Index of Notes

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Contents

Preliminary

you might want this one

!!! Important In order to save on export just use a vim-macro `@s` is save and git export, this is way easier

Then you can just use F4 to execute the last macro over and over.
so do <Esc> q s SPC f s SPC m e h h Enter then use F4 to save
just append a 0 to the name of the default CSS !!!
TODO Write up notes on good coding style here
The Markdown Wiki

- Searching
  - Through Notes

SEARCH ~/Notes	emacs	vim	Bash
Filename	Not that I'm aware of	:FZF <CR> ~/Notes	cd ~/Notes ; =fzf
File Contents (by Line ONLY!)	Spc a o / ; (occur-in-agenda-files)	:Rg	cd ~/Notes ; rg / (

- You Could also use Spc a o m to get tags
- Across Drive:

SEARCH ~/	emacs	vim	Bash
Filename	helm-locate ; SPC f L	:FZF	fzf
File Contents	helm-ag	:Rg	rg / (s) sg / ack / grep

- If you know exactly where the file is you could also use helm-find-files ; SPC f f

To search only agenda files use SPC a o / To search all files use helm-ag or use vim C-p, vim :rg
To search all file names use helm-locate which is SPC f L or use fzf

Using Org

Main Org Notes
TODO All these links point to ‘org‘ files for some reason, I can't make the links behave.

Data Science Notes

Introduction to data science IntroDataSci

Supervised Learning

1. Regression
   - (02/03) Simple and Multiple Linear Regression
2. Classification
3. Re-sampling Methods

[1] find ~/Notes -name KEYWORD

Unsupervised Learning

1. Principal Component Analysis (PCA)
2. Clustering

Data Visualisation

Using Data Visualization with ggplot2 (Part 2)

Statistics Dump

I've just taken that massive Word Document of statistics work and converted it to `org` as a sort of expermient

Time Series Analysis Stats Export Stats Export

Predictive Modelling

- All the PDF Notes
  - RelativeLink

Mathematics

Abstract Algebra

Abstract Algebra

Calculus ATTACH

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preliminary

- Fundamental Theorem of Calculus

PDF Notes ATTACH

- Math Modelling Notes
  - LaTeX Source
- Calculus Rules

Analysis

1. Notes All the notes I took in class are: Tex Source Files are Currently In This Directory

    - 1. Sets
    - 1. Sets
    -
    - 2. Sequences
        - 1. Sequences (Cauchy Criterion)
    - 3. Series
        - 1. Series (Old)
        - 2. Series (Stewart Calculus Excerpt)
    - 4. Limits
    - 5. Continuity
    - 6. Stu-vac
    - 7. Complex Values
    - 8. Complex Variables
    - 9. Elementary Functions
    - 10. Complex Integrals
    - 11. Power Series (MD)
        - 1. Power Series Excerpt

2. Working The working is all handwritten so I couldn't attach it, there linked here in Dropbox.

3. TextBooks The textbooks can be found here in Dropbox Textbooks

Statistics ATTACH

- Time Series Analysis
    - PDF Version
        - Word Document
        - (02) Confidence and Prediction Intervals TimeSeries
            - LaTeX Source
- Stats Export
    - Simple Linear Regression

Note Taking Manual

- NoteTaking

The manual for my strategy

Journal

Correspondence

1. Zheng

   (a) Email to Zheng Related to Damping Dear Dr Zheng,
   Sorry for the late reply, I've been really busy with Christmas.

   i. Should k always be positive? I wasn't able to clearly interpret what the *Bloom* paper was trying to express with regard to any values for damping, it just wasn't clear to me. Instead what i did was:

   A. Solve the Cross Product to given the Bloch Equations
   B. Numerically Solve the Bloch Equations
   C. Generate a Plot
   D. Reduce the domain of the plot until the plot has a reasonable number of periods
   E. Create a dynamic Plot allowing me to sweep a range of k values that produce any change.

