Introduction

M219 - Principles and Applications of MRI

Kyung Sung, Ph.D.

1/9/2023

Department of Radiological Sciences
David Geffen School of Medicine at UCLA

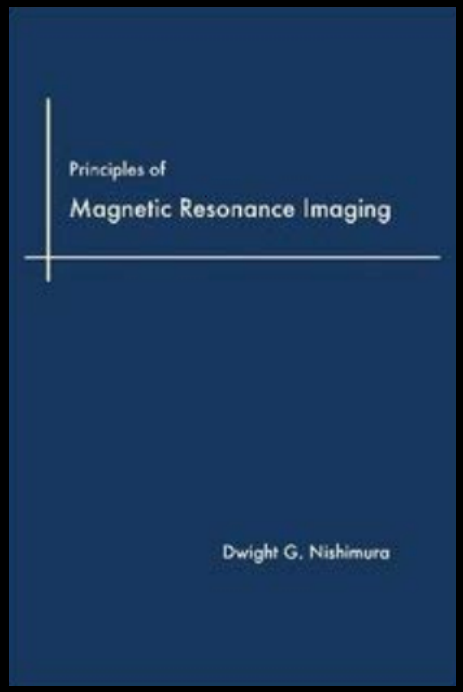
Introduction

- Your instructor
  - Kyung Sung
- Your TA
  - TBD
- Guest lecturers
  - Drs. Albert Thomas and Holden Wu
  - Dr. Zhaoyang Fan (USC)
- You

Course Overview

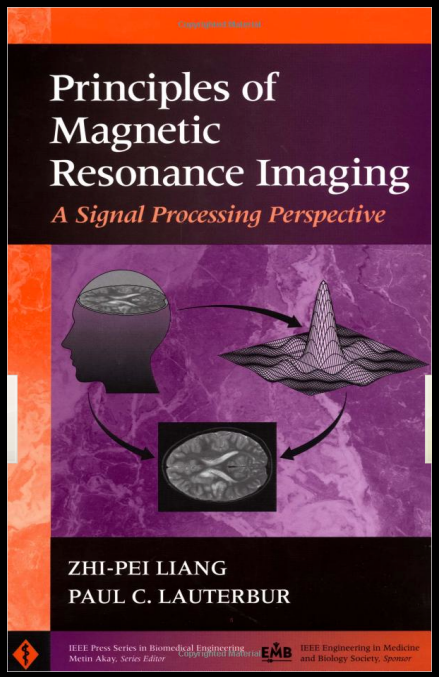
- https://mrrl.ucla.edu/pages/m219
- Assignments
  - 3 homework assignments (20 points each)
  - 1 final exam (30 points)
  - Class participation (10 points)
- Bring questions to class!
  - Slides will be available prior to lecture
- MATLAB
  - Required for homework

