same as in the β-phase. In this structure, the shared edges (3.16 Å) are longer than the unshared edges (3.02 Å) for the Mn octahedra. However, for β-Mn_2GeO_4, the shared edges (3.06 Å on the average) are shorter than the unshared edges (3.12 Å on the average). Because a shortening of the shared polyhedral edges is an important stabilizing factor for the ionic crystals (*9*), the stability of the β-phase in Mn_2GeO_4 might be explained by this shortening.

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Visual Transient Phenomenon: Its Polarity and a Paradox

Abstract. *Luminance stimuli modulated at frequencies above flicker fusion create perceptible visual transient responses when the frequency is changed abruptly. The polarity of these transients, as directly perceived and objectively confirmed, is shown enough by itself to yield a powerful criterion for visual models. An apparent paradox when light flashes are superposed on the frequency discontinuity has further implications for models and suggests a possible nonconservation of polarity in the brightness perception process.*

A light whose luminance oscillates rapidly enough around a constant level $\bar{L}$ is seen as the unvarying luminance $\bar{L}$ (Talbot-Plateau law), provided among other things the frequency is constant. Flicker can be sensed, however, even with oscillations always faster than fusion and $\bar{L}$ kept constant, if the frequency itself is modulated by abruptly alternating increases and decreases (*1*). Not surprisingly, the alternation rate must be below fusion (*2*). Of great interest, however, is the fact that the eye does respond to the individual frequency jumps (*3*). We are studying that elemental response and discuss here its curious nature.

The stimulus studied (Fig. 1) contains one abrupt frequency change, with both periods t_1 and t_2 shorter than the fusion limit, and both wavetrains long enough to insure that the eye is in a steady-state at the time of the period discontinuity and is unperturbed by the stimulus cutoff. When one views this stimulus, a transient effect is experienced at the jump in period if $|t_2 - t_1|$ is large enough (*3*). For example, with a moderately high mean luminance $\bar{L}$, the effect is readily apparent for the case $t_1 = 1$ msec and $t_2 = 5$ msec.

These transients have an interesting appearance. Careful observers agree that with t_1 less than t_2 as depicted in Fig. 1, the period jump is perceived as a brief eclipse, whereas, with the reverse configuration t_1 greater than t_2, the experience is a momentary increase in brightness. That period discontinuities are perceived as brightness changes is interesting, but understandable (see Eq. 5). Also, details of the thresholds, reaction times, $\bar{L}$ dependence, and so forth no doubt contain a wealth of information on the temporal sensitivity of the eye. However, we focus here on just the polarity of the transients, for it alone is very significant.

In reporting (*4*) on the polarity of the transient, we described some objective tests (thresholds and reaction times) which confirm the direct perception. If, as is natural with luminance increases taken as positive, we assign positive sign to brightness increments and negative to decrements, the observed polarity is summed up by

$$\text{sign of transient} = \text{sign of } [t_1 - t_2] \quad (1)$$

This property is readily reconciled with only one of the deLange-Kelly class of visual models (*4*). Here we shall generalize that result, deducing from Eq. 1 a stringent criterion applicable to many different models.

An apparent paradox was also noted on adding a short flash simultaneous with the period jump (*4*)—the percept is diminished by a flash of the same sign as the transient alone (Eq. 1), and is enhanced by a flash of opposite sign. The paradox is highlighted by related studies which deduced incorrectly a sign for the transients (*5*). One simple and plausible way it might be resolved (*4*) is extended below to general linear theories.

Turning now to visual models, let us require that they reproduce the observed polarity and the apparent paradox. For brightness perception at high frequencies, deLange (*6*) has argued in favor of linear models. For these, or for the linear limit of a nonlinear model, we can easily demonstrate how severe our requirements can be.

Consider any linear model whose response, subject to some detection rule, is to be a brightness analog. The response $R(t)$ to an input $I(t)$ may be expressed in general as (*7*)

$$R(t) = \int_{-\infty}^{\infty} G(t,t')\, I(t')\, dt' \quad (2)$$

where the Green's function $G(t,t')$ is the response to an impulse $\delta(t-t')$, which completely specifies the model. For the input discontinuous at $t=0$ (Fig. 1) we write

$$I(t) = I_1(t) + S(t)\,[I_2(t) - I_1(t)] \quad (3)$$

where the unit step $S(t) = \int_{-\infty}^{t} \delta(t')dt'$. Inserting Eq. 3 into Eq. 2 and using causality ($G(t,t') = 0$ for $t < t'$) gives $R = \int_{-\infty}^{\infty} G I_1$ for $t < 0$ and $R = \int_{-\infty}^{\infty} G I_2 + \int_{-\infty}^{0} G[I_1 - I_2]$ for $t > 0$. Now if I_1 and I_2 oscillate rapidly about the same mean $\bar{I}$ and if we require the model to satisfy the Talbot-Plateau law above, then $\int_{-\infty}^{\infty} GI_1 = \int_{-\infty}^{\infty} GI_2 \propto \bar{I}$ within undetected fluctuations. Therefore we obtain the

$$\text{transient} = S(t) \int_{-\infty}^{0} G(t,t')\, [I_1(t') - I_2(t')]\, dt' \quad (4)$$

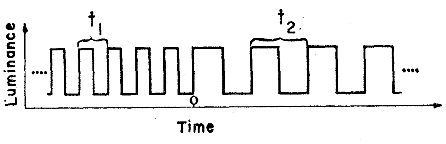

Fig. 1. Stimulus waveform [see (*4*)].

