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Academic MRI - 3020

Education NMR & MRI System

EPCC / PRODUCTS / APPLICATION / SOFTWARE / ACCESSORIES / CONSUMABLES / SERVICES

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The Academic MRI 3020 system consists of a compact 0.5T NMR/MRI system combined with virtual data acquisition and image reconstruction teaching software (EDU 2.0). This combination provides a convenient teaching platform which makes the realistic teaching of NMR principles and techniques much more achievable.

Academic MRI 3020 MRI system is ATL's original product, first used as an integral part of other products. After nearly 10 years of enhancements, its design and functionality are comprehensive and mature. Academic MRI 3020 can be used by physics lecturers to demonstrate NMR experiments and imaging professionals to teach courses, so that multiple students gain experience in using MR technology without needing to operate expensive instruments.

Through a tailor made range of 32 experiments and related materials, students gradually learn to master NMR/MRI technology through observation of a range of diverse sequences, different magnetic resonance signals, K spatial distribution for different settings, imaging parameters organization, and the impact of different levels of image contrast. What is more, the accessible software and hardware architecture allow the functionality of the instrument to be extended and enhance the students' capability. Combining teaching and research greatly enhances the professional capacity of the university for research while at the same time providing the community the same quality of training as magnetic resonance imaging professionals.

The core of the NMR/MRI Integrated Experimentation Platform is a virtual platform combined with a magnetic resonance imaging test device. EDU 2.0 is a virtual system and run independently to simulate the entire process of NMR/MRI. On the one hand, it allows many students to learn simultaneously without needing to invest in expensive hardware or needing several supervisors to train multiple users. Moreover, it greatly shortens the time in imaging with two modes selectable: normal mode and accelerated one. The latter one facilitates a faster imaging therefore improves teaching efficiency. On the other hand, EDU 2.0 is able to demonstrate NMR sequences in a practical way. For instance, the performance of EPI, a complicated sequence, needs a demanding hardware which is beyond the basic configuration in the lab. However, EPI could easily programmed and purposely integrated in the virtual system which enables students to operate EPI-based experiments.Furthermore, with the parameter driven interface users can select imaging sequences, the original level and imaging technology, carry out the relevant data collection process and perform K space filling of reconstructed images.

Introduction of Academic MRI 3020

Academic MRI 3020 is a compact desktop magnetic resonance imaging test instrument designed for magnetic resonance imaging technology teaching experiments. It can be used to teach NMR principles, demonstrate the magnetic resonance imaging process and conduct many other NMR/MRI experimental courses under the professional engineering disciplines (such as Modern Physics, Applied Physics, Radio Physics, Electronics and Information Engineering) and medical imaging related professions (Fig.).

Two main characteristics of this device：Openness and Authenticity

Openness: both the hardware and software are very accessible.

