# Two-Dimensional J-Resolved LASER Spectroscopy of Human Brain at 3T

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## Introduction

The limited radiofrequency (RF) bandwidths (BWs) not only cause chemical shift displacement error (CSDE) but also lead to spatially dependent evolution of J-coupling, which results in additional J-refocused peaks in two-dimensional (2D) J-resolved spectroscopy (JPRESS) (1,2). For a pair of coupled spins with a large chemical shift difference, one of the coupled spin pair may not undergo the 180° refocusing pulses due to the finite BWs of the RF pulses in the voxel selected for its J-coupled spin partner. Therefore J-coupling will be refocused instead of evolving during the echo time (TE), which leads to additional so-called J-refocused peaks and reduces the intensities of intended J-resolved peaks and thus impairs spectral quantification. The above issues can be solved or mitigated using adiabatic RF pulses (3,4). Adiabatic RF pulses offer large BWs and produce a uniform flip angle despite variation in $B_1$. In this work, a J-resolved spectroscopy sequence using localization by adiabatic selective refocusing (LASER) (4), named as "J-resolved LASER", was proposed to address the issues of conventional JPRESS such as the CSDE, spatially dependent J-evolution, and sensitivity to $B_1$ inhomogeneity.

## Methods

Fig. 1 shows the diagram of J-resolved LASER pulse sequence. To build the second dimension, the first half of the incremental period $t_1$ was inserted between the last pair of AFP pulses in the 2D J-resolved LASER sequence.

All experiments were performed on a Philips Achieva 3T whole body scanner. Phantom experiments on NAA and in vivo experiments on the brain of healthy volunteers were performed to compare the conventional JPRESS and J-resolved LASER sequences. The adiabatic pulse used in J-resolved LASER sequence is 5.3 ms long with a BW of 4748 Hz. A 30×30×30 $mm^3$ voxel was placed at the center of the phantom. All data were acquired with VAPOR (variable pulse power and optimized relaxation delays) scheme for water suppression. TR = 2000 ms, number of averages = 8 for each $t_1$ step, 1024 × 32 points with $\Delta t_1$ = 10 ms, spectral widths = 2000 Hz × 100 Hz in the $F_2$ × $F_1$ dimensions, total scan time = 8 mins and 32 s. The data was zero-filled to 2048× 128 before Fourier transformation.

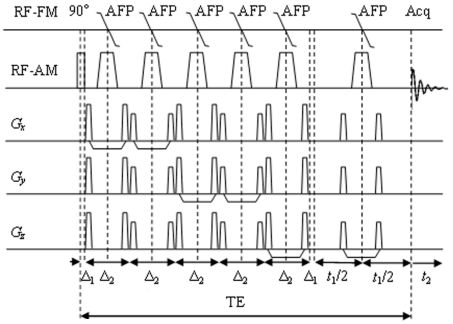


Fig. 1 J-resolved LASER sequence

## Results and discussion

The experiments on the NAA phantom (Fig. 2) show the additional J-refocused peaks in the JPRESS spectrum while these additional artifactual peaks were significantly reduced in the J-resolved LASER spectrum. The additional peaks appeared because the coupled spins did not equally undergo the 180° refocusing pulses in the JPRESS sequence due to the limited BWs of the pulses compared with the significant chemical shift difference between the coupled spins.

Fig. 3 shows two spectra acquired from a voxel encompassing the parieto-occipital junction of a healthy volunteer using the two 2D J-resolved spectroscopy sequences. The CSDEs in the form of extracranial lipid signal were reduced evidently in the J-resolved LASER spectrum compared to the JPRESS spectrum. Therefore, the outer volume suppression (OVS) is possibly not necessary in J-resolved LASER to suppress the signal from the outside of voxel. Decrease in residual water and out-of-volume lipid/MM signals will benefit the spectral quantification, especially for those metabolites with resonances close to the strong "phase-twisted" water or lipid peaks.

The suppression of the sensitivity to RF field inhomogeneity, chemical shift artifacts and additional J-refocused artifactual peaks make the proposed J-resolved LASER spectroscopy promising in the in vivo application for more reliable and accurate quantification of metabolites.

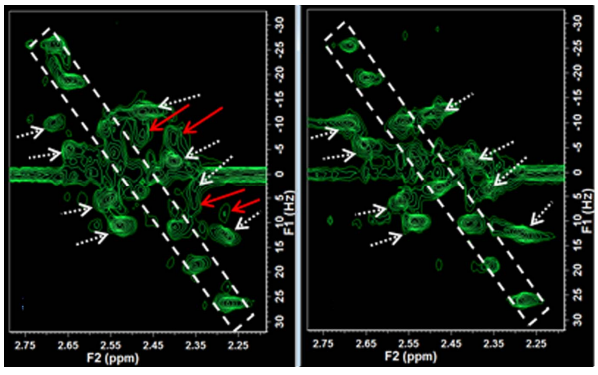


Fig. 2. 2D spectra of NAA at 2.20-2.75 ppm using the JPRESS (left) and J-rosolved LASER (right) sequences. The red solid arrows mark the additional J-refocused peaks and the white dashed arrows the intended J-resolved peaks. There are eight additional peaks due to strong J-coupling effects in both spectra, marked by the white dashed boxes.

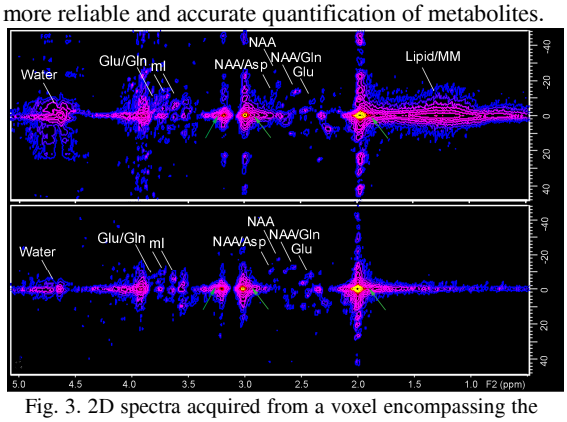


Fig. 3. 2D spectra acquired from a voxel encompassing the parieto-occipital junction of a healthy volunteer using JPRESS (top), and J-resolved LASER (bottom) sequences. The lipid signal from the scalp is clearly seen in the conventional JPRESS spectrum but barely observed in the J-resolved LASER spectrum. The green arrows mark the phase-twisted lineshapes.

## Reference

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