An Observation on Hofstadter's Butterfly

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1. J. D. Walker, *Am. J. Phys.* **44**, 421 (1976).
2. Reference 1, p. 424.

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Causes and Correlations of Master's Degree Statistics

The article in the June 2003 issue of PHYSICS TODAY (page 32) on master's degree recipients in physics states:

> People who added a master's to their resumé rated their undergraduate education as more useful preparation than those who stopped after the bachelor's. This rating shows the important role of physics departments, says report coauthor Rachel Ivie. "People who had a better undergraduate environment—better advising, better relationships with professors and other students—are more likely to complete graduate degrees."

Those statements are an example of the well-known fallacy of confusing correlation with causality. An equally plausible explanation, one of many possibilities, for why master's degree recipients gave a high rating of their undergraduate education is that students skilled in physics tend to enjoy their undergraduate education and also tend to obtain higher degrees. The study's authors are not necessarily wrong, but they certainly do not have the data to prove their point.

It is disappointing, but all too common, to see scientists abandon their logical skills in discussions of policy and other nonscientific matters.

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Ivie replies: Many skilled physics bachelors choose not to obtain graduate degrees for various reasons. And 60% of the physics bachelors who earned master's degrees did so in fields other than physics.

I suggest that Laurette Tuckerman read the full report, available at http://www.aip.org/statistics/trends/reports/masters.pdf. It details our multiple measures of physics bachelors' evaluations of their undergraduate experiences. As the report shows, those with graduate degrees in any field are more satisfied with undergraduate advising, supportiveness of professors, and working relationships with professors and students than are those without graduate degrees. However, those who earned master's degrees and work in scientific fields actually rate their undergraduate physics preparation lower than those who did not earn graduate degrees and who work in scientific fields. So at least retrospectively, physics bachelors without graduate degrees felt more prepared in physics than those who earned master's degrees in any field.

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Joseph Avron, Daniel Osadchy, and Ruedi Seiler have nicely highlighted the relevance of topological invariants, or Chern numbers, to the integer quantum Hall effect and to the conductance of a Hofstadter model when the Fermi energy lies in a gap (PHYSICS TODAY, August 2003, page 38).

As an addition to their remarks, it is intriguing and suggestive that one can go beyond these facts and construct, for the quantum Hall effect, a mean-field theory that has the unique property of covering both the integer and fractional regimes in a single framework. In such a model, Hofstadter's butterfly (figure 5 in the article) maps out the essence of what is observed in the lab: the odd-denominator selection rule and hierarchy in the plateau widths and resolution.[1] The surprising unity of the effect results simply from the unity of the butterfly spectrum, with its self-similar features reflecting the hierarchies seen at very low temperatures.

As Douglas Hofstadter mentioned in his PhD thesis, his friend David Jennings, on seeing the spectrum, described it as "a picture of God."[2] Perhaps that is going too far, but one can certainly see this particular butterfly flying very high.

References

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2. D. R. Hofstadter, "The Energy Levels of Bloch Electrons in a Magnetic Field," PhD thesis, U. of Oregon (1975), p. vii.

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Correction

December 2003, page 40—The Industrial Applications of Physics Prize, presented biennially by the American Institute of Physics, is sponsored by the General Motors Corp and AIP corporate associates. ■