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Estimation of the NMR signal height correction introduced by the lock-in phase

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Abstract

We present a method to estimate the contribution of both lock-in channels to the NMR signal height.

1 The Lock-in NMR Signal

The NMR signal detected at 91 kHz by the pick-up coils surrounding the target chamber is sent to the lock-in amplifier located in the counting house. The lock-in is used in the X-Y mode, where it measures the so called "In Phase X component" of the signal and the "Quadrature Y component". Refer to [1]. These two components may be written :

$$X = Rcos\phi \tag{1}$$
$$Y = Rsin\phi \tag{2}$$

where R is the main NMR signal amplitude at 91 kHz, and ϕ is the so-called "lock-in phase". The lock-in phase can be manually adjusted (see [2]) so that all the NMR signal can be sent to one channel only, this other channel containing only noise. Unfortunately, the manual setting is never perfect and a small fraction of the NMR signal is usually detected in the other channel. Refer to Figure 1.

The NMR signal measured in the channel containing the strongest component (let's say the X component) is first fitted using the traditional square root of a Lorentzian plus a linear background, as shown on the first plot of Figure 2. The height of the signal is then extracted from the fit. The component in the other channel shows usually a pretty noisy peak that does not fit to any interpretable mathematical function. Therefore, we try to estimate the height of the NMR signal in that channel by looking at the difference between a linear background fit to the noise and the peak highest point. Refer to the second plot of Figure 2. The ratio of the peak height measured in the Y channel to the signal height detected in the X channel gives us the tangent of the lock-in phase ϕ (with a constant offset). Then the height of the NMR signal is obtained by dividing the height of the signal measured in the X channel by the cosine of that angle. For the example shown on Figure 2, the cosine value is 0.999982. The corrected signal is shown on the third plot of Figure 2. The relative correction is very small and about 2.10^{-5}.

References

[1] Stanford Research systems, "Model SR844 RF Lock-In Amplifier", Operation Manual

[2] S. Incerti "The NMR system of the Hall A polarized Helium 3 target", E94-010 Technical Note 9 (November 1998)

