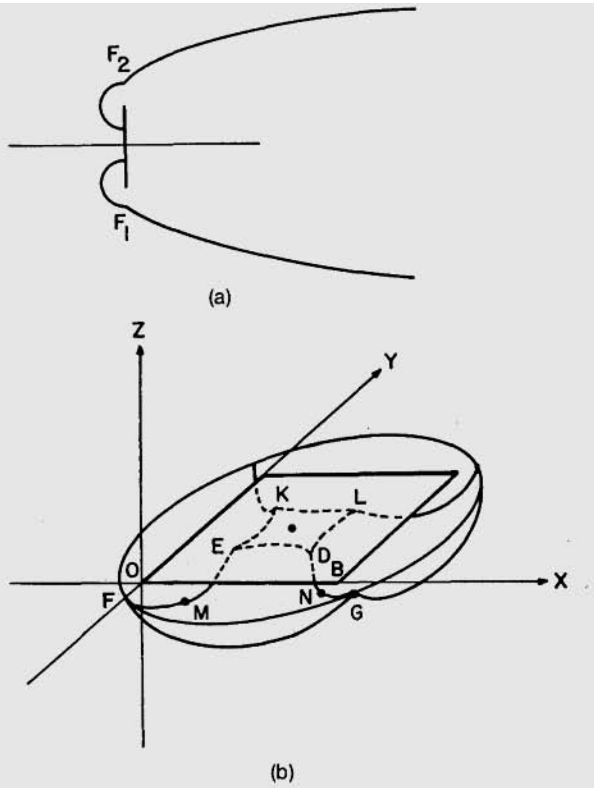

Fig. 1. (a) Cross section of cavity on concentrator having exit aperture F_1F_2. (b) Perspective of cavity under square absorber.

We actually prove the contrapositive: that no part of the bolometer can see itself in the cavity. Hence, the bolometer sees only radiation incident from the entrance aperture, and this radiation is of full intensity by Liouville's theorem. Consider a ray emitted downward by the bolometer. Such a ray has negative angular momentum L_x around the x axis, where $L_x = yp_z - zp_y$ is a constant of the motion for a ray, and $p = (p_x,p_y,p_z)$ is the momentum of the ray. If this ray strikes the surface *FMEDNG* (the foreground section of the cavity), its L_x is unchanged since that surface is a figure of revolution about the x axis. The ray can bounce any number of times from this section, and its L_x is still negative. When it reaches $z = 0$ again it must, therefore, be traveling upward ($p_z > 0$) and, hence, $y < 0$; so it misses the bolometer and escapes.

If, on the ther hand, the ray should pass from the front quadrant to the left-hand quadrant of the cavity, we can still show it must escape. In this case we want to show $L_y > 0$ to prove escape. We evaluate L_y at the quadrant boundary plane $x = y, z < 0$. Since the ray is going to the left, $p_x < p_y$, so $zp_x > zp_y$. Hence, $L_y = zp_x - xp_z = zp_x - yp_z > zp_y - yp_z = -L_x > 0$. Hence, if $z = 0$ and $p_z > 0$, then $x < 0$, and the ray escapes without hitting the bolometer. This argument may be continued to show that no ray emitted by the bolometer ever comes back to it, regardless of reflections on the cavity. Q.E.D.

I thank R. Winston for very helpful discussions.

References

1. W. T. Welford and R. Winston, *The Optics of Nonimaging Concentrators* (Academic, New York, 1978).
2. I. D. Bassett and G. H. Derrick, Optical and Quantum Electronics **10**, 61 (1978).

Alternate approach to the analysis of solar photometer data: comments

Andrew T. Young

San Diego State University, Astronomy Department, San Diego, California 92182.

Received 18 September 1981.
0003-6935/81/233993-01$00.50/0.

Herman *et al.*[1] point out the need to divide observations of the sun by the air mass of each observation before applying the method of least squares, if the errors are caused by fluctuations in atmospheric transparency. Thus, the weight of each observation is inversely proportional to the square of its air mass. This suggestion is not new; I have used this weighting system myself[2] for over 15 years in reducing astronomical photometry.