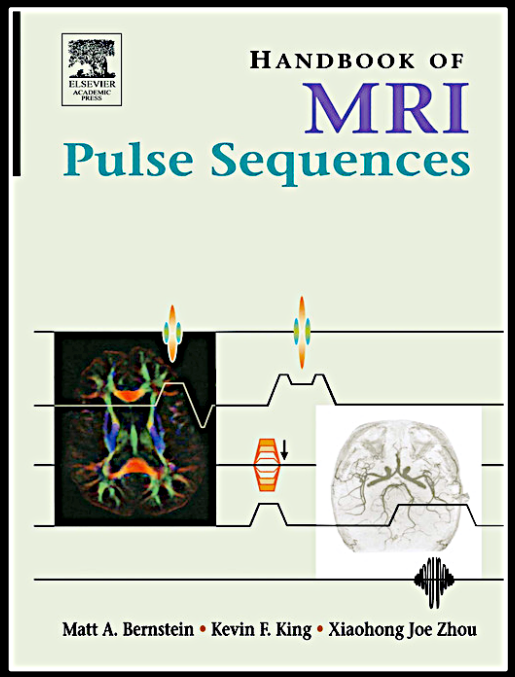
Primary Books



https://ee.stanford.edu/~dwight/
lulu.com - hardcover | paperback

Supplementary Books





Prerequisites

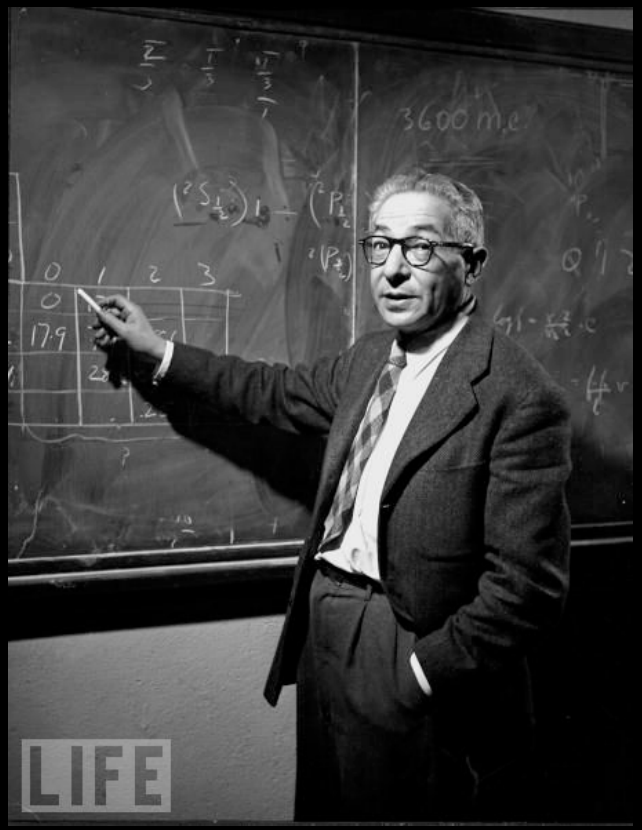
- Vectors and Vector Operations
  - dot product
  - cross product
- Basic Matrix Algebra
  - Determinant
  - Inverse
  - Transpose
  - Matrix Multiplication
  - Eigenvectors

A Brief History of MRI

Detection of the Signal

1944 Nobel Prize in Physics

"for his resonance method for recording the magnetic properties of atomic nuclei"

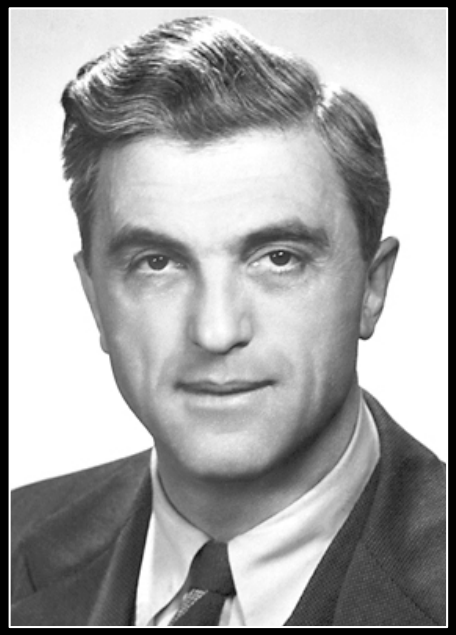


Discovery of NMR

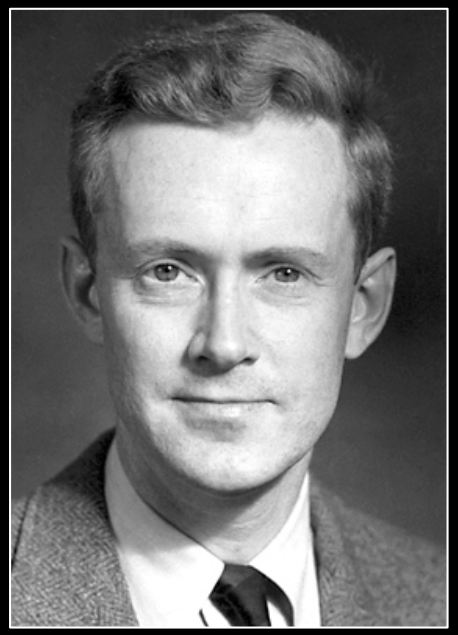
Isidor Isaac Rabi
b. 22 Jul 1898
d. 11 Jan 1988

