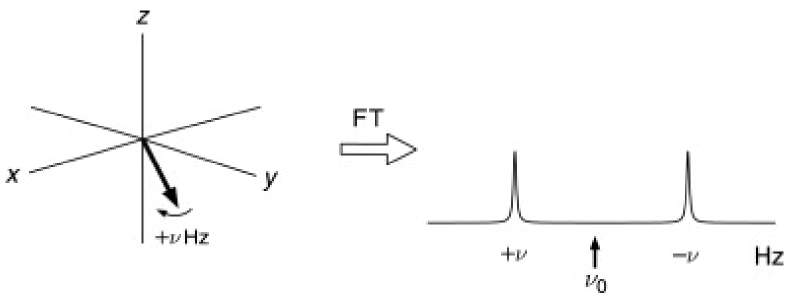
Phase-Sensitive (Quadrature) Detection in NMR

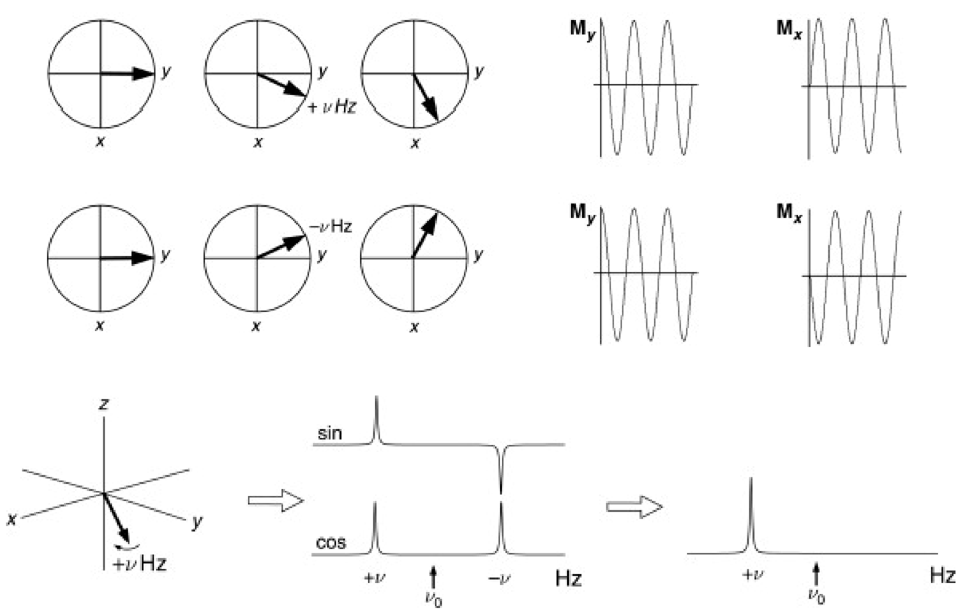
NMR detects signal in rotating frame, subtracting from a reference frequency.

But, this can lead to mirror, phase-shadowed peaks on opposite side of reference if “listening” occurs on one axis only.



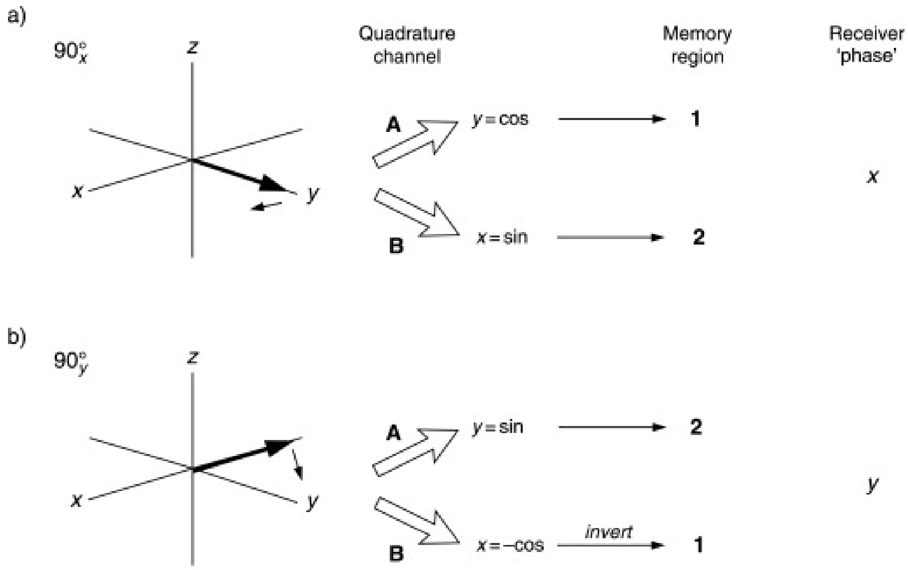
Phase-Sensitive (Quadrature) Detection

Solution: Detect on two axes using two simultaneous detectors. Method is *phase-sensitive*.