While my experience has been that this scheme is superior to unweighted least squares, it has some disadvantages. First, unless transparency variations are the dominant error source, it does not weight the observations optimally. In practice, fixed instrumental errors usually dominate at small air masses; and, at least in stellar photometry, other errors grow faster than the first power of the air mass. Second, if transparency variations do dominate, they are usually slow enough that successive observations have partially correlated errors,[3–5] causing the standard deviations of the estimated quantities to be underestimated.

Examples of actual error dependences on air mass and a much more detailed discussion of both systematic and random extinction errors in astronomical photometry were published several years ago.[6] It is a pity that observers have been so slow to adopt more efficient statistical methods.

References

1. B. M. Herman, M. A. Box, J. A. Reagan, and C. M. Evans, Appl. Opt. **20**, 2925 (1981).
2. A. T. Young and W. M. Irvine, Astron. J. **72**, 945 (1967).
3. D. Clarke, Mon. Not. R. Astron. Soc. **190**, 641 (1980).
4. G. Grec, E. Fossat, P. Brandt, and F. L. Deubner, Astron. Astrophys. **77**, 347 (1979).
5. E. Fossat, J. Harvey, M. Hausman, and C. Slaughter, Astron. Astrophys. **59**, 279 (1977).
6. A. T. Young, "Observational Technique and Data Reduction," in *Methods of Experimental Physics, Vol. 12, Astrophysics, Part A: Optical and Infrared*, N. P. Carleton, Ed. (Academic, New York, 1974), p. 123.

Experimental contradictions of Fresnel drag

Wallace Kantor

5648 Marne Avenue, San Diego, California 92120.

Received 5 June 1981.
0003-6935/81/233993-02$00.50/0.

There is an extraordinarily inexpensive experimental opportunity in relativistic optics that a fortunately situated lone experimenter can undertake.

It has long been known that to first-order accuracy the ether point of view and the special theory of relativity lead to the same result for the *parallel* convection of light by a moving medium:

$$w = (c/n) + v(1 - 1/n^2), \tag{1}$$

where c/n is the propagation speed of the light relative to a medium of refractive index n, v is the speed of the medium itself, and w is the resultant convection speed. This expression is independent of the wave or photon nature of light, so that the wave–particle dichotomy is of no concern.

If in a classical *etherless* point of view the two speeds c/n and v are simply additive, the *exact* convection speed is simply

$$w' = (c/n) + v. \tag{2}$$

The Fresnel coefficient $(1 - 1/n^2)$ of v in Eq. (1) is readily discriminated experimentally from the unity coefficient of v in Eq. (2).

It will sorely tax the credulity of most physicists that contrary to widespread belief there is no satisfactory experimental support for Eq. (1). There is, in fact, disturbing experimental contradiction of Eq. (1).

The earlier experimental methods involved interferometric measurements for both the distance between fringes corresponding to the monochromatic wavelength of the light and the shifting of the fringes corresponding to the actual convection effect. Fizeau's 1851 work[1,2] and Michelson's modified repeat[3] of it in 1886 used *white* light, which, as Michelson himself noted,[4] "does not give even an approximately accurate result." A monochromatic wavelength is measurable; the wavelength of *white* light is only coarsely known. The Sagnac experiments[5,6] and their modified repeat by Dufour and Prunier[7–9] also used an unfiltered continuous spectrum light source, whereby these experiments were rendered quantitatively valueless.

In 1914 Zeeman[10] stated explicitly that a monochromatic source had to be used, and yet his work[11–13] on convection by flowing water was not satisfactory. There was a 5–10% uncertainty in the assumed length of the water column. There was a 10–20% uncertainty in the measured speed of the turbulent flow.

In addition, Zeeman confessed that he did not fully understand the critical adjustment of his rather complex interferometer. He published photographs of fringes at widely different wavelengths showing interfringe widths that were not correspondingly different. He seemed to be unaware that by selecting the fringe widths arbitrarily "according to the circumstances" he was also altering the calibration and the sensitivity of his interferometer, rendering his measurements unreliable and ambiguous.

Zeeman reverted to the use of an unfiltered continuous spectrum carbon arc source to make the fringes more visible in his last 1922 experiments[14,15] with shuttling flint-glass rods. Licence[16] noted that these experiments "are not regarded as productive of conclusive results."