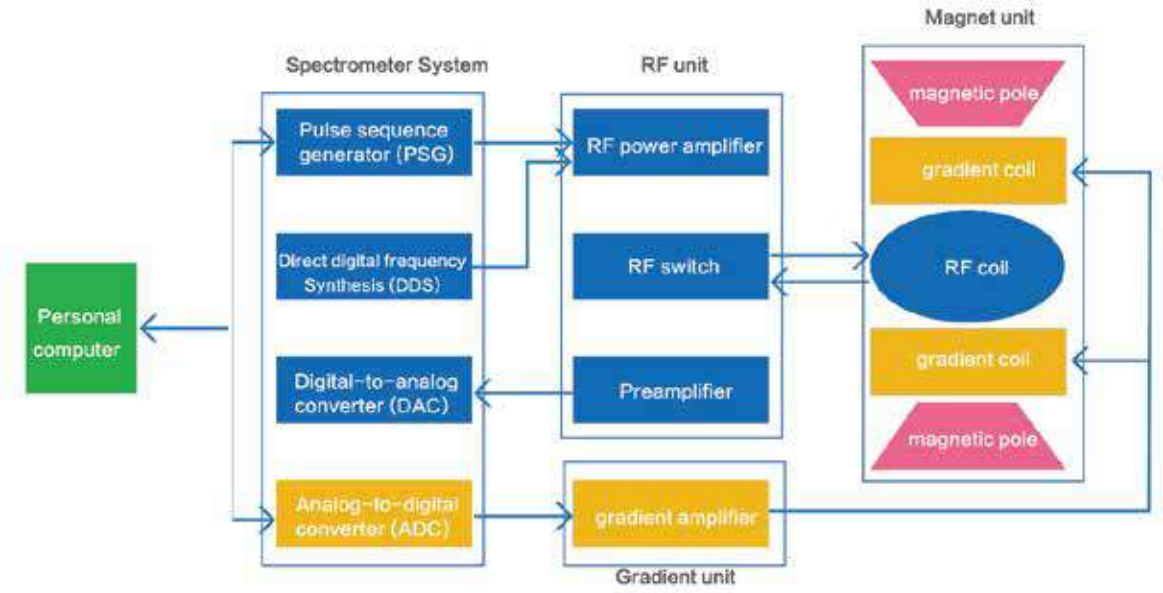
1. Accessible Hardware: In classroom presentations you can not only simulate continuous wave NMR experiments, but also disassemble and reassemble the hardware. With an oscilloscope, multi-meter, and other auxiliary tools, you can exercise the abilities of students, and enhance students' knowledge about the hardware configuration of the instrument.

2. Data accessibility: Accessing the open K-space raw data, enables image reconstruction to be carried out in simulation experiments for signal processing and data processing direction. This-can provide a lot of real and effective data for students as well as lecturers, and thus use a variety of algorithms to expand research and investigate other aspects of the processed image.

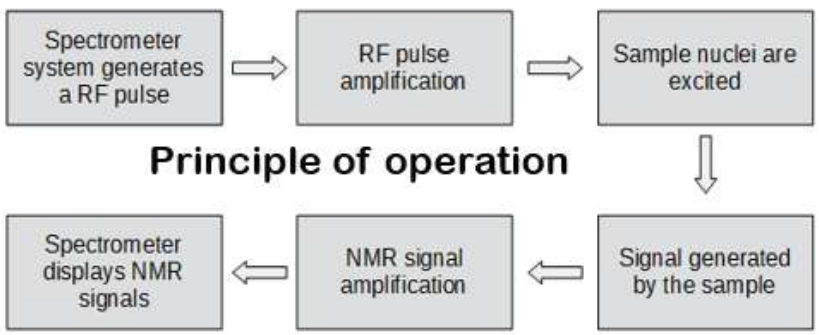
Authenticity: The Academic MRI 3020 medical magnetic resonance imaging apparatus uses the same modules as other working instruments which provides a real-life experience of the principle of magnetic resonance principles, instruments, and applications.

Description of the overall system structure:

The five major sub-components of the instrument include the console with spectrometer (green), a radio frequency system (blue) and gradient unit (yellow), magnet cabinets (pink), and power supply (with thermostats). Structure of the device is shown below (Fig.).



The console receives the operator's instruction and generates control signals to pass through the sequencer software to coordinate the work of the various components of the spectrom ter system. The console also carries out tasks of data processing, storage, image reconstruction and display. The RF system mainly receives the transmitted RF signal and sampling pulse sequence, and the gradient system generates the magnetic field gradient. The magnet primarly provides a uniform, stable main magnetic field, and the temperature control system assists in maintaining a stable magnetic field. A block diagram of the magnetic resonance imaging hardware system is depicted below (Fig.):



Low-field MRI teaching experimental program :

An annotated version of the integrated software interface of Academic MRI 3020 is displayed below (Fig.).

