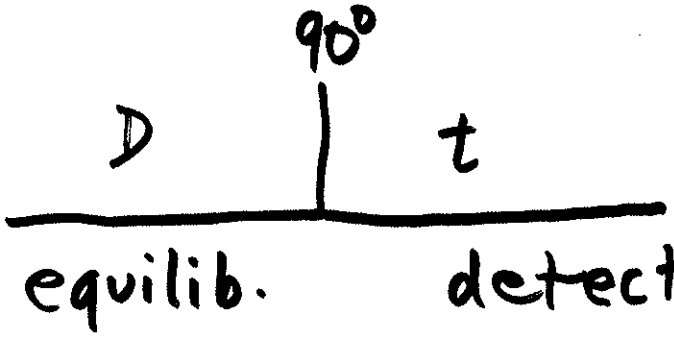
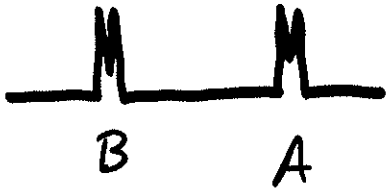
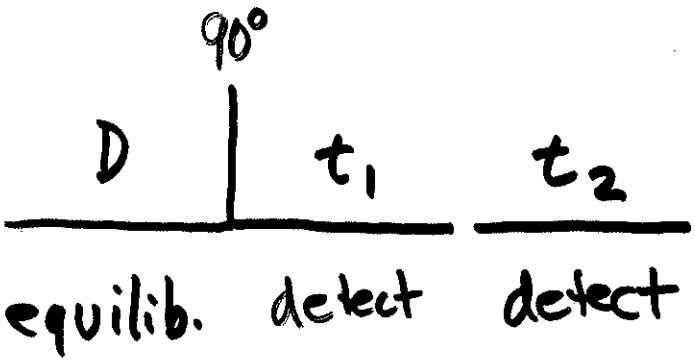
2D Spectrum





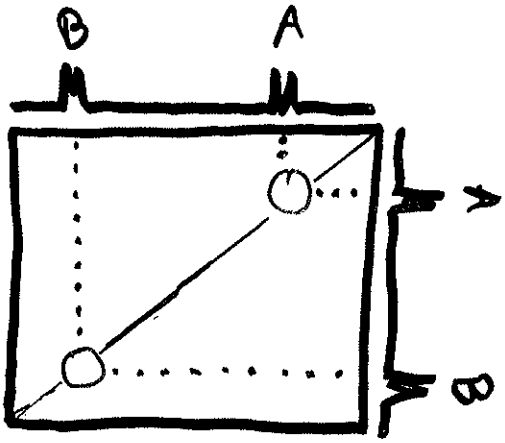
* Detect Twice *



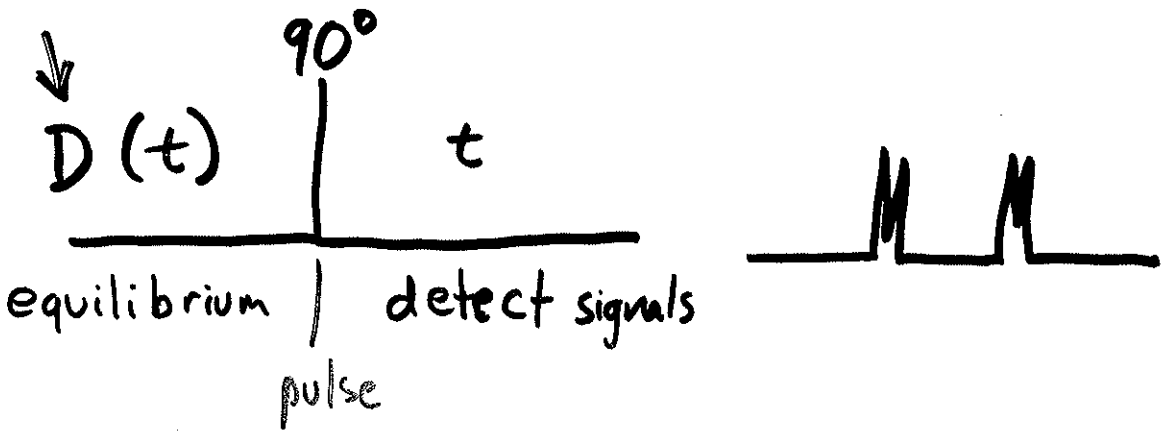
Each spin will have the same resonance frequency in t_1 and t_2 periods. Store as separate 1D spectra

