Problem 1: Diffusion MRI Quiz

Diffusion MRI has become a very helpful clinical tool, e.g. for diagnosis of stroke. It uses the fact that some cell structures hinder the diffusion of water protons in a non-isotropic way, i.e. forcing them to preferably diffuse in a specific direction. Here are some quiz questions about this imaging technique.

a) Usually, spin-echo sequences are used for diffusion weighted imaging. Can you figure why?

b) A typical (clinical) diffusion scan takes about 4 minutes. Can you think of a major problem one is facing in everyday practice? Explain why and what you would do to reduce it.

c) In a diffusion pulse sequence, the diffusion-weighting gradient produces a b-value of 500 s/mm^2. The measured DW signal is $S = 0.4 \cdot S_0$. What is the apparent diffusion coefficient (ADC) value?

Problem 2: Relaxation and Diffusion Imaging

We are interested in characterising the magnetic resonance properties of two compounds.

a) Define T_1 and T_2 relaxation and explain the basis of the underlying mechanism.

b) What is the difference between T_2 and T_2* and how do they relate quantitatively?

c) Describe the pulse sequences you would use to measure T_1, T_2 and T_2*.

d) Here are the results of the three experiments from c. Choose the corresponding graph below and estimate the T_1, T_2 and T_2* for compound A (——)and B (·····).

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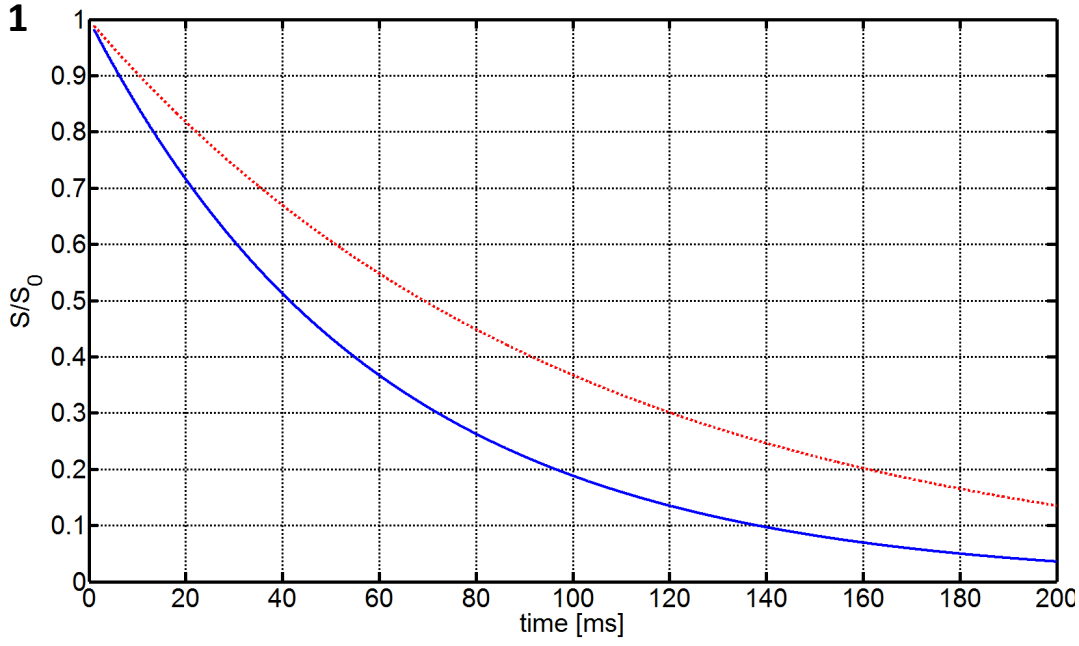
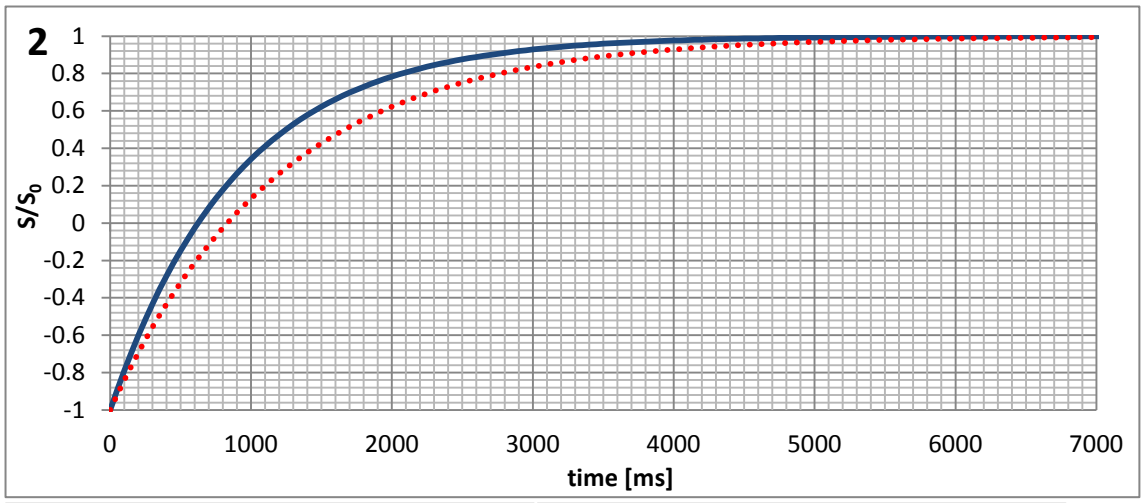
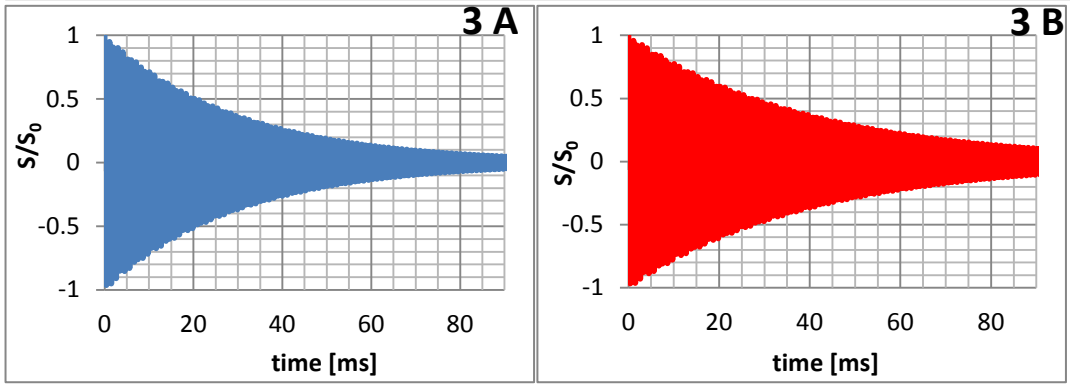