Imaging Experiments

• Understanding of various imaging sequences (SE, IR, and GRE sequences), imaging procedures and principles

• Multi-dimensional imagings: understanding selected layer thickness concepts;

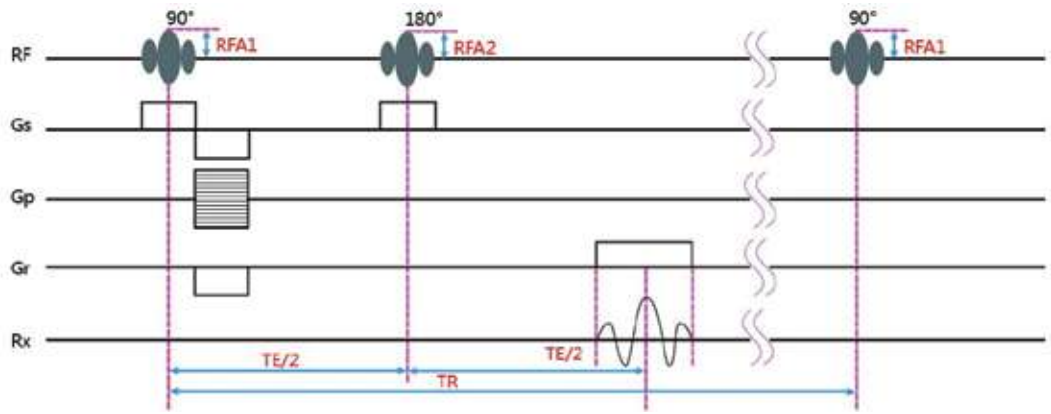
• Different weighted imagings: understanding how the relaxation time of different tissues or samples affect weighted grey scale image;

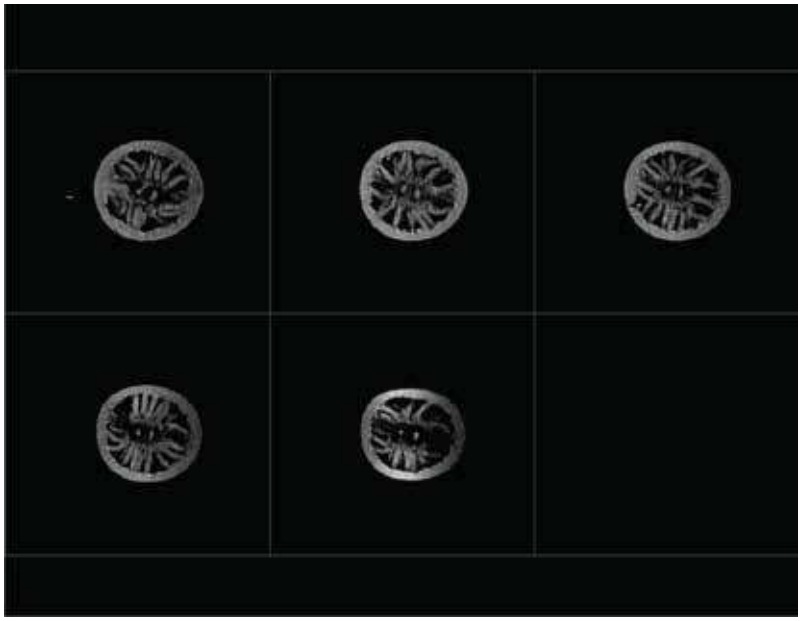
• Analysis of how sampling parameters affect the image size and shape, observation of truncation artefacts, their causes and solutions.

Sequences:

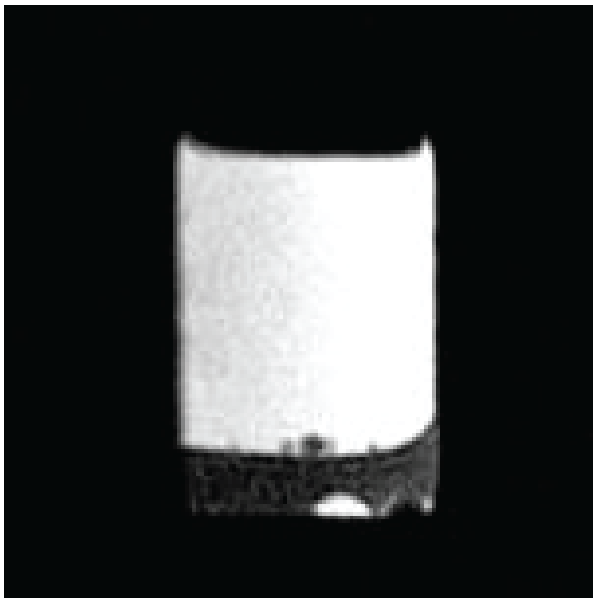
No.	Academic MRI 302020
1	FID
2	CPMG
3	IR
4	SE
5	MSE
6	GRE
7	3D-SE