-OR-

Create a matrix! which shows how the two spectra are correlated



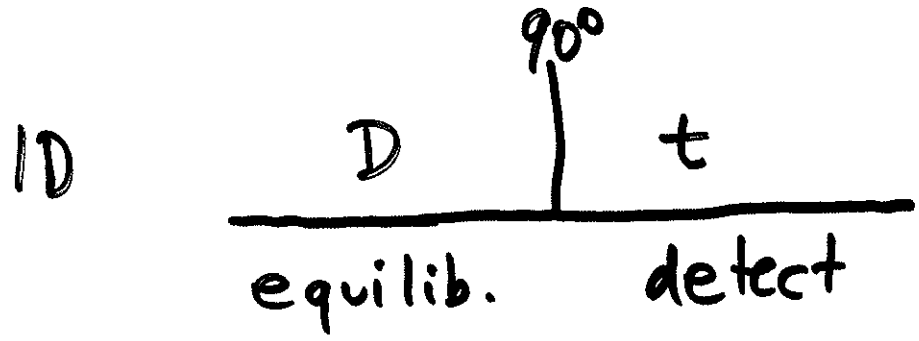
Indirect Detection



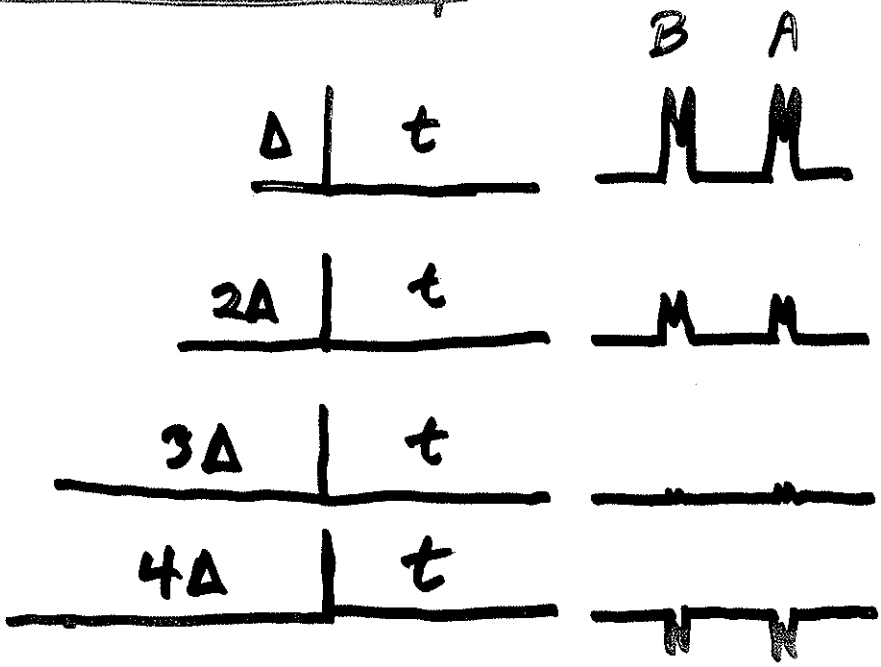
- What if the system was not in equilibrium?