   A. Laboratory Frame
   B. Math So in the laboratory frame:

$$\mathbf{B} = \begin{pmatrix} B_{\mathrm{RF}} \cdot \cos(\omega_{\mathrm{RF}} \cdot t + \phi_0) - k \cdot M_y \\ B_{\mathrm{RF}} \cdot \sin(\omega_{\mathrm{RF}} \cdot t + \phi_0) + k \cdot M_x \\ B_0 \end{pmatrix} \mathbf{M} \quad = \begin{pmatrix} M_x \\ M_y \\ M_z \end{pmatrix}$$

   and hence:

$$\begin{aligned}\frac{\mathrm{d}\mathbf{M}}{\mathrm{d}t} &= M \times B - \mathbf{R}(\mathbf{M} - M_0) \\ &= \begin{pmatrix} \gamma\left[B_0 y - kxz + B_{\mathrm{RF}} z \sin(\phi + t\omega)\right] - R_2 x \\ \gamma\left[-B_0 x - kyz + B_{\mathrm{RF}} z \cos(\phi + t\omega)\right] - R_2 y \\ \gamma\left[kx^2 + ky^2 - B_{\mathrm{RF}} y \cos(\phi + t\omega) - B_{\mathrm{RF}} x \sin(\phi + t\omega)\right] - R_1(z - M_0) \end{pmatrix}\end{aligned}$$

   If I solve this Differential Equation Numerically, I have no problem getting solutions for an arbitrarily long time period, although if we were to do something like a binomial pulse then the pulse duration would have to be much smaller in order to generate points corresponding to different IC's.
   So for example using the following code I could solve for an entire 1 ms pulse, but because there are so many periods it isn't very useful:

   C. Code

```
In[321]:= Clear["Global`*"]
Remove["Global`*"]
Clear[Derivative]
```

```
T1=4;
R1=1/T1;
R2=1/2;
M0=1;

=Pi;
IC={0,0,1};
length =0.1*10^-6;
=42.65*10^8;
=42.65*10^6;
Brf = 2*10^-3;
k=200*Brf
B0=11.7; (*11.7 Tesla Corresponding to 500 Mhz at-resonance Pulse *)
=*B0*1.000(* 2 N[Pi] *);



(*length=/;*)
BlochX=x'[t]==-R2 x[t]+ (B0 y[t]-k x[t] z[t]+Brf z[t] Sin[+t ]);
BlochY=y'[t]==-R2 y[t]+ (-B0 x[t]-k y[t] z[t]+Brf z[t] Cos[+t ]);
BlochZ=z'[t]==-R1 (-M0+z[t])+ (k (x[t])^2+k (y[t])^2-Brf y[t] Cos[+t ]-Brf x[t]
(s=NDSolve[{BlochX, BlochY, BlochZ, x[0]==IC[[1]], y[0]==IC[[2]], z[0]==IC[[3]]
x[t_] = x[t] /. s[[1]];
y[t_] = y[t] /. s[[2]];
z[t_] = z[t] /. s[[3]];

{x[length], y[length], z[length]}

Plot[x[t],{t,0,length}]
Plot[y[t],{t,0,length}]
Plot[z[t],{t,0,length}, PlotRange->Full]
z[ Range[0,length,length/100]]
```

D. Results

Figure 1: image-20191225113857809

E. Smaller Domain By reducing this to a 0.1 \$$\mu$\$s pulse the results become more meaningful:

Choosing a \$k\$-value
For a pulse of 0.1 μ s, I tried a variety of k values, I found that only k values from -50 to about 5 made any significant difference, this is shown in the animation here

https://ryangreenup.github.io/NMR-Project/Working/RadiationDamping/RadiationDamping.html#laboratory-frame

F. Rotating Frame

G. Math So in the rotating Frame:

$$\mathbf{B} = \begin{pmatrix} B_{\mathrm{RF}} \cdot \cos\left(0 \times t + \phi_0\right) - k \cdot M_y \\ B_{\mathrm{RF}} \cdot \sin\left(0 \times t + \phi_0\right) + k \cdot M_x \\ \Delta B_0 \end{pmatrix} = \begin{pmatrix} B_{\mathrm{RF}} \cdot \cos\left(\phi_0\right) - k \cdot M_y \\ B_{\mathrm{RF}} \cdot \sin\left(\phi_0\right) + k \cdot M_x \\ \frac{\Omega}{\gamma} \end{pmatrix} \mathbf{M} = \begin{pmatrix} M_x \\ M_y \\ M_z \end{pmatrix}$$