Title Bar
Menu Bar
Positioning Image Display Area
Parameters Panel
Status Bar
NMI-V1.03.10 MiniMR-60
NEW SAMPLE
OPEN
SAVE
SAVE TO DICOM
1-PRESCAN
STOP
2-SCOUT
3-SCAN
CONFIG SYSTEM...
CONFIG MIN TE...
CONFIG PS D0/TR...
EXIT SYSTEM
Sagittal
Coronal
Axial
SPIN ECHO (SE)
View Auto01
View AutoShim
View AutoAmp
Save To Configuration
Test RG
Test SCOUT RG

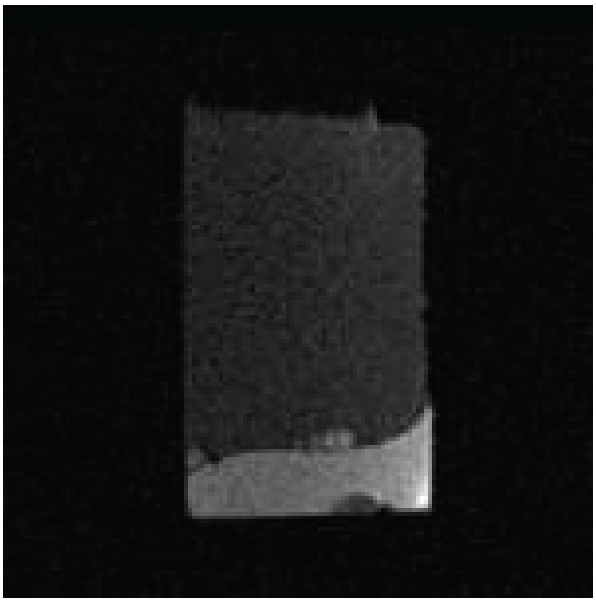

90°
180°
90°
RFA1
RFA2
RFA1
RF
Gs
Gp
Gr
Rx
TE/2
TE/2
TR



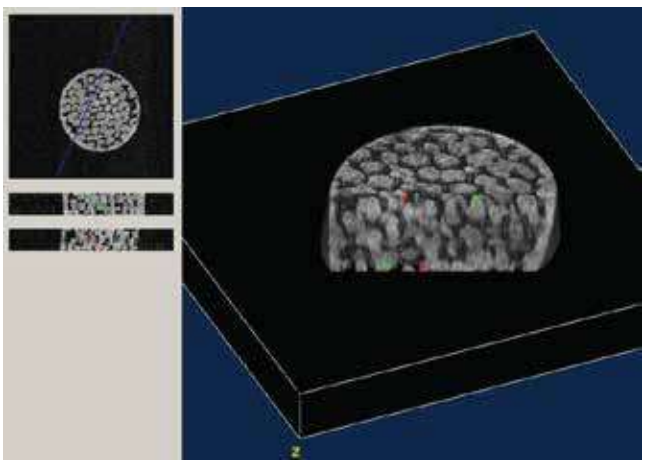
Images of multi-slice pepper



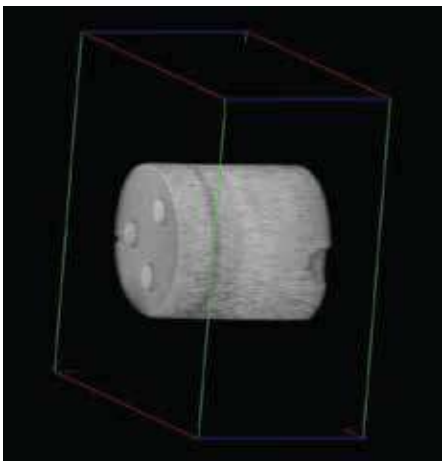