This astonishing state of affairs lay unsuspected for the next forty-two years. In 1964, Macek *et al.*[17] published the results of their fortuitously designed ring laser experiment on the *nonparallel* convection of IR light in flowing carbon tetrachloride. Their results were admittedly *not* in accord with their uncritically assumed expression for parallel convection only, rather than the actual skew convection configuration of their experiment. A detailed analysis of this experiment has been published elsewhere.[18,19]

Their graphically presented observations, with $\sin r = (1 - 1/n^2)^{-1/2}$, are shown as they gave them except for the superposition of the classical *etherless* line and the correct Einstein theory line, *both for skew convection* (see Fig. 1).

In 1966, Batifol and Pécile[20] briefly noted a convection effect in a flowing gas that contradicted the special theory of relativity.

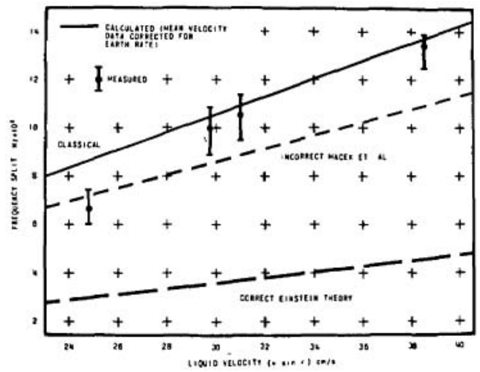

Fig. 1. Skew convection of light.

It stuns the imagination to realize that such an utterly incredible oversight of the experimental evidence concerning the convection of light in moving media could persist for these past one hundred and thirty years.

The serendipitous design of the Macek *et al.* experiment neatly avoided the pitfalls of prior experiments. This experiment is very inexpensive. It is almost an off-the-shelf experiment. It is, therefore, readily repeatable without undue expenditure of time and effort. It is a project that can be undertaken by a sole experimenter.

The consequences of this first-order, uniquely discriminatory, experiment hardly require explanation. It has been this author's purpose to stimulate a healthy curiosity that will lead to independent repetitions of this experiment.

The evidence of experiment in relativistic dynamics is widely regarded as most convincing. It is to be noted as Einstein has suggested that it takes but one experiment in kinematics *on which dynamics is based* to cause a revision of our current understanding and beliefs.

References

1. H. Fizeau, C. R. Acad. Sci. **33**, 349 (1851).
2. H. Fizeau, Ann. Chim. Phys. **57** (3), 385 (1851).
3. A. A. Michelson and F. W. Morley, Am. J. Sci. **31**, 377 (1886).
4. A. A. Michelson, *Light Waves and Their Uses* (U. Chicago Press, 1902), p. 155.
5. G. Sagnac, C. R. Acad. Sci. **157**, 708, 1410 (1913).
6. G. Sagnac, J. Phys. Radium, **4**, 179 (1914).
7. A. Dufour and F. Prunier, C. R. Acad. Sci. **204**, 1925 (1937).
8. A. Dufour and F. Prunier, C. R. Acad. Sci. **208**, 988 (1939).
9. A. Dufour and F. Prunier, J. Phys. Radium, **3**, 153 (1942).
10. P. Zeeman, Proc. R. Acad. Amsterdam, **17**, 445 (1914).
11. P. Zeeman, Proc. R. Acad. Amsterdam, **18**, 398 (1915).
12. P. Zeeman, Proc. R. Acad. Amsterdam, **22**, 469 (1920).
13. P. Zeeman, Proc. R. Acad. Amsterdam, **22**, 512 (1920).
14. P. Zeeman, W. deGroot, A. Snethlage, and G. C. Dibbetz, Proc. R. Acad. Amsterdam, **23**, 1402 (1922).
15. P. Zeeman, Proc. R. Acad. Amsterdam, **24**, 207 (1922).
16. A. B. C. Licence, Sci. Abstr. **A25**, 753 (1922).
17. W. M. Macek, J. R. Schneider, and R. M. Salamon, J. Appl. Phys. **35**, 2556 (1964).
18. W. Kantor, Spectrosc. Lett. **4**, 99 (1971).
19. W. Kantor, *Relativistic Propagation of Light* (Coronado Press, Lawrence, Kans., 1976).
20. E. Batifol and D. Pécile, C. R. Acad. Sci. **B263**, 446 (1966).