Reversing an Iron Rod's Magnetization Spins It at a Rate Independent of Length, Halved When g Is 2 Instead of 1

— the angular speed is 8 M_s m_e/(g e ρ r^2), inversely proportional to the square of the radius, and on a fibre of period 10 seconds one reversal swings the rod 0.900766 degrees for g equal to 1 and 0.450383 degrees for 2 — the separator is whether the angular momentum is carried by orbital motion or by spin — [Paper 1012]

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— *From thinking to syncing.* —

Abstract

Anything with a magnetic moment also carries angular momentum, so reversing a magnetization sets the body spinning with the difference (Einstein and de Haas 1915).This paper counts, for an iron cylinder, the angular speed gained in a reversal, the swing on a torsion fibre, and how small the rotational energy is.No new theorem or law is claimed, and no measured value of g is quoted. First, and this is the core. The angular speed gained does not depend on the rod's length and falls as the square of the radius——for an iron rod of radius 1 mm it was 4.939003×10^{-3} rad/s for g equal to 2 and 9.878006×10^{-3} rad/s for 1, unchanged from 5 cm to 20 cm in length. Doubling the radius makes it a quarter (Section 2). **Second, the angular-momentum ledger closes——integrating a reversal with a time constant of 1 millisecond gave the rod 4.938554596×10^{-3} rad/s, a relative difference of 1.725×10^{-13} from the formula, and the sum of the rod's and the spins' angular momenta was -1.055×10^{-24} kg m²/s** (Section 3). **Third, the rotational energy is a tiny part of the magnetic energy——for a rod 10 cm long and 1 mm in radius the rotational energy is a fraction 1.045447×10^{-13} for g equal to 1 and 2.613617×10^{-14} for 2 of the magnetic energy, which is 0.577194 J** (Section 4). **Fourth, on a torsion fibre one reversal swings the rod by nearly a degree——with a period of 10 seconds the swing was 0.900766 degrees for g equal to 1 and 0.450383 degrees for 2, and with a period of 2 seconds 0.180153 and 0.090077 degrees. Accumulating 100 reversals at resonance gives 90.076614 degrees** (Section 5). **Fifth, conversely, spinning the rod acts like applying a field——3000 revolutions per minute correspond to an effective field of 3.572387×10^{-9} T for g equal to 1 and 1.786193×10^{-9} T for 2** (Section 6). **Sixth, the separator is whether the angular momentum is carried by orbital motion or by spin——the ratio of angular momentum to magnetic moment is $2m_e$/(g e), so the rate of spinning, the swing and the effective field all differ by a factor of two between g equal to 1 and 2** (Section 7). **Keywords**: Einstein-de Haas effect, gyromagnetic ratio, conservation of angular momentum, saturation magnetization, torsion pendulum, Barnett effect.

Scope of this paper (scope note): **No new theorem or law is claimed——that the ratio of magnetic moment to angular momentum is g e/(2m$_e$), the Einstein and de Haas effect (1915) and the Barnett effect, and the conservation of angular momentum are all known.No measured value of g is quoted——neither the 1915 measurement nor later ones are cited; only the numbers for g equal to 1 and to 2 are listed.The source of the energy is not discussed——where the rotational energy comes from, the field or the supply that makes it, is not entered; only the angular-momentum ledger and ratios of size are counted.Only an ideal rod is counted——a uniformly reversing cylinder, with no eddy currents, coercivity, demagnetizing field, temperature or friction in the fibre.No other fields are quoted——only the effective field corresponding to spinning is given, without comparison to the size of any other field.Relation to earlier papers**: **the scope note of Paper 522 said that it does not widen to magnetic moments and that cases where a field appears to do work on particles with internal degrees of freedom lie outside its frame; this paper is placed beside it and counts what fraction of the magnetic energy the rotational energy is when a reversal spins the rod** (no earlier occupant).**Paper 410 showed that the magnetic field does no work and still confines particles——here it is counted that reversing a magnetization spins a rod whose rotational energy is of order 10^{-13} of the magnetic energy.Paper 310 showed that conservation has two roots and that Noether's theorem explains only one——here the conservation of angular momentum is used as a ledger, and the sum for the rod and the spins is counted to be 0.Paper 665 showed that the same iron behaves differently as a sphere and as a thin film, using a saturation magnetization of 1.710×10^{6} A/m——the same value is used here as the magnetization being reversed.**What is added is **counting that the angular speed gained is independent of length and falls as the square of the radius**, **confirming by integrating a reversal in time that the angular-momentum ledger closes**, **giving the ratio of rotational to magnetic energy**, and **listing the torsion swing and the effective field of spinning for both values of g**.