T1-weighted image



T2-weighted image



3D MRI of sample 1



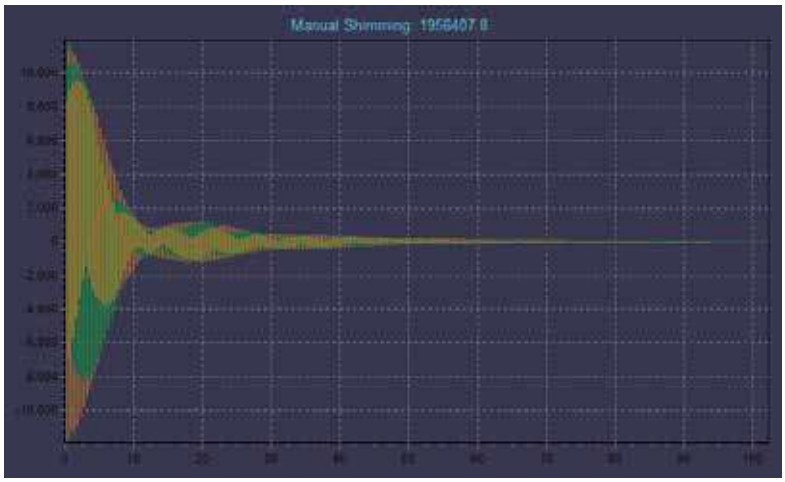
3D MRI of sample 1

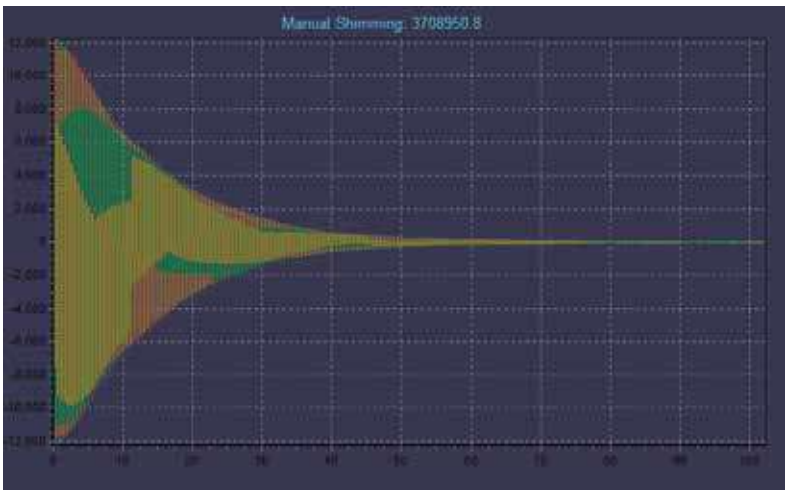
Principles taught through the experiments

• Understand the importance of uniformity of the magnetic field, factors affecting homogeneity, and how to shim (Fig.);

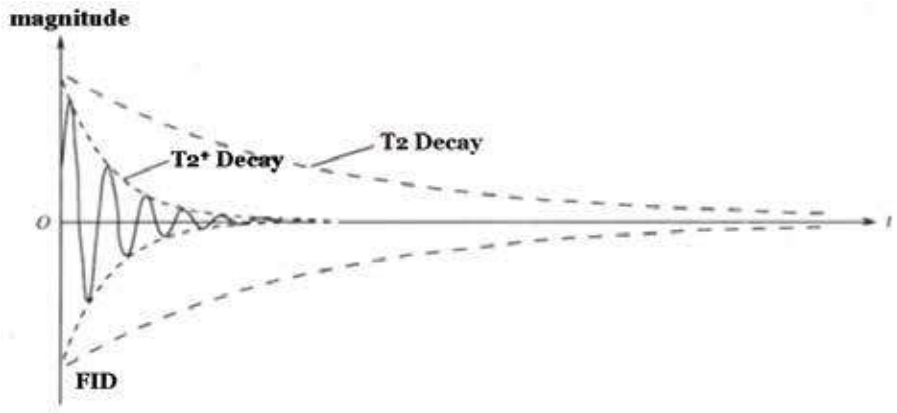
• Grasp the characteristics of the Free Induction Decay (FID), FID signal processing sequence, and understand the basic principles of nuclear magnetic resonance (Fig.);