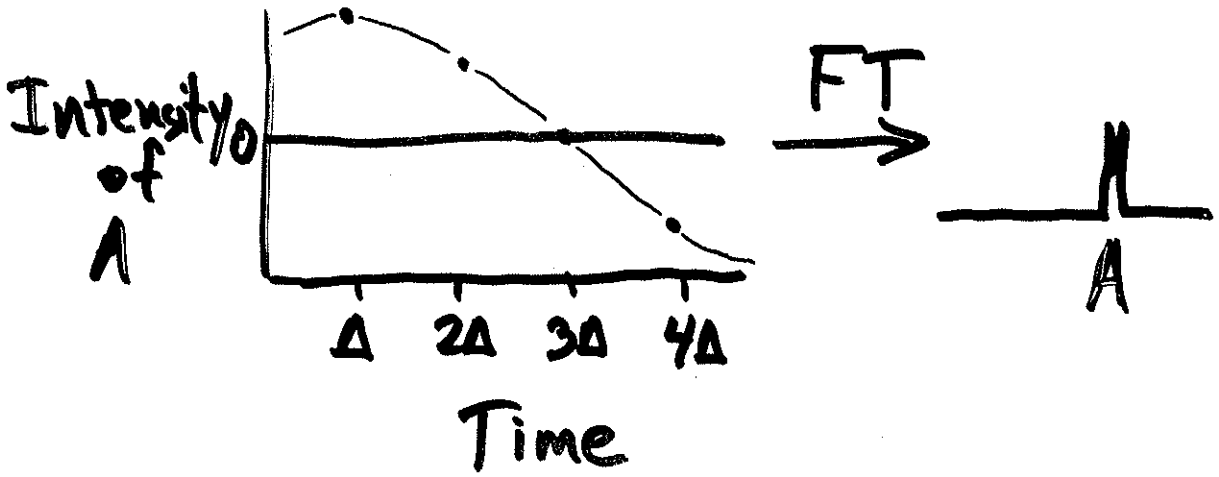
- What if we caused the peak intensity to vary at a rate equal to the precession frequency? And followed how that intensity varies over time

