# Appendix C3: Hasselkamp's Experiment
## (Second Order Doppler Shift)

One of Einstein's major findings in Special Relativity was *Relativistic Time Dilation*: for an object in motion, time-experience will be slowed down. This finding is supported by spun-light physics, with the crucial difference that Relativity sees this effect as totally relative whereas spun-light physics shows it to be absolute, *i.e.* all motion is related to the objective universal rest state.

One consequence of this effect is what's now known as *Transverse* (or S*econd Order*) Doppler Shift. SODS is based on the premise that if an atom is operating at a reduced time-scale then emissions from that atom will be in accordance with that reduced time-scale: *i.e.* the frequency of any photon emissions will be lower than they would be for the same event in a static atom of the same type.

Various experiments have been undertaken to test this expectation. In several of them the SODS effect has been difficult to detect as it's overshadowed by the much greater normal (first-order) Doppler effect, which is simply foreshortening or lengthening of photon wavelength relative to a static observer (similar to the increase or decrease of siren frequency from a police car speeding towards or away from a static observer).

Earlier experimenters were able to confirm the existence of the effect, which is the same irrespective of whether motion of the emitting particle is towards, away from or even tangential to the observer. But Hasselcamp *et al.* separated out the transverse component by literally measuring it transversely, *i.e.* from a position situated to one side of the line of motion of the emitting atoms. This meant that the first-order Doppler component, which only has an effect along the line of motion, wouldn't swamp the much smaller SODS effect.

The combined Doppler effect on the wavelength of photons emitted from atoms moving at speed $v$ (where $v$ is expressed as a fraction of $c$, the speed of light) is:

$$\lambda' = \frac{\lambda_0 (1 - v \cos \theta)}{\sqrt{(1 - v^2)}}$$

where: $\lambda_0$ is the emission frequency for a static atom; $\lambda'$ is the resulting frequency; $\theta$ is the angle between the line of motion of the emitting atoms and the line of approach of those emitted photons to the detector.

The bracketed term in the numerator is the factor for first-order Doppler effect; the denominator, which is the time dilation factor, gives rise to the second-order effects. If that denominator is expanded as a polynomial to be multiplied by the numerator, we get:

$$\lambda' = \lambda_0 (1 - v \cos \theta)(1 + \tfrac{1}{2}v^2 \text{ + terms in } v^4 \text{ and higher})$$

giving: $$\lambda' = \lambda_0 (1 - v \cos \theta + \tfrac{1}{2}v^2 \text{ + terms in } v^3 \text{ and higher})$$

Hence the reference to 'second order': $v$ is a first-order term, $v^2$ is second-order.

Since $\cos 90^{\circ} = 0$, then if $\theta = 90^{\circ}$ that first-order term disappears.

Since $v$ is bound to be very small (as a fraction of $c$) then $v^2$ will be equally small compared to $v$ (just a few percent at most), so eliminating that first-order term dramatically increases the visibility of the second-order effect. It's for this reason that Hasselkamp *et al*. arranged their experimental apparatus so that the photons emitted from the high-speed atoms were sampled in a direction perpendicular to their line of motion, *i.e.* $\theta = 90^o$.

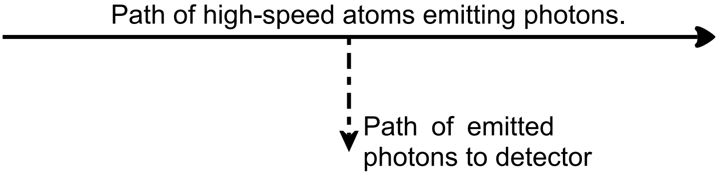


**Figure C3.1**

A simple schematic of Hasselkamp's experimental setup, showing the path taken by the emitting atoms and the perpendicular path taken by the photons emitted by those atoms, so ensuring no interference from first-order Doppler effects.

Experimental limitations made it impossible to ensure a precise 90° angle, so the experimenters used their observations at various speeds to plot a line that made it possible to identify, and so eliminate, the minimal first-order component. In this analysis we'll use the mid-point of that line, corresponding to emitting atoms moving at $0.02c$, *i.e.* 2% of the speed of light.

This experiment confirmed the contribution of second order Doppler effect to the fractional change in wavelength of emitted photons as $0.5v^2$, as predicted by Special Relativity [1]. So how does this result pan out when viewed from the perspective of spun-light physics?

