Flow, Chemical Shift, and Phase-based B1 Mapping

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Introduction: Accurate B1 assessment allows optimum set up of a scan and accurate determination of transverse magnetization after scanning.

The Bloch Siegert phase shifts allow B1 mapping [1]. Irradiating transverse magnetization above resonance lowers its Larmor frequency and vice versa such that a phase difference image between above and below resonance effects determines B1. In radian measure

$$\omega_1^{\,2} = (\varphi_{below} - \varphi_{above})\omega_{off} \,/\, T_{BS}$$

with T_{BS} the effective Bloch Siegert pulse length. These phases are independent of TR so the method can be faster than amplitude methods such as dual flip angle [2,3] and less (if at all) T1 dependent. Comparing Bloch Siegert to dual flip, 6 minute, dual flip B1 maps show residual T1 dependence but 30 second, Bloch Siegert maps did not.

While influences on amplitude, such as T1 or receiver coil coupling, do not affect phase based B1 mapping, influences on phase may. Here we examine the affect flow and chemical shift.

Methods: Images were made in the standard head coil of a 3 Tesla Signa (GE Healthcare, Milwaukee WI). Bloch Siegert pulses were 4 kHz off resonance, 8 ms long. Low amplitude pixels were masked. For flow studies, 6 mm ID Tygon tube was wrapped around a static gel phantom. A peristaltic pump gave tap water in the tube steady laminar flow at a mean speed of 0.47 m/s, Reynolds number 2800. Chemical shift studies imaged a static phantom with regions of water and of Wesson oil.

Results & Discussion: Turning the pump on changes pixel phases ~120° (fig 1) but has much less effect on B1 measurements than does position in the head coil (fig 2). The oil water boundary is imperceptible in B1 maps made with several different TE. Fig 3 shows a case with oil and water in phase and another with them out of phase. These results suggest Bloch Siegert B1 maps are robust.

References: [1] Sacolick, Wiesinger, Hancu, Vogel, MRM in press. [2] Hornak, Szumowski, Bryant, MRM 1988;6:158-163. [3] Stollberger, Wach, MRM 1996;35:246-251.

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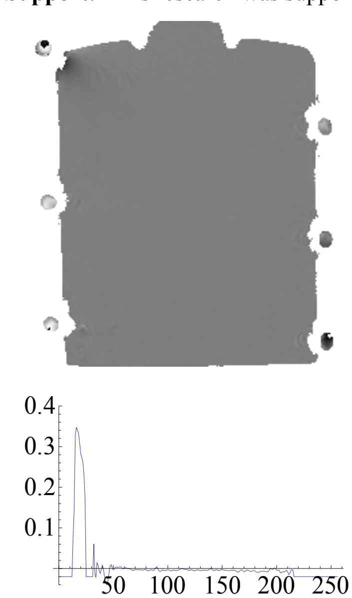
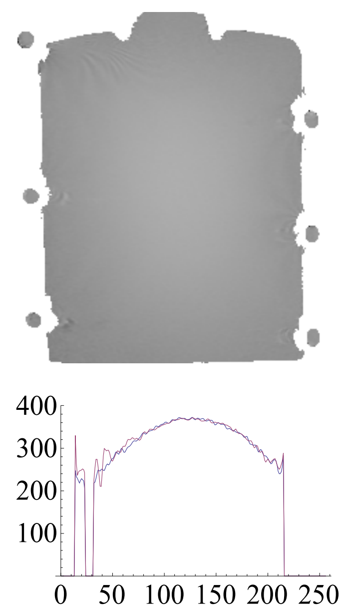


Figure 1, left. Phase change caused by flow. Image: The turns on one side have higher phase than static part of phantom, those on the other side where flow is opposite, lower. Plot: Profile though middle turn at image left showing flow induced phase change in revolutions. As expected, change in static region to the right is only noise.

Figure 2, right. Image: A Bloch Siegert $B1^2$ map of a bottle of doped water wrapped in a 6 mm ID Tygon tube with flowing water. Variation of B1 within the bottle is larger than the difference between flowing and nearby static water. Plot: Profiles of B1, in Hz, along a horizontal line through the middle turn of the hose on left of the image. Blue without flow, red with.



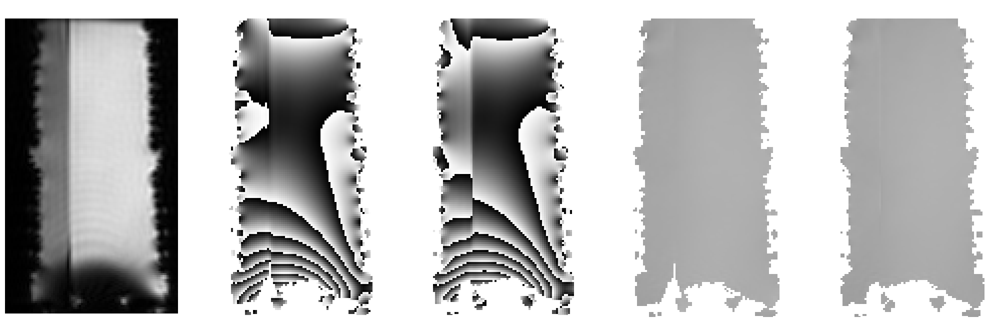


Figure 3. Oil-water phantom. Left to right: magnitude image shows oil at left, water at right. Phase images with oil and water in and out of phase. B1 maps with oil and water in and out of phase.