

# Letters

## About W. R. Hamilton

Marc Dixmier, Dublin • Ireland

I wish to comment upon Luke Drury's interesting overview of Hamilton's scientific works, published in *Europhysics News* 37/1, 8 (2006).

Among his many contributions to Mathematics, Hamilton also delved into another sort of non-commutative algebra, that of square matrices, to which he contributed the theorem of Cayley-Hamilton: "any square matrix satisfies its own characteristic equation."

Hamilton's contributions to Optics, Mechanics and Algebra were actually connected in a much deeper way than he could have foreseen: the least-action principles of optics and mechanics led Louis de Broglie, in 1923-1924, to postulate the existence of matter waves. The non-commutation of operators forms the mathematical basis of the quantum uncertainty principle, put forward by Werner Heisenberg in 1925. These two approaches later merged into modern quantum mechanics.

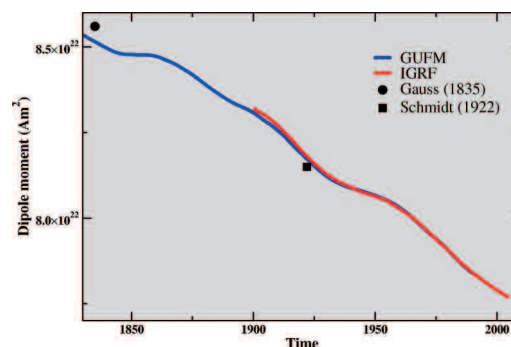
Although Hamilton did coin the expressions "scalar product" and "vector product", he is not the founder of modern vector calculus; that belongs to the American Josiah Willard Gibbs (1839-1903) whose methods superseded Hamilton's. I often think that this is unfortunate since Hamilton's quaternions provide a logical explanation for the breaking of time reversal symmetry and of mirror symmetry (i.e. parity) in some physical systems.

Since I now live in Ireland it is a pleasure for me to add my own contribution to the cult of William Rowan Hamilton. ■

## Remark on the Earth dipole moment decay

Emmanuel Dormy, CNRS/ENS/IPGP • France

In *Europhysics News* (Vol. 37/2), "The origin of the Earth's magnetic field", I present a figure showing the rapid decay of the Earth's dipole moment. This graph largely relies on the GUFM field model, which is based on historical measurement of field intensity and direction over the 1600-1990 period. This plot is often used to support the possibility of an approaching polarity reversal. In fact, as Dr. Frank Lowes kindly pointed to me, no direct intensity measurements were available prior to C.F. Gauss's invention of a method for determining intensity in 1832. As a result, while directional observations over the period 1600-1832 can constrain field morphology, the intensity is left unknown. Following Barraclough (1974), the GUFM model was therefore scaled in time assuming a linear decrease of the axial dipole strength. It results that there is absolutely no evidence in the GUFM model for, or against, a decrease in the dipole moment prior to 1832. The decrease in dipole moment, as shown in figure 1 of the article, is only supported by observations after 1832 (see figure, with historical measurements after Fraser-Smith, 1987). This fact only appears to weaken the clues for an approaching reversal. For completeness, we should however note that indirect intensity measurements from archaeological sources appear to confirm field decay over the last 3000 years. ■



## References

- [1] D.R. Barraclough, "Spherical Harmonic Analyses of the Geomagnetic Field for Eight Epochs between 1600 and 1910", *Geophys. J. R. Astr. Soc.*, 36, 497-513 (1970).
- [2] A.C. Fraser-Smith, "Centered and Eccentric Geomagnetic Dipoles and Their Poles, 1600-1985", *Reviews of Geophysics*, 25, 1-16 (1987).

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