<u>Doppler effects as seen from spun-light perspective</u>

The spun-light view of material reality shows all velocities, of matter and light, to be relative to the unique universal rest state. This is most likely to correspond to the rest-frame of the *Cosmic Microwave Background*, relative to which our solar system is moving at a speed $0.001c$ ($0.00123c$ to be precise). This has been taken in the following analysis as the objective speed of a laboratory fixed on the earth, such as that used by Hasselkamp *et al*. for their experiment.

Spun-light reality, then, shows all Doppler effects, first- and second-order, to be dependent on velocities of both emitter and receiver with respect to the universal rest state. In general we should consider: (a) Doppler effects from the moving emitter to the rest state; then (b) Doppler effects from the rest state as experienced by a moving receiver. Much of the time, however, these considerations may be simplified to quite a degree or even ignored for many practical purposes.

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1. Actually 0.52 ± 0.03, allowing for experimental uncertainty

**In brief:**

(a) The first-order Doppler shift (FODS) is the product of the FODS from the emitter to the objective rest frame and the FODS from that rest frame to the receiver – measured at the angle between the direction of motion of emitter or receiver, respectively, and the line joining them at any given instant.

In practice this works out to the same as the conventional result for FODS based on velocity of receiver relative to emitter, if we ignore second order terms in those two absolute velocity components (square of each, product of the two); this difference will in general be several orders of magnitude lower than that conventional result (and so can generally be neglected).

(b) The SODS effect depends on the absolute speeds (irrespective of direction) of both emitter and receiver, and so is fairly independent of the velocity of one relative to the other (unless that relative velocity happens to be zero, *i.e.* they're moving at the same speed in the same direction).

The factor for second-order increase in wavelength from emitter to receiver is: (time dilation for emitter) / (time dilation for receiver).

*i.e.* $\text{SODS} = \dfrac{\sqrt{(1-u^2)}}{\sqrt{(1-v^2)}}$ [where emitter and receiver are moving at speeds $v$ and $u$ respectively.]

This differs from the conventional SODS factor (where receiver is assumed to be static) by a factor of at most $(1-u^2)/(1-uv)$ [when emitter and receiver are moving in the same direction]. In practice SODS is always assessed in the receiver's frame by either a human or appropriate laboratory equipment, placing serious limits on possible values of $u$; so this multiplier of an already tiny term is bound to be very close to 1: if $u = 0.001$ and $v = 0.02$ it's 1.000019.

There's another reason why that small anomaly is unlikely to be detectable: in the spun-light understanding of reality, the earth is moving at speed with respect to the universal rest frame. If indeed that is the rest frame of the CMB then the earth is moving at around 300 Km/sec in objective terms; comparison with SODS from a moving emitter to a static detector is not a possibility since a state of absolute rest is not available to us.[2]

But there's also another, rather more significant, reason. Read on.

Implications for Hasselkamp's Experiment

The first thing to note is that, if (as seems very likely) reality is indeed as this book describes it, then the Hasselkamp experiment is not measuring what it is intended and believed to be measuring. Rather than measuring the second order Doppler shift of emissions from atoms moving at $0.02c$, it's measuring SODS from emissions at $0.02c + \Delta$, where $\Delta$ is between $-0.00123c$ and $+0.00123c$, to a detector moving at $0.00123c$.

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2. Note that, since in cases of apparently-static emissions on earth emitter and receiver would be moving at the same velocity, identical time dilation would apply for both – so measurement of such emissions *will* give true results.

More significantly, if this is the case then the measurement process must without question involve an element of first-order Doppler effect. This follows logically from the situation as shown in Figure C3.2, which shows a scenario in which the emitter and the receiver (in a laboratory on earth) are travelling in the same direction at different speeds; a comparable scenario will apply for any other mix of velocities satisfying experimental requirements, *i.e.* speed of emitter relative to receiver = $v$ (equal to $0.02c$ in the Hasselkamp scenario).