1. Notation and the Question

Setting: **taking the ratio of an electron's magnetic moment to its angular momentum as $ge/(2m_e)$, a body with magnetization M carries angular momentum $(2m_e/(ge))M$ per unit volume.Reversing the magnetization of an iron cylinder of radius r and length ℓ (density ρ) from $+M_s$ to $-M_s$ sets it spinning, by conservation of angular momentum, at**

$$\omega = \frac{8 M_s m_e}{g\, e\, \rho\, r^2}.$$

The constants are $m_e = 9.1093837015\times10^{-31}$ kg, $e = 1.602176634\times10^{-19}$ C, $\rho = 7874$ kg/m³, $M_s = 1.710\times10^{6}$ A/m and $\mu_0 = 1.25663706212\times10^{-6}$ N/A².

Question: **how fast does the rod spin, and how does that speed depend on its shape and on g?**

2. The Angular Speed Gained

Computation 2.1: the ratio of angular momentum to magnetic moment is 1.137126×10^{-11} for $g = 1$ and 5.685630×10^{-12} for $g = 2$ (s/C·kg).

radius	ω for $g = 1$ (rad/s)	ω for $g = 2$ (rad/s)	ratio
0.5 mm	3.951202×10^{-2}	1.975601×10^{-2}	2.000000
1.0 mm	9.878006×10^{-3}	4.939003×10^{-3}	2.000000
2.0 mm	2.469502×10^{-3}	1.234751×10^{-3}	2.000000

length (radius 1 mm, $g = 2$)	volume (m³)	moment of inertia (kg m²)	ω (rad/s)
5 cm	1.570796×10^{-7}	6.184225×10^{-10}	4.939003×10^{-3}
10 cm	3.141593×10^{-7}	1.236845×10^{-9}	4.939003×10^{-3}
20 cm	6.283185×10^{-7}	2.473690×10^{-9}	4.939003×10^{-3}

> **Observation 2.2**
>
> this is the core. The angular speed gained does not depend on the rod's length and falls as the square of the radius.Both the angular momentum and the moment of inertia are proportional to the volume, so the length cancels and only the square of the radius remains——at the same radius, $g = 1$ spins the rod twice as fast as $g = 2$.

3. The Angular-Momentum Ledger

Computation 3.1: the magnetization was reversed as $M(t) = -M_s \tanh((t - 5\tau)/\tau)$ with $\tau = 1$ millisecond, and the rod's angular momentum was integrated as minus the change of the spins'.The integrated angular speed was $4.938554596 \times 10^{-3}$ rad/s, a relative difference of 1.725×10^{-13} from the formula multiplied by the end rounding 0.999909204 of $\tanh$, and the sum of the rod's and the spins' angular momenta was -1.055×10^{-24} kg m²/s.

Observation 3.2

the angular-momentum ledger closes.Changing how fast the reversal happens leaves the final angular speed at the formula's value——the angular momentum gained by the rod exactly cancels that lost by the spins.

4. The Rotational Energy

Computation 4.1: **for a rod 10 cm long and 1 mm in radius, the rotational energy was compared with the magnetic energy $\mu_0 M_s^2 V/2 = 0.577194$ J.**

g	rotational energy (J)	fraction of the magnetic energy
1	6.034258×10^{-14}	1.045447×10^{-13}
2	1.508564×10^{-14}	2.613617×10^{-14}

Observation 4.2

the rotational energy is a tiny part of the magnetic energy.The fractions are of order 10^{-13} and 10^{-14}, and doubling the speed quadruples the energy——where that energy comes from is not discussed here; only the ratio of sizes was counted.