1952 Nobel Prize in Physics

"for their development of new methods for nuclear magnetic precision measurements and discoveries in connection therewith"



Felix Bloch
b. 23 Oct 1905
d. 10 Sep 1983

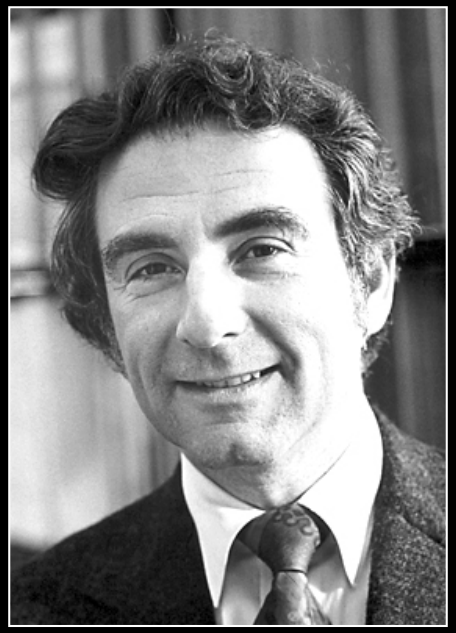


Edward Purcell
b. 30 Sep 1912
d. 07 Mar 1997

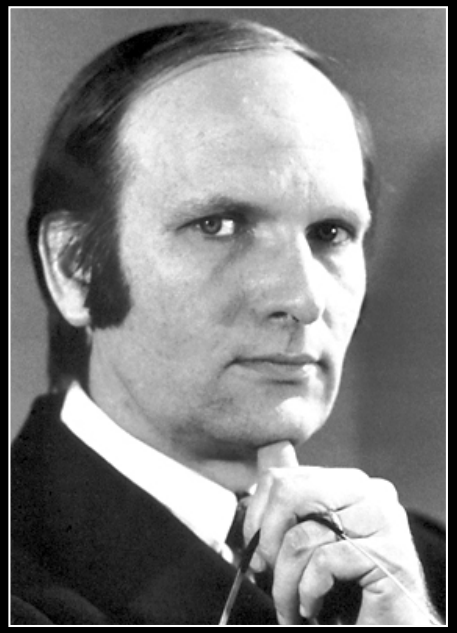
1972 Nobel Prize in Physics

"for their jointly developed theory of superconductivity, usually called the BCS-theory"

John Bardeen
b. 23 May 1908
d. 30 Jan 1991



Leon N. Cooper
b. 28 Feb 1930
d. —



Robert Schrieffer
b. 31 May 1931
d. —

Improved NMR Detection

1991 Nobel Prize in Chemistry

"for his contributions to the development of the methodology of high resolution nuclear magnetic resonance (NMR) spectroscopy"

Richard Ernst
b. 14 Aug 1933
d. –

Magnetic Resonance Spectroscopy

2002 Nobel Prize in Chemistry

"for his development of nuclear magnetic resonance spectroscopy for determining the three-dimensional structure of biological macromolecules in solution."