Phase-Sensitive (Quadrature) Detection

Procedure is optimized by phase-cycling.
Scans collected in sets of four pulses.

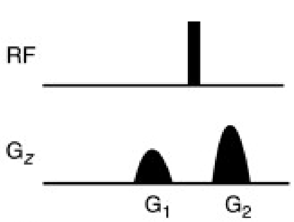


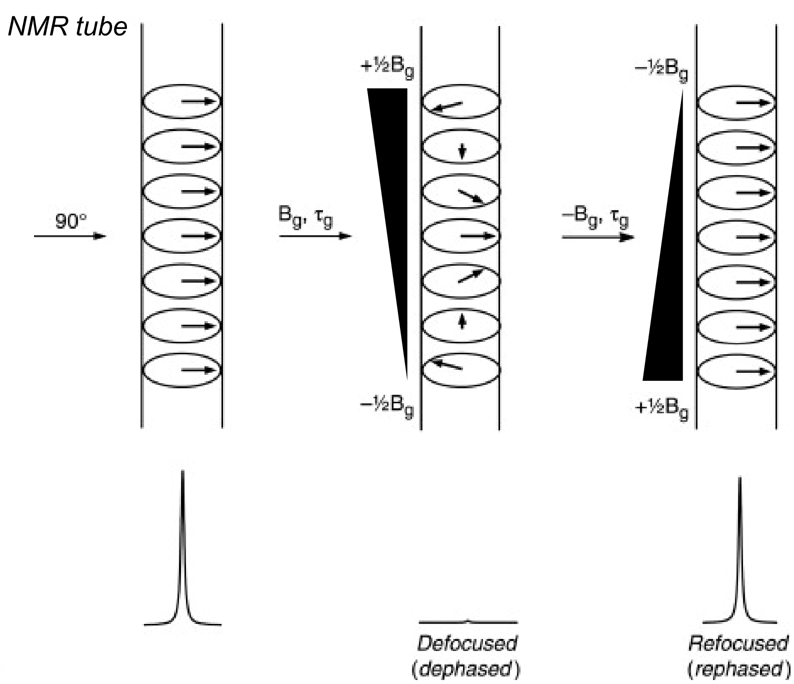
and then two more, -*x*(-cos, -sin) and -*y*(-sin, cos).

Gradient-Enhanced COSY (gCOSY)

Quadrature detection lengthens time (x4) of 2D NMR.

Can solve this by using *pulsed-field gradient*—vertical range of $\mathbf{B_0}$ field, applied via RF coil.



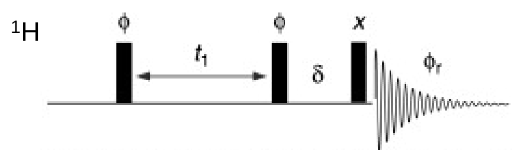


Double-Quantum Filtered COSY (DQF-COSY)

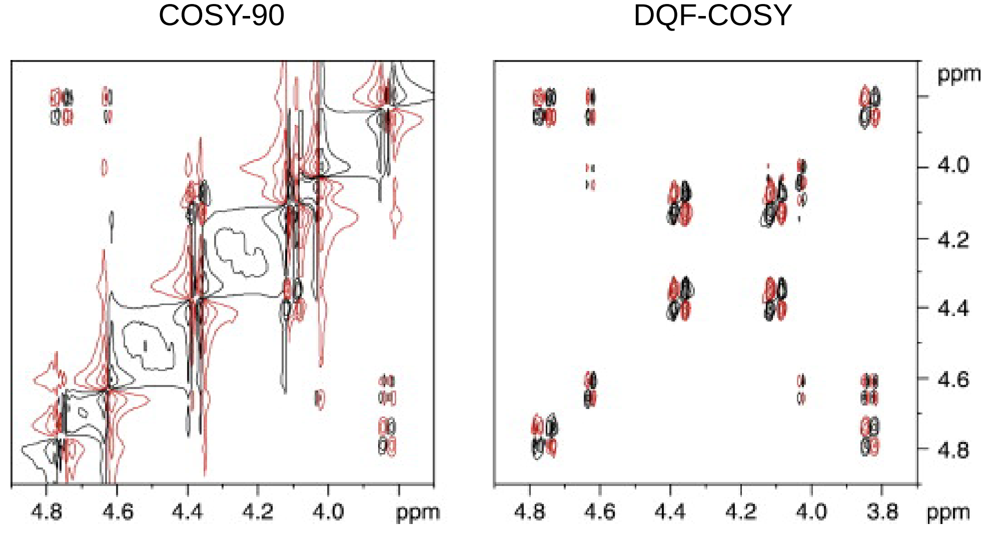
Occasional problem: Diagonal peaks overwhelm crosspeaks close to diagonal.