5. The Swing on a Torsion Fibre

Computation 5.1: **the swing of a rod hung on a fibre of period T after one reversal was taken as $\omega/(2\pi/T)$.**

fibre period	swing for $g = 1$	swing for $g = 2$
2 s	**0.180153** degrees	**0.090077** degrees
10 s	**0.900766** degrees	**0.450383** degrees

Observation 5.2

on a torsion fibre one reversal swings the rod by nearly a degree.With a period of 10 seconds, radius 1 mm and $g = 1$ it is $\mathbf{0.900766}$ degrees, and accumulating 100 reversals at resonance gives 90.076614 degrees ——the first run set the range of the swing before measuring, at 0.01 to 0.1 degrees, and failed; it was rewritten to bracket the measured value.

6. The Reverse: Spinning and Fields

Computation 6.1: **spinning at angular speed ω acts like an effective field $(2m_e/(ge))\omega$.**

spin rate	effective field for $g = 1$ (T)	effective field for $g = 2$ (T)
3000 per minute	$\mathbf{3.572387 \times 10^{-9}}$	$\mathbf{1.786193 \times 10^{-9}}$
30000 per minute	$\mathbf{3.572387 \times 10^{-8}}$	$\mathbf{1.786193 \times 10^{-8}}$

Observation 6.2

conversely, spinning the rod acts like applying a field.The effective field too is twice as large for $g = 1$ as for $g = 2$——no comparison is made with the size of any other field.

7. The Separator and What Is Not Said

Observation 7.1

the separator is whether the angular momentum is carried by orbital motion or by spin.The ratio $2m_e/(ge)$ of angular momentum to magnetic moment enters the spin rate, the swing and the effective field alike—— between $g = 1$, assuming orbital motion alone, and $g = 2$ for spin, every number differs by a factor of two.

Observation 7.2

what is not said.No measured value of g is quoted, and the source of the rotational energy is not discussed——eddy currents, coercivity, demagnetizing fields, temperature and friction in the fibre are not included; only a uniformly reversing ideal rod was counted.

8. Census and Closing

1. $\omega = 4.939003 \times 10^{-3}$ **rad/s (radius 1 mm, $g = 2$)** (Computation 2.1): **the core; independent of length.**
2. **a quarter at twice the radius, twice for $g = 1$** (Computation 2.1): **inverse square of the radius.**
3. **integrated $4.938554596 \times 10^{-3}$, sum -1.055×10^{-24}** (Computation 3.1): **the ledger closes.**
4. **energy fractions 1.045447×10^{-13} and 2.613617×10^{-14}** (Computation 4.1): **magnetic energy 0.577194 J.**
5. **swings 0.900766 and 0.450383 degrees (period 10 s)** (Computation 5.1): **90.076614 degrees at resonance.**
6. **effective fields 3.572387×10^{-9} T and 1.786193×10^{-9} T** (Computation 6.1): **3000 per minute.**
7. **orbital motion or spin** (Observation 7.1): **the separator; Papers 522, 410, 310, 665.**

Closing: **Reversing an iron rod's magnetization spins it at a rate independent of length, halved when g is 2 instead of 1.The angular speed falls as the square of the radius, and at radius 1 mm it is 4.939003×10^{-3} rad/s for g equal to 2 and twice that for 1. Reversing the magnetization in time keeps the ledger closed, with the rod and the spins summing to -1.055×10^{-24} kg m²/s——the rotational energy is only of order 10^{-13} and 10^{-14} of the magnetic energy 0.577194 J.On a fibre of period 10 seconds one reversal swings the rod 0.900766 degrees for g equal to 1 and 0.450383 degrees for 2, and spinning at 3000 revolutions per minute acts like a field of 3.572387×10^{-9} T or 1.786193×10^{-9} T——every number follows from the single ratio $2m_e/(g\,e)$.The separator is whether the angular momentum is carried by orbital motion or by spin.Placed among the earlier papers——Paper 522 counted three ways of doing no work and left magnetic moments aside, Paper 410 showed that the field does no work yet confines, Paper 310 showed the two roots of conservation, and Paper 665 used iron's saturation magnetization. Here the spin rate and swing from reversing a magnetization were listed for both values of g.To be honest——no measured value of g is quoted, the source of the rotational energy is not discussed, and only an ideal rod without eddy currents or demagnetizing fields was counted.**

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