TECHNICAL COMMENT TO "SCIENCE".

OPTICAL (OR LASER ENHANCED) NMR, INTERPRETATION USING THE PHOTOMAGNETON OF LIGHT

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In a recent technical comment [1] on the remarkable optical NMR experiments reported by Warren *et al.* [2], Harris and Tinoco give a conventional calculation of optically induced NMR shifts. In their reply [3], Warren *et al.* report careful and repeated experimental checks which confirm beyond doubt that the experimentally observed shifts are *many orders of magnitude* larger than those given by conventional theory [1]. The observed shifts [2, 3] are of the order 0.1 to 1.0 *Hz* for laser intensities of 1 to 3 $W\,cm^{-2}$, while Harris and Tinoco [1] assert that the shift for 10 $W\,cm^{-2}$ is theoretically no larger than about 10^{-15} *Hz*. There is therefore an enormous discrepancy between experiment and conventional theory, clearly signalling the presence of a novel property of light.

I would like to suggest that the novel [4–8] photomagneton of light, $\hat{B}^{(3)}$, is the source of the shifts seen by Warren *et al.* [2, 3] with circularly polarized light.

Extensive theoretical work [4–8] has shown that the spin angular momentum of the photon, the operator $\hat{J}$, generates the phase free photomagneton,

$$\hat{B}^{(3)} = B^{(0)} \frac{\hat{J}}{\hbar}, \qquad (1)$$

per photon in vacuo. Here $B^{(0)}$ is the scalar magnitude of magnetic flux density in vacuo (tesla), calculable from the intensity I_0 of the light beam through the relation $B^{(0)} \sim 10^{-7}\, I_0^{\frac{1}{2}}$. For a beam intensity of 1,0 $W\,cm^{-2}$, $B^{(0)}$ is about 10^{-5} tesla, which for a 270 *MHz* (~ 10 tesla) spectrometer is expected to shift resonances by about ~ ± 27 *Hz*, depending on the sense of circular polarity of the light beam. This theoretical figure is about an order of magnitude too large, but the conventional theory [1] *produces results some fifteen to sixteen orders too small*. The operator $\hat{B}^{(3)}$ is zero in linearly polarized

or incoherent light [4–8] and switches sign with the sense of circular polarity of light. This switch of sign is consistent with experimental data [2, 3]. The fact that $\hat{B}^{(3)}$ appears to produce shifts which are about an order too large could easily be due to the fact that only a fraction of available beam intensity reaches the sample, or may be due to some novel, incompletely understood, mechanism of shielding by the electrons, a novel type of useful chemical shift.

The photomagneton $\hat{B}^{(3)}$ is a novel and fundamental [4–8] photon property, which is responsible for magnetization by light, as in the inverse Faraday effect [9-13], which can be expressed very simply as

$$\boldsymbol{M} = \langle \hat{M} \rangle = AB^{(0)} \langle \hat{B}^{(3)} \rangle . \qquad (2)$$

Here A is an ensemble averaged molecular property tensor, a hyperpolarizability [14].

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