How Amplitudes Carry Frequency Labels



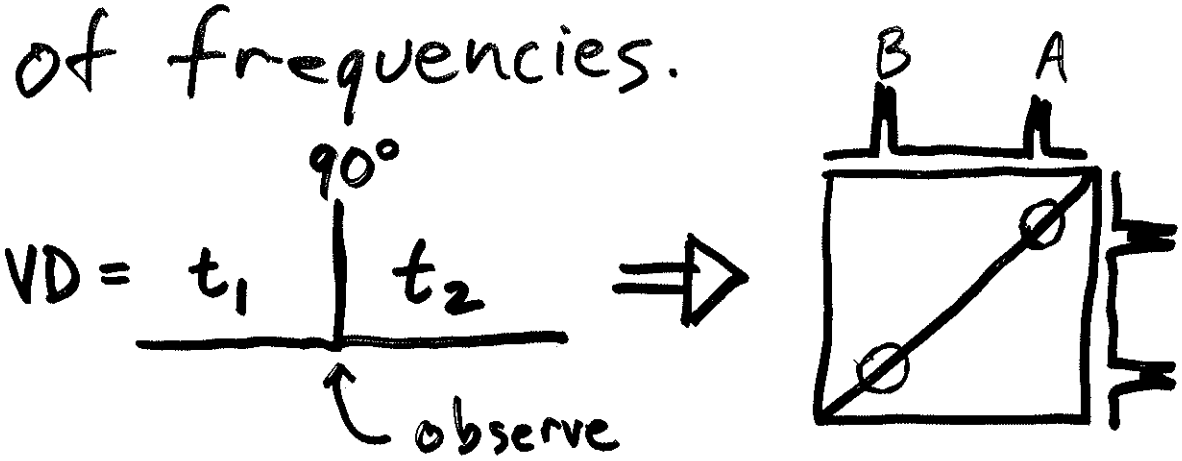
Variable Delay



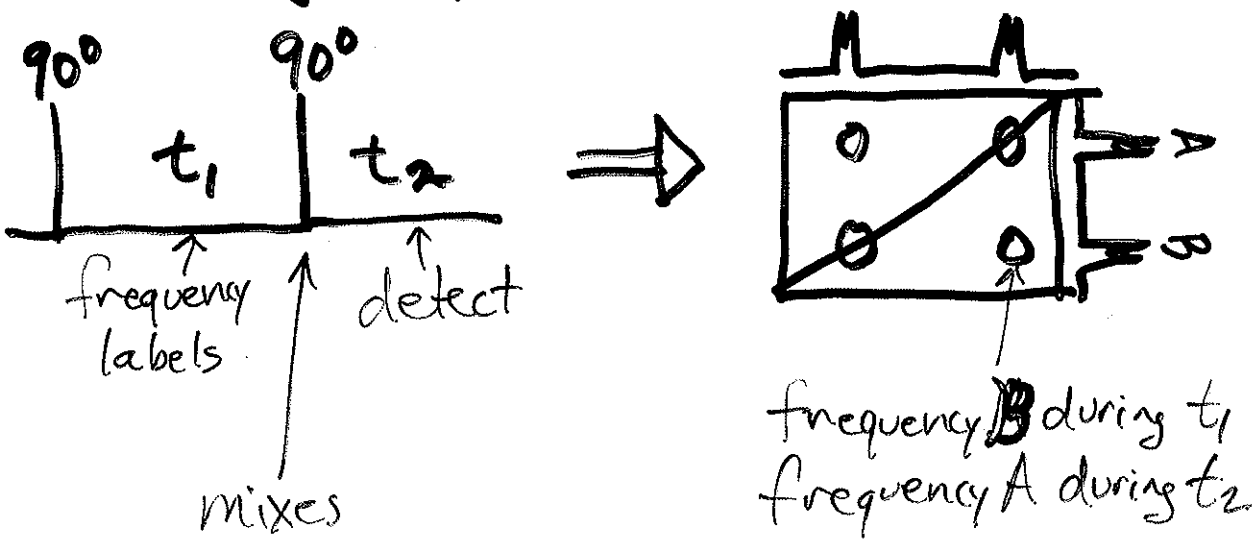


Indirect Detection

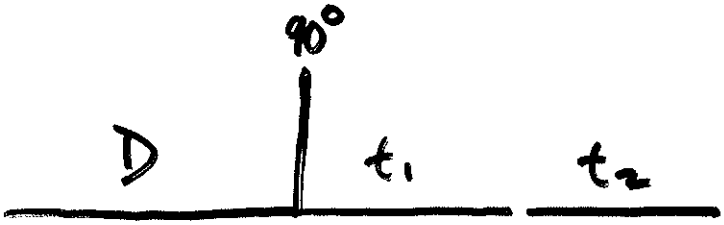
- The step-by-step build up of the signal by varying the delay is called <u>indirect detection</u> of frequencies.



- Adding a pulse creates COSY!