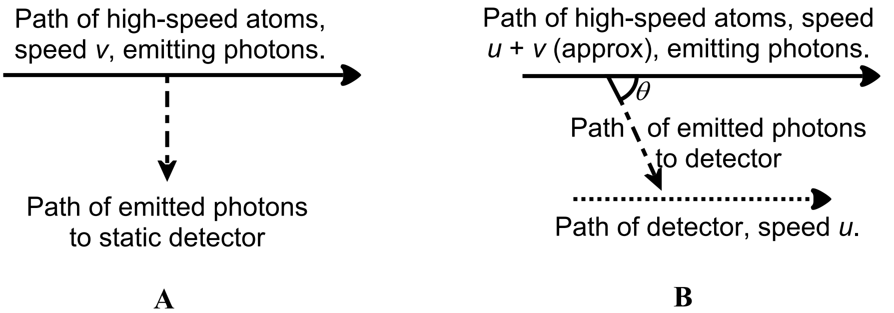


**Figure C3.2**

**A** shows the situation as perceived by an observer considering him/herself and the detector to be static.

**B** shows the situation from an objectively static viewpoint: the detector is moving at speed $u$, the photon-emitting atoms are moving at speed $v$ relative to the detector.

If we now consider the mathematics of the situation shown in Figure C3.2B:

As the horizontal component of the velocity of the emitted photons is $u$ and the full velocity of those photons is $c$, then it follows that $\cos\theta = u$ (speeds expressed as proportions of $c$). From this we are able to derive an expression for the full Doppler effect as experienced at the detector.

If the speed of the emitter is perceived as $v$ by an observer moving at speed $u$, then both Relativity and spun-light physics tell us that the speed of that emitter is in fact: $\dfrac{u+v}{1+uv}$ [as given by the Lorentz transformation.]

The calculation for the Doppler-shifted wavelength of those emissions, as seen at the emitter, is then (incorporating both first- and second-order Doppler shifts for both emitter and receiver):

$$\lambda' = \lambda_0 \frac{\left(1 - \frac{u+v}{1+uv}\cos\theta\right)(1-u^2)^{1/2}}{\left(1 - \left(\frac{u+v}{1+uv}\right)^2\right)^{1/2}(1-u\cos\theta)}$$

which becomes:

$$\lambda' = \lambda_0 \frac{\left(1 - \frac{u+v}{1+uv}\,.\,u\right)(1-u^2)^{1/2}}{\left(1 - \left(\frac{u+v}{1+uv}\right)^2\right)^{1/2}(1-u^2)}$$

This simplifies to:

$$\lambda' = \lambda_0 \frac{(1 - u^2)(1 - u^2)^{1/2}}{(1 + u^2v^2 - u^2 - v^2)^{1/2}\,(1 - u^2)}$$

or:

$$\lambda' = \lambda_0 \frac{(1 - u^2)(1 - u^2)^{1/2}}{[(1 - u^2)(1 - v^2)]^{1/2}\,(1 - u^2)}$$

which of course reduces to:

$$\lambda' = \frac{\lambda_0}{(1 - v^2)^{1/2}}$$

In short: Doppler effect in the following two situations is *identical*:

(a) emissions transverse to path of emitting particles moving at speed $v$, as seen by a static observer (this will *only* include second-order effects);

(b) emissions perceived by a moving observer as transverse to path of emitting particles moving at speed $v$ relative to that observer (this will include *both* first- and second-order effects).

It follows that:

(i) A Hasselkamp-type experiment in a laboratory in motion will give identical results to that same experiment in an objectively static laboratory;

(ii) Even if such an experiment were aligned in both directions of the earth's motion relative to the CMB rest-frame to maximise any possible difference in readings ($u = +0.001/-0.001$), absolutely *no* difference would be detected.

Since (ii) is the 'worst-case scenario' it can be logically inferred that motion of an emitter oblique to motion of the detector would likewise not detect any difference (*i.e.* it wouldn't detect a greater difference than that worst case). Without having to do the maths, then, this implies that any other configuration of this experiment would also produce that 'static' result: $\lambda' = \lambda_0/(1 - v^2)^{1/2}$.

This is clear support for Galilean Relativity, also the Principle of Relativity as embodied in the postulates of Special Relativity [3]. But it's equally clear that those Principles (basically: *it's not possible to tell the state of motion of the lab from experimental results*) do *not* require a universe that's 'absolutely relative' in the sense that relativity is, without exception, applied today.

**Hasselkamp's result, and any extensions of it, are fully consistent with an objective universal rest state. Even so, such experiments will inevitably appear to confirm that such a rest state does not exist.**

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3. Chapter 9 shows how the Principle of Relativity only ceases to apply if we're prepared to look 'beyond the particle' and see what's going on *within* particulate matter.