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Comment on mr-2022-1

Anonymous Referee #2

Referee comment on "SORDOR pulses: expansion of the Böhlen–Bodenhausen scheme for low-power broadband magnetic resonance" by Jens D. Haller et al., Magn. Reson. Discuss., https://doi.org/10.5194/mr-2022-1-RC2, 2022

In this manuscript, Haller et al. describe a possible application of a recently reported class of radio-frequency pulses to low-power broadband NMR. The SORDOR pulses were designed with optimal-control theory to achieve universal rotation by 90° or 180° and a quadratic offset dependence of the phase. In this work combination or SORDOR pulses are used, with a specific example given for the case of the PROJECT pulses sequence. The idea of using OC-derived pulses for low power broadband MR, and, e.g., allow for broadband mixing, is interesting and useful. The reported experimental data is also well presented. However, several aspects of the theory and simulation are very difficult to follow for the non-expert reader. I recommend addressing the following issues before the paper can be considered for publication. They mainly consist in giving more background for the key concepts and results, and stating the main conclusions of the paper much earlier.

Throughout the paper, reference is made to the Böhlen-Bodenhausen scheme. It would be useful to explain what this actually is. My expectation was that this phrase referred to the use of combinations of frequency modulated pulses to remove the non-linear offset dependence of the phase that arise when using just one (the first paper by Böhlen and Bodenhausen). But the authors specifically do not show this. So what it the Böhlen-Bodenhausen scheme ? Using combination of frequency swept pulses ? Or is there some specific combination that should be met ?

In the same line, it might be useful to name the method with a phrase that describe what it does, rather than the name of those who first described it (especially since they described several different things).

The authors write “the quadratic phase correction of the acquired FID may be compensated by using a SORDOR-180 pulse with twice the rf-amplitude and half the pulse length tp for refocusing. In this case the frequency sweep is twice as fast as for the nominal SORDOR pulses and the quadratic phase should fully refocus to a normally

phased spectrum." Considering the relevance of having directly phasable spectra, the authors should demonstrate this experimentally…

… especially since the introduction states "if a simple quadratic phase correction of the spectra can be tolerated". In which cases is there a solution if it cannot be tolerated ?

One of the main point seems to be that SORDOR pulses achieve universal rotation, which classic chirp pulses do not. Figure 1 illustrates this, but it is difficult to follow without a more detailed description of what "effective rotation" means, and what the different frames are (x, y, z) and (X, Y, Z). Please give more background information.

It is known that linearly frequency swept pulses with gamma B1 / (2pi) = sqrt(BW/Tp) achieve uniform 90° excitation (see Tal and Frydman, Prog. Nucl. Magn. Reson. Spectrosc. 2010), with a quadratic dependence of the phase. How can this be reconciled with Fig. 1? And with the statement "it is obvious that the adiabatic pulse can only used to excite a single component". Addressing these two questions and the previous one would help (the non expert reader) to understand what is it that can be done with SORDOR pulses and not chirp pulses.

Looking at Fig. S1, the difference between SORDOR and chirp pulses seems to be significant mostly for 90° pulses. It is stated in the conclusion but it would help if it were stated much earlier. It would be interesting to rearrange Fig. S1 so that it can be included as Fig. 1.

It would help to address all of the above if l. 33-38 could be rewritten in more details:. what does "matching pulse shapes" mean ?

. "the inversion pulses acts as a refocusing […]"; how is that a consequence of the fact that "the effective phases of the pulses are matched"

. "Matching UR-90 pulses, however, […]"; this sentence seems to be the key part of the paper but it is difficult to understand.

. the explanation on COOP pulses is confusing, as it mentions "the least amount of restrictions" and then "similar restrictions".

The author could define, maybe in the SI, what the "pulse performance" and "quality factor" are.

A comment following the posting or review 1: I entirely agree with reviewer 1 that the citation styles makes some parts of the manuscript very difficult to read. It would be much preferable to use numbered references.