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 Running controversies among letter writers will not be published.

1937 NOBEL PRIZE

In the well-written and very informative article by J. Bernstein on Max Born published in this journal,[1] there is a small error. Bernstein writes, "In 1927, the Bell Telephone Laboratory physicists C. J. Davisson and L. H. Germer and independently, G. P. Thomson in England, showed that this wave nature was true experimentally. DeBroglie was awarded the Nobel Prize in 1929 and the three experimenters in 1937."

The truth is that only the two experimenters; C. J. Davisson and G. P. Thomson received the 1937 Nobel Prize in Physics, not L. H. Germer.[2] It would be very interesting if someone could offer an explanation of why Germer was exempt from the 1937 Nobel Prize.

[1] J. Bernstein, "Max Born and the quantum theory," Am. J. Phys. **73**, 999–1008 (2005).

[2] According to http://nobelprize.org/physics/laureates/1937/index.html, the 1937 Nobel Prize in Physics was awarded to Clinton Joseph Davisson (1/2 of the prize) and George Paget Thomson (1/2 of the prize) "for their experimental discovery of the diffraction of electrons by crystals."

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AUTHOR'S REPLY

Lester Germer was Davisson's assistant, and the Nobel committee no doubt took that into account.

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THE PIONEER SPACECRAFT

The problem set studying the anomalous acceleration of the Pioneer spacecraft[1] examines the Lorentz force generated by the interplanetary magnetic field (Problem 3.5), but neglects the force due to the electric field caused by the Sun's electric charge.

The Sun may be expected to have a positive electric charge, because the low mass of the electrons on the Sun's surface generates a larger population of electrons with the escape velocity compared to the slower thermal speeds of the protons. Equilibrium may be expected when the Sun has a charge of +77 C, as derived by Neslusan (Ref. 2, and references therein). The mass and anomalous acceleration of the spacecraft can be used to calculate the required force, and Coulomb's Law gives the amount of charge the spacecraft would have to have, as equal to 14 MC. This is completely unrealistic but worth checking as a pedagogical exercise.

[1] S. G. Turyshev, M. M. Nieto, and J. D. Anderson, "Study of the Pioneer anomaly: A problem set," Am. J. Phys. **73**, 1033–1044 (2005).

[2] L. Neslusan, "On the global electrostatic charge of stars," Astron. Astrophys. **372**, 913–915 (2001).

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AUTHOR'S REPLY

The recent reports on the anomalous acceleration of the Pioneer 10 and 11 spacecraft[1,2] have motivated a number of proposals to explain this anomaly. The letter to the editor by Steven Morris[3] is an example of this recent activity. In particular, Morris's letter discusses the potential influence of an electric force on the motion of the Pioneer probes. But not only do Morris's estimates put the Coulomb charge of the craft at the unrealistic value of 14 MC (which drastically disagrees with our value of 0.1 μC established from experimental situations), the force, expected from such an interaction, would necessarily exhibit a $1/r^2$ distance dependence. As the craft moved from 20 to 70 AU, this $1/r^2$ power law would necessarily have resulted in an order of magnitude decrease in the value of the corresponding Coulomb acceleration, which was not seen in the Pioneer data.[1]

Although we agree with Morris that, for illustrative and educational proposes, the acceleration due to an electric charge might have been included in our problem set,[2] the fact that the model disagrees so strongly with the data, in both size and functional form, led us to emphasize other possibilities.

Also, we disagree with Neslusan's claims[4] that the Sun's outer plasma is in electrostatic equilibrium and people have forgotten this for over 40 years. What really happened is that over the last 40 years the space program discovered that the Sun's plasma is strongly out of equilibrium and the solar wind sweeps out particles of all charges into deep space. Thus, a force due to a small electric charge accumulated on the craft moving through the interplanetary magnetic fields could be a more appropriate explanation of the effect. However, the strength of even this proposal is far too small to explain the detected Pioneer anomaly (as seen in Problem 3.5 of Ref. 2).

As far as the motion of Pioneer 11 is concerned, the spacecraft is headed toward the stars in the constellation of Aquila (The Eagle), northwest of the constellation of Sagittarius. Pioneer 11 will pass near one of the stars in the constellation in about four million years. If the anomaly is due to a conventional physics mechanism (such as a thermal recoil force from on-board power sources or propulsive gas leakage from the on-board propulsion system), the spacecraft will continue toward the original destination with a slightly perturbed trajectory. However, if this anomaly turns out to be due to some new physics, the spacecraft's dynamics will depend on the particular mechanism that is the origin of the anomaly. Our upcoming effort to analyze the recently recovered set of Doppler data for the durations of the Pioneer 10 and 11 missions should help us to establish the origin of the anomaly. The preliminary results of this analysis will be available in approximately one year.

[1] J. D. Anderson, P. A. Laing, E. L. Lau, A. S. Liu, M. M. Nieto, and S. G. Turyshev, "Study of the anomalous acceleration of Pioneer 10 and 11," Phys. Rev. D **65**, 082004/1–50 (2002), gr-qc/0104064.
[2] S. G. Turyshev, M. M. Nieto, and J. D. Anderson, "Study of the Pioneer Anomaly: A Problem Set," Am. J. Phys. **73**, 1033–1044 (2005), physics/0502123.
[3] S. Morris, "The Pioneer Spacecraft," Am. J. Phys. **74**, 373 (2006) (preceeding letter).
[4] L. Neslusan, "On the global electrostatic charge of stars," Astron. Astrophys. **372**, 913–915 (2001).

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REPEATED PROBLEM SOLVING

Fiona McDonnell's editorial, "Why so few choose physics" (July 2005, pp. 583-586), carries many messages for physics educators. One of them is that "repeated problem solving (with an emphasis on reduction and simplification) through application of formulas and equations" is alienating students from our profession. Although it has been said and documented many times that problem solving is greatly overemphasized in introductory courses for both scientists and nonscientists,[1–5] many teachers still cling to traditional math-based problems as their primary teaching tool. I hope that McDonnell's article will guide more instructors toward greater emphasis on qualitatively understanding the concepts of physics, in contrast to mechanically applying poorly understood equations.

[1] One of the earliest and best demonstrations is David Hestenes, Malcolm Wells, and Gregg Swackhamer, "Force concept inventory," Phys. Teach. **30**, 141–166 (1992).
[2] Paul C. Hewitt, "Directly to stage three—and you're out!," J. Coll. Sci. Teach. **24**, 6–7 (1994).
[3] John Roeder, "Hewitt champions relevancy of physics," report on a talk by Paul Hewitt, Teachers Clearinghouse for Science and Society Education, Spring 2004, p. 19. Copies are available from John Roeder, 194 Washington Road, Princeton, NJ 08540-6447, ⟨JLRoeder@aol.com⟩.
[4] Art Hobson, "Designing science literacy courses," J. Coll. Sci. Teach. **30**, 136–137 (2000).
[5] Barbara Whitten, Suzanne Foster, and Margaret Duncombe, "What works for women in undergraduate physics?," Phys. Today **56**(9), 46–51 (2003).

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