• Know the role and structure of a magnetic resonance spectrometer, at the same time grasp the impact of sequence and acquisition parameters on callback signals





Before and after manual shimming (A and B)



Relaxation produced by the T2 characteristics of tissue and the T2* effects associated with magnetic field inhomogeneity

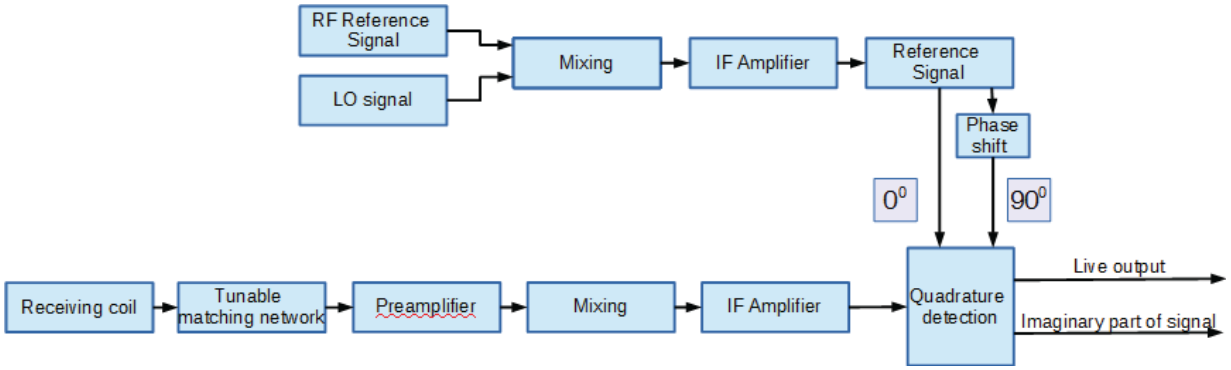
Test Hardware architecture

• Master the principles of how the nuclear magnetic resonance signal is received and understand how to tune and match the receiving coil.

• Understand MRI systems emit radio frequency signals from the power amplifier, and method for receiving pulse sequences.

• Understand the principles and analog NMR signal data processing (Fig).

• Through NMR experiments understand the role and structure of magnetic resonance spectrometer core control system components, then understand how the various spectrometer systems generate control signals (Fig).



Processing the magnetic resonance signals (analog portion)

Application of development experiment

• After familiarization with the basic principles of nuclear magnetic resonance and imaging, MRI-related simulations could be created with Matlab software, such as magnetic resonance imaging, simulation of 2 D-FFT / 3D-FFT image reconstruction algorithm and assessment on magnetic resonance image quality;

• Apply low-field nuclear magnetic resonance to polymer materials, food and agriculture, oil and energy, life sciences and other fields. Use NMR analysis and the imaging teaching platform for related basic research and various applications.

Summary of the experiments performable with Academic MRI - 3020

A wide range of experiments are available, more than 30 experiments covering various aspects of MRI and NMR operation listed below (not all). ATL will also collaborate with users who want to develop additional experiments.

