

LETTERS TO THE EDITOR

GEOPHYSICS

Antimatter and Tree Rings

RECENTLY, Cowan *et al.*¹ discussed the interesting case of the Tunguska meteor—the event and its origin mainly in the context of release of a rather high energy of $\sim 10^{24}$ ergs on its impact. Various theories concerning its origin and the nature of the energy source were discussed (for example, asteroidal origin and energy from impact or nuclear reactions). They have shown that none of the theories can satisfactorily explain the amount of energy released during the impact. The authors have invoked the antimatter hypothesis and, as an experimental verification to this, have calculated the expected increase in the carbon-14/carbon-12 ratios in the atmosphere subsequent to the fall of the meteorite. Considering the total energy release, they obtained a value of 7 per cent for the expected increase in activity. Their measurements of the atmospheric carbon-14/carbon-12 ratios, based on annual rings of a 300-yr.-old tree, show a possible increase of 1 per cent in the year 1909, leading them to the conclusion that probably 1/7th of the energy release in the Tunguska meteorite impact came from antimatter annihilation.

It is the purpose of this communication to point out that the probability of such an interesting conclusion is unfortunately very much reduced if one considers the nature of secular variations of carbon-14/carbon-12 ratios in the atmosphere. It was Stuiver² who first pointed out that there existed a good inverse correlation, for the past 1,300 yr. of record, between the solar activity and carbon-14/carbon-12 ratios in the atmosphere. (In what manner sunspot activity brings about this correlation is, however, not well understood as yet.) If we compare the solar activity and the observed carbon-14/carbon-12 ratio during 1870–1933, within the errors of measurements, we do find a fair anticorrelation between the sunspot activity

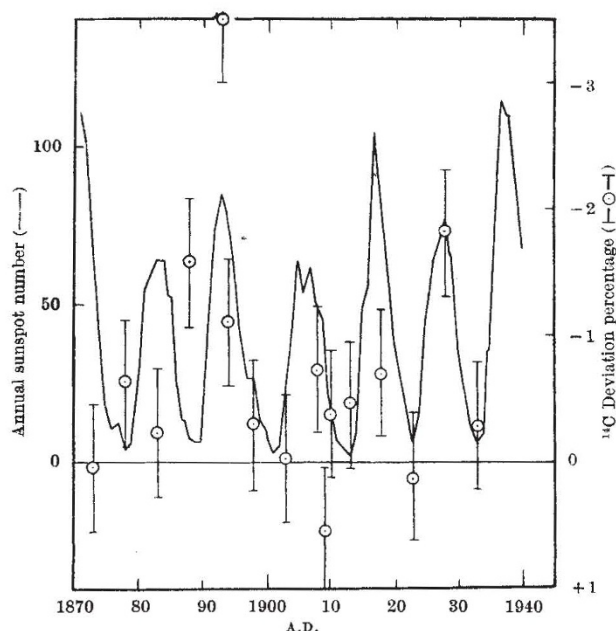


Fig. 1. Measured carbon-14 activity in tree rings (ref. 1) and sunspot activity during the same period

and the carbon-14 deviations (see Fig. 1), there being some phase differences which are not unexpected because of time delays in interactions of relevance to the carbon-14/carbon-12 ratios, for example, air–biosphere and air–sea exchange.

Thus, it is clear that if one takes into account the nature of secular variations of carbon-14/carbon-12 ratios in the atmosphere, it becomes difficult to reach any conclusions which may be of significance to a possible antimatter content of the Tunguska meteorite.

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¹ Cowan, C., Atluri, C. R., and Libby, W. F., *Nature*, **206**, 861 (1965).

² Stuiver, M., *J. Geophys. Res.*, **66**, 273 (1961).

PHYSICS

Delayed Fluorescence from Organic Crystals

DELAYED fluorescence lifetimes and spectra have been observed from crystals of naphthalene, anthracene, pyrene, 3,4-benzopyrene, *t*-stilbene and *p*-terphenyl, using conventional techniques¹. In each case a delayed fluorescence spectrum was observed with a resolution of 8 nm, the spectrum being identical with the prompt fluorescence spectrum. Precautions reported necessary for the observation of delayed fluorescence from microcrystalline samples² were not found important in the present work, as the crystals used were at least 1 mm thick.

A description of phosphorescence and delayed fluorescence in pure and mixed crystals has been obtained, based on a triplet–triplet annihilation process and assuming a uniform distribution of impurity traps throughout the host crystal^{3,4}. This description predicts an extremely rapid triplet–triplet annihilation rate in pure crystals, or crystals containing a high concentration of impurity traps. Associated with such a rapid annihilation rate is a very short lifetime of delayed fluorescence, and, consequently, a vanishingly small efficiency of phosphorescence and delayed fluorescence when observed using normal msec time resolution techniques.

In the present work, the triplet–triplet annihilation rate constant (γ) has been calculated from delayed fluorescence measurements made on commercially available anthracene crystals. For times short compared with the triplet lifetime, the fluorescence signal (F) is given by⁵:

$$F = \frac{1}{2} A \gamma [\eta_{T0} / (1 + \gamma \eta_{T0})]^2$$

where A is an instrumental factor and η_{T0} the initial density of triplet states. From a plot of $1/\sqrt{F}$ against t , the ratio of slope/intercept gives the quantity $\gamma \eta_{T0}$. Linear plots were obtained for each anthracene crystal, the results being similar to work reported previously for anthracene crystals⁶. For excitation times (t_x) short compared with the triplet lifetime, the initial density of triplets is given by:

$$\eta_{T0} \doteq Q_T t_x \varepsilon I_0$$

Q_T represents the efficiency of triplet formation, equal to one minus the prompt fluorescence efficiency⁷. This gives $Q_T = 0.35$ for thick anthracene crystals⁸. ε is the absorption coefficient for the exciting light⁵. I_0 is the exciting light intensity measured using a thermopile.