Kurt Wüthrich
b. 1938.10.04
d. –

Magnetic Resonance Imaging

2003 Nobel Prize in Medicine

"for their discoveries concerning magnetic resonance imaging"

Paul C. Lauterbur
b. 1929.05.06
d. 2007.03.27

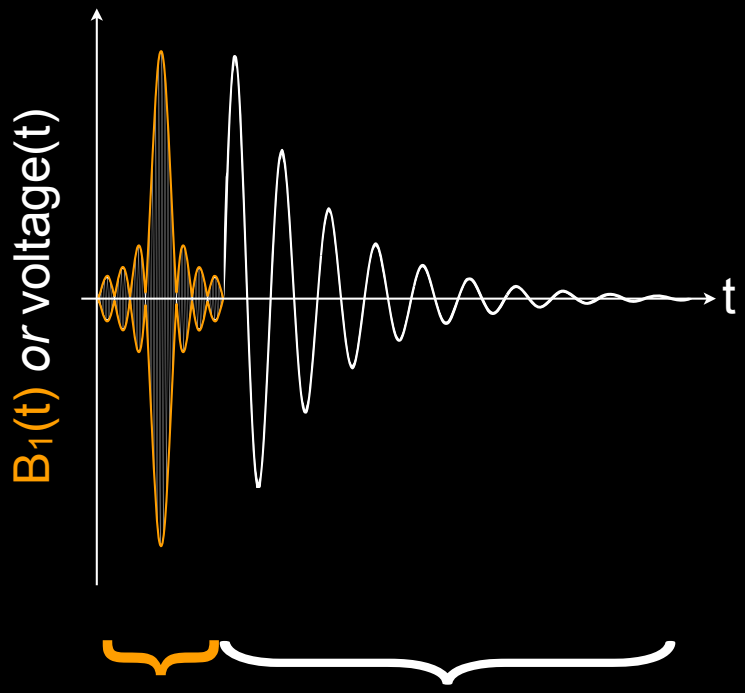
Peter Mansfield
b. 1993.10.09
d. 2017.02.08

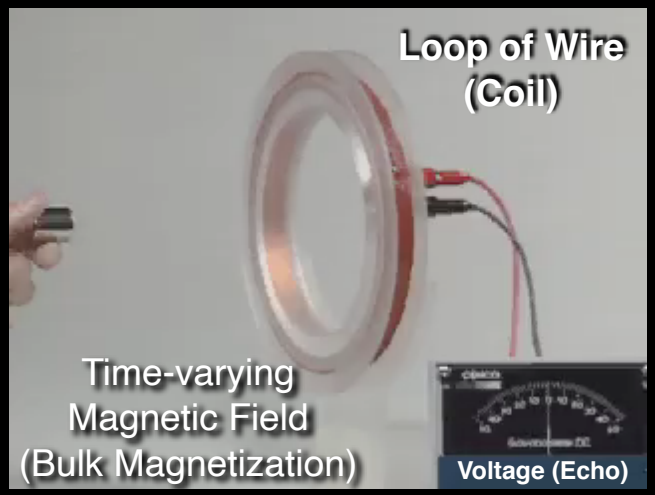
What is MRI?

- Magnetic
  - We need a big magnet
- Resonance
  - Excitation energy has to be on-resonance
- Imaging
  - We can make pretty pictures

What is MRI?

MRI follows a classic excitation-reception paradigm.





Faraday's Law of Induction

MRI encodes spatial information and image contrast in the echo.

Requirements for MRI

- NMR Active Nuclei
  - e.g. ^{1}H in H_20
- Magnetic Field (B_0): Polarizer
- RF System (B_1): Exciter
- Coil: Receiver
- Gradients (G_X, G_Y, G_Z): Spatial Encoding