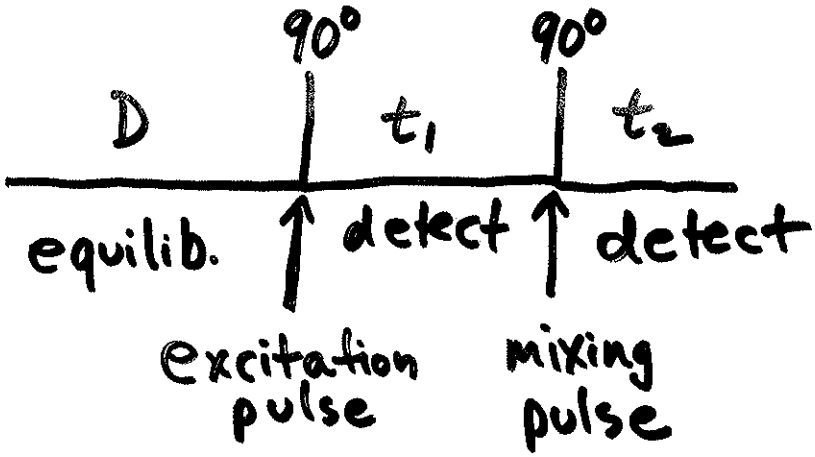
Mixing - The last step



Only provides redundant information

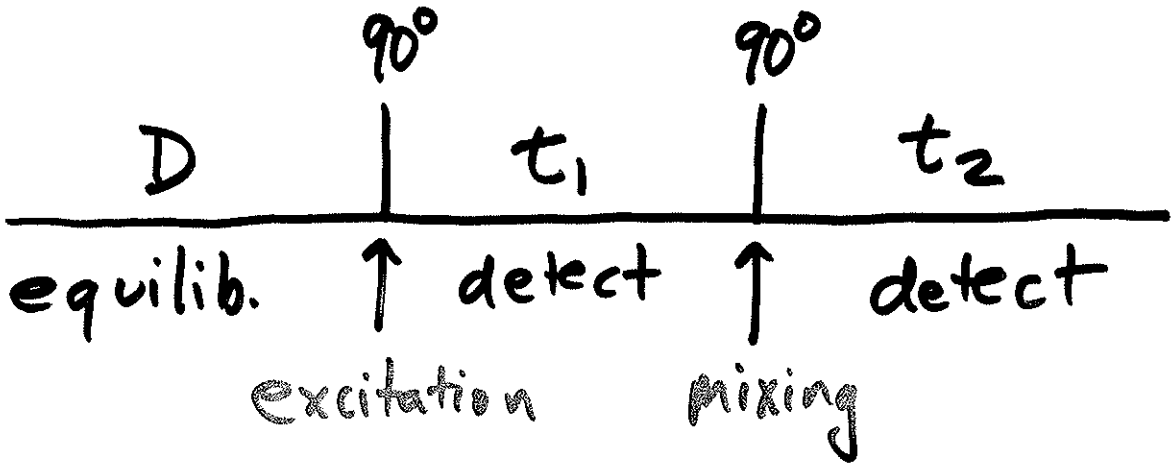
Now, let's do some spin physics between the two detection periods.
This is called Mixing.

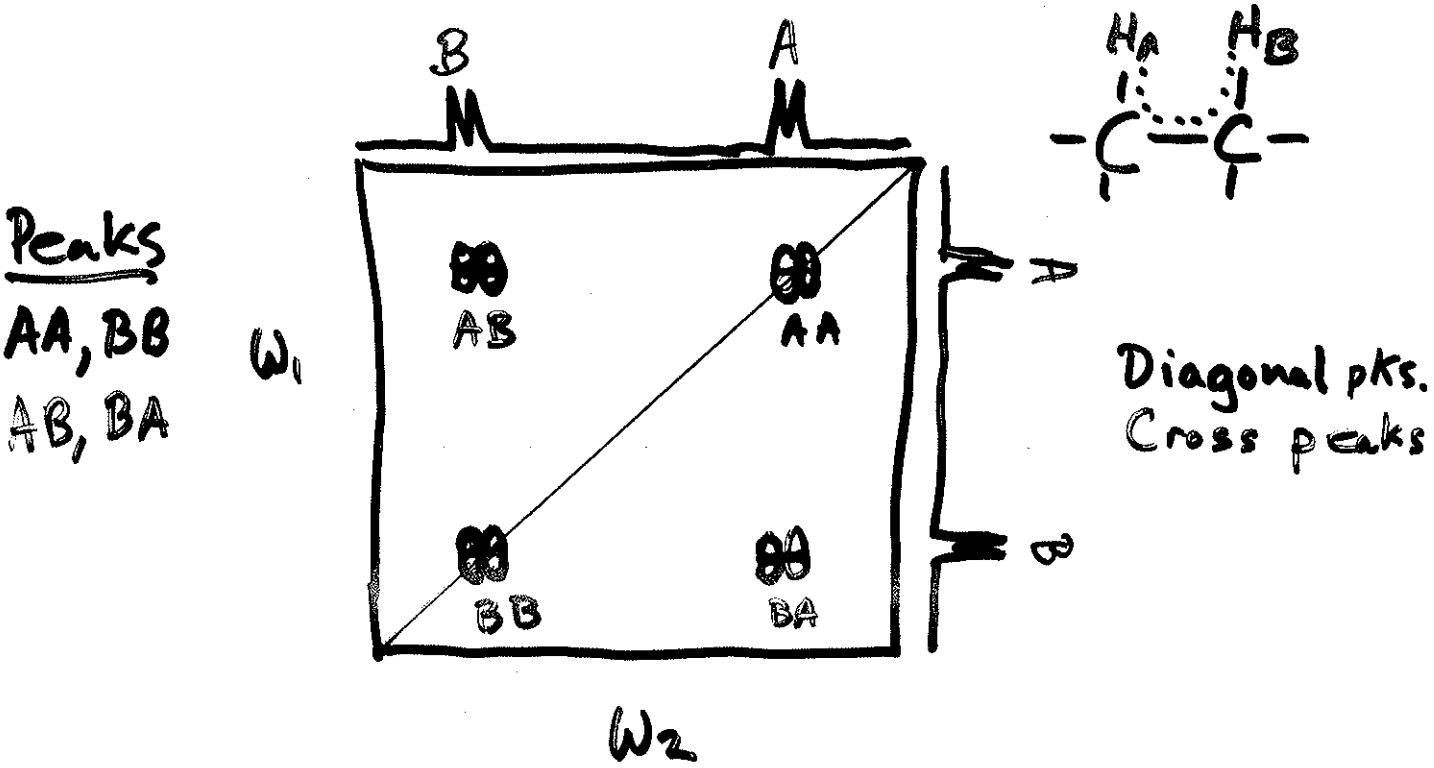
The simplest experiment is called COSY (Correlated Spectroscopy)