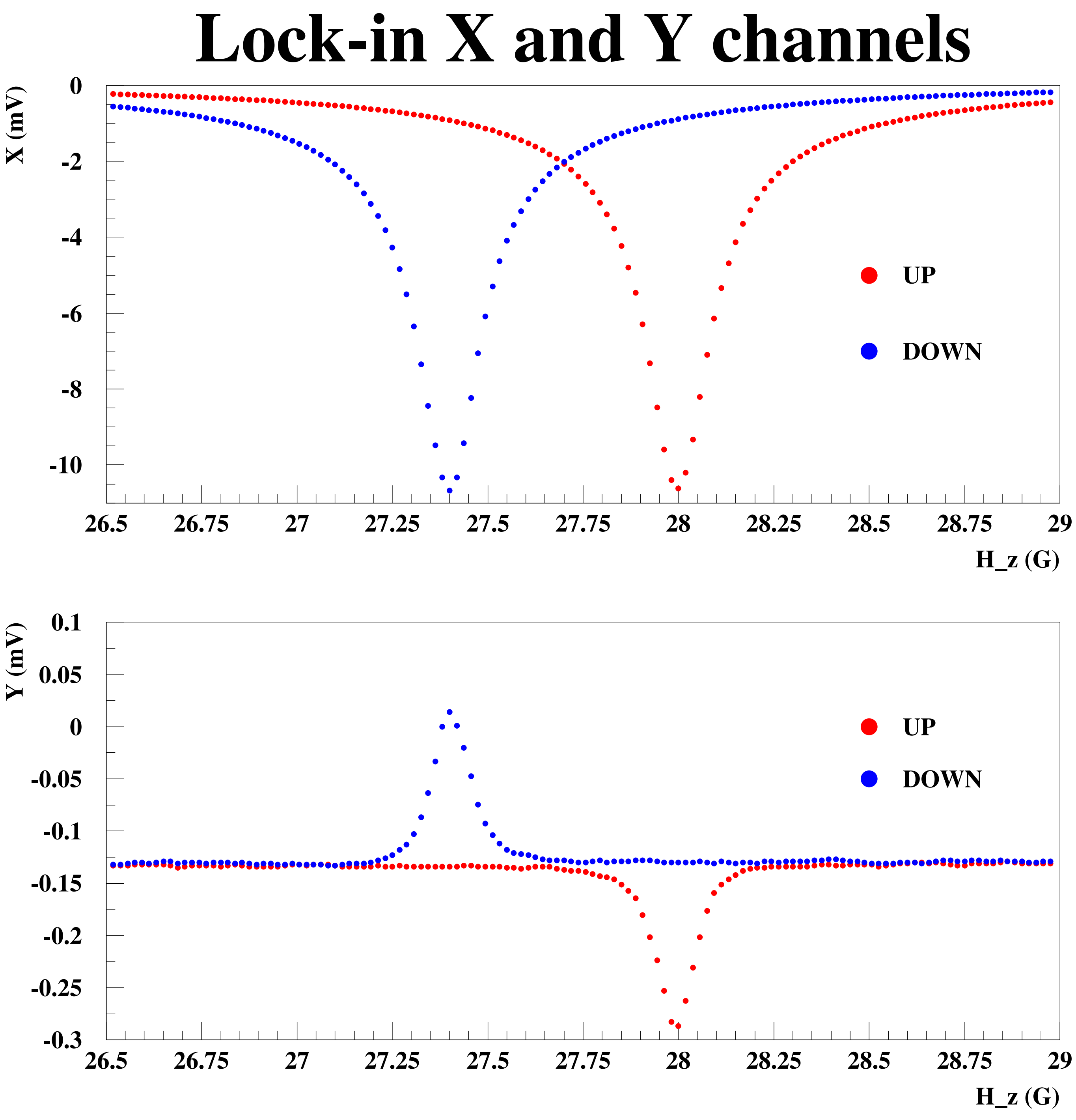

Figure 1: Example of NMR signals (in mV) detected by the lock-in amplifier in both channels, for the UP and DOWN ramps. The time shift between the two signals is 0.50 ± 0.02 s and is caused by a communication delay between the Macintosh and the Function Generators driving the Kepco power supplies. It can be artificially correted.

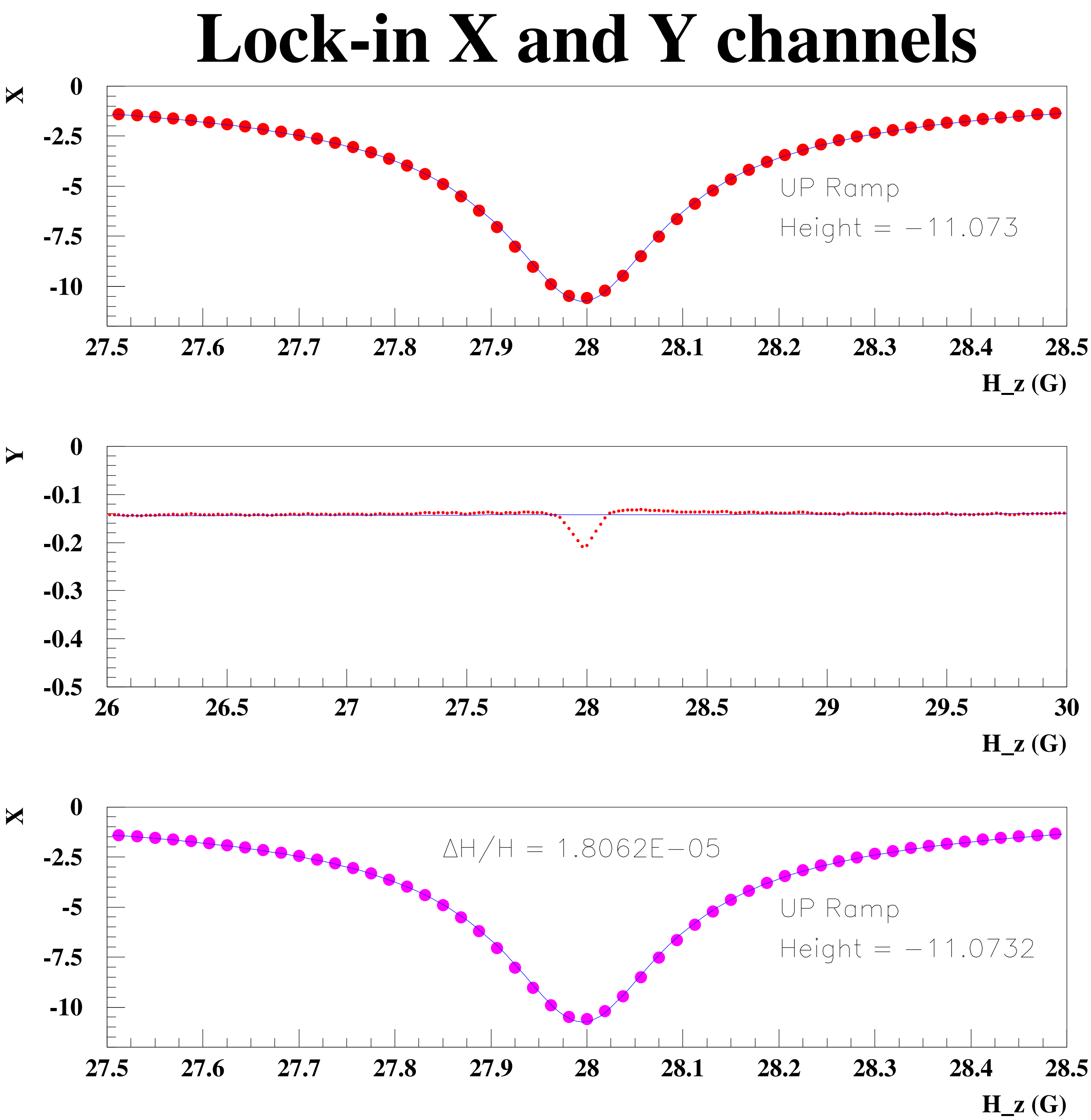

Figure 2: NMR signal (in mV) corresponding to a "UP ramp" detected in the lock-in X channel (first plot), in the Y channel (second plot), and the main NMR signal after recombination of both channels (third plot). These plots are shown as a function of the main holding field H_z, provided by the Helmholtz coils.