Academic MRI 3020 NMR/MRI theory and the equipment structure

NMR/MRI basic theory (Physics)

• Fundamental principles of NMR/MRI
• Nuclear magnetic resonance phenomenon
• Relaxation and NMR signal
• Spatial location of NMR signal
• Image re-construction of MRI
• Pulse sequences of NMR

Academic MRI 3020 MRI system (Electronic information engineering)

• Magnetic unit
• Radio frequency unit
• Gradient unit
• Spectrometer
• Magnetic shielding and radio frequency shielding

Academic MRI 3020 NMR/MRI advanced experiment items

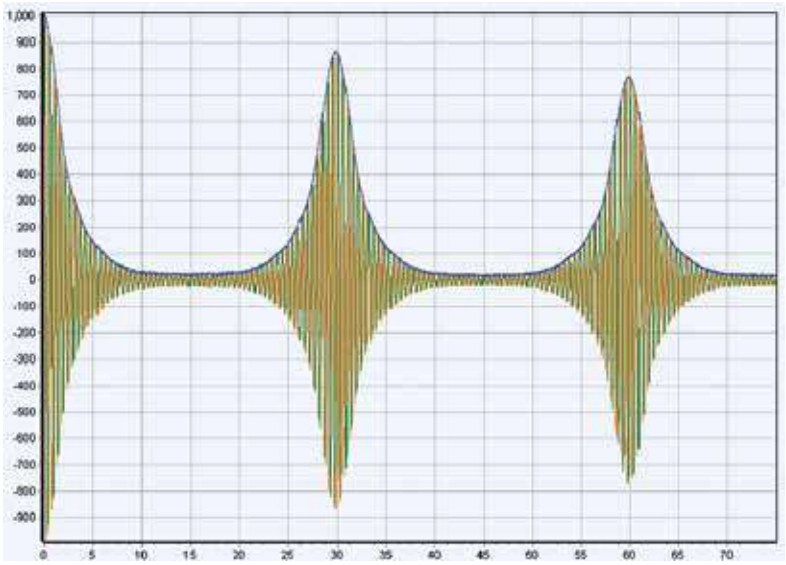
NMR/MRI theoretic experiments

- Electronic shimming
- Measuring the Larmor Frequency by 90° FID Sequence
- FID signal in rotating coordinate system
- Hard RF determined by Hard Pulse-echo Sequence
- Soft RF determined by Soft Pulse-echo Sequence
- Soft Pulse-echo Sequence
- T1 determination by inversion recovery method (IR) and saturation recovery method
- T2 determination by CPMG

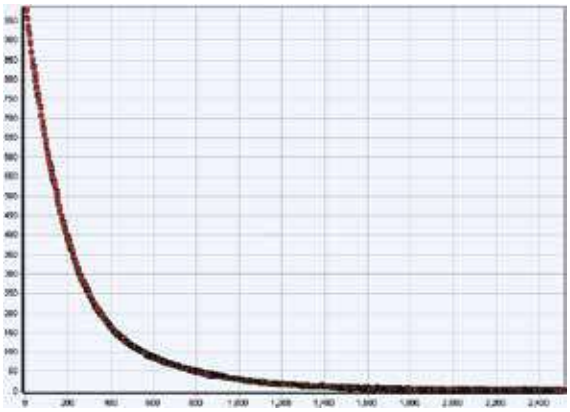
MR Imaging technicalexperiments

- Spin echo imaging
- Multi-slice spin echo imaging
- T1, T2 weighted imaging
- IR imaging
- 2D imaging
- 3D imaging
- FOV, space location, slice gap, slice thickness, slice angle

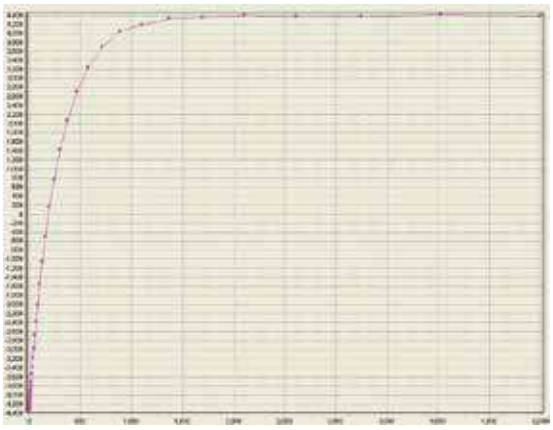
Application of development experiment



Two echos of Spin Echo sequence results



T2 measurement by CPMG sequence



T1 measurement by IR sequence

Application of development experiment

Advantages of Academic MRI - 3020

Using the EDU software platform has many advantages including:

- Perform virtual sequence selection, parameter adjustment, data acquisition, K space filling and image reconstruction function.
- The influence of magnetic field inhomogeneity and electronic noise can be simulated.
- Maximize the number of students trained with minimal investment in hardware.
- Perform fat suppression imaging.
- Perform water suppression imaging.
- Perform Half-Fourier scanning &Imaging technique.
- Overcome the problem of long time of acquisition through inadequate instrumentation.
- More than four pulse sequences (SE sequences, FSE sequence, IR sequence, GRE sequence) can be used for virtual imaging data collection.
- Observe how the scan parameters affect the image.
- Minimize the impact of gradient eddy current and analog acquisition in severe T2-weigh ed images.
- Options in data acquisition (normal speed and very-fast speed).

NMR/MRI Integrated Experimentation Platform

For effective, efficient, and economic teaching ATL recommends an integrated system that use 5 virtual systems combined with one actual experimental device.
This 5+1 configuration has the following advantages

- Quickly create a comprehensive NMR/MRI experiment teaching platform
- Meet the teaching demands while minimizing device costs
- Every student can get actual operation experience, without needing to become familiar with a different software interface.
- Expand teaching and experiment capacity by adding more virtual systems or specialized ATL hardware systems later.

Material and Energy

1. 1H-NMR Relaxation and State Evolvement of Evaporable Water in Cement Paste
2 .Effect of Superplasticizer on Transverse Relaxation Time Curve of Cement Paste
3. Application of Composite Insulator Aging Test using Low Field NMR technology
4. Visualization experimental investigations of supercritical CO2 inject into porous media with the fissure defect
5. Determination of Fibre Saturation Point in Wood by Low Field Nuclear Magnetic Resonance Technology
6. Research of Narrow Molecular Weight Distribution Oilgochitosan Modified GD-DTPA MRI Complexes Synthesis Function and Properties
7. Inspect ion and Analysis on the Aging of Sill icone Rubber f or Composite Insulators
8. Low field NMR application in the hydrate formation of THF

Hardware

9. Development of variable-temperature probe using in Low-resolution NMR analyzer
10. Design of active shimming coils on mini-type permanent magnetic resonance imaging system
11. NMR applied research in liquid-solid-liquid interface contact angle measurement
12. Manuscripts Analysis on gender of Silkworms by MRI Technology

Food and Agriculture

13. Characterization of Water State and Distribution in Textured Soybean Protein Using DSC and NMR
14. Study on Solubilization Properties of NPES/AOT ReverseMicelles in Diesel Oil
15. Stabilization of soybean soluble polysaccharide on acidified milk drinks
16. Research on the Change of Moisture State in Rice during Soaking Process by LF-NMR
17. Preparation for Fermented Mineral Beverage from GynostemmaPentaphyllum
18. Effect of microbial transglutaminase on functionality of pork myofibrillar protein gel - a low field NMR method
19. Heat-Induced Gelation of Myofibrillar Proteins as Affected by pH——A Low Field NMR-Study
20. Rapid detection of adulterated milk by low field-nuclear magnetic resonance coupled with PCA method
21. Development of Water's State in Meat and Meat Products

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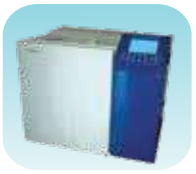

Optima Gas Chromatograph 2979 Plus

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Optical Emission Spectrophotometer

DSC/TGA

Semi Auto Bio Chemistry Analyzer

HEMA 2062 Hematology Analyzer

Micro Plate Reader/Washer

URINOVA 2800 Urine Analyzer

Total Organic Carbon 3800

Fully Automated CLIA

NOVA-2100 Chemistry Analyzer

PCR/Gradient PCR/ RTPCR

TOC Analyzer

Laser Particle Size Analyzer

Ion Chromatograph

Water purification system

Regulatory compliances

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