The addition of the mixing pulse causes an exchange between spins that are coupled.

COSY





* Excitation and Mixing can be Varied over a wide range to generate different experiments

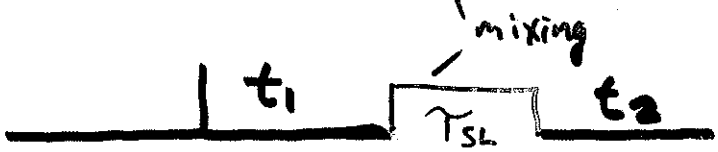
2D ^1H NMR Experiments

Scalar Coupling

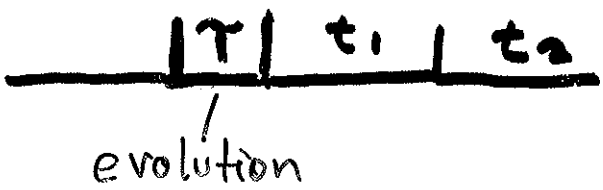
COSY

Relayed-COSY

TOCSY

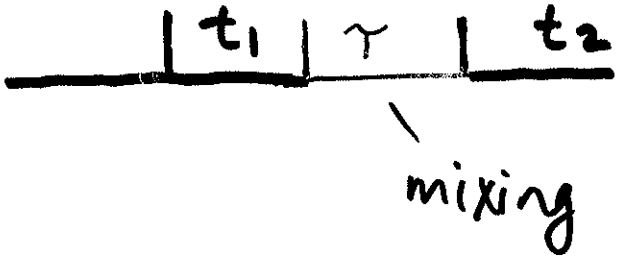


MQ (2Q, 3Q)

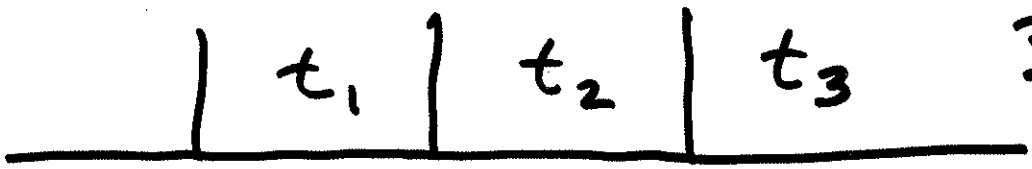


Dipolar Coupling

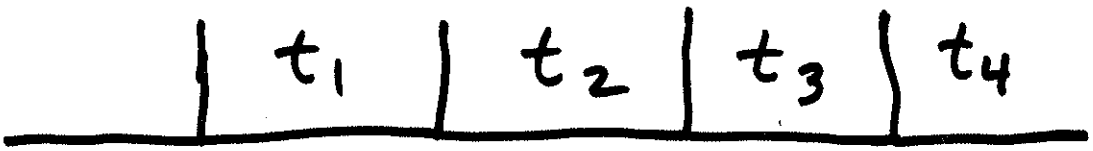
NOESY



Any nD NMR Experiments



COSY - COSY



COSY COSY COSY

$^1H \leftrightarrow {}^1H \leftrightarrow {}^1H$

$^{13}C \leftrightarrow {}^{13}C \leftrightarrow {}^{13}C$

Homonuclear

Triple $^1H \leftrightarrow {}^{15}N \leftrightarrow {}^{13}C$

Double $^1H \leftrightarrow {}^{15}N \leftrightarrow {}^1H$

Heteronuclear