MRI Hardware

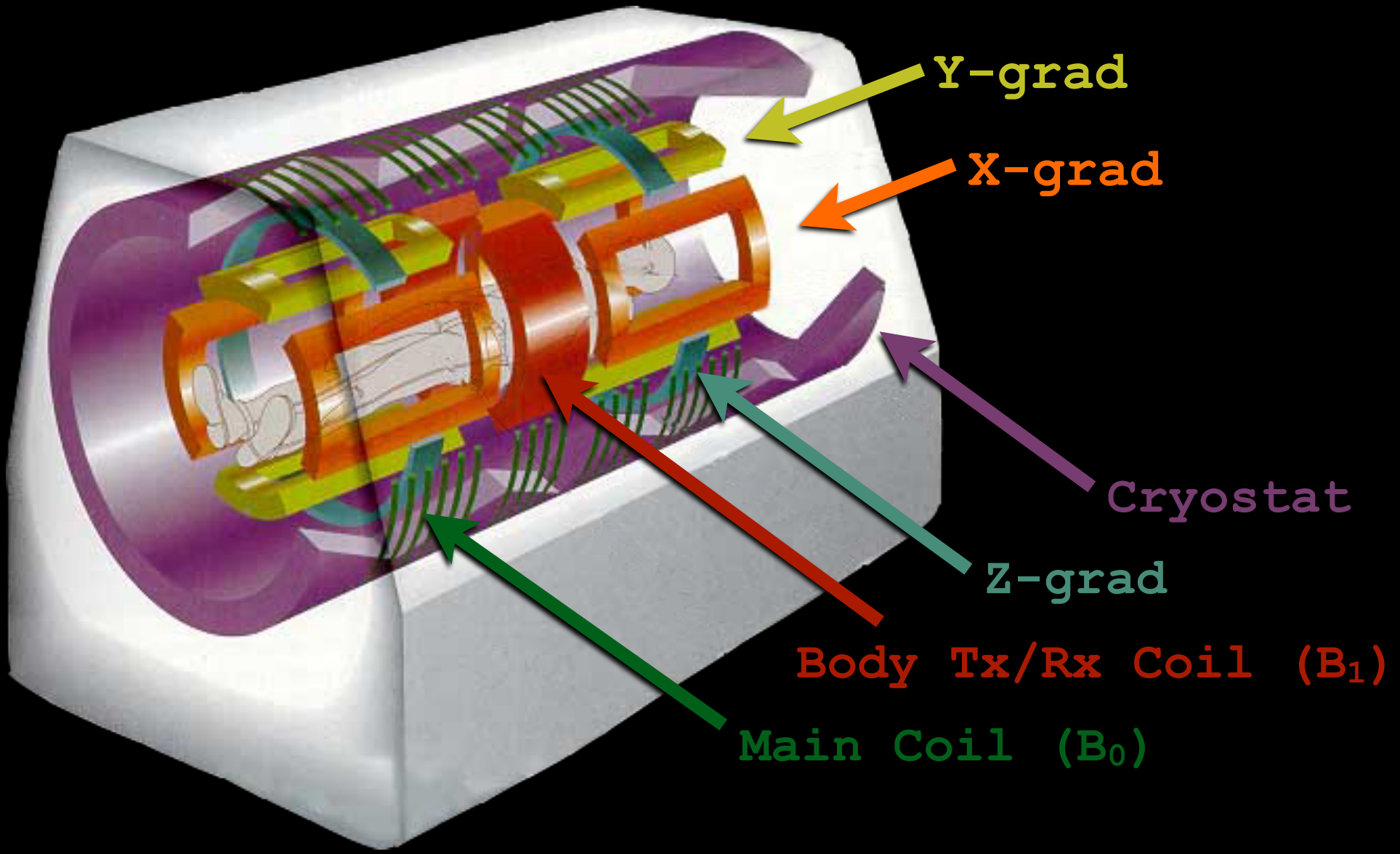


Image Adapted From: http://www.ee.duke.edu/~jshorey

Questions?

- Related courses of interest
  - M229 Advanced Topics in MRI (https://mrrl.ucla.edu/pages/m229)
  - PBM 222 MR Spectroscopy
  - PBM 225 MR Contrast Mechanisms

Kyung Sung, Ph.D.
KSung@mednet.ucla.edu
http://mrrl.ucla.edu/sunglab