Entertaining Research

Alicious Adventures of a Malkanthapuragudi-an! (Perseus cluster — thanks to Chet at Science Musings blog)

The case of the curious reference

Today, I came across a reference to what is called Landau-Lifshitz-Gilbert (http://en.wikipedia.org/wiki/Micromagnetism) equation; a little bit of googling got me the reference to Gilbert's paper (http://portal.acm.org/citation.cfm?id=1111034):

> T.L. Gilbert, A Lagrangian formulation of the gyromagnetic equation of the magnetic field, Phys. Rev. 100 (1955) 1243.

However, when I tried Phys. Rev. site (http://prola.aps.org/), I got the error message:

> Phys. Rev. **100** 1243
> **No data available for this citation**
>
> A valid journal, volume, and page or article id are required. Please try again.

So, I thought there probably is something wrong with the page numbers; I thought a Google Scholar (http://scholar.google.com/scholar?q=T+L+Gilbert&hl=en&lr=&btnG=Search) search might help me get the correct volume and/or page number. That didn't help me either:

> **[CITATION]** A Lagrangian formulation of gyromagnetic equation of the magnetization field
> **TL Gilbert** – Phys. Rev, 1955
> Cited by 272 (http://scholar.google.com/scholar?hl=en&lr=&safe=off&cites=15417948337421566162) – Related Articles (http://scholar.google.com/scholar?hl=en&lr=&safe=off&q=related:0kBWOVOO99UJ:scholar.google.com/) – Web Search (http://www.google.com/search?hl=en&lr=&q=%22Gilbert%22+%22Lagrangian+formulation+*+gyromagnetic%22)

Now, that is strange; there is only citation (and, a whopping 272 at that), but, no link to the article itself. Surely, there is no way so many of them got it wrong.

I went back to PROLA and browsed through the volume 100 of Phys. Rev. to find that pp. 1236-1272 (http://prola.aps.org/vtoc/PR/v100) are missing; however, the stuff that is published on p.1235 of the issue indicates that the missing pages should contain some abstracts, and probably Gilbert's paper is one among them.

This suspicion was confirmed when I found this page (http://portal.acm.org/citation.cfm?id=1247765.1248364&coll=GUIDE&dl=%23url.coll):

> T.L. Gilbert. Phys. Rev., 100:1243, 1955. [Abstract only; full report, Armor Research Foundation Project No. A059, Supplementary Report, May 1, 1956] (unpublished).

Wow! Finally, a couple of researchers who not only took the pains to locate the article (abstract, in this case) but also to note it for those who might be trying to hunt it down.

Of course, I do not understand why Phys. Rev does not host pdf pages of these abstracts in their archive. In any case, a visit to the library helped me get the abstract, which reads as follows:

> D6. **A Lagrangian formulation of the gyromagnetic equation of the magnetization field**. T. L. Gilbert, *Armour Research Foundation of Illinois Institute of Technology*.–The gyromagnetic equation, $d\mathrm{M}/dt = \gamma \mathrm{M} \times \mathcal{G}$, for the motion of the magnetization field $\mathrm{M}(\mathbf{r})$, in a ferromagnetic material can be derived from a variation principle, as first shown by Doering.[1] Here $\mathcal{G}$ is the effective internal field, including the magnetic field and contributions from exchange, anisotropy, and magnetoelastic effects. Using the variational principle, the equations of motion can be recast into a Lagrangian form. This makes possible a consistent derivation of the equations of motion of the magnetization field and other fields to which it may be coupled (e.g., the displacement field of the lattice and the electromagnetic field). It also permits the introduction of viscous damping effects in a consistent manner using the Rayleigh dissipation function. It is shown that viscous damping of the magnetization fields leads to an equation of motion which reduces to the Landau-Lifshitz equation only when the damping is small. It is also shown that this Lagrangian formalism permits the introduction f damping due to disaccomodation in a consistent and very general way.
>
> [1] W. Doering, Z. Naturforsch. **3a**, 374 (1948)

So, there are a couple of morals to this story: sometimes, if it is good enough, a paragraph like above can get you hundreds of citations; and, if you find some pages of Phys Rev are missing (before 1955; a note in 1955, Vol. 100, issue 4 notes that they will not be published thenceforth), it probably is an abstract of some meeting, and you can only get it in the hard copy format.

