LETTERS TO THE EDITOR

Letters are selected for their expected interest for our readers. Some letters are sent to reviewers for advice; some are accepted or declined by the editor without review. Letters must be brief and may be edited, subject to the author's approval of significant changes. Although some comments on published articles and notes may be appropriate as letters, most such comments are reviewed according to a special procedure and appear, if accepted, in the Notes and Discussions section. (See the "Statement of Editorial Policy" in the January issue.) Running controversies among letter writers will not be published.

A PAUSE BEFORE THE ACTION

In his guest editorial, "A call to action" [Am. J. Phys. **71** (5), 423–425 (2003)], Edwin F. Taylor promotes the principle of least action (traditionally—that is, pre-Feynman—labeled "Hamilton's principle") as the fundamental starting point in the study of classical motion. This he advocates as a substitute for the laws in standard use. One should realize, nevertheless, that the laws of classical motion are implicitly involved in at least two respects in the architecture of the elegant principle promoted by Dr. Taylor: (i) In the tacit assumption that the adopted system of coordinates is fixed relative to an inertial reference frame, use is made of the first law, by means of which the inertial frame is defined. (ii) Use is also made of the third law, by means of which mass is defined.

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DEFLECTION OF LIGHT IN GENERAL RELATIVITY

Readers of the paper "Deflection of light to second order: A tool for illustrating principles of general relativity" by J. Bodenner and C. M. Will, published in the August 2003 issue of the *American Journal of Physics*, will find a similar discussion in "Inevitable ambiguity in perturbation around flat space–time" by S. Ichinose and Y. Kaminga, published in Physical Review D, Vol. 40, No. 12, page 3997 (1989). That paper discusses the coordinate system dependence of the deflection of light and the perihelion shift of Mercury, but focuses particular attention on the Shapiro time delay, where the problem of coordinate dependence is more complex.

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PAULI AND THE RUNGE–LENZ VECTOR

In a recent article, Pauli's 1926 article was recalled with special emphasis on his elegant use of the Runge–Lenz vector to derive the energy levels of the hydrogen atom and the changes resulting from the presence of electric and magnetic fields.[1] The key is an equation which was termed the "Pauli identity" [Eq. (2) in Ref. 1] by the author. This equation involves the quantum expectation values of the position operator and the Runge–Lenz vector, and was rederived fifty years later by Becker and Bleuler.[2] As a former Ph.D. student of Bleuler, I was told the background of this equation by him. First, Pauli did not guess this equation, guided by a classical analogy as stated in Ref. 1, but he was aware of the classical treatment of the same problem by Lenz in 1924,[3] and decided to calculate the quantum mechanical equivalent of averaging over orbit cycles.[4] Pauli asked Bleuler thirty years later to work on an alternative derivation of this identity. Before Bleuler found the time to do so, it was used by Schwinger in his 1960–1961 Harvard lectures to derive the first and second order Stark shifts in hydrogen;[5] it was later rediscovered by Meadors.[6] For oscillatory electric fields, it can be used to illustrate advanced concepts such as Zeldovich's concept of quasi-energy for sinusoidally time-dependent Hamiltonians by calculating the exact time-dependent eigensolutions.[7]

[1]G. Vallent, "The hydrogen atom in electric and magnetic fields: Pauli's 1926 article," Am. J. Phys. **71** (2), 171–175 (2003).
[2]H. G. Becker and K. Bleuler, "O(4)-Symmetrie und Stark-Effekt des H-Atoms," Z. Naturforsch. **31** (6), 517–523 (1976).
[3]W. Lenz, "Über den Bewegungsverlauf und die Quantenzustände der gestörten Keplerbewegung," Z. Phys. **24** (2), 197–207 (1924).
[4]A. A. Stahlhofen, "Once more the perturbed Kepler problem," Am. J. Phys. **62** (12), 1145–1147 (1994).
[5]These lectures are unpublished. The citation is according to L. C. Biedenharn, L. S. Brown, and J. C. Solem, "Comment on 'The strange polarization of the classical atom' [Am. J. Phys. **55**, 906 (1987)]," Am. J. Phys. **56** (7), 661–663 (1988). The late Professor Biedenharn showed me a copy of these lectures while working as a postdoc with him.
[6]J. G. Meadors, "The Stark effect in hydrogen," Ph.D. thesis, Auburn University, 1961.
[7]L. C. Biedenharn, G. A. Rinker, and J. C. Solem, "Solvable approximate model for the harmonic radiation from atoms subjected to oscillatory electric fields," J. Opt. Soc. Am. B **6** (2), 221–227 (1989).

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MOTION OF AN ELECTRIC CHARGE IN THE FIELD OF AN ELECTRIC DIPOLE

The motion of an electric charge in the field of an electric dipole has been discussed recently by McGuire[1] and earlier by Jones.[2] Both authors correctly point out that the path of the charge is semicircular and the motion is oscillatory if the charge starts from rest at a point on the plane bisecting the dipole and perpendicular to its axis. However, if the charge starts at other points, it will oscillate back and forth along a full semicircle if the direction of the initial velocity is parallel to the unit vector $\mathbf{u}_\theta$, and its magnitude is such that the total energy $E = mv^2/2 + (qp/4\pi\epsilon_0 r^2)\cos\theta$ is zero, because in this case the component of the force in the direction $\mathbf{u}_r$ produces exactly the necessary centripetal acceleration. This requirement limits the motion and the starting position to points below or above the plane, depending on whether the charge is positive or negative. The same behavior occurs with a pendulum if it is released at any angle with an initial velocity such that its total energy relative to the suspension point is zero.

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[1]C. McGuire, "Using computer algebra to investigate the motion of an electric charge in magnetic and electric dipole fields," Am. J. Phys. **71** (8), 809–812 (2003).
[2]S. Jones, "Circular motion of a charged particle in an electric dipole field," Am. J. Phys. **63** (11), 1042–1043 (1995).