and hence:

$$\begin{aligned} \frac{\mathrm{d}\mathbf{M}}{\mathrm{d}t} &= M \times B - \mathbf{R}\left(\mathbf{M} - M_0\right) \\ &= \begin{pmatrix} \gamma\left[-kxz + \frac{y\Omega}{\gamma} + B_{\mathrm{RF}} z \sin\left(\phi\right)\right] - R_2 y \\ \gamma\left[-kyz - \frac{x\Omega}{\gamma} + B_{\mathrm{RF}} z \cos\left(\phi\right)\right] - R_2 y \\ \gamma\left[kx^2 + ky^2 t - B_{\mathrm{RF}} y \cos\left(\phi\right) - B_{\mathrm{RF}} x \sin\left(\phi\right)\right] - R_1\left(z - M_0\right) \end{pmatrix} \end{aligned}$$

This can just as easily be solved numerically and plotted

H. Code

```
Clear["Global`*"]
Remove["Global`*"]
Clear[Derivative]

T1=4;
R1=1/T1;
R2=1/2;
M0=1;

=0;
IC={0,0,1};
length =1*10^-3;
=42.65*10^6;
Brf = 2*10^-3;
k=0.0001;
=5000;

(*length=/;*)
BlochX=x'[t]==-R2 x[t]+ (-k x[t]* z[t]+(y[t] )/+Brf z[t] Sin[]);
BlochY=y'[t]==-R2 y[t]+ (-k y[t]*z[t]-(x[t] )/+Brf z[t] Cos[]);
BlochZ=z'[t]==-R1 (-M0+z[t])+ (k (x[t])^2+k (y[t])^2-Brf y[t] Cos[]-Brf x[t] Si
(s=NDSolve[{BlochX, BlochY, BlochZ, x[0]==IC[[1]], y[0]==IC[[2]], z[0]==IC[[3]]
x[t_] = x[t] /. s[[1]];
y[t_] = y[t] /. s[[2]];
z[t_] = z[t] /. s[[3]];

{x[length], y[length], z[length]};
```

```
Plot[x[t],{t,0,length}, PlotRange->Full, PlotLabel->"X-Value of Magnetic Moment
Plot[y[t],{t,0,length}, PlotRange->Full, PlotLabel->"X-Value of Magnetic Moment
Plot[z[t],{t,0,length}, PlotRange->Full,PlotLabel->"X-Value of Magnetic Moment

(*z[ Range[0,length,length/100]]*)
```

I. Results

Figure 2: image-20191225120345717

J. Longer Pulse I could have also pulsed this longer in the rotating frame, a 100 s pulse returned:

Figure 3: image-20191225121305034

K. Choosing a k value In this case I only found that k values from -0.1 to 0.1 made any significant difference, the varying k values are shown in the animation here.

   https://ryangreenup.github.io/NMR-Project/Working/RadiationDamping/RadiationDamping.html#rotating-frame

ii. Length of Pulse

- I set the phase of the pulse to 0^o rather than 90^o but I don't think that should make a significant difference
- The strength of the RF-Pulse is 1 mT.
  - i.e.ă$B_{\mathrm{RF}} = 10^{-3}$ T
    - I was able to practically solve the System for:
      - 1 ms in the lab frame
      - 100 s in the rotating frame
- The length of the pulse wasn't really an issue, this issue was more so trying to interpret the solution, in the plots above the x-axis represents the number of seconds passed, so I found that a reasonable pulse length to visualise was:
  - 0.1 μs in the laboratory frame
  - 1 ms in the laboratory frame

iii. Skype I'm a little preocupied with Christmas, would we be able to schedule a Skype following Boxing Day other than that any time works for me so how about?

   6:30 PM Sydney Time sounds good on the 27^{th}?

This was converted from ‘md‘ to ‘org‘ using ‘pandoc -f gfm‘ at time: 2020-02-09T05-26-42

Appendx

You may need to configure `customize RET org-export-html-extension`

```
(setq org-html-extension "html")
```