Solution: Apply "quantum filter" to discriminate intramolecular coupling from intermolecular coherence transfer.

Issues: Loss of sensitivity, splitting patterns observed in 2D.



Double-Quantum Filtered COSY (DQF-COSY)

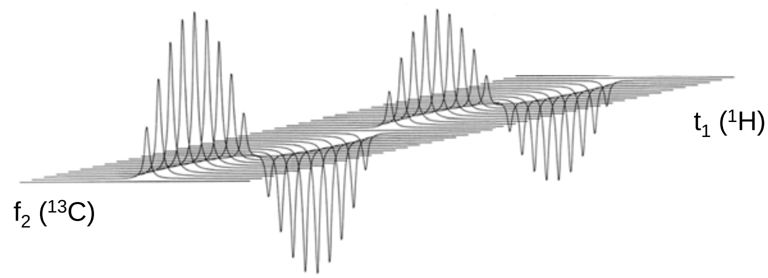


Heteronuclear Correlation Spectroscopy (HETCOR)

Objective: Correlate protons with attached carbons.

Problem: ^{13}C NMR is inefficient, so HETCOR very insensitive.

f_2 must be ^{13}C spectrum, because $^1H \rightarrow$ ^{13}C coherence unlikely.



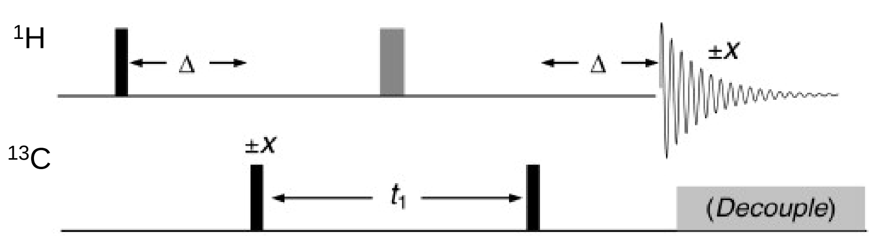
Often requires high-concentration or pure (liquid) sample.

Heteronuclear Multiple-Quantum Correlation (HMQC) Spectroscopy

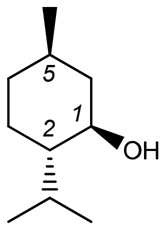
Alternative method to ^1H-^{13}C HETCOR.

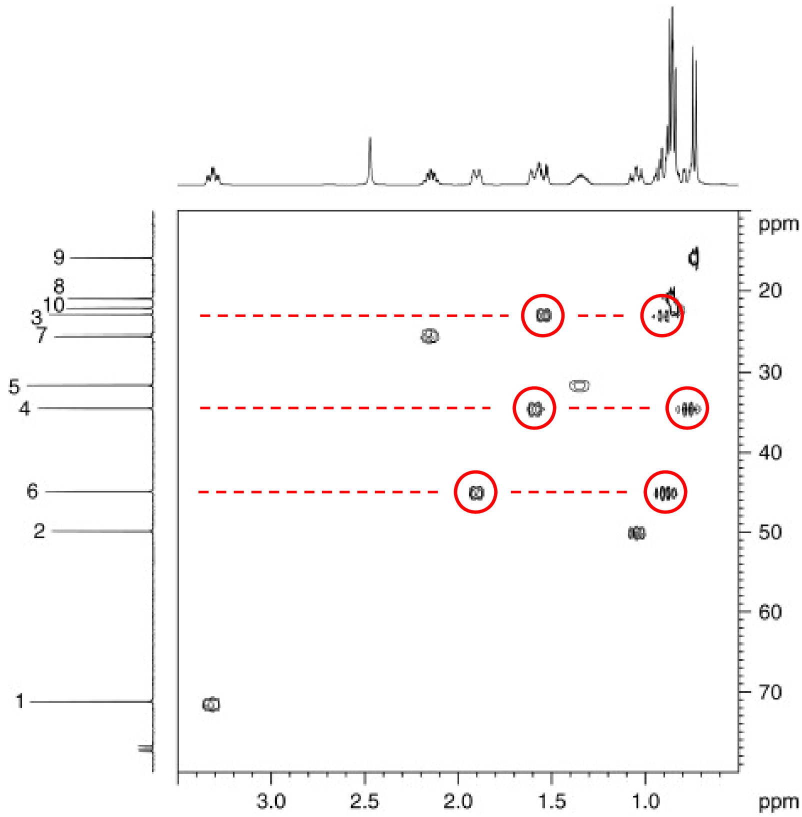
Uses *inverse detection*: ^{13}C frequencies are detected as echoes in ^1H channel.

(This avoids low sensitivity of ^{13}C NMR.)



HMQC





Each peak corresponds to a $^{1}J(CH)$ correlation (*i.e.*, a C-H bond).

Particularly useful in identifying inequivalent geminal H's.