Well, the successful resolution of the mystery calls for a cup of coffee, don't you think! See you around.

PS: For those of you who are interested in using LLG equation to numerically solve domain evolution in giant magnetostrictive materials (of course, using phase field methods — you knew it was coming, didn't you?), here is a paper (http://dx.doi.org/10.1016/j.actamat.2005.03.002):

Title: Phase-field microelasticity theory and micromagnetic simulations of domain structures in giant magnetostrictive materials

Authors: J.X. Zhang and L.Q. Chen

Abstract:

A computational model is proposed to predict the stability of magnetic domain structures and their temporal evolution in giant magnetostrictive materials by combining a micromagnetic model with the phase-field microelasticity theory of Khachaturyan. The model includes all the important energetic contributions, including the magnetocrystalline anisotropy energy, exchange energy, magnetostatic energy, external field energy, and elastic energy. While the elastic energy of an arbitrary magnetic domain structure is obtained analytically in Fourier space, the Landau–Liftshitz–Gilbert equation is solved using the efficient Gauss–Seidel projection method. Both Fe81.3Ga18.7 and Terfenol-D are considered as examples. The effects of elastic energy and magnetostatic energy on domain structures are studied. The magnetostriction and associated domain structure evolution under an applied field are modeled under different pre-stress conditions. It is shown that a compressive pre-stress can efficiently increase the overall magnetostrictive effect. The results are compared with existing experiment measurements and observations.

Have fun!

Tags: citation (https://mogadalai.wordpress.com/tag/citation/), ferromagnetism (https://mogadalai.wordpress.com/tag/ferromagnetism/), giant magnetostrictive materials (https://mogadalai.wordpress.com/tag/giant-magnetostrictive-materials/), gyromagnetic equation of the magnetic field (https://mogadalai.wordpress.com/tag/gyromagnetic-equation-of-the-magnetic-field/), Lagrangian formulation (https://mogadalai.wordpress.com/tag/lagrangian-formulation/), Landau Lifshitz Gilbert equation (https://mogadalai.wordpress.com/tag/landau-lifshitz-gilbert-equation/), LLG (https://mogadalai.wordpress.com/tag/llg/), Magnetism (https://mogadalai.wordpress.com/tag/magnetism/), micromagnetism (https://mogadalai.wordpress.com/tag/micromagnetism/), phase field modelling (https://mogadalai.wordpress.com/tag/phase-field-modelling/)

This entry was posted on October 11, 2007 at 2:26 pm and is filed under Academic life, Materials Science. You can follow any responses to this entry through the RSS 2.0 feed. You can leave a response, or trackback from your own site.

11 Responses to “The case of the curious reference”

Guru Says:
October 14, 2007 at 9:14 pm | Reply
Dear Ortigoza,

Thanks for stopping by and the reference. One good thing about blogs is that such information can be published almost immediately, so that, if somebody else is googling for the same stuff, the information becomes available immediately.

MARISOL ALCANTARA ORTIGOZA Says:
October 14, 2007 at 7:30 pm | Reply
Hi,

Last week, I was also deperately trying to find that inexistent paper cited about 200 times at least. Even of the pages are missing it should be recorded in the list of publications of Gilbert given by the APS.
He never published his work, as he mentioned in the paper below in 2004. Some people even cite his PhD thesis which was not published either. Fortunately, Gilbert published his work recently and clarified this messy situation:

AUTHOR = {T. L. Gilbert},
JOURNAL = IEEE Trans. Mag.,
VOLUME = {40},
PAGES = {3443},
YEAR = {2004}

Thanks for opening this page.

NNS Says:
January 17, 2008 at 7:34 pm | Reply
I was also searching for the source paper, or a book describing the origin of the LLG equation. Your blog and Ortigoza’s reference was a great help.

Christine Says:
June 6, 2008 at 5:23 pm | Reply
Thanks! I have searched for that reference many times and never understood why it wasn’t available!