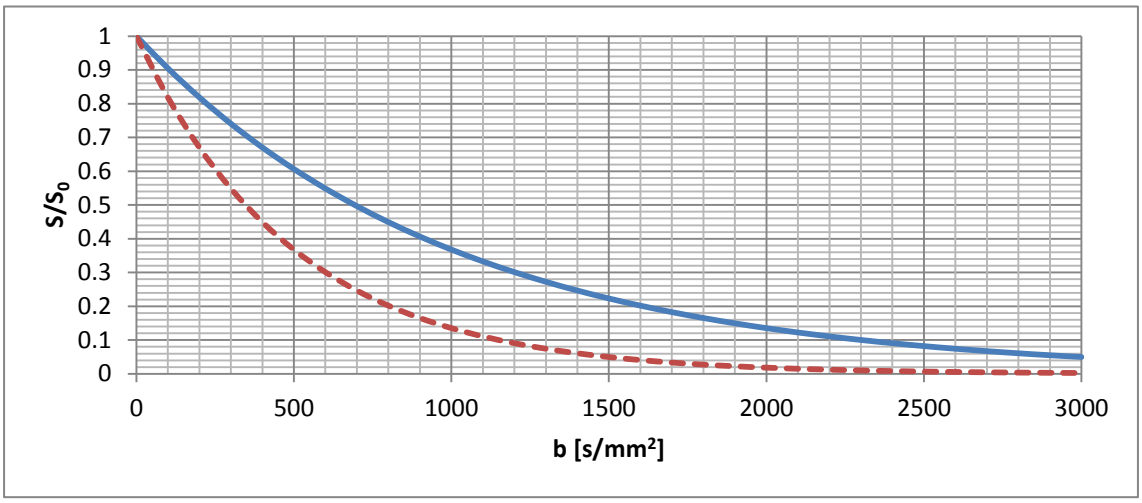
e) With which imaging technique would you have the best contrast between these two compounds (if contrast = |signal(compound 1) – signal(compound 2)|). Use an equation to justify your answer.

f) Another type of contrast can be achieved with diffusion experiments.

The signal intensity depend on two factors: firstly the apparent diffusion coefficient of the compound *(D* [mm^2/s]), and secondly the b-value *(b* [s/mm^2]) which is related to the parameters of the pulse sequence (gradient strength, gradient spacing,…).

$$Signal \propto e^{-b \cdot D}.$$

Based on figure 4, estimate the diffusion coefficient for the 2 compounds:



g) Calculate the optimum b-value for the best contrast between the two compounds and compare it to the result obtained in e).

Problem 3: Combining Your Knowledge

Among the different imaging techniques you know, which one would you use in the following cases? Explain why you would choose this technique and why the other techniques are not suitable for this purpose. If more than one is possible, state the advantages and disadvantages of the different methods.

What would you use if you were to...

1) ...image lesions in a multiple sclerosis patient.
2) ...image growing bone in a transgenic mouse model.
3) ...detect if a patient with a tumour has developed metastasis.
4) ...investigate metastasis development in a specific area.
5) ...image a bee in amber.
6) ...image heart reperfusion in order to detect reperfusion failure.
7) Finally, explain why ultrasound is the method used to image foetuses.