	7	12·9	7 per cent
Simulation	7	14·0	5 per cent

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Stimulated Inverse Compton Scattering in Radio Sources

OSTER[1] has claimed that energy losses due to the inverse Compton effect can be considerably larger than was previously thought, when stimulated scattering is taken into account. If true, this would seriously hinder the understanding of compact radio sources. We wish to point out that Oster's discussion is erroneous and grossly exaggerates the importance of stimulated inverse Compton scattering.

We first consider the scattering of radiation by an electron at rest, neglecting recoil. The radiation field is described by $N(\varepsilon, \theta, \varphi)$ photons per unit volume, per unit energy interval, per unit solid angle, θ and φ being polar co-ordinates centred on the electron. We are neglecting recoil, and so the photon energy is not changed by scattering. The rate at which photons of energy ε incident from a small element of solid angle $d\Omega(\theta,\varphi)$ are scattered into an element $d\Omega'(\theta', \varphi')$ is given by

$$c\sigma(\chi)\, N(\varepsilon, \theta, \varphi)\,[1 + \frac{hc^3}{8\pi\varepsilon^2} N(\varepsilon, \theta', \varphi')]\, d\Omega d\Omega'$$

where χ is the angle between the directions of the incoming and outgoing photons, and $\sigma(\chi)$ is the differential cross-section. The second term in the brackets is the number of photons per unit volume of phase space (occupation number), and gives the contribution of stimulated scattering. Similarly, the reverse rate is given by

$$c\sigma(\chi)\, N(\varepsilon, \theta', \varphi')\,[1 + \frac{hc^3}{8\pi\varepsilon^2} N(\varepsilon, \theta, \varphi)]\, d\Omega d\Omega'$$

We observe that the net contribution from stimulated scattering is zero.

Oster considered the case of relativistic electrons, with Lorentz factor γ, moving through an isotropic radiation field. In the rest frame of an electron, the radiation field then consists of an intense beam of angular spread $\sim\gamma^{-1}$ and a weak component from all other directions. This argument, which applies to an arbitrary angular distribution of radiation, shows that the stimulated term has no net effect. Oster obtained a large contribution from stimulated scattering (even though he neglected recoil)