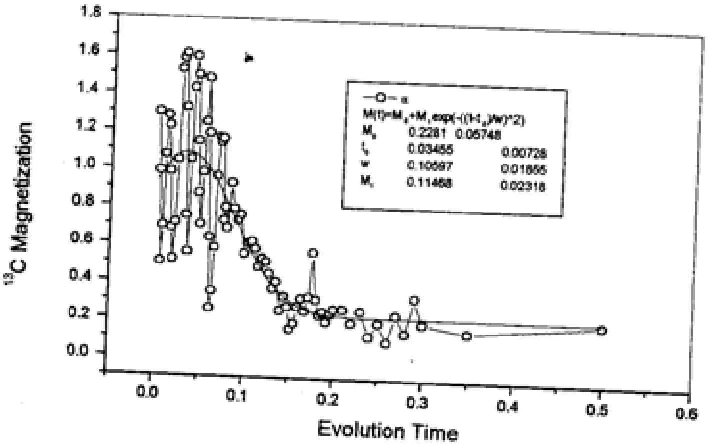
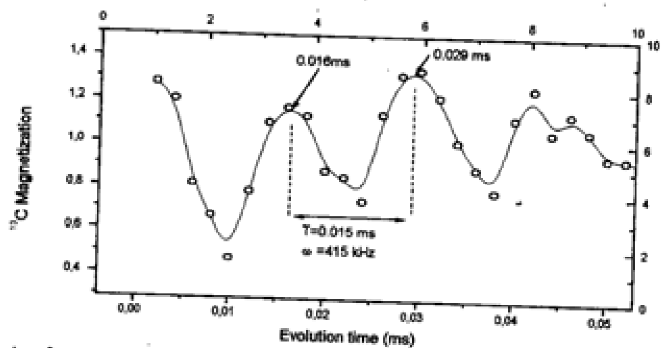
4. Appendix 3: Time-domain interferencies between ^1H and ^{13}C polarization states [Pas96].

We saw, in the study of the spin forward dynamics, that near the top of the echo *oscillations* of charasteristic pulsation ω_1 are superpimposed with the experimental curve.





The spin forward dynamics in 5CB, and a zoom at short times. Well-defined oscillations of pulsation ω_1 appear. They can be explained as quantum interference between ^1H and ^{13}C polarization states.

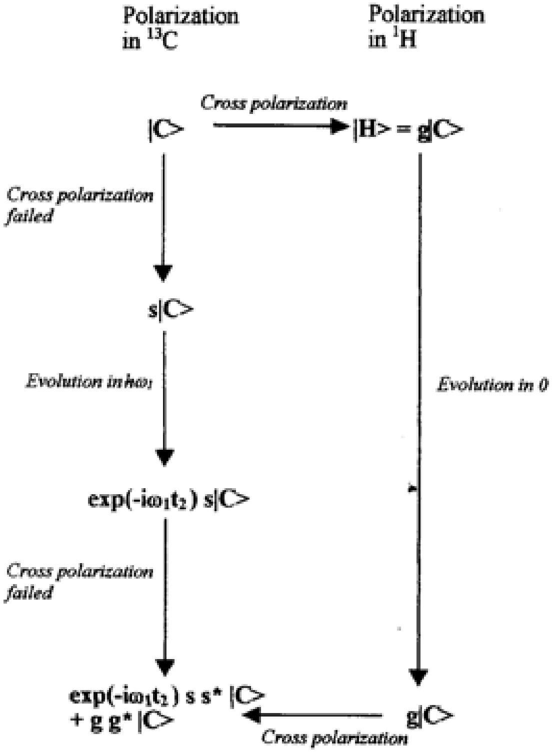
These oscillations can be explained as follows:

During the short cross-polarizations, the polarization transfer is not perfect. (A polarization is transferred from ^{13}C to ^1H with a probability amplitude g, and remains in the initially polarized state with a probability amplitude s ($|s|^2 + |g|^2 = 1$).

Thence the final polarization detected in ^{13}C is the sum of:

- a polarization that remained all the time in ^{13}C, evoluating in the time t_2 in the Zeeman hamiltonian $\hbar\omega_1$ in the rotating frame, thus acquiring an additional phase $\exp\left(-\frac{it_2}{\hbar}\hbar\omega_1\right) = \exp(-i\omega_1\ t_2)$.(The cross-polarization has never been efficient)

- a polarization that has first been transfered from ^{13}C to ^1H, then evoluated in the time t_2 in the Zeeman hamiltonian 0 in the rotating frame , than trasferred from ^1H to ^{13}C. (Both cross-polarizations have been efficient).



The two paths of the polarization during the forward-dynamics pulse sequence:
Initially in ^{13}C, it may:
-stay in ^{13}C all the time;
-be transferred to ^{1}H and then back to ^{13}C.
These two paths are not equivalent, since the hamiltonian in ^{13}C and the one in ^{1}H are different.
Thus the respective wave functions acquire a relative phase and interfere with each other after rejoining.

The probability of measuring the polarization in ^{13}C is, in the end:

$$P(^{13}C) = |s|^4 + |g|^4 + 2|s|^2|g|^2\cos(\omega_1 t_2)$$

We observe very well defined *time-domain quantum interferences.*

*Remarks: 1)*The described simplistic description of the "polarization" as wave functions is of the type proposed to implement simple computations [Sci270]. It seems to work well !

2) The relative amplitude of the oscillations, $(2|s|^2|g|^2)/(|s|^4+|g|^4)$, is a measure of the cross-polarization efficiency ($|g|^2$).

In our experiments the efficiency is (in %):

-in 5CB: 81%

-in ferrocene: 85%