Guru Says:
June 6, 2008 at 5:50 pm | Reply
Dear Christine,

Thanks for stopping by and it is my pleasure; by the way, I checked out your blog and it is very nice and interesting.

Guru

Srinivas Says:
July 8, 2008 at 10:24 pm | Reply

Hi Guru,
Pretty much I have hone through same hassle. Your blog helped me in understanding what has been done in the past. I need detailed explanation of LL and LLG equations. Can you please tell me the correct source. Can you please reply onto email "polisetty.srinivas@gmail.com" in addition to pasting here in this blog.
Thanks,
Srinivas

Wayne Saslow Says:
September 7, 2008 at 1:01 am | Reply
Thank you for posting this abstract. I had once looked it up, but I had forgotten it. If you like, I can send you a pdf of the article T. L. Gilbert and J. M. Kelly, "Anomalous rotational damping in ferromagnetic sheets", Conf. Magnetism and Magnetic Materials, Pittsburgh, PA, June 14–16, 1955 (NewYork: American Institute of Electrical Engineers, Oct. 1955, pp. 253-263). I will be giving a talk on this at the MMM conference in Austin this November. I already had strong theoretical reasons that Gilbert damping is wrong. This paper gives the data and the analysis that supports the statement that, for large damping, Gilbert damping gives a better for to the data than LL damping. However, an expert in the field (Sam Bhagat, of Maryland), said he knows of no one else who has used the non-resonant experimental method of Kelly. Personally I doubt the samples were homogeneous enough to neglect inhomogeneous broadening, and that the magnetic fields were aligned well enough to satisfy the assumptions of the theory. That enough would explain why LL damping (which neglects inhomogenous broadening) would fail.

Steven Says:
April 3, 2009 at 7:00 pm | Reply
Thanks.

Manu Paranjape Says:
April 27, 2011 at 2:57 am | Reply
I referred to the paper by Gilbert, without ever looking at it… then the page proofs guys could not find it! Can we ask PROLA to post it?

Barney Says:
July 22, 2014 at 5:39 am | Reply
Wow, I've been looking for this paper for like an hour. Thanks for pursuing this!!!

Wayne Saslow Says:
January 31, 2015 at 9:26 pm | Reply
Six comments:
1) Gilbert introduced the constant alpha (precessional analog of inverse Q in oscillation). I think this will survive although I do not favor the Gilbert form of damping.
2) I have posted the nearly 60-year-old MMM paper (1st MMM Conference!) by Gilbert and Kelly at http://people.physics.tamu.edu/saslow/MMMConf55_253GilbertKelly.pdf. Gilbert told me by phone (2007?) that text references to the non-existent Figures 5 and 6 likely are to Tables 1 and 2, which makes sense to me. Kelly performed non-resonant experiments on a thin permalloy disk, measuring torque vs frequency. Gilbert gave a nice analysis and concluded that LL damping couldn't fit the data, which prompted him to come up with his own theory. With his theory he could fit torques at six frequencies using a constant Gilbert gamma, but he had to let alpha vary with frequency, being as large as 9 at the lowest frequencies.
3) I just obtained a copy of Gilbert's PhD and it is rather different than the IEE article. I have not had the time to read it.
4) I critique the theory of Gilbert damping in "Landau–Lifshitz or Gilbert damping? That is the question," J. Appl. Phys. 105, 07D315 (2009). At least three independent derivations using

irrreversible thermodynamics obtain Landau-Lifshitz damping. Key objections are that mxH is the appropriate thermodynamic "force", and that mx(dm/dt) has no definite signature under time-reversal.

5) In Appendix B of "Spin Hall effect and irreversible thermodynamics: Center-to-edge transverse current-induced voltage." Phys. Rev. B 91, 014401 (2015), I critique Gilbert's interpretation of Kelly's data in terms of a theory that considers only variations that are continuous (in magnetization space). Cited late 1950's papers by devoted magneticians note that permalloy films have (apparently due to substrate strain) uniaxial anisotropy, so that for a rotating magnetic field at low frequencies a thin film of permalloy can flip from one minima to another. Such flip provides an excess source of dissipation that cannot be expressed in terms of continuous motions (as with LL or LLG damping).

6) Form your own opinion!