This is zero for $t<0$, of course, and may jump at $t=0$ depending on the discontinuity in I and the structure of G. For $t>0$ ($\geqq t'$) we assume G differentiable and I_1, I_2 rapidly oscillating (periods t_1, $t_2 << $ model time scale Θ). Then we may integrate by parts and drop terms of higher order in $t_{1,2}/\Theta$. With $G(t,-\infty)=0$ (*7*), and $I_{1,2}=\bar{I}+\bar{I}\Sigma(4/\pi\ell)\sin 2\pi\ell t/t_{1,2}$ ($\ell=1,3,5,\cdots$) for the analog of Fig. 1, we thereby reduce Eq. 4 to

$$\text{transient } (t>0) \approx G(t,0)\cdot[t_2-t_1]\cdot\tfrac{1}{4}\bar{I} \qquad (5)$$

with relative error $\sim$ $(t_{1,2}/\Theta)^2$. This generalizes readily to $G(t,0)\cdot[m_2t_2 - m_1t_1]\cdot\bar{I}\Sigma(c_\ell/2\pi\ell)$ for any $I_{1,2}$ that are periodic and odd, differing only in period and perhaps modulation ($m_{1,2}$) and with Fourier sine coefficients c_ℓ. Thus abrupt changes in modulation or in period give similar effects. Note that Levinson's (*5*) pure sinusoids correspond to $\Sigma(c_\ell/2\pi\ell)=1/2\pi$ and the special cases either $m_1=0$ or $m_2=0$.

The transient Eq. 5 separates into a model factor $G(t>0,0)$ and a stimulus factor $\propto[t_2-t_1]$. If visibility corresponded solely to the size of the model transient, this would imply threshold curves $t_1 \approx t_2$ $\pm$ a constant for any linear model, with only the constant dependent on specifics—which is the general trend observed (*1*). We defer numerical studies and consider now only the sign of the transient.

The polarity criterion follows at once from Eqs. 5 and 1: a model to be consistent with the polarity observations requires

$$G(t>0, t'=0) \text{ predominantly} < 0 \quad (6)$$

by whatever detection scheme the model assumes, that is, an acceptable model must have impulse response G detected as negative. This does not say the response to a finite pulse is negative, for that depends on $\int G$, including any singularities of G at $t=t'=0$ which are excluded in Eq. 6. Indeed the model had better give positive response to a step or a long "flash." Hence, Eq. 6 is a serious restriction.

The general power and facility of this polarity criterion is reflected in the fact that the great majority of proposed models are not immediately compatible with it (*8*). A few examples must suffice here, selected for ease of illustration only and with no space to do justice to their merits in other respects. Perhaps most familiar are the "deLange models" [n-stage integrators, see (*5*)] for which $G(t,t')=G_n(t-t')$ where $G_n(t)=S(t)\exp(-t/\theta)(t/\theta)^{n-1}/(n-1)!\,\theta$. This is always positive, so that Eq. 6 absolutely excludes a pure deLange model. The broader class of "deLange-Kelly models," which include also differentiations, have $G(t,t')$ a linear combination of the above G_n's and, as indicated earlier (*4*), only one is easily reconciled with Eq. 6. An example of the entirely different class of "Ives (diffusion) models" is Veringa's (*8*) for which the G (his R_6) is positive and cannot be reconciled with the criterion Eq. 6. Finally, a nonlinear example is the nicely posed model of Sperling and Sondhi (*8*) which, on the basis of its linear limit and assumed detector, has G (their figure 7) unacceptable by our criterion.

Now consider the flash paradox. To resolve it in a linear model, the superposition principle requires that a brief input by itself give response detected as opposite in sign to the input. Previously (*4*), we found a simple amplitude-duration detector,—added to the allowed deLange-Kelly model in order to preserve steep flanks in "deLange curves"—also accomplishes this. Here we show it does the same for any model satisfying, as it ought, Eq. 6. Thus, for a rectangular input $I=I_0$ for $0 \leqq t \leqq \tau$ and $I_0=0$ otherwise, Eq. 2 gives $R(t) = I_0\int_0^\tau G(t,t')\,dt'$. Now if τ is less than a duration threshold Δt, say, the initial response by itself is not detected, but only that at $t>\Delta t>\tau$. Then $t>\tau\geqq t'$ in $\int_0^\tau G$, so singularities again are excluded, and by parts

$$R(t>\tau) \approx G(t,0)\cdot\tau\cdot I_0 \qquad (7)$$

with relative error $\sim$ τ/Θ. Hence, by Eq. 6, this detected response is opposite in sign to I_0, as desired. Further, superposing Eqs. 7 and 5, we see that their forms permit complete cancellation (*5*) for $\tau \approx \tfrac{1}{4}[t_1-t_2]\cdot(\bar{I}/I_0)$.

We return finally to the eye. If superposition remains valid even very roughly, then also in the perception of brief flashes a nonconservation of polarity must somehow occur. However, if in reality polarity is conserved, the paradox deepens. In any event, the danger in interpreting observations on an assumption of polarity conservation (*5*), though in accord with most models, is pointed up by the flash paradox. Conversely, it is striking that direct perception gives so selective a test for models as the polarity criterion, Eq. 6.

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Carbon: Observations on the New Allotropic Form

Abstract. *The recently characterized "white" allotropic form of carbon has been produced at high temperature and low pressure during graphite sublimation. Under free-vaporization conditions above ~2550°K, the white carbon forms as small transparent crystals on the edges of the basal planes of graphite. The interplanar spacings of this material are identical to those of a carbon form noted in graphitic gneiss from the Ries Crater.*

The new allotropic form of carbon has been produced during the sublimation of pyrolytic graphite (*1, 2*). Small bars of pyrolytic graphite (2 by 3 by 40 mm